GAUGING THE QUALITY OF MANAGERIAL DECISIONS REGARDING INFORMATION TECHNOLOGY DEPLOYMENT

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ABSTRACT

This paper presents a new approach for evaluating the quality of managerial choices in information technology (**IT**) deployment. The approach involves measuring the extent to which deployment sites perform in accordance with the firm's objectives, given the constraints of their competitive environment. Our method is to model environmental descriptors as inputs to a production process that yields business outputs. This production process is then evaluated via standard productivity assessment methods to obtain "competitive efficiency" scores. Interpreting why different deployment sites exhibit different levels of competitive efficiency involves estimating regression models in which competitive efficiency scores are the dependent variables and management's IT design choices are the independent variables. Such measurement and interpretative methods provide managers with new tools to improve their IT location and design decisions. Our framework is illustrated in the context of automatic teller machine (**ATM**) deployment.

1. INTRODUCTION

When managers deploy information technology (**IT**) they frequently are forced to make decisions about two different, yet related sets of issues simultaneously. *First*, they identify the characteristics of the competitive or business environments in which the IT will be deployed. This enables them to select the most beneficial deployment environments, to maximize the potential that the IT contributes business value to the firm. *Second*, recognizing that all deployment environments are not created equal, they also find it may be worthwhile to adjust the characteristics or features of the IT to take into account those differences. Often it is difficult to separate the influences of the deployment environment (which may be beyond the control of management) and the features of the IT (which management can quite readily select). Still, in order to successfully deploy IT to create competitive advantage or sustain competitive parity at an acceptable cost, managers need to be good at choosing deployment locations and the features of the ITs they invest in.

1.1. IT and Competitive Efficiency

In this paper, we propose and illustrate a new class of IT performance evaluation method metrics that gauges "competitive efficiency." *Competitive efficiency* metrics involving IT are measures for the efficiency of the transformation between the characteristics of the deployment environment of the IT and business outputs that are related to the IT. This transformation can be thought of as an input-output process with one important aspect to distinguish it from the standard production processes of microeconomics. The inputs here -- the descriptors of the deployment environment -- are not physical inputs, per se, since they are not consumed in the transformation; instead, they act as relatively fixed "inputs" that management must take into account in its deployment decisions. The shape of the competition, customer demand for services, population, and numerous other descriptors that we will discuss in more detail below may all play a role. Thus, the reader should think of competitive efficiency not only in terms of how well a firm does in relation to its competitors, but also in terms of how well its IT deployment decisions take advantage of the competitive environment.

When we measure the performance of an IT deployment in this way it is apparent that varied environments may constrain or enhance IT's ability to produce the desired business outputs. In order to develop a clearer understanding of the potential of the IT, it is beneficial for management to think about this problem as a management scientist might view it -- see what happens to the level of a business output when:

(1) the environment is allowed to vary while holding the features of the IT fixed; or,

(2) the environment is held fixed while allowing the features of the IT to vary.

Measures for competitive efficiency, combined with additional follow-up analysis, enable this approach to be undertaken directly. The features of the IT being deployed are directly controllable by managers and involve alternative designs carrying different costs. Thus, to promote competitive efficiency related to the deployment of IT, managers only should invest in those IT features which increase the firm's ability to produce business outputs.

1.2. Competitive Efficiency Measurement Contexts

The concept of competitive efficiency and measures that can gauge it are readily motivated in a number of well-known IT-related contexts. We briefly present two scenarios for their use, in advance of providing a fuller illustration later.

> *Hardee's Inc, a large nationwide fast food chain, has been a major investor in IT to improve the operational efficiency of its owned and franchised locations. One highly successful example of Hardee's investment in IT was a point-of-sale device called "Positran" that connects the order counter with the food preparation area, to improve communication and reduce material waste. Hardee's stores are located in different competitive environments and this influences management's choices about the scope of the menu, the introduction of new menu items, product pricing and whether to deploy Positran (BANK90).*

Measuring competitive efficiency for fast food restaurants would involve quantifying descriptors for the environments the restaurants compete in (e.g., population, location quality and competitors as inputs) and the business outputs of interest to management (e.g., sales revenue or market share) via a productivity ratio. Competitively efficient restaurants would be those that make the best of their relatively fixed environments, in view of management's choices about menu, new products, pricing and IT deployment.

> *A large oil company that owns and operates retail gasoline service stations across the U.S., recently conducted a pilot program in California to investigate how offering customers a debit card program as an alternative way to pay for gasoline affected sales revenue. In this business, the quality of the service station's location and its competitors' pricing decisions are the primary determinants of its success in producing revenues. However, even given these environmental constraints on its business, secondary decisions such as increasing the number of ways to pay can leverage sales. The study suggested that offering a debit card payment alternative may lead to more "fill-ups" on average, and hence higher sales revenues per customer serviced (KAUF88).*

Competitive efficiency metrics would serve well in this context, permitting management to compare the relative performance of service stations in more or less constraining environments in terms of their ability to produce "fill-up" servicing. Taking the analysis a step further, management could also control for environmental influences on demand to gauge the leverage on "fill-up" servicing created by the debit card alternative.

Thus, competitive efficiency metrics enable managers to make "fair" performance comparisons for ITs deployed in different competitive environments. They also provide a starting point to help management identify the extent to which IT design features leverage business outputs.

1.3. Outline of the Paper

In the following section, we present a conceptual model for gauging the quality of managerial decisions regarding IT deployment, from which measures for competitive efficiency are readily developed. Section 3 provides background and motivation for the illustration of our approach to gauging competitive efficiency in electronic banking operations. We discuss the relevance and application of competitive efficiency measures to a variety of decisions faced by banks operating ATMs in areas with competing electronic banking networks.

Section 4 presents the details of the empirical work we carried out to illustrate how to measure competitive efficiency in electronic banking and the extent to which managerial decisions about ATM placements explain the results. It also discusses the implications of these findings for the bank's management. The paper concludes by summarizing the contributions of our research, its limitations, and how we plan to extend it in the future.

2. COMPETITIVE EFFICIENCY: CONCEPTUAL MODEL AND ANALYTIC PROCESS

2.1. Conceptual Model for IT Deployment

To begin a more detailed discussion of the competitive efficiency dimension of IT performance discussed in Section 1, we next present a conceptual model for IT deployment evaluation. Our conceptual model is characterized by the following:

* "inputs" representing important aspects of the competitive environment of the IT deployed that constrain its ability to produce business outputs;
* operating unit business outputs;
* an "environmental" production process describing the transformation between "inputs" and the relevant business outputs;
* IT design and location decisions under management control.

Figure 1 depicts this conceptual model.

INSERT FIGURE 1 ABOUT HERE

Variables describing the environment -- the "inputs" -- represent managerially non-controllable features that may constrain an IT's ability to produce business outputs. We identified four kinds of factors as potential candidates for consideration by managers interested in conducting competitive efficiency analysis:

* *Regulatory factors*, such as prohibitions against monopolies or limitations on interstate or international data interchange, may constrain the leverage the IT was meant to provide. (For example, limitations on trans-border data flows may pose problems in deriving full value from electronic data interchange in the international automotive industry.)

* *Competitive factors* represent information about the presence of competitors or other ITs deployed within the environment that provide the same basic service. These are among the most important factors that may constrain the performance of an IT. (For example, the ability of United Airline's computerized reservation terminals to generate additional travel agency business (and hence increased route market share, i.e., the so-called "halo-effect") may be constrained by the presence of terminals from American and other competing airlines.)

* *Demographic factors*, such as the population of potential users, user experience with the technology, age, income and education, influence the public's pre-disposition to use an IT. This may enhance or constrain the productive capability of an IT. (For example, the extent to which home computer use has grown has done much to raise the likelihood of success of Citibank's experiments with retail home banking. (GLAS88))

* *Technological factors*, including current and emerging standards, independent sources of user support or networks in which firms share costs, reflect the technological infrastructure into which an IT is deployed, and which supports the IT's ability to contribute to a firm's business. (For example, the slow growth of the Society for Worldwide Interbank Financial Telecommunication (SWIFT) -- an organization which acts as the main conduit for international funds transfer activity in banking -- in non-North American and European

Community markets was largely due to unstable technical environments that prohibited making the international funds transfer links fully reliable.)

Utilizing any of these input dimensions for competitive efficiency analysis still requires the analyst to identify the relevant business outputs that arise in environmental production. We also identified three kinds of outputs that should be considered, based on our prior work with an IT investment evaluation methodology called "business value linkage" impact analysis (BANK89).

* *Output measures of local operational performance*, that may not directly measure business value, are frequently used in the management of operations. (For example, the number of debit card purchases of gasoline at a service station or transactions at a Citibank ATM is an often-used indicator of performance that doesn't have a one-to-one relationship with revenues or business value.)

* *Output measures of intermediate production process performance* depict outputs of production processes that are one-step removed from the local production process involving IT. (For example, these include market share which is normally determined in firm-to-firm market competition, and the number of new customer accounts which is determined by competitive product offerings and pricing decisions.)

* *Output measures of business value* measure outputs that would normally be reported directly in the income statement or elsewhere in the financials of an annual report. (For example, the most obvious measure is sales revenue for a product delivered via IT or in which the IT service is the product. Return on assets and return on equity are also possible output measures for business value, provided the analyst is able to develop a convincing argument that there is some linkage between these outputs and the IT deployed (BANK89).)

While this list may not be exhaustive and competing typologies of IT-related output exist in the literature (See, for example, WEIL89 and ICIT88.), the output measurement dimensions we suggest provide a useful basis for the analyst who wishes to develop an "environmental" production process to support the measurement of competitive efficiency.

2.2. Competitive Efficiency Analysis Process

Once managers have created the environmental production process, the next step is to measure competitive efficiency. This can be readily accomplished using a variety of techniques, including calculating productivity indices (EILO85), estimating a production function (BERN79), or employing non-parametric "efficiency frontier analysis" (BANK90), among others. Each of these methods enables the analyst to construct metrics -- what we call "competitive efficiency scores" -- comparing the performance of one IT deployment site or unit of the firm with others under study.

The crucial part of the analysis comes in determining the extent to which IT influences competitive efficiency and how the IT can be reconfigured to produce more desirable impacts. For the manager and the management scientist alike, this process involves specifying basic hypotheses about how the presence or features of the IT affect the competitive efficiency scores. This provides a means to explain the competitive efficiency scores and to gain a better understanding of how the technology affects the business.

Examples of simple hypotheses in a variety of IT deployment contexts are:

* The deployment of scanner technology at grocery store checkout counters results in a larger average number of customers serviced on busy days (local operational performance).

* The presence of an airline's computer reservation systems at travel agencies in large urban markets is consistent with higher load factors on flights departing from those cities (intermediate production process performance).

* Electronic banking machines that offer cash withdrawals only (no inquiries, deposits or funds movement) deliver no less fee income from use by other banks' customers (business value) than full-service machines, given equally constraining competitive environments.

3. COMPETITIVE EFFICIENCY AND ELECTRONIC BANKING DEPLOYMENT AT MERIDIAN BANCORP

We next consider a specific IT deployment environment -- electronic banking -- for more careful analysis using the approach we have outlined above. The purpose of the illustration is to demonstrate the approach, the metrics utilized to implement it, and the relevance of the results and the insights they provide for managerial decision making.

3.1. Competitive Efficiency Issues in Electronic Banking Management

In the past decade, automatic teller machines (ATMs) have become pervasive in the retail banking industry. However, rather than providing an edge over competitors, ATM services are viewed virtually as a commodity that banks must provide to their customers or risk losing market share (STEI89). In this "hook-up-or-lose-out" world, banks which fail to recognize the strategic necessity of making an appropriate investment in electronic banking technologies are often forced to exit the business or catch up at greater cost later (CLEM86, CLEM90). But, with an estimated $3 billion spent on ATMs to date in the U.S. (CHIP89), electronic banking managers and senior executives at large retail and commercial banking firms increasingly recognize the need to control the costs of providing ATM services, despite their strategic necessity.

The set of questions frequently asked by managers in this context include: How, where and with what network should the bank hook up? To what extent does it lose out if electronic banking deployment decisions are off-target? Given the cost minimization impetus associated with strategic necessity, how should the technology be managed operationally and how should the bank's ATM services be positioned? Should the bank own ATMs, but follow a network leader? Should the bank be a network owner/operator, creating the strategic profile for electronic banking services in a region? Or, might it be unwise to get involved in a market where over-capacity is the norm, and pay competitors to provide the requisite services? The link-ups of proprietary ATM networks into the shared regional and national networks and the trend toward the consolidation of the ownership of these networks and U.S. banking in general further intensifies the pressures on management to obtain answers to these questions.

Many of these questions can be understood in competitive efficiency terms. For example, the deployment environment in electronic banking can be characterized by a set of regulatory, competitive, demographic and technological descriptors at several levels of analysis: at the level of the bank as a whole; or regionally or locally, related to the management structure of branch banking; or right in the immediate neighborhood of an ATM. Business outputs of ATMs can also be classified as local operational outputs (inquiry or money transfer transactions), intermediate production process outputs (teller labor substitution, new account volume or deposit market share), or business value outputs (revenues from "interchange" transactions, when other banks pay fees for their customers use of a "foreign" ATM).

Most important, however, is how competitive efficiency measures can be used to provide insights for managerial decisions about the shape of a bank's involvement in electronic banking. At the level of the firm, decisions about the ownership of a network versus membership in a successful network should only be undertaken with an understanding of how the deployment environment is likely to reward differential investments. At the level of the branch, competitive efficiency is relevant to the extent that sufficient electronic banking capacity exists in the locale to support the bank's clientele and provide revenues consistent with the qualities of the competitive environment. At the level of the individual ATM, the production of transactions for the bank's customers and interchange transactions for other banks' customers should also reflect the qualities of the deployment environment. In each case, electronic banking design decisions can be re-cast as hypotheses for subsequent testing with real data.

3.2. Illustration: Electronic Banking at Meridian Bancorp

We found the competitive efficiency issues discussed above to be of interest during the course of other research we conducted on electronic banking in the state of Pennsylvania. Prior to 1987, Mellon Bank of Pittsburgh owned and operated the CashStream network, while Philadelphia National Bank/Core States Financial in the eastern part of the state owned the MAC network. Although both were represented throughout the state, in 1987 ownership of a major portion of the CashStream business passed from Mellon to Core States. This resulted in the elimination of the CashStream name and the consolidation of the two networks under the MAC trademark. (See CLEM89 for a detailed and probing examination of electronic banking strategy in this region.) With that change in the state-wide electronic banking regime, considerable over-capacity and duplication of electronic banking assets were created. As a result, many banks in Pennsylvania began to pursue aggressive programs to identify sites that performed poorly in order to rationalize their electronic banking assets.

For the illustration of our competitive efficiency ideas, we obtained data from Meridian Bancorp for a subset of their ATM operations prior to the 1987 CashStream/MAC merger. The bank's primary operating territory is in the southeastern quarter of Pennsylvania, and it has grown rapidly to become one of the state's largest commercial banks. Its association with the MAC network dates back to 1985. Prior to that time the bank operated a proprietary network of ATMs. Today it owns in excess of 150 retail branches and approximately as many ATMs.

Joseph S. Pendleton III, senior vice president of the firm's electronic banking operations, had the following to say about the bank's rationale for deploying ATMs:

> *"Meridian deploys ATMs for four reasons. The primary reason is to extend the service coverage of our branch banking operations to a full 24-hour basis. We must do this to remain competitive. In addition, ATMs provide the bank with a means to hold the line on bank costs while delivering effectively more service at a higher quality. We also deploy ATMs to earn direct interchange fees when the customers of competing banks use our ATMs. This prompts us to identify locations that have a lot of traffic from people who need cash ... for example, malls, shopping centers and supermarkets. Finally, we also deploy ATMs to support corporate relationships in special cases, for example, by placing an ATM on-site for firms whose employees use our direct payroll deposit services."*

Prior to the network merger, Meridian was evaluating whether to "backfill" ATMs at branch and non-branch locations where they had not been located previously. With budgetary limitations to carry out this program, Pendleton sought to deploy ATMs to only those locations that would be able to support the creation of measurable business benefits. Following the network merger, evaluation of existing operations for over-capacity became the more pressing issue, since the already regionally large installed base of MAC ATMs was nearly doubled by the merger. More recently, the issue of "greater ATM functionality" emerged, as the bank's competitors eyed investments in new generation hardware to change the essential quality of the service provided at ATMs.

For each of these initiatives, management required metrics to determine whether location choices and hardware configurations can produce business outputs consistent with the bank's electronic banking strategy. This provided us with an opportunity to develop several environmental production processes related to the bank's electronic banking business, and to test the extent that managerially controllable factors affected competitive efficiency. To distinguish this research from other work we have conducted involving ATM influences on *intermediate production* of branch labor savings and deposit market share, here we have chosen to focus on two ATM business outputs:

* US_ON_US transactions are associated with *local production*, readily counted at most ATMs and representative of an output that is indicative of the bank's customer service orientation.

* OTHERS_ON_US transactions can also be counted at an ATM. Each carries a fee payable to the bank by the competitor whose customer used an ATM. Thus, they represent an output which occurs at the operational level that has immediate *business value* that will show up in the bank's income statement.

3.3. Competitive Efficiency Models for US_ON_US and OTHERS_ON_US Transactions

To service its own customers, the bank places ATMs primarily in its own branches. These locations tend to exhibit a larger proportion of US_ON_US transactions. The bank also deploys ATMs at shopping malls, supermarkets and other places where commercial activity is likely to draw customers who require cash. As a result, these non-branch locations also considerable potential for generating interchange revenues via OTHERS_ON_US transactions.

Utilizing US_ON_US transactions to gauge the competitive efficiency of branch ATMs on Meridian's customer service criterion follows from prior research and standard industry practice. For example, Libbey (LIBB86A) reports that a period usage or transaction count criterion is often used to distinguish between acceptable and unacceptable performance.

We developed the input side of the environmental production process based on interviews with managers and prior research. The managers suggested that the greater the population of a territory, the greater the potential for generating ATM transactions, confirming prior research results about the influence of the demographic environment (MEAR78, MURP83, KOUZ87). The total number of branch transactions by Meridian's customers in the local banking territory also was believed by management to characterize the user population and its potential to use the bank's ATMs. Finally, the smaller the number of MAC ATMs deployed in a competitive environment, the more likely was a given MAC ATM to capture local transaction demand. Thus, we characterized the deployment environment related to these observations in terms of three variables (POPULATION, TERR_BRANCH_TRANS and MAC_SCARCITY).

The IT design decisions under management control were modeled using three indicators of the immediate site that management could select and configure within the larger deployment environment. These are the auto (AUTO) and foot (FOOT) traffic around an ATM, and its visibility (VISIB) to passersby. Other aspects under management's control were the scheduled number of hours of availability (AVAIL_HRS), and whether the ATM was located at a branch or elsewhere (BRANCH_LOC). Figure 2 below summarizes the US_ON_US production process.

INSERT FIGURE 2 ABOUT HERE

Most analysts recognize OTHERS_ON_US interchange as the most tangible and direct payoff from ATM location. And, banks that are serious about generating this business output must engage in a game of "out-locating" their competitors to turn net transaction demand by competitors' customers in their favor (LIBB86B, MESH86). Although this can readily end up as a tit-for-tat location game, shrewd electronic banking managers are able to show consistently favorable interchange ratios over time through effective placement and service feature choices. (In New York City, for example, Citibank remains unwilling to allow competitors' customers to use its ATMs, fearing (in part) that its high quality touch-screen ATMs would generate excess demand, degrading the service its own customers might experience.)

Our interviews with bank managers suggested that the features of the deployment environment affecting interchange levels would be roughly similar, with one exception. The user population was now other banks' customers, not Meridian's. Since the number of transactions they performed at their own banks was proprietary information not available to Meridian, we used the total amount of customer deposits with other banks competing locally as a surrogate (OTHER_BK_DEP). Figure 3 below summarizes the US_ON_US production process.

INSERT FIGURE 3 ABOUT HERE

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4. COMPETITIVE EFFICIENCY AND IT DEPLOYMENT DECISION EVALUATION

4.1. Description of Data Employed

To evaluate our two models, we obtained data on 78 ATMs included in the study) and nearby branches covering a three month period prior to the CashStream/MAC merger. (These were broken into two overlapping sets of 64 ATMs.) The months chosen were identified by management to represent a period least influenced by seasonal activity and with average levels of transaction volumes. We later confirmed this by examining monthly samples of branch and ATM transaction levels. The bank continues to capture nearly all of the transaction data we obtained on a routine basis from its ATM and branch systems. What was not available in computerized reports was built up from other records kept by a unit of the bank's operations charged with supporting ATM operations. This included technical facts about each ATM, such as its scheduled hours of availability. This factual background helped us to appreciate the scope of the bank's electronic banking business, and capture the values of the transaction outputs included in our competitive efficiency models.

We also gained access to a data base of factual demographic information based on the 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 managerially defined branch operating territories. Matching census tracts to these territories required us to identify those census tracts most representative of a branch's account holders' addresses. This resulted in the construction of unique and disjoint sets of demographic data.

Finally, two senior electronic banking managers rated each ATM in the study group in terms of why it had been deployed. (Recall that the head of Meridian's electronic banking operation suggested that the bank's ATM are placed with four strategies in mind: customer service, cost reduction through teller labor substitution, interchange fee generation and corporate relationship support.) Their scaled responses (0 to 5) were captured in a larger questionnaire that provided a rich description of each ATM. We later identified several major discrepancies in a preliminary analysis of the two managers' responses, and conducted a follow-up meeting to investigate if these were mistakes, differences of opinion or otherwise. A number of errors were corrected in this way, and then we averaged the two sets of ratings.

4.2. Competitive Efficiency Analysis Results

We used a frontier efficiency evaluation technique called data envelopment analysis (**DEA**) to evaluate competitive efficiency (CHAR81, BANK84, BANK85). DEA generates a frontier of the most efficient units, which are assigned a score of 1.00. Less efficient units are assigned scores between 0.00 and 1.00, based upon their distance from the efficient frontier. The lower the score, the less efficient is the performance of the deployment site. DEA was chosen because it provides a robust mechanism for comparing productivity. It also delivers readily understood metrics even when multiple inputs and/or outputs are involved. DEA requires that the outputs be a monotonic, increasing function of the inputs. However, it does not require the restrictive assumptions associated with econometric estimation of parameters in production functions. Nor does it measure performance relative to the mean as fitting production functions to empirical data does; instead it focuses managerial interest on comparisons to realistically obtainable levels of production. (For additional background on DEA applied to IT investment evaluation, see (CHIS85), (BANK87) and (BANK90).)

The competitive efficiency scores obtained from an appropriate DEA model are summarized in Table 1 below.

INSERT TABLE 1 ABOUT HERE

In evaluating the ability of Meridian's ATMs to deliver business outputs to match the bank's customer service and revenue generation objectives, we found that the competitive efficiency scores varied widely, with the average score being about .50. The number of ATMs achieving frontier performance was quite small: five ATMs in the US_ON_US data set and nine ATMs in the OTHERS_ON_US dataset. The minimum scores also were quite low, and many more ATMs scored low on OTHERS_ON_US than US_ON_US competitive efficiency. This is indicated by the standard deviations (0.25 for US_ON_US and 0.32 for OTHERS_ON_US) and the DEA scores bounding the bottom quartile of performance (0.31 for US_ON_US and 0.21 for OTHERS_ON_US). On the other hand, we noted that a larger number of ATMs was relatively more efficient in the production of OTHERS_ON_US transactions, as evidenced by the top quartile DEA scores (0.68 for US_ON_US and 0.81 for OTHERS_ON_US).

Further examination of the competitive efficiency scores revealed sites which should be targeted for a more thorough managerial review. For example, one ATM was more than twice as efficient as another in producing US_ON_US transactions, though both were located in the same territory. Other pairs of ATMs in the same competitive territories also varied significantly in their ability to produce interchange transactions. In fact, one pair's efficiency ratings differed by a factor of times. This result no doubt indicates the great sensitivity of an ATM to the qualities of its immediate location. These results may indicate that initial estimates about the goodness of the locations may have been wrong, or that environmental conditions around the ATMs have changed since their installation. However, in isolation these scores do not tell the whole story.

To expand on the picture provided by the competitive efficiency scores in advance of running explanatory regression analyses for the managerial choice variables, we examined just those ATMs in the lowest quartiles. Of the sixteen ATMs scoring low in terms of US_ON_US competitive efficiency, four had been deployed primarily to capture interchange fees, one had been deployed to support a special corporate relationship, while the remainder were meant to deliver customer service. (In some cases, these purposes were relatively balanced.) Thus, eleven of these ATMs did not appear to be meeting at least one of Meridian's intended objectives.

For ATMs scoring low in terms of OTHERS_ON_US competitive efficiency, two had been deployed primarily to serve Meridian's customers, one had been deployed to support a special corporate relationship and four had been deployed to reduce teller labor costs. Thus, their low interchange efficiency scores, even in the absence of information about the other dimensions of performance, were not unexpected. The remaining nine, however, had been deployed with interchange revenue or a balance of the four objectives in mind. Clearly, these were not meeting one of the intended objectives, and were targeted for closer scrutiny.

Our next step was to compare the competitive efficiency scores for both objectives side-by-side, and see what additional conclusions could be reached given information about management's rationale for their deployment. (Note that in a fuller analysis, a reading on competitive efficiency for each of the four dimensions could be matched with ratings describing management's rationale for the deployment.) Nine ATMs were chosen for discussion below. Our results are shown in Table 2.

INSERT TABLE 2 ABOUT HERE

Comparisons made for the first three ATMs (lowest quartile performers in both US_ON_US and OTHERS_ON_US) suggest that they may be potential targets for removal, if efforts to improve their performance are unsuccessful (e.g., improving signage and up-time performance, if they had been substandard, or more closely monitoring cash stockouts and routine machine maintenance). Since management indicated that these ATMs met a balance of the strategic objectives, the labor cost reduction effects of the ATMs should also be studied more carefully.

The middle two ATMs shown on Table 2 also were deployed for multiple strategic reasons. Their contribution to customer service was quite good, as indicated by the relatively high US_ON_US efficiencies (.68 and .74), however, their ability to produce interchange fees was less than management expected (.21 and .21). The analysis suggests that the ATMs are probably not targets for removal, but the locations may need to be "fine-tuned" to make the ATMs more attractive to other banks' customers.

The final three ATMs shown in Table 2 either met or surpassed management's expectations. Two delivered frontier efficient performance in interchange revenues, although US_ON_US transaction efficiency (.31 and .24) was lower than the environment might suggest. It is also possible that we are seeing the symptoms of over-capacity here; or that the bank's customers are under-represented in the local population, and that the variables in our conceptual model failed to pick this fact up. Based on the information presented in the table, management seems to have a good understanding of the performance of at least one ATM that delivers very little customer service: its competitive efficiency rating is very low for US_ON_US transactions, however, management indicated that the ATM had been deployed to generate interchange revenue only. The OTHERS_ON_US competitive efficiency rating is high and right on target (.88).

4.3. Regression Results

A regression model of the form:

$$h_o = e^{(\alpha_0+\alpha_1 AUTO+\alpha_2 FOOT+\alpha_3 VISIB+\alpha_4 AVAILHRS+\alpha_5 BRANCHLOC+\epsilon)}$$

was used to evaluate the impact of managerially controllable ATM features on the competitive efficiency scores. The variables in the regression were defined as follows:

AUTO, FOOT = managerial ratings of traffic in immediate vicinity around an ATM (1 to 5 scale);

VISIB = ATM's relative visibility to the passersby (1 to 5 scale);

AVAIL_HRS = continuous variable for hours ATM is available for use each week;

BRANCH_LOC = 0/1 variable for presence of an ATM at a bank branch;

ϵ = an error term;

α_0 to α_5 = regression parameters to be estimated.

A regression model with the DEA scores as an exponential function of the managerial decision variables indicates that our expectation for the value of the sum of the exponent as a whole will be negative. This matches the intuition that after a point, positive increases in the values of the managerial decision dimensions will yield marginally less impact on the efficiency score. This is also true because the values of the efficiency scores vary between 0 and 1.

This regression analysis enables us to attempt to explain the competitive efficiency scores in terms of the IT-related factors under management's control. The results analyses are presented in Table 3 below.

INSERT TABLE 3 ABOUT HERE

The results of the US_ON_US competitive efficiency regression reveal that AUTO traffic (α_1 = .23, signif. = .01) and VISIBility (α_3 = .18, signif. = .01) are positive and highly significant. The findings confirm the beliefs of marketing research and electronic banking staff of the importance of these factors as indicators of good locations. The positive impact of BRANCH_LOCation (α_5 = .18, signif. = .12) agrees with the findings of a previous study (BANK89), and managers' intuition that branch location probably contributes to US_ON_US transaction volume. Interestingly, FOOT traffic (α_2 = .01, signif. = .43) did not have a significant positive impact on transaction volume. This result seems reasonable since branch ATMs are placed to service account holders who primarily use the bank's branch.

In the OTHERS_ON_US competitive efficiency regression, only FOOT traffic (α_2 = .33, signif. = .001) and VISIBility (α_3 = .18, signif. = .07) appear to have a positive and significant impact on interchange transactions. Since transactions by other banks' customers are the result of the intentional placement of ATMs in locations that are highly accessible to many people, this was expected. Moreover, FOOT traffic appears to measure a dimension of population flow not represented by AUTO traffic (α_1 = .05, signif. = .36).

A significant and positive coefficient for VISIBility was also the expected result, since other banks' customers are more likely to use a bank's ATM if they can easily see it when walking by or shopping. However, contrary to management's expectations, the parameter estimate for BRANCH_LOC (α_5 = .03, signif. = .45) indicated that there was no significant difference or decrease observed for interchange transactions in those locations. Thus, other bank's customers often use ATMs within Meridian's branches.

This result may provide the impetus for the bank to consider implementing promotional campaigns within branches to convince these non-Meridian account holders to switch their accounts to Meridian. (At least one other bank that competes with Meridian in the region is considering deploying a new generation of ATMs that will help to make the sales pitch. They provide value-added information including interchange transaction analyses for non-customers, and suggest how they can best make use of the bank's services.)

The coefficient of scheduled hours of ATM availability, AVAIL_HRS, was not significantly different from zero in both estimations. ATM hours of operation appear to be closely matched to their deployment environments. For example, most through-the-wall branch ATMs are available 24 hours each day, and the majority of transactions cluster during "prime time" hours (mostly during the day and in the early evening). Off-premise ATMs, however, are often located where they require protection, for example, as stand-alone machines or inside supermarkets and shopping malls. But, these locations may also concentrate transactions during certain portions of the scheduled hours of an ATM's availability.

5. CONCLUSIONS AND FUTURE RESEARCH

The primary contribution of this research is the "competitive efficiency" modeling and analysis approach we suggest for gauging the quality of managerial choices in deploying IT. For the manager considering the deployment of ITs other than electronic banking technologies, our study has shown the wide range of competitive efficiency results likely to be observed in different deployment environments. Obtaining a reading on competitive efficiency related to specific aspects of a firm's technology strategy offers insights into the tactical actions that can be taken to increase the business value of existing deployment sites.

Utilizing regression to explain competitive efficiency scores for IT deployments provides a readily implemented approach for gauging the quality of managerial decisions that influence the success of an IT investment. Using the general strategy of testing IT impact hypotheses provides considerable power to gain new insights into IT performance, in terms of the non-controllable environmental factors and the managerial choices about IT deployment that may result in differential returns.

The limitations of our approach center around the requirements for its appropriate use, many of which may not be met in other IT deployment scenarios.

(1) Our approach requires multiple IT deployment sites and emphasizes their relative, rather than absolute effectiveness.

(2) It can only be used when objectives are quantifiable. Many of the difficulties in measuring the value contributed by IT arises from the intangible nature of its outputs (KAUF89). The quantification of outputs such as improved decision quality or customer satisfaction may require additional research before these constructs can be incorporated into our models. In this research, we recommended that the analyst make a conscious decision about the kind of business output to be included in the analysis.

(3) The strength of our recommendation to create models for competitive efficiency rests upon management's ability to identify appropriate environmental inputs, business outputs and IT design features.

(4) In almost any study evaluating IT performance, data collection seems to be problematic. The requirements of the research approach discussed in this paper are bound to hinder evaluation in some deployment settings because it is hard to obtain relevant data.

To follow up on this exploratory work, we plan to carry out the hypothesis testing portion of the competitive efficiency analysis approach discussed, but not demonstrated, in this paper. To make this work of maximal value to the bank and to the IS research community, we believe that stronger, more managerially informative empirical results will emerge by expanding our analysis using time-series data on ATM performance. This will enable us to perform pre-implementation and post-implementation competitive efficiency evaluations for electronic banking locations that are added or eliminated.

Electronic banking offers a ready test-bed to examine how IT performance is affected by a changing deployment environment. In retail banking, changes such as a major competitor's deployment of new generation ATMs, a large bank's decision to move from one network to another, or the elimination of a competing network's franchise and identity change the conditions for all competitors. Times-series data would enable hypotheses about the efficacy of a bank's electronic banking strategies and design choices to be developed and tested in view of these changes. In the case of Meridian Bancorp, time series data would give us an opportunity to assess how the bank's backfilling strategy panned out. Overall, it will contribute to the growing base of IT value research that enables researchers and practitioners to tackle increasingly hard IT assessment problems with stronger methods to yield more refined and informative results for management (ALPA90, CROW87, HARR88, KAUF89).

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Figure 1. A Conceptual Model for IT Deployment Evaluation

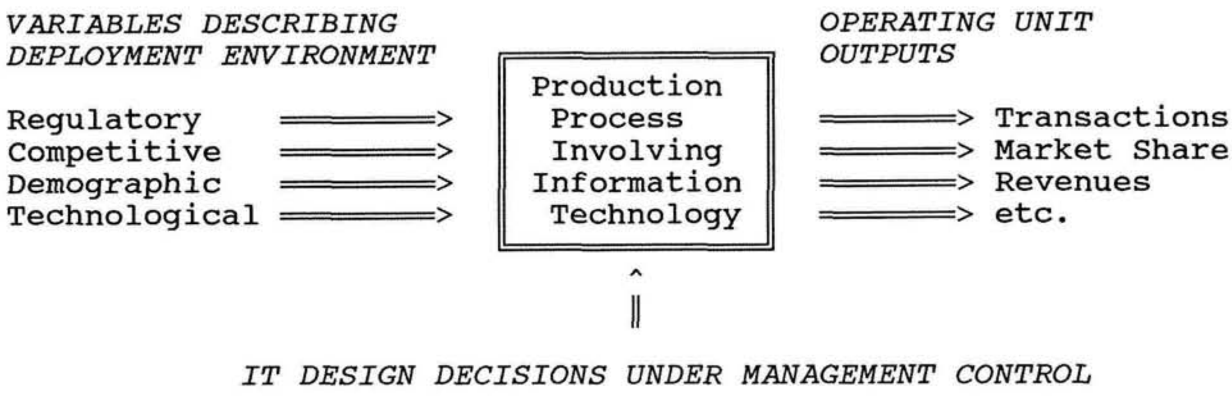

Figure 2. US_ON_US Transaction Production Process

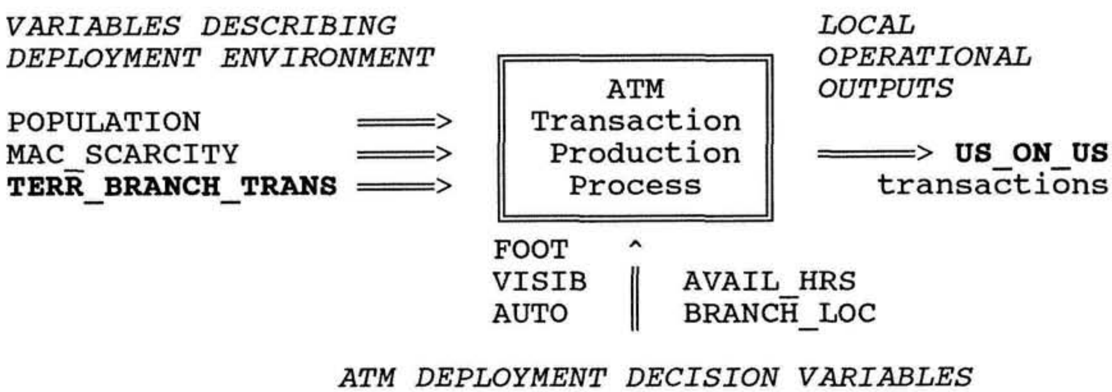

Figure 3. OTHERS_ON_US Production Process

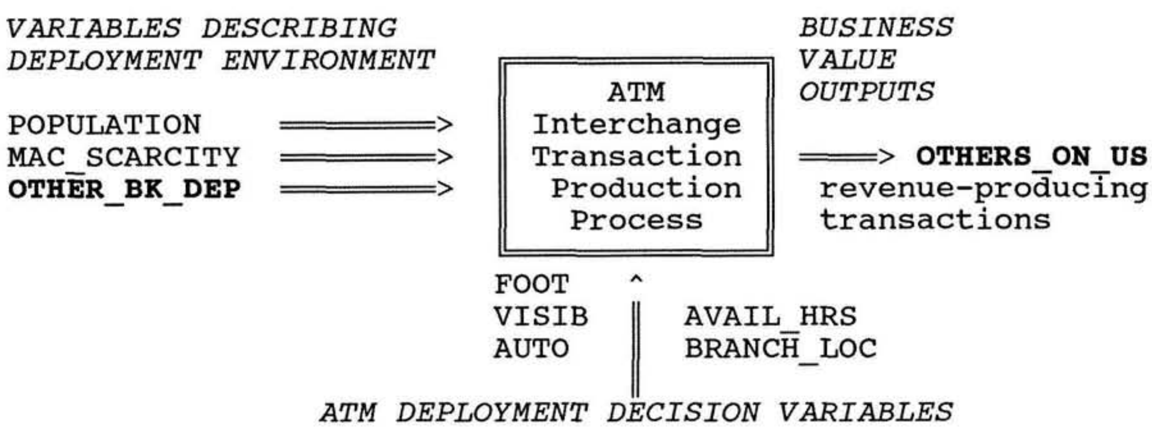

Table 1. Summary of Competitive Efficiency Results

COMPETITIVE EFFICIENCY SCORES	US_ON_US TRANSACTION MODEL	OTHERS_ON_US TRANSACTION MODEL
NUMBER OF ATMS	64	64
# ON FRONTIER	5	9
MAXIMUM	1.00	1.00
MINIMUM	0.10	0.04
AVERAGE	0.49	0.50
STD DEVIATION	0.25	0.32
TOP QUARTILE	> 0.68	> 0.81
2ND QUARTILE	> 0.46	> 0.45
3RD QUARTILE	> 0.31	> 0.26
BOTTOM QUARTILE	<= 0.31	<= 0.26

Table 2. Analysis of Selected Lowest Quartile Efficiency ATMs

ATM SITE NO.	US_ON_US COMPETITIVE EFFICIENCY SCORE (UOU)	OTHERS_ON_US COMPETITIVE EFFICIENCY SCORE (OOU)	MANAGEMENT STRATEGY FOR ATM LOCATION	COMMENT OR RECOMMENDED ACTION FOR MANAGEMENT
1	.30 *	.13 *	Balanced	Further study required; underperforming mgmt expectations. Possible target for elimination.
3	.23 *	.08 *	Balanced	Same as #1 above.
9	.22 *	.05 *	Balanced	Same as #1 above.
37	.68	.21 *	Balanced	Good UOU performance supports customer service strategy, but mgmt goal for fees not met. Examine why interchange not materializing.
42	.74	.19 *	Balanced	Same as #37 above.
29	.31 *	1.00	Balanced	Surpassing mgmt's expectations for fee generation. Are the site characteristics different from when ATM installed?
30	.21 *	.88	Fees only	Matches mgmt expectations very well.
46	.24 *	1.00	Balanced	Same as #29 above. Closer study advised.

Note: Asterisks indicate efficiency scores in the lowest quartile.

Table 3. Regression Results

US_ON_US TRANSACTIONS

VARIABLE NAME	COEFFICIENT	SIGNIF.
CONSTANT	-2.66	.001 ***
AUTO	.23	.01 ***
FOOT	.01	.43
VISIB	.18	.01 ***
AVAIL_HRS	.00	.15
BRANCH_LOC	.18	.12
R-SQUARED = .37	ADJUSTED R-SQUARED = .31	

OTHERS_ON_US TRANSACTIONS

VARIABLE NAME	COEFFICIENT	SIGNIF.
CONSTANT	-3.07	.001 ***
AUTO	.05	.36
FOOT	.33	.001 ***
VISIB	.18	.07 **
AVAIL_HRS	.00	.22
BRANCH_LOC	.03	.45
R-SQUARED = .22	ADJUSTED R-SQUARED = .16	

*Note: *** indicates .01 level one-tailed significance*
*** indicates .10 level one-tailed significance*