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AN INVESTIGATION OF THE BUSINESS IMPACT OF AUTOMATED UNDERWRITING SYSTEMS ON MORTGAGE LENDERS

By

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A Dissertation
Submitted in Partial Fulfillment of the Requirements for
The Doctor of Philosophy Degree

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An Investigation of the Business Impact of Automated Underwriting Systems on Mortgage Lenders

Major Professor: Dr. Arkalgud Ramaprasad

Implementation of Automated Decision Support has impacted the structure and function of financial institutions, and, in particular, lending institutions since the 1970's (DiGiammarino and Kuckuk, 1991). While studies of Information Technology adoption in the banking industry in general are not uncommon Banker and Kaufman, 1988), Alpar and Kim, 1990), little attention has previously been given to the specific needs of lending operations. Additionally, when such studies have been done, output variables have typically specified at a global organizational level such as Return on Investment.

The current study isolates the impact of Automated Decision Support adoption by using variables closer to the business function where the technology is used. Output variables of interest are: Productivity, efficiency, and asset quality of the mortgage lending function. Data collected from survey respondents highlights the linkage between technology adoption and these measures of performance.

For clearer understanding of research subjects and toward meaningful integration into business value of IT literature, Automated Decision Support

Systems used by lenders were divided into four categories: Loan Origination / Workflow Tools, Electronic Verification Tools, Origination Decision Support Tools, and Underwriting Decision Support Tools. Adoption of each technology type was treated as a separate research question.

Much academic and practical study has focused on the importance of re-engineering business processes in realizing the benefits of Information Technology (Sampler and Short, 1994). This literature stream has been incorporated into the research by including questions about adopters 'strategic use' of the technologies they have acquired. Respondents reported the strategic use of each technology they adopted as a proxy for their willingness to modify business structure and function to exploit the technology. The moderating effect between this intent and benefits realized from technology adoption were tested and

The central focus and research question of this study is "How does adoption of Automated Decision Support impact the performance of mortgage lenders?" The results of the study add to several academic literature streams, including: IT and Organizational Performance, Business Process Reengineering, and MIS Research Methods. Additionally, it will be of continuing value to the mortgage lending community by helping them understand the most effective use of investments in Information Technology.

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Chapter One

Introduction

Automated decision support is a technology of great interest in the mortgage lending community. Electronic tools for augmenting each stage of decision-making in this problem domain are being developed and sold by software vendors at a rapid pace (Peterson, 1998). From initial intake of applicant data to the final decision to approve or deny the application, Information Technology (IT) plays an increasing role in the mortgage origination process (Portner, 1995). This trend is driving localized and global changes in the mortgage lending, which will eventually change the very shape of this industry (Lebowitz, 1996).

A specific family of technologies of interest to mortgage lenders is Automated Decision Support [ADS] (DiGiammarino and Kuckuk, 1991). There is no universally accepted definition of ADS, nor is there a well defined taxonomy of specific technologies and applications within the ADS family. The range of ADS functionalities includes: Workflow management, connectivity channels and tools for inter-organization business networking, rule based decision support systems, and distributed systems.

It has been observed by IT researchers that any given technology does not impact all adopters equally. This lack of uniformity has interested the academic community from the very beginning of organizational use of IT (McFarlan, 1984). Some have observed that it is difficult to identify a positive relationship between IT spending and firm performance at all (Brynjolffson, 1993). It is this problem that the current study attempts to pursue - does adoption of Automated Decision Support impact mortgage lenders in a positive way, and is there an explanation for disparate impact on adopters?

This introductory segment first describes the regulatory, competitive and technological contexts of mortgage lending. Secondly, a specific research problem within the domain of mortgage lending is identified and a methodology for exploring the problem described. Finally, the chronology and organizing structure of this study is presented.

Parameters of Production and Performance in Mortgage Lending

Mortgage lending is the process of using a bank or lending unit's available funds to finance the purchase of real property (real estate) where that property is used as collateral (Koch, 1995). Numerous entities and pieces of information come into play during the process of evaluating potential loans and determining which loan applications will be funded. The market for mortgage instruments is highly competitive, and the cost of a poor decision is high. (Maselli, 1994).

Due to the high dollar volume and social importance of mortgage lending, it is a highly regulated activity. Rules exist to ensure not only economic responsibility on the part of lenders, but social responsibility in determining the final disposition of each loan application(Miller, 1994). Parameters of mortgage lending process and the economic, technological and regulatory forces that bear on it will be discussed hereunder.

Production Volume

Many institutions that originate mortgage instruments do not hold them. Instead, the note is sold to some other institution or into the financial markets as part of a package. Therefore, a significant portion of the institution's income is derived from origination and servicing fees rather than interest (Johnson and Berg, 1996). The overall size of the market for mortgage instruments in a given period of time is largely a function of interest rates, which fluctuate with economic conditions which are unpredictable (Toevs and Ziska, 1994). Given these factors, the overall performance of lending institutions will be sensitive both to economies of scale and to scalability of operations over wide ranges of volume (without violating parameters of efficiency).

Asset Quality

To a lending institution, 'asset quality' refers to loans that will consistently perform until maturity. Stated differently, loans that are repaid slowly or default are of poor quality, and result in economic loss to the

originator and/or holder of the instrument (Koch, 1995). Only a few non-performing loans in a large portfolio will dramatically affect the return on that portfolio to its owner. Lending institutions must use all available tools and procedures to prevent the acquisition of poor quality assets (Weimer, 1994). Application of information technology toward the end of asset quality will be discussed in this and subsequent sections.

Efficiency

Banks and other lending institutions measure efficiency in mortgage origination by using several key indicators. Included are: Cycle time, dollars of overhead per origination, originations per person, and dollar volume of originations per person. Efficiency and volume are related by the construct of scale economy. At any given volume, however, efficiency parameters must be met, or profits will suffer. The use of information technology is seen not only to impact efficiency by increasing volume without increasing personnel, but also to act as an enabler to promote the 're-engineering' of origination to eliminate unnecessary steps (Portner, 1995).

Regulatory Forces

Mortgage lending accounted for the "..highest percentage of total loans at most commercial banks in 1993" (Koch, 1995). It is through mortgage loans that most Americans are able to realize home ownership. Due to the overwhelming economic and social impact of home lending, it is a competitive and highly regulated business. The Community Reinvestment Act of 1977

was enacted to make sure that lenders did not neglect geographic areas that their deposits came from in the generation of mortgage loans (Groskind and Weiss, 1990).

In addition to anti-discrimination legislation, lending institutions are required to operate financially within set parameters, which are monitored by bank regulators. It has long been the opinion of federal and state institutions which oversee banking operations that it is their duty to ensure that these institutions do not fail. They carry out this mission by two means: 1) Providing insurance that the claims of depositors will be paid even if the institution cannot meet its obligations, and 2) requiring banks to operate within strict guidelines of financial soundness and stability (Koch, 1995)

IT Trends and Emerging Technologies In Mortgage Banking

Information Technology by mortgage lenders in all of the areas mentioned above to meet the challenges of a changing market and regulatory constraints (Thinakal, 1996). The table shown hereunder summarizes some of the prominent technologies commonly associated with each of these areas of performance or regulation. The graphic will be followed by a more detailed description with examples. There will be some overlap, as certain technologies can address multiple goals:

Table 1.1

Summary of Technology Types and Expected Performance Parameters

Performance Parameter/Constraint	Technology Product / Application
1. Production Volume	• Loan Origination Systems • Workflow Management • Electronic Verification
2. Asset Quality	• In-house Decision Support • Automated Underwriting
3. Overhead	• Loan Origination Systems • Workflow Management • Electronic Verification
4. "Fairness in Lending" requirements	• In-house Decision Support

Loan Origination and Workflow Management Systems

In the late 1980's, due in large part to the advent of desktop computing, mortgage origination began a slow metamorphosis from a document centered process to an electronically captured and managed process. (Johnson and Berg, 1996). With Loan Origination and Workflow Management Systems, operating on distributed, client/server systems, information is entered only once, instead of repeatedly on many forms. This technology can facilitate the dramatic rearrangement of tasks associated with originating a mortgage (process re-engineering). A number of vendors market these systems, many offering the capability of integrating into existing systems.

Common functionalities in Loan Origination and Workflow Management systems include:

- Mobility for Loan Officers (by using laptop computers with modems
- Interactive input screens, featuring validity checks and reminders about omitted data
- "To Do" lists for loan officers and clerical assistants
- Correspondence generation
- Summaries and Progress Reports
- Capture of applicant data into a standardized format

Specific packages may offer subsets or (more likely) supersets of these features (Gleit, 1997).

Electronic Verification:

Traditional mortgage origination involves telephone or postal contacts to verify credit rating, title status and other factors related to the application. Computer based interconnectivity technologies allow automating these processes so that verifications may be done in a matter of seconds (Pachura, 1996). Credit bureaus and electronic title registries are the most prominent example of business partners who may be linked to mortgage originators electronically. While the former is now commonplace, the latter has not yet gained universal acceptance (Johnson and Berg, 1996). Electronic Data Interchange (EDI) specifies common formats by which these pieces of

information can be passed. As internet communication becomes more widely accepted, object classes will replace EDI standards.

In-house Decision Support

Automated Decision Support Systems (DSS) are in wide use across many organizational forms and missions (Meyer and Foley Currey, 1991). Their intended use is usually to exploit knowledge of experts or knowledge of domain experts that is programmed in directly or knowledge which is acquired by applying a learning algorithm to a set of solved cases (Messier and Hansen, 1988). In mortgage lending, in-house DSS are implemented in the form of rule bases that govern the acceptance or rejection of loan applications based on known attributes (DeZube, 1996).

Many integrated mortgage lending software systems have DSS as a standard feature or an option group. The features are distinct enough, however to ask system adopters to characterize their system as having DSS or not. Some common DSS features are: Risk characterization of applicant(s), application of internal lending rules and policies (with the ability to input new policies for implementation, identification of a 'fit' between an applicant and a particular product, and specific accept / reject / refer decisions (Maselli, 1994). Many articles are available in the industry literature about successful implementations of in-house DSS, but no systematic study measuring quantifiable benefits of these systems was previously available

Automated Loan Underwriting

Automated Underwriting (AU) is a form of DSS which utilizes specific rule bases maintained by large mortgage underwriters, specifically Freddie Mac and Fannie Mae (Peterson, 1998). A critical factor in mortgage loan origination is determining whether the loan will be underwritten by one of these organizations. To facilitate and expedite this determination, lenders can acquire the ability to subject application parameters directly to underwrites' rule bases either by incorporating them into internal systems or passing the information into the underwriters' systems and waiting (a few seconds) for a response (Maselli, 1994).

Adoption of Automated Underwriting was straightforward to measure since two underwriters dominate the market and the names of their software implementations are well known. Fannie Mae's rule base is known as 'Desktop Underwriter' (Knightly, 1996). The comparable product maintained by Freddie Mac (Federal Home Loan Mortgage Corporation) is 'Loan Prospector' (Maselli, 1994). Both of these products offer seamless integration with many in-house systems used by lending institutions.

The Research Problem

Banking institutions in the United States which originate and service mortgage instruments face serious competition among themselves and from nonbank entities. (Johnson and Berg, 1996) Information Technology (IT) is both a driver of change and a mechanism for coping with change. New

(information) technologies are being delivered and old technologies are being upgraded continuously for every phase of the mortgage lending process.

Automated Loan Underwriting Systems (ALUS) assist mortgage lenders in the origination and servicing of new loans (Portner, 1994, Neckopoulos, 1995). ALUS's consists of multiple technologies that are applicable to all phases of mortgage lending. These technologies can be employed to bring about transformations in the lending process at levels ranging from localized improvements in efficiency to redefinition of business scope (Venkatraman, 1994)

Some work has been done to ascertain general level of adoption of Information Technology among lending institutions, (1998 MORTECH Survey). However, no grounded, testable model had been constructed linking implementation of ALUS technologies to measurable benefits. While several studies of the value of IT in banking are available, none has dealt directly with ALUS. Most such studies are done either at the individual level or at the firm level (Blanton, Watson and Moody, 1992). Studies of the value of IT to banks done at the firm level are not granular enough to capture the value technology in a single functional area, and in terms of performance variables specific to that area. Most use gross dollars invested in all IT projects as the independent variable (Post, Kagan and Lau, 1995). Where the output variable is financial performance, it has normally been measured at the firm level (Turner, 1982, Delone and McLean, 1992).

The Research Questions

The research question for this paper can be stated in three parts:

1. What is the nature of Automated Loan Underwriting Systems?
2. What perceived and actual value accrues to the Mortgage Lending function of banking firms which adopt Automated Loan Underwriting Systems at various levels?
3. What contextual factors moderate the perceived and actual value of Automated Loan Underwriting Systems among adopters?

The General Research Model

A general research model is proposed which links ALUS adoption, Lending Performance and Contextual Factors in the following fashion:

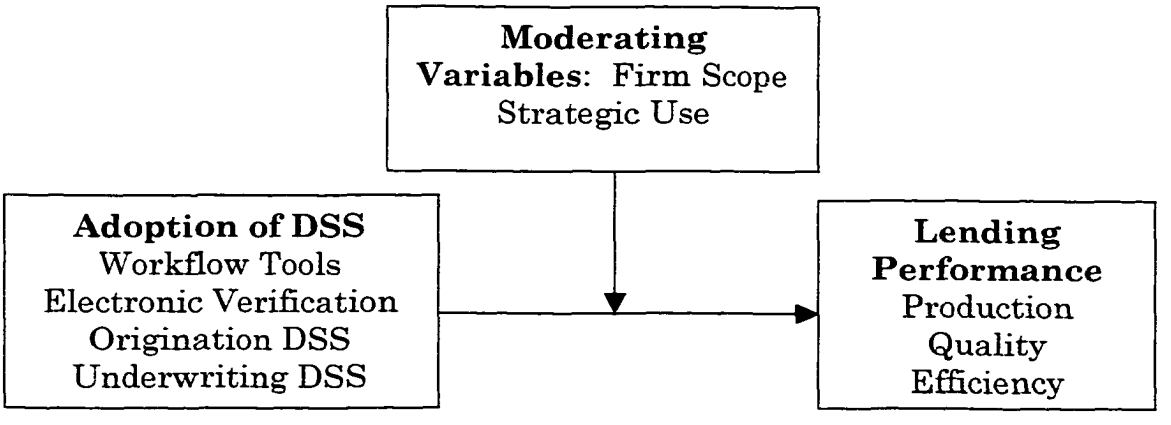

Figure 1.1

The General Research Model

The Independent Variables

Automated Loan Underwriting Systems broadly encompass one or more of the following functionalities

1. Loan Origination / Workflow Management
2. Electronic Verification
3. Origination Decision Support
4. Underwriting Decision Support

Each independent variable will be captured as 'yes/no' decisions on each class of technology which has been adopted by the respondent. When respondents indicate that one of these technologies has been adopted, they will be expected to also have the technologies above it (as represented above). However, no structural relationship exists among these technologies to the extent that they can be represented as points on a single continuum. Additionally, no research is in hand to show that actual implementations follow this pattern. Therefore, adoption of each technology will be measured independently. An investigation of patterns of adoption may be performed during data analysis.

Dimensions of Lending Performance:

Dependent variables to be used in this study are stated below. They were measured in two ways, using primary and secondary data. All were related to organizational performance at a department level. In the case of

firms that engage only in mortgage lending, this was equivalent to measuring the variable at the firm level. In other cases, these variables will be sub-firm level.

Actual Default Rate

Hard data on loan assets outstanding and recent default rates is available through federally mandated reports. By computing the ratio of defaults to total mortgage loan assets, the default rate can be computed. Using a stratified random sampling approach, enough publicly traded respondents will be included to test hypotheses related to this DV.

Self Reported Default Rate Among All Respondents

Default rates in mortgage loan assets are well known within lending institutions. Self reports of these default rates are expected to be reasonably accurate, especially if anonymity is guaranteed. The questions will be posed in terms of ranges, which are based on published industry distributions. Such ranges will facilitate treatment of this variable as interval data.

Self Reported Overhead Related to Mortgage Operations

Again, overhead rates related to mortgage lending are known to managers in lending institutions. Also, means and distributions of this variable among industry participants are published by a trade organization. This will facilitate posing the question as a series of ranges, and asking each

respondent to indicate which most accurately represents the firm. This variable will also be treated as interval data.

Self Reported Measures of Volume Gain

Increase in the total volume of mortgage loan assets will be gauged by asking each respondent to report the volume of such assets in 1991 as well as the current figure. The two figures will be compared to yield a percent increase over the past five years. This will then be compared to industry norms over the same period and converted to increments based on comparison to norms.

Self Reported Closing Rate for Applications

Loan applications which are accepted but not closed are a burden on the firm. The degree to which rejections can be avoided is a reasonable performance measure. Again, ranges will be offered to respondents based on published industry norms. The responses will be treated as interval data.

Self Reported Cycle Time

The cycle time, in days, can be seen as a surrogate efficiency. It will be captured by self report, and included in the composite measure of efficiency.

Moderating Effects

The impact of Information Technology on lending performance is moderated by one or more contextual variables, based on a review of prior research. Foster and Flynn (1984) note that the implementation of IT simply

as a cost saving method yields poorer results than when IT is used to redirect skilled labor to areas where their contributions can be leveraged more highly. Venkatraman (1994) notes that IT can yield higher levels of total organizational benefit when it is used to change business processes, networks and scope that when it is used simply to gain localized efficiencies. Strategic use of Adoption, therefore, is posited as an influential factor in the determination of organizational benefit due to each class of technology

Organizational scope may also have an impact on organizational return on IT investment. One theory states that larger organizations have more and larger transactions over which to recover investments in technology (Brynjolfsson, et. al, 1994). Alternatively, it has been posited that smaller firms can achieve more dramatic results from IT adoption since they are more dramatically impacted (negatively) by underutilization of specialized assets (Clemons, Reddi, and Row, 1993). Organizational size, as measured by total lending volume for the responding unit(s) is positioned as a moderating variable.

Finally, institutional type is investigated as a potential moderator of the relationship between technology adoption and organizational performance. This aspect of the study is purely exploratory, as no existing research or theory postulates differences between mortgage banks and commercial banks (for example) as beneficiaries of IT adoption.

Justification and Purpose of This Research

The academic literature has many examples of both individual studies (Yoon and Guimares, 1995) and organization level studies (Leonard-Barton, 1987) of Decision Support System use (Gill, 1995). In the individual studies, input variables are usually task characteristics, user characteristics, system characteristics and contextual variables. Output variables are either decision quality (Holsapple, Tam and Whinston, 1988) or user acceptance. Alternatively, the output variable may be impact on the decision making process of the user (Silver, 1991) or user satisfaction (Gill, 1996)

Value studies of Information Technology applications are similarly available. Applied value research focuses on very specific applications with measurable benefits (Mukhopadhyay, Kekre and Kalathur, 1995). More theoretical approaches look at the transactional elements of business processes, and propose ways that Information Technology can impact those transactions, re-arrange them, or even eliminate them (Clemons and Row, 1993). Such studies are commonly grounded in literature from Industrial Economics (Bakos and Brynjolfsson, 1993).

The output variable in value studies depends on the unit of analysis. When the individual is used as the unit of analysis, value is generally determined by differentiating decision quality between laboratory trials using the technology of interest versus control groups (Silver, 1992). Organization level studies are more likely to use global financial indicators

such as profitability, overhead ratios, gross revenue, or even stock price to measure input. Such studies utilize published and unambiguous measures, but poorly control for other factors that may affect the outputs (Brynjolfsson and Seidmann, 1997).

Few studies investigate value of specific information technology applications at a functional level. Functional level is proposed to be a level higher than individual, but most likely less than firm level. It is limited to a particular business activity, considering marginal revenue derived from that activity and marginal expense incurred in the generation of that revenue. When such a study can be executed, it will measure benefits to the firm, but minimize confounding factors impacting the output variables. Output variables will have to do with the activity of the function of interest only.

The current research project is a functional level study. The mortgage origination function of a commercial bank, savings and loan, credit union, or mortgage company comprise a differentiable subset of the firm's entire operation. Subjects were chosen based on affiliation with a mortgage lending institution and affiliation with a technical interest group. They should therefore be able to understand what technology is being asked about, as well as having knowledge of operational scope and performance.

The research project is grounded in prior applied and theoretical work in MIS, Organizational Behavior, Organizational Strategy, and Industrial Economics. In the MIS field, prior researchers have cited needs for continual development both in the area of theoretical model building in the area of IT

value (Bakos and Treacy, 1986) , and in the functioning of Decision Support Systems within organizations (Hoch and Schkade, 1996). In adding to the base of empirical data relating Information Technology and organizational performance, this will be of continuing use in building more defensible theoretical models as well as having practical value in the support of technology acquisition by practitioners.

Organization of the Study

This study is organized into five chapters: Introduction, Literature Review and Model Development, Research Methodology, Data Presentation and Analysis, and Conclusions. The current segment concludes the introductory chapter. Scope and purpose of subsequent chapters are briefly summarized below.

Literature Review and Model Explication

MIS research in general, and IT value in particular are grounded in many literature streams. Industrial Economists have always been interested in any mechanism that impacts the delivery channel, delivery speed, accuracy, aggregation and filtering of information (Melody, 1987). Researchers from the MIS community have created a rich body of theoretical development and empirical analysis in the areas of: Decisional Guidance (Silver, 1992), Industrial Cooperation (Clemons and Row, 1992), Strategies for Value Measurement (Brynjolfsson and Hitt, 1998), Reorganization of Markets (Bakos, 1986) and others.

Chapter two integrates these literature streams as fully as possible to support the research model to be tested. Elements of organizational behavior and economics which have previously been identified and supported (Transaction Cost Economics - Clemons and Row, 1993 for example) are utilized to propose relationships between IT and performance which were tested empirically. Venkatraman's (1994) hierarchy of levels of organizational impact serve as an organizing framework. A listing of specific hypotheses related to the general research model will conclude chapter 2.

Research Methodology

This project uses a traditional approach from a new perspective. The study was carried out as a basic survey. However, one response channel was a web page. Subjects received a mailing and an e-mail (if email address is known), then be asked to respond via a web page. A paper survey was included in each solicitation.

Chapter 3 discusses the general strengths and limitations of survey type research, and propose specific questions. Specific questions were related to the theoretical constructs described in Chapter 2, either through use of existing scales or through content. Observations on the use of survey methodology in MIS research are presented (Pinsonneault and Kraemer, 1993). Implications of the Internet as a data collection channel were discussed briefly.

Data Presentation and Analysis

After the data is collected, a summary of responses, and the results of analytical procedures are presented. Primarily, data analysis was performed to test specific hypotheses set forth in Chapter 2. The primary analytical procedure used for hypothesis testing was Analysis of Variance. Input variables were captured as categorical data while output measures were continuous in nature. In addition to the primary effects of the input variable on outputs, the impact of proposed moderating variables were measured by ANOVA and related techniques.

Conclusions

Upon completion of data analysis, empirical findings are explained in terms of the theoretical model proposed. Where hypotheses were supported, the relationships implicit in the model were been given support and validation. It is proposed that the findings be accepted and built upon by the research community and exploited for practical value by the business community.

Chapter Two

Review of the Literature and Research Model

In order to establish a comprehensive framework for measuring the value of Automated Loan Underwriting technology in the mortgage industry, several bodies of literature must be surveyed and meaningfully integrated. This chapter will establish a research model based on existing Organizational, MIS, and Industrial Economic theory. The model is structured so as to facilitate testing of possible causal relationships between DSS adoption by mortgage lenders and organizational outcomes.

The chapter proceeds along three functional tracks. First, current research in the nature and value of computerized Decision Support Systems (DSS) and Expert Systems (ES) as they relate to decision support is reviewed and summarized. Functional aspects of DSS as they fit into existing taxonomies of IS features are listed and related to elements of value identified from other literature. Available field studies and theoretically grounded models relating DSS directly to business value are identified.

Secondly, previous approaches to IS value measurement are reviewed toward the end of supporting hypotheses about testable value relationships in the current context. In each general body of theory (scale economics, value

chain, transaction cost, etc,) parallels are drawn between the context of the previous research and the current context. Research designs and methodologies are explored as well as hypothesized causal relationships. Since business value measurement has traditionally been considered difficult in the IT arena, conclusions about appropriate methodologies are of particular interest.

Finally, gaps in the existing literature and opportunities to integrate and expand on foundations discussed earlier are identified. Scaling and approaches to measurement, which have been successfully used in the past by MIS researchers, are surveyed and built into the research model. A general framework relating IS implementation to business value are offered. The model will show levels of adoption of Automated Loan Underwriting Systems (measured by degree of organizational transformation) and the benefits expected to be associated therewith.

Information Technology and the Process of Making Decisions

Decision Support Systems (DSS) constitute a unique application of Information Technology. Because of DSS's unique characteristics, their impact on organizational performance and interactions with organizational/contextual variables are also unique. Measurement strategies must take into effect the nature of organizational processes before and after DSS systems or components of them are employed (Gill, 1996). This section will identify a process model of decision making, investigate the interactions

between technology and the decision making process that defines DSS, then establish an agenda for DSS research.

Most prior research in DSS use focuses on the individual and how individual decision-making is impacted (Benbasat and Taylor, 1982) or on implementation success factors at an organizational level (Guimares, Igbaria, and Lu, 1992). Some studies have, however, focused specifically on organizational benefits of DSS and establish useful frameworks for future studies (Money, Tromp and Wegner, 1988).

Human Decision Making: Processes and Limitations

Since a preponderance of the research on interactions between technology and decision making (at least in the IS literature) is based on Simon's (1977) model, it bears explication in the context of this study. By decomposing decision making into its components a systematic analysis of the impact on technology on decision process and outcome may begin. Several studies have located DSS on the frontier of IS technologies. These are reviewed following discussion of decision process elements and their interactions with IT.

According to Simon's model, decision-making takes place in three phases: Intelligence, Design, and Choice. Each phase of this process, when exercised by humans is impacted by cognitive and intellectual limitations. At least two broad types of limitations may bear on quality and productivity of decision making: Cognitive 'strain' or overload, and bias. The interactions

between phases of decision making and aspects of cognitive limitation are summarized below:

Table 2.1

Limitations in Human Decision Making

	Cognitive Overload	Bias
Intelligence Gathering	Limited items in STM (Cermak, 1972) Bounded Rationality (Simon, 1977)	Availability (Tversky and, Kahneman 1974)
Design	Limited number of simultaneous inputs (Benbasat and Taylor, 1982) Computational Cost (Simon, 1977)	Pre-existing L-M models (Ramaprasad, 1987) Bias toward linear models (Hoch and Schkade (1996) Representativeness, (Tversky and Kahneman (1974)
Choice	Bounded Rationality, Satisficing (Simon, 1977)	Motivation (Thomas, 1988)

Each of these phenomena bears on the application of technological tools in the decision-making process. MIS/DSS researchers have differed somewhat in the exact rationale for interjecting technology into decisions, but most recognize human limitations that impact outcomes. A review of these limitations, with the above matrix as an organizing framework, will establish a need and start a foundation for model building in the use of decision aids in organizational settings.

Cognitive scientists have noted limitations of short term memory which may impact intelligence gathering. Some have noted that seven items appears to be a maximum (Cermak, 1972). Any limitations on the sheer number of facts (representations of facts) that can be held in memory during

intelligence gathering will impact the remainder of the process. It is axiomatic that some sort of memory aid would help decision makers manage more information.

A natural consequence of the cognitive limitation just described is that human decision-makers artificially limit the number of factors they will consider in formulating and executing a decision. The phenomenon of self-imposed limitation of inputs has been designated "bounded rationality" by Simon (1977). When a decision-maker engages in bounded rationality in order to screen out inputs beyond his/her ability to consider them, the resulting decision may be fairly described as sub-optimal, compared with one which could have been reached if all factors were considered. The term used to describe this purposeful sub-optimality is "satisficing" (ibid). The difference in economic outcome of optimal decisions as opposed to 'satisficed' decisions will vary across problem domains, and with decision-makers' skill and experience. However, it is reasonable to assign some non-zero positive value to that difference in justifying and designing decision support systems and metrics to assess their usefulness.

Problems of bias also enter into the intelligence-gathering phase of a decision. Tversky and Kahneman (1974) cited three groups of specific problems relating to rendering judgments. One is group is labeled 'availability', and is concerned with decision-makers' propensity to stop seeking new data when that data is more difficult to find. Availability problems include retrievability, search set limitations, and low imaginability.

Retrievability problems have to do with decision makers underestimating frequency of membership in a certain class when no notable examples come to mind. Search set effectiveness is an issue when search criteria to estimated members of a class do not match internal memory retrieval mechanisms of subjects. Imaginability is a limiting factor in intelligence gathering if existing cases do not exist and hypothetical cases are difficult to visualize.

After intelligence is gathered, according to Simon's model, decision-makers engage in designing solution frameworks. In this critical phase, intelligence is organized, and strategies for reaching a solution are formulated. Model formulation is impacted by human limitations in several ways. For one, decision-makers simply cannot consider a very large number of inputs at once (Benbasat and Taylor, 1986). Model formulation (design) in complex problem solving is restricted by how many inputs are required. Computational cost (Simon, 1977) must also be considered in the formulation of problem solutions. A rational problem solving approach my not be feasible because its computational cost is too high for a human decision-maker.

Bias in the formulation of problem solving models (design) is a significant problem for human decision-makers in many domains. The very nature of expertise is often defined as a predisposition to certain methodologies and approaches in solution formulation (Prietula and Simon, 1989). Another perspective on this phenomenon is derived from Piaget's (1974) model of learning. Formulation and application of Logico-Mechanical

Structures (knowledge structures) may be influenced by bias and are generally unique to each problem-solver (Ramaprasad, 1986).

Systematic bias in problem assessment and solution formulation has been observed by Tversky and Kahneman (1974). They characterized several specific biases in interpretation and characterization of observed events as 'representativeness problems'. By mischaracterizing observations, decision makers will tend to formulate ineffective solutions to problems and invalid models for reaching decisions in future cases. Specific representativeness problems include illusions of validity and misconceptions of regression (assuming relationships which are not really there). Clearly, the design phase of decision-making is strongly influenced by individual (hence unpredictable) factors. Many of these factors are mistaken beliefs about the state of nature and society.

Human decision makers are most constrained by their limitations at the stage of choice in decision-making. By this point in the process, cognitive limitations have already impacted the outcome by restricting the number and diversity of inputs and nature of decision models used. Beyond that, however, the act of choice itself is impacted by cognitive overload and bias. Simon's (1977) "Bounded Rationality" concept is fully actualized in the exercise of choice. Decision makers, unable to consider all inputs in most real world contexts, deliberately choose 'satisficing' as a goal rather than optimizing, to rationalize the self imposed restrictions in prior stages.

Satisficing as a process objective is rational to the extent that limitations on inputs are informed and purposeful, and 'satisfactory' in the decision makers view matches the organization's definition. However, there is another significant influence on choice in human decision makers. Most behavioral scientists believe that humans are capable of purpose in their actions (Rychlak, 1979). Purposefulness in decision makes process models very difficult to justify, since it is most difficult to truly know one's thoughts. Theorists can at least include consideration of purpose in their models by identifying some common themes found in organizational decision-making. The 'rational actor' theme credits decision makers with acting toward betterment of their organization, while the 'political' model assumes that the decision maker acts in his own interest, whether the organization is served or not (Thomas, 1988). Business costs associated with managers' decisions being tainted by self serving motives ('agency costs') are considered in the value model proposed in this chapter.

The foregoing is a very brief overview of the limitations of human decision-making and the potential for impacting decision quality. Some of these points represent major literature streams. Certainly, some decision makers are more skilled than others. It has been posited that the very nature of expertise is having wider boundaries and intelligently selecting inputs that are important to the problem domain where the expertise exists (Prietula and Simon, 1989). However, the notion that human decision-making is fraught with shortcomings and bias is widely recognized and is

often cited in IS research. The next section will examine Information Technology as a mitigating factor in each problem area cited above.

Technology and the Decision Making Process: Where DSS Fits In:

A comprehensive definition of Decision Support Systems must be presented in order to support models of business value based on their use. Keen and Scott Morton (1978) provide the following general definition:

> "Decision support systems couple the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions. It is a computer-based support system for management decision makers who deal with semi-structured problems."

El-Najdawi and Stylianou (1993) summarize several authors' views on DSS with the following list of characteristics:

1. They are interactive, computer based information systems (IS)
2. They are aimed at semi-structured problems at the middle- and upper-management levels
3. They utilize models and/or analytic techniques with internal and external databases.
4. They emphasize flexibility, effectiveness, and adaptability

In addition to this general definition, these authors relate an often-cited functional decomposition of DSS software: Data, models, and communications subsystems.

The preceding general definitions support attempts to appropriately position DSS within a larger framework of IS types. Such positioning is done in support of both the matching of benefits to IS application and the fit of IS with particular problem types. Gorry and Scott-Morton juxtapose the business activity classifications of Anthony (1965) and the problem classification of Simon (1978) to produce a 'grid' on which information technology systems can be meaningfully placed. This representation, in conjunction with DSS characterizations above, shows not only that DSS 'fits' in certain decision making areas of organizations, but also that those areas have been under exploited with respect to managerial use of DSS:

Table 2.2

Degree of Exploitation of DSS across Task Type and Level of Control

Management Level/Task Type	Operational Control	Management Control	Strategic Planning
Structured	Highly Exploited	Highly Exploited	Highly Exploited
Semi-Structured	Moderately Exploited	Moderately Exploited	Moderately Exploited
Unstructured	Marginally Exploited	Marginally Exploited	Marginally Exploited

Their article is a foundation for much of the later work that seeks to meaningfully classify Information Technology as to the areas of

Organizational Control it serves and to match Information Technology type with intended purpose or strategic orientation of the firm. These findings are later integrated into a model for mapping implementation of DSS to expected organizational benefits.

The grid used earlier to summarize research findings on limitations in human information processing and decision making can now be used to summarize findings in the usefulness of IT in mitigating those limitations. Each general area is reviewed briefly in order to complete a working definition of DSS. The general characterization of DSS as the intersection of Information Technology and decision making is supported:

Table 2.3

Information Technology Responses to Limitations of Human Decision Making

	Cognitive Overload	Bias
Intelligence Gathering	User interface can prompt for appropriate inputs and ignore irrelevant ones (El-Najdawi and Stylianou, 1993)	Cost effective access to information and tools (Gurbaxani and Whang, 1991)
Design	Multiple pieces of information can be combined in artificial representations (Simon, 1977, Benbasat and Taylor, 1982)	Ability to derive decision rules from data (Messier and Hansen, 1988)
Choice	System restrictiveness (Silver, 1990)	Decisional Guidance (Silver, 1990) Value of Structure (Simon, 1977)

Decision Support Systems are characterized by a "data subsystem" which may be a part of the DSS itself (El-Najdawi and Stylianou, 1993) or a

link to data stores which may be internal or external to the firm (Plenert, 1996). Such direct links mitigate the tendency to stop looking for information when it is hard to get (Tversky and Kahneman, 1974). Decision makers are thus supported by technology in overcoming their inherent limitations in collecting sufficient and necessary information to make a sound judgment.

The use of artifacts to represent large amounts of data and to combine data from several sources predates modern computers by many years (Simon, 1981, Tufte, 1983). However, since computers with graphical displays have become widely used, direct links from data to representations have been made possible, allowing users powerful tools for extracting knowledge from complex data sets (Benbasat and Taylor, 1982). Decision makers bias towards models which are easy to visualize and models which use inputs which are easy to obtain is addressed by DSS's ability to store and invoke decision models based on experts' knowledge or rules derived directly from data (Kattan, Adams and Parks, 1993, Gill, 1996).

Finally, there is the problem of managers making decisions for reasons other that profit maximization or other forms of utility to the organization. Their motivations may be simple self-interest or (organizational) political advancement (Markus and Robey, 1988). The costs to the firm of this sub-optimal decision making by non-owners ("Agency Cost" - Gurbaxani and Whang, 1991) may be mitigated by having owner's wishes enforces through decisional guidelines implemented by DSS. Silver (1991) addresses the 'overload' problem at the point of choice by positing 'restrictiveness' as a DSS

characteristic. Degree of 'Guidance', another DSS parameter, determines the extent to which decision makers are influenced by decision suggestions made by the system.

Expert Support Systems: A Marriage of Technologies:

'Expert Systems' (ES) have a research base as robust as Decision Support Systems. Much effort has been made to define Expert Systems, establish guidelines for their construction and implementation, and study their impact on decisions from both individual and organizational perspectives. In many practical settings, there is an intersection of these two technologies. Appropriately, several studies have been done to establish boundaries between DSS and ES, as well as explain overlapping and complementary functionalities.

Expert Systems are generally defined as a set of decision rules stored in a computer (rule base) that assists 'non-experts' in making correct decisions in the problem domain of interest. Few Expert Systems are sufficiently robust to be applicable to multiple problem domains (Lenat and Fiegenbaum, 1991.) Rules may be represented in a number of formats, but the most common is a chain of "IF-THEN" rules that, when used appropriately, mimic the problem solving approach and threshold values used by a domain expert.

Rules used to construct Expert Systems may either be solicited directly from domain experts or 'induced' through learning algorithms which process

prior cases with known outcomes (Weiss and Kulickowski, 1991). Either way, they are generally considered to be appropriate for solving relatively structured problems (Rubin, 1993). Some of the most well known ES applications have been in the domains of specific disease diagnosis, classification of plants within a certain family, and credit approval/denial based on financial history (Turban, 1993).

Given that DSS has been defined as pertaining to semi-structured or unstructured problems, characterizing the intersection of ES and DSS is an interesting problem. Two separate attempts to reconcile these differences have followed a very similar approach. Turban and Watkins (1986), while recognizing the differences between traditional DSS and ES definitions, proposed an integrated model that positioned ES as a component of DSS. The resultant system was labeled an "Intelligent DSS" based on the embedding of knowledge within a problem solving mechanism. Such a system, they concluded would not only combine the benefits of ES and DSS taken separately, but yield additional benefits due to synergies resulting from the combination.

Similar conclusions were reached by Goul, Henderson and Tonge (1992) in their attempt to position Artificial Intelligence (AI) as a "..Reference Discipline for Decision Support Systems Research". AI research was characterized as fragmented and lacking in cumulative tradition, while DSS research was more mature. DSS research was also more broadly grounded,

with ties to learning theory and organizational learning (ibid.). They proposed that the reference base for DSS be expanded to include AI, since:

"AI can broaden DSS research beyond its original focus on supporting rather than replacing human decision making by selectively incorporating machine-based expertise in order to deliver the potential of DSS in the knowledge arena."

It is legitimate, therefore, to frame the current study as DSS research. It will build on DSS research tradition, while recognizing the unique contribution of Expert Systems. This approach is consistent with the suggestion of Benjamin and Scott-Morton (1988) that information technology had engendered a fourth 'era' of institutional research-the knowledge era. They observe: " ... expert systems allow us to capture qualitative knowledge and exploit it with new forms of systems architecture [i.e. DSS]. Goul Henderson and Tonge (1992) recognize the emergence of this era in their statement that "Future DSS research must reflect the reality from AI that machine-based intelligence has become an important aspect of computer based support for humans".

Business Value of IT / DSS: Imperatives for Continuing Study

"Very little is known about the relations between information structures and other institutional characteristics, or how changing information structures affect the rise and fall of particular institutions." (Melody, 1987) Relationships between Information Technology adoption and

organizational performance are still a matter of much discourse and discord in the MIS research community. There is little disagreement, however in the importance of discovery new value relationships in all areas of IT adoption, including DSS. "Decision making research ... has focused more on how decisions are made than on how they can be improved" (Hoch and Schkade, 1996).

Several works relating IT and corporate strategy, notably Porter (1980), and Rockart and Scott Morton (1984), were recognized by Bakos and Treacy (1986) in their call for integration of existing frameworks and foundational model development. Their study is also a response to Keen's (1981) observation that fundamental changes in the nature of work and organizations due to advances in Information Technology are imminent. Historically, though, IT/business value research has been found lacking in theoretically grounded, empirically testable models (Bakos and Treacy, 1987, Mahmood and Soon, 1991). Early research in IT success was largely episodic and descriptive (DeLone and McLean, 1992). Very little was accomplished in the way of broadly useful measures of success or value.

Brynjolfsson (1993) coined the phrase "Productivity Paradox" in his review of research dealing with the relationship between investment in IT and measurable business results. He and others (Loveman, 1988, Barua, et al, 1991, Strassman, 1990) had found in earlier research that it was very difficult to show a positive relationship between investment in IT and firm level financial performance.

Some others, however, had been able to show at least a weak linkage (Weill, 1990 Harris and Katz, 1991, Brynjolfsson and Hitt, 1993). This apparent 'paradox' was attributed not to a lack of any significant relationship between IT and business performance, but rather to a lack of appropriate grounded value measures and scales to operationalize those measures. In short, IT and business value research was said to be suffering from the use of 'blunt instruments' (Brynjolfsson and Hitt, 1993).

Some recent studies have made progress in identifying useful measures of IT value. However, the authors almost universally cite the early developmental stage of this category of research and call for more grounded, testable models (Mahmood and Mann, 1993, Brynjolfsson and Hitt, 1996, Mitra and Chaya, 1996). Broadly understood financial indices ("macrofinancial impact"-Dixon and John, 1989) are still seen as desirable output measures.

Goul, Henderson and Tonge (1992) characterize organizational DSS research as "..representative of an emerging research agenda". Several studies have called specifically for more in depth investigation into the impact of adoption of DSS both from individual (Silver, 1991), and organizational (Plenert, 1996) perspectives. Such systems are particularly worthy of study because of their ability to leverage individual decisions and knowledge to produce significant impacts on organizations - either positive or negative (Turban, 1993). Rapid increases in availability of data (Dyche, 1999), complexities of representing knowledge and choices meaningfully

(Simon, 1990) and the diversity of competitive forces (Porter, 1980) support the need for appropriate models to aid in selection of decision analysis tools in organizational settings.

Value Research in MIS: Past and Future Directions

Measurement of organizational performance related to Information Technology implementation is a critical and challenging issue (Mahmood and Mann, 1993). Substantial research issues include: Unit of analysis, input and criterion variables, and relevant findings or prior studies. Historical approaches, their strengths and limitations, and contextual factors should be reviewed prior to building new models or testing existing models and/or constructs in new contexts. Such a review and implications for new models are the focus of this section.

Unit of Analysis in IS Research

Selection of the appropriate unit of analysis is critical in IT research. This choice will impact appropriate input and output variables as well as measurement approaches (DeLone and McLean, 1992). Most published reviews of MIS research divide studies into two groups by unit of analysis - Individual and Organizational (DeLone and McLean, 1992, Fichman, 1992). Using the department or business function within a larger organization is less common. However, the merit of doing so is highlighted by observations in prior organizational level value research about the efficacy of using organization level financial measures to measure the results of an IT

implementation. Shank and Govindarajan (1992) point out that simple financial measures leave out strategic considerations, while a strategic business orientation framework (Porter) leaves out the financial considerations.

Precedent for measuring performance criteria in only one functional area can be found in the Diffusion of Innovation literature. Cook, Johnston, and McCutcheon (1992) measured implementation effectiveness at a "Decision Making Unit" level which they likened to a functional department. Gatignon and Robertson (1989) used the sales departments of 125 large US firms for their survey of PC technology adoption. The unit of analysis was the department, although both organizational and individual decision-maker characteristics were used as moderator variables in their model.

Dependent Variables: Performance Criteria in IS Value Models

Determination of an appropriate output variable for IS research is a critical issue, which has been debated at length in the literature Many IS studies use 'successful implementation' of some new technology as a criterion variable (DeLone and McLean, 1992). Choosing business value as a focus, however, makes the task somewhat more straightforward. While both direct and indirect measures of organizational performance have been used, Mahmood and Mann (1993) suggest that direct measures are more desirable. Indirect approaches typically involve consumer attitude (Breshnihan, 1986) or global organizational financial ratios Cron and Sobol, 1983). One well

known study used stock price of the firm as a proxy for IT related business value (Dos Santos et al, 1993).

Direct measures of organizational performance involve some specific observations of expenses, labor utilization, inventory held, or ratios comprised of the foregoing. Loveman (1988) measured materials expenditures and purchased services. Scale economics were used as the output variable by Harris and Katz (1991). Weill (1992) used the number of non-production employees per million dollars in sales as a measure of overhead. A significant study in the banking industry performed by Alpar and Kim (1990) used several measures of business volume and capital utilization as indicators of organizational performance.

Tying direct organizational benefits to a particular IT implementation is sometimes not practicable. For example, Barua, Kriebel, and Mukhopadhyay found it necessary to measure secondary benefits of an IT related service given away free to customers. They measured increases in account volume and associated revenues as a result of increased quality of customer service. In the banking sector, it was found, several examples exist of IT related customer benefits which are not explicitly priced or are not priced sufficiently to cover costs. Automated Teller Machines (ATM's) are given as an example.

Several IS value studies have used new constructs or new aggregates of existing measures as output variables. Sethi and King (1994) proposed the CAPITA construct ("Competitive Advantage Provided by an Information

Technology"). This construct combined five dimensions of competitive advantage which were identified through factor analysis. Each of the five could be used independently as an output measure in IS / Competitive Advantage research. Shank and Govindarajan (1992) used the "Strategic Cost Management" construct that was developed by measuring costs at several points along the value chain of paper goods.

The banking industry has its own specialized portfolio of performance measures for estimating the soundness and viability of a particular institution. This portfolio consists of the following measures: Capital Adequacy, Asset Quality, Management Quality, Earnings, and Liquidity (Koch, 1995). Known by its acronym 'CAMEL', this construct is appropriate for rating institutional performance as a whole; it is too coarse for measuring a single functional unit within the firm. In order to measure the results of a technology that impacts only one functional area directly, criteria applicable to that function must be used.

Banker and Kaufman (1991) used market share and loan volume as their primary criteria for measuring the impact of adoption of an IT innovation in banking. In their 1995 study, Post, Kagan and Lau suggest that strategic business impact be "...evaluated in terms of vendors, buyers, competitors (existing and potential), product offerings, and the effect on underlying cost structures". They further point out that "responses of other agents" [i.e. customers] are an important consideration in gauging the potential impact of a new technology. In both cases, market share of one

functional area (retail deposits) was posited as a measure of the business value of the technology.

Associated direct and indirect cost per unit of output, or overhead, is always a primary measure of functional performance. In mortgage lending, overhead is commonly measured as operating expenses of the lending function per loan produced (Portner, 1995). 'Loans serviced per employee' is another approach to measuring overhead (ibid). Dramatic reductions in both measures are expected as Information Technology drives process restructuring (Maselli, 1994).

Product quality in mortgage lending is measured predominantly by default rate. Selection of loans that will yield consistent income until maturity will determine success or failure of the enterprise (Koch, 1995). It is appropriate that default rate be included in a list of output variables in research models investigating the value of IT to lenders. Traditionally, human experts or panels of experts have made lending decisions. Technology is allowing this 'expertise' to be modeled in computer programs that then become available to lower level operatives (Johnson and Berg, 1996).

In the current study, output variables can be grouped into three primary areas, as supported above: Productivity, efficiency and quality. Operational measures within each of these areas are shown in the table below:

Table 2.4

Operationalization of Performance Constructs

Performance Area	Operationalized Measures
Production	Percent increase in loan volume held over 12 months prior Cycle Time Dropout Rate
Efficiency	Loan volume per employee Overhead cost per loan originated Percentage of applications closed
Quality	Percent of outstanding loans overdue or not performing

Independent Variables in IS Research

The selection of independent variable(s) is similarly critical in construction of a meaningful study in business value of IT. Gross investment in Information Technology has often been presented as a measurement criterion. Mitra and Chaya (1996) surveyed 400 firms using total IT spending as their independent variable. Their study was similar in approach to work done by Alpar and Kim (1990). Brynjolfsson and Hitt (1996) input IT spending into a production function in their effort to demonstrate business value of IT econometrically.

Ratios using IT expenditures (both capital outlay and operational) have also been used as independent variables. Turner (1985) used the ratio of IT expense to total expenses in savings banks. Harris and Katz (1991) used a similar measure in their study of insurance firms. In a survey of

manufacturing firms conducted by Weill (1988), the ratio of IT investment to total sales was used as an independent variable.

Successful adoption of a particular technology has been widely used in IS research - both as a dependent variable in adoption/diffusion studies and as an independent variable in IT/business value studies. Both applications can be instructive. Diffusion of innovation studies position level of adoption as a criterion variable and look for factors that explain why some adopters are more 'successful' than others (with success being defined as high level of adoption).

Fichman (1992) summarizes a large body of diffusion research. In this article, he points out the difference in approach between individual level and organization level adoption studies. One such difference is the need for definition of diffusion 'stages' where adoption is the dependent variable. An alternative to qualitatively assessed stages of adoption was proposed by Zmud (1984) in his study of influences on innovation. Zmud gauged level of adoption by how often the innovation was used (from 'not used at all' to 'usage is an established standard'.

Using the features of a various related technologies to classify them was practiced by Hackathorn and Karimi (1988) and Gorry and Scott Morton (1989). That approach is used in the current study. That approach is repeated in the current study. Based on a review of industry technology reviews (Portner, 1995, Lebowitz, 1996) and vendors' product literature, the following four technologies and identifying features are proposed:

Table 2.5

Classification of Lending Decision Support Technologies

Technology	Significant Features
Work Flow / Loan Origination	Computerized input forms for applicant data Prompts to ask for necessary data Performs computations such as payment amount and amortization tables Manages / generates correspondence Generates 'to-do' lists for lending personnel Generates summaries of loans in progress and their status Generates mandated government reports Maintains or provides access to regulations
Use Electronic verification	Uses Electronic links (VAN or Internet) to communicate with credit bureaus Uses Electronic links (VAN or Internet) to communicate with title registries
Origination Decision Support	Guidance in suggesting specific products to applicants Risk characterization of applicant Accept / Refer decision Compare applicant data against lending unit's internal rules, policies, and guidelines Ability to be programmed with lending unit policies Assess impact of potential new loan on lending unit's existing loan portfolio Uses a rule base Emulates the decision of an experienced lending officer
Underwriting Decision Support	Electronic link to Underwriters' scoring / decision models

The strategic use or purpose of an IT investment as a mitigating factor in its success has been posited by Barua, Kriebel and Mukhopadhyay (1991), Post Kagan and Lau (1995) and Reich and Benbasat (1996). Adam, Fahy and

Murphy (1998) used "the extent to which they organizations used DSS for different decision situations" as an input variable in their adoption study. Two specific measurements were posited: 'DSS spread' and 'DSS complexity'. Svare (1995) urges bankers to "... strive to put their IT dollars where they will create the most value- on their top business objectives.

A useful model for gauging the strategic use of technological infusion into an organization was proposed by Venkatraman (1994). He proposed that business transformation experienced by organizations could be characterized at five levels. Each successive level represents a higher degree of change and potential for economic impact. " the range of potential benefits increases from the first level ... to the final level." (ibid.). Venkatraman's levels of transformation can be summarized as follows:

Table 2.6

Venkatraman's Levels of Transformation

Degree of Transformation	Characteristics
Localized Exploitation	Standard IT applications deployed locally - no changes to process
Internal Integration	Technical interconnectivity and interoperability. Process interdependence
Business Process Redesign	Fundamental restructuring of process as a result of IT adoption
Business Network Redesign	Rearranging value chain - restructuring partnerships
Business Scope Redefinition	Changing the fundamental mission of the enterprise.

Following the example of Adam et al, the 'level of transformation' is the grounding construct for moderating variable in the current study. While Venkatraman's stage model was originally posed as an 'after the fact' scale of business impact, it is being used here as an indicator of the degree of business transformation that adopters intend to achieve by adopting the technology in question. This use is expected to have a powerful moderating effect between adoption and measurable results, especially in the two Decision Support (ES) tools. Venkatraman's levels of transformation will also serve as an organizing framework for the review of prior value research in the following section.

Foundations of Value: Research Findings in Value of IT

A central tenet of any theory linking Information Technology and organizational performance is that all organizations are fundamentally information processing enterprises (Tushman and Nadler, 1977,Orlikowski and Robey, 1991). Economists warn that organizational theorists will ignore the information dimension of organizations "at their peril" (Melody, 1987). Theory based IT/organizational performance models are largely rooted in this perspective.

Asymmetrical distribution, differential dissemination, velocity, and concentration, of information are all potentially related to organizational performance. Information of private value is not immediately and universally available to the World, both by inherent lack of efficiency of

transfer mechanisms and by design. When organizations have differential access to valuable information, they will exploit it, and use information technology to limit and dissemination toward its own ends (Melody, 1987, Milgrom and Roberts, 1987).

Information Technology and its relationship to velocity of information are of particular concern in building organizational performance models. IT, through its ability to accelerate and direct the transfer of information, can time-compress the value adding process in the creation of a good or service (Hess and Kemerer, 1994). Improving the throughput of any productive process will result in greater asset utilization and thus enhanced firm performance. Improved asset utilization has been posited as an offset to diminished bargaining power when firms use IT to co-ordinate their activities in "virtual hierarchies". (Clemons and Row 1991)

Computer storage has exceptional capacity to concentrate valuable information as collective organizational memory. Organizational memory facilitates productive management activities such as performance monitoring and adaptation (Huber, 1991). Adaptability is possibly the most key element in organizational performance over time. Technology based organizational memory structures are so important to success that some see information architecture as the key component of organizational design. (Allen and Boynton, 1991)

Viewing information as a vital organizational resource which contains value and may be profitably exploited is also useful in the formation of

grounded, testable models. Kimbrough and Moore (1992) describe the function of organizations as processing "information events". They propose that adopters of standardized IT functionalities by way of scale economies and specialization will gain certain benefits. It is widely held that the value held in information and expertise (often captured in computer information systems) are under-recognized as corporate assets (Keen, 1981). 'Operationalizing' these assets to the maximum benefit of the firm is largely dependent on contextual factors relating to the industry the firm operates in (Sampler and Short, 1994). When used properly (recognizing the contextual forces) IT can radically alter the firm's ability to exploit information and expertise.

Levels of Business Transformation as an Organizing Framework:

As referenced in a prior section, Venkatraman's (1994) five levels of business transformation will serve as an organizing framework for the following review of prior research relating adoption of information technology to business / organizational performance. At each level, significant research that supports linkages between IT and value is briefly reviewed toward the construction of a model and set of testable hypotheses relating to the current context of Automated Decision Support Systems in mortgage lending.

Localized Exploitation: IT and Managerial Effectiveness

While numerous researchers have defined success of a localized system as whether or not people use it (Adams, Nelson and Todd, 1992, Fichman and

Kemerer, 1993), it must be clearly recognized that this approach is not the same as measuring the business value of the implementation. It is necessary but not sufficient that a technology actually be used for benefits to accrue to the adopter. Measurement strategies for local level of benefit must involve some criteria that is reducible to dollars (labor hours, material wastage, holding cost..).

Localized exploitation has been typically associated with "back office" applications, such as payroll or accounts receivable (Sampler and Short, 1994). Such projects may yield some measurable savings in labor and overhead. In fact, when taken alone, dollar benefits from localized applications are relatively easy to measure (Gleit, 1997).

By definition, localized exploitation does not impact basic business processes in the areas where it is adopted (Venkatraman, 1994). However, similar technologies may be exploited locally by one adopter and used by another as a technological 'enabler' to fundamentally alter a process (Davenport, 1993). For this reason, it is impractical to identify a technology with a specific level of process innovation. Rather, the technology in the context of the way it is used should be pegged to a level of innovation under Venkatraman's framework. At least one research effort (Zmud, Boynton and Jacobs, 1987) has been directed at discovering toward what level of business advantage various adopters use a technology.

When a technology is exploited locally, its benefits are confined to the department where it is adopted. Traditionally, 'System Islands' have sprung

up in organizations to improve operational efficiency in the areas of: Physical assets, financial resources, and people (Tapscott and Caston, 1993). Savings in each of these areas can be measured in a straightforward manner. A research tradition has been established whereby benefits are measured at each point in a 'value chain' locally, even though the total impact of a technology is the complete restructuring of a business process (Mukhopadhyay, Kekre, and Kalathur, 1995, Shank and Govindarajan, 1992).

Measuring the benefits of localized exploitation or IT directly is not always feasible. West and Courtney (1993) state "...the output of an information system is not usually a good or product with a value established in a market. Instead, information is a complementary good with respect to productive processes. It has no value except as realized through the manipulation of other resources."

The value of an information system, then, is measurable as improvements in operational efficiency by virtue of better management decisions. Given superior (in timeliness, richness, and quality) information, organizational decision-makers should make more economically sound decisions, leading to enhanced organizational performance. This linkage is particularly relevant to the measurement of IT value, given that managers consume 64% of the typical IT budget while accounting for only 31% of total costs (Strassman, 1990).

Some researchers (Mitra and Chaya, 1996) posit a similar perspective, that Managerial Information and Control is the primary source of benefit from Information Technology. This observation is made in response to others who have found little evidence of direct labor savings (Brynjolfsson, 1993) while finding lower total costs for a given level of business (Harris and Katz, 1991). Managerial control is seen as resulting in lower overall costs due to more efficient organization of work and use of labor toward tasks that are of more benefit to the firm. Gurbaxani and Whang (1991) explicitly label cost of sub-optimal managerial decisions due to lack of relevant information as "decision information costs".

Managers' ability to utilize Information Technology should not be taken for granted. It was found in one study (Daft, Lengel and Trevino, 1987) that managers who are more able recognize the value of rich media for interpreting ambiguous messages perform better than those who do not. This observation suggests that the relationship between adoption of (electronic) managerial decision tools and organizational performance is not necessarily a simple one. Kraemer et al (1993) identified two specific types of public sector mangers – the Knowledge executive and the CBI consumer. Knowledge executives, they proposed, were those managers who could use Information Technology as a vital resource, extracting valuable information in novel ways.

Temporality of information is a key element is determining its value at both individual and organizational levels. Linkage between temporality of

management information and management effectiveness has been suggested in several studies. Ariav (1992) for example, proposed that temporality of management information is a critical element in system design. Clement and Gotlieb (1987) found that IT improved managerial control by diminishing the time needed to process certain transactions. A significant but not yet attained goal for the design of Information Systems is the facilitation of "Anything, Anytime, Anywhere" communications (Kimbrough and Moore, 1992).

Huber (1982), had earlier identified message delay as an important determinant of IS performance. His study found that message delay in Information Systems is related both to intentional delay of 'unimportant' messages and to unintentional delay related to 'workload of the sending unit' and 'number of sequential links in the communication chain connecting the receiver to the message source'. The implication of these findings to IT value models is that temporality of information is a key element in how IT impacts the value of information to managers and hence the value of IT to the organization.

A significant determinant of the business value managers are able to extract from events and data is the level at which data can be analyzed. Stuchfield and Weber (1992), and Clemons and Weber (1994) determined that the ability to analyze customer relationships individually (as a result of Information Technology) led to improved profitability of the firm. "Granularity of Analysis" as a benefit of IT was also noted by Post, Kagan

and Lau (1995). Their study of banks found that IT allowed individual loans to be monitored much more effectively.

IT and Internal Integration: Economies of Scale

Information Technology implementations that span multiple 'islands' can be described as internal integration applications. While it is difficult to separate internal integration and process redesign in practice, some efforts have been made to quantify the benefits accruing from data integration, that is, merging data from different parts of an enterprise into a single architecture.

Information Technology driven integration's impact on business value is often explained by way of scale economies. While differing theories on exactly how IT impacts optimal organizational size can be found, there is general agreement that managers, through IT, can oversee a higher volume of transactions, and co-ordinate the utilization of a greater number of resources. Melody (1987) proposed that only the largest trans-national companies have access to Information Technology, enabling them to exploit local opportunities globally and benefit from scale economies. Brynjolfsson, et al (1994) found a negative relationship between IT investment and firm size, using data from US companies. They suggested that, when external coordination costs shrink faster than internal coordination costs and production costs, average firm size will decrease.

Benjamin and Wigand (1995) cite a widely held tenet of IT economics, which is that IT may lead to increased competition and lower profit margins among competitors but, at the same time, will allow greater volume. Clemons, Reddi and Row (1993) had identified this trend as a "move to the middle". Lowering internal and external coordination costs should lead to greater utilization of specialized organizational assets, while shifting less profitable or manageable processes to other agencies.

Several foundational constructs related to scale economy are reviewed by West (1994) in his study of information system costs. In the context of production organizations, it can be inferred that IT serves as a moderating force between each construct and realized economies of scale. West cites, among other things, a "public good" property of information systems, whose only cost is the initial implementation. An example might be the access to vital production and efficiency statistics which have ongoing management value.

The benefits of labor specialization (Smith, 1937) and the mitigating force of Information Technology thereon are subjects of major interest to the IT research community. Specialization is actually less critical with the quick access to information facilitated by IT. This leads to improved use of labor, even when the organization is small (Brynjolfsson et al, 1994).

Full employment of capital and thereby its cost can be impacted by employment of IT in a productive organization. Inefficiencies caused by mis-matched capital assets are costly. The full cost of a piece of equipment must

be amortized over units of output even if the equipment is underutilized. On the other hand, buying more units of smaller capacity each is usually less efficient. IT's ability to reduce internal and external coordination costs (Clemons, Reddi, and Row, 1993) can lead to more complete utilization of existing equipment and the retirement of underutilized capital assets.

Finally, West cites the ability to adapt to random deviations as a component of scale economy. As output volume in a production organization increases, inventory and capacity reserves needed to meet unexpected demands do not usually rise commensurately. The use of Information Technology can substitute for volume increase as an organizational response to variations in demand (West and Courtney, 1993)

Given the Scale Economy / IT relationships cited above, it is clear that no universal positive relationship between IT and organizational size can be validated. Post, Kagan and Lau (1995) have, however, found some evidence of such a relationship in the banking industry, although the parameters of the relationship change over time. Their study concluded that small banks were less likely to adopt innovative IT due to the lack of ability to amortize it over a large volume of business. As the cost of the technology declines however, the smaller firms will adopt.

The implications of these prior research findings for IT/business value model building then, are:

1. Information Technology is a mitigating factor in the relationship between firm size and efficient utilization of

assets. That is, firms that employ IT are expected to report more production per unit of capital or human assets.

2. Larger firms will report a greater reduction in per-unit of production cost due to adoption of a particular technology than will smaller firms.
3. Smaller firms are slower to adopt a particular technology than larger firms, all other factors being equal.

Information Technology and Business Process Reengineering

The magnitude of tangible benefits perceived as being related to technology driven Business Process Reengineering (BPR) have made this topic a major focal point of IS research. A business processes is a "specific ordering of work activities across time and place" (Davenport, 1993). Therefore, business process reengineering is the reordering, augmentation, or integration of activities, toward some goal (Hammer and Champy, 1993). Information Technology driven reengineering can be viewed as a recursive, synergistic relationship between the rapidly expanding capabilities of IT and the organization's ability to utilize them to restructure core business processes such that they achieve dramatic improvements in efficiency (Davenport and Short, 1990).

By definition, BPR involves completely restructuring the process, not just automating or streamlining it. Achieving this result "... cannot be

planned meticulously and accomplished in small, cautious steps. It's an all or nothing proposition with an uncertain result" (Hammer, 1990). Only by rebuilding a business process radically can the maximum benefit of a new, innovative information related technology be realized. This is what makes BPR such a critical element in business value of IT studies. Measurement of the organizational impact of adoption of some innovation in IT cannot ignore BPR as a contextual issue or moderator variable (Stoddard and Jarvenpaa, 1995).

Foundations of business value related to IT driven BPR have been studied in depth. The fundamental inefficiency of the hierarchical management model has been cited as both a driving force behind and a source of value related to BPR (Tapscott and Caston, 1993). A slightly different perspective is that manufacturing assembly line approaches to ill structured processes is burdened with excessive slack time caused by passing the work from one processing point to the next and finding it when an unexpected request occurs (Davenport and Nohira, 1994). Under such conditions, using IT to allow the work to stay with one person until completion, and giving that person all the tools to complete the work will yield dramatic improvements in throughput.

Less tangible but some authors feel, very important consequences of reengineering business processes are enhanced sense of 'ownership' by the persons performing tasks (Foster and Flynn, 1984, Davenport and Nohira, 1994). Such feelings of ownership may engender commensurate

improvements in task completion rate and attention to customer satisfaction. While these benefits are less simple to measure, they can be gauged to some degree by self report of personal satisfaction and by customer satisfaction feedback.

Two major questions arise when integrating BPR into IT/Business Value Models: (1) Was the reengineering project successful - that is, did was the implementation plan successfully carried out? and (2) Was the project effective - that is, what level of organizational performance improvement was observed? The difference between these two criteria and approaches to measuring them must be clearly specified when building a research model. Many research efforts have focused on factors leading to successful BPR implementation (Grover, et al, 1995, Hall, Rosenthal and Wade, 1993, Tyre and Orlikowski, 1993), but it is the successful completion of the implementation, not the process, which is of interest when using BPR as an independent variable or a moderator variable (Venkatraman, 1994).

One approach to measuring successful implementation of a reengineering project has been to measure the angular difference between a "Strategy Espoused" vector and a "Strategy in Use" vector (Clemons, Thatcher and Row, 1995). Data needed to describe the respective vectors are collected through questionnaires. Another approach to measuring adoption of innovation is to imply that if an organization has acquired a technology that, in itself requires process redesign, then the redesign has been implemented (Fichman and Kemerer, 1993). Finally, one could simply ask

respondents if they have successfully redesigned key processes in conjunction with the adoption of a particular technology.

Once a successful implementation has been determined, level of benefit yielded becomes of primary interest. It is of great importance to place the reengineering process in context to determine its potential and actual organizational impact. One study (Sampler and Short, 1994) places projects in a two-dimensional (4 cell) grid juxtaposing "information half life" (high and low) and "expertise half-life" (high and low). According to this theory, successful organizational change and sustained organizational benefits are more likely when IT can be used to enhance the value of the information and expertise assets that an organization possesses.

According to Sampler and Short, when information half-life in a particular industry is short, then using IT to speed the flow of information through the organization will improve competitiveness and business performance. Financial services and consumer retailing are given as examples of industries with short information half-life. In banking, this can be exemplified by the volatility of interest rates, exchange rates and other parameters of commerce in financial instruments. Using IT to reengineer decision-making processes in financial institutions can reasonably be expected to have positive impacts on business unit performance.

A foundational concept for linking IT/BPR projects with organizational performance is Transaction Cost Economics (TCE). Transaction costs are incurred whenever information must be passed from one organizational unit

(actor) to another. In the passing of information, time and other resources must be consumed (Williamson, 1994). Additionally, the quality of the information degrades as it is passed from one actor to another. Transaction cost theory posits that organizations exist primarily to reduce transaction costs among economic actors (Klein, Crawford and Alchian, 1978).

In addition to explicit costs associated with information transfer (transactions), one study proposes that transaction risk exists when information is passed between actors who are in economic or political competition (Clemons and Row, 1992). The possibility that opportunistic behavior will occur is the source of this risk. Legal contracting can reduce the risk of opportunism somewhat, but not eliminate it.

Information Technology can mitigate transaction costs in three ways. First, it can diminish the cost of transfer of information simply by making it more efficient (Goodhue, Wybo and Kirsch, 1992). Secondly, IT can lead to changes in business processes that have the effect of pushing decision-making authority downward (Gurbaxani and Whang, 1991). Removing hierarchical control of decision making authority can result both from embedding business rules in technology available to lower level workers and from restructuring the organization itself. Finally, IT can impact transaction risk by improving monitoring and control of information transactions by all concerned parties (Clemons and Row, 1992).

Agency Cost Theory (Alchian and Demsetz, 1972) is also relevant to business value of IT research. Agency Cost posits that when actors not in a

position of economic ownership of the enterprise execute decisions relating to organizational mission, those decisions will not always be made in the best economic interest of the organization. Information Technology has the potential to diminish agency cost by (1) enabling a restructuring of the organization whereby fewer levels of subordinates are required to make decisions and implement policy, (2) enabling owners to more tightly monitor and control decision making by subordinates, and (3) Embedding decision rules in the decision making tools used by subordinates (Gurbaxani and Whang, 1991).

Transaction Cost Theory and Agency Cost Theory would seem to lead in different directions in the area of organizational locus of decision-making authority. However, as Gurbaxani and Whang (1991) point out, both can be impacted by implementation of appropriate IT. The result is a model that relates both types of costs to an optimal firm size, based on a minimum value of the combined cost function. The role of IT is embedded in the shapes of the two curves that comprise the composite. The implications for model building are that specific types of IT will have specific impacts on Transaction Costs and Agency Costs, and that these impacts be gauged or at least hypothesized when linking IT to organizational performance.

Business Network Redesign

Competition among business entities is inevitable in a market economy. It has been shown that there are several broadly applicable

business strategies which an enterprise may follow, and the Information Technology can either support or hinder that strategy, depending on whether it is used wisely (McFarlan, 1884, Porter and Millar, 1985). A useful framework for organizing and integrating IT and Competitive Strategy studies can be drawn from Bakos and Treacy's (1986) two central themes related to this topic - Comparative Efficiency and Bargaining Power. These two themes map to Venkatraman's (1994) fourth level of business transformation - Business Network Redesign.

Subsumed under the Comparative Efficiency theme are: Technology and Competitive Strategy 'Fit', theories of interorganizational efficiency including sustainability of competitive advantage, Electronic Markets and Hierarchies, and Value Chain restructuring. Bargaining power related to IT covers research areas such as product design, transaction risk, and virtual hierarchies.

IT and Comparative Efficiency

The 'fit' between Information Technology and competitive strategy has been extensively explored in MIS and business literature. McFarlan (1984) enumerated several areas where IT has the potential to impact competitive strategy. He proposed that, to the degree that an IT application had the effect of raising barriers to entry, raising switching costs, or dramatically lowering costs, it was strategic.

He then attempted to categorize the strategic role of IT in adopting firms by constructing a two dimensional grid and locating IT adopting firms on it. One dimension of the grid is "Strategic impact of existing operating systems". That is, do these firms currently have information technology applications that have strategic importance? The other axis is "Strategic impact of application development portfolio. This measurement is the degree to which new applications have the potential to impact the firm's strategy.

By locating adopting firms along both axes, McFarlan proposed that they could meaningfully be assigned to one of the following four categories, indicating strategic role of Information Technology: Support, Factory, Turnaround, and Strategic. Institutions where the role of IT was 'support' were expected to experience the most limited benefits, while those adopters where the IT's role was 'strategic' could be expected to reap the most benefit. These classifications still serve as an important foundation for model building in the area of the relationship between IT investment and organizational performance, especially as contextual or moderator variables.

Porter and Millar (1985) built on McFarlan's work in their study of Information Technology and competitive advantage. They observed that the rate of advances in the technology of sharing information about manufactured products had surpassed the rate of technological advancement in the manufacturing processes themselves. They proceeded to identify three ways in which IT affected the very nature of competition in industrialized

societies: Changing industry structure, changing competitive advantage and spawning new businesses.

Based on the foregoing observation, Porter and Millar concluded that executives must keep themselves informed of the role of information technology in their industry and capitalize on opportunities to use IT as a strategic tool. Embodied in their five recommendations are the roots of many other studies (*) in the business value of IT:

- Assess information intensity (* Jarvenpaa and Ives, 1990)
- Determine the role of information technology in industry structure (*Egelhoff, 1992)
- Identify and rank the ways in which information technology might create competitive advantage (*Kettinger, Grover, Guha and Segars, 1994).
- Investigate how information technology might spawn new businesses (*Brynjolfsson, Malone, Gurbaxani and Kambil, 1994)
- Develop a plan for taking advantage of information technology (*Das, Zahra, and Warkentin, 1991).

The impact of Information Technology on interorganizational efficiency and the economics of industrial ownership has accounted for a great deal of IS research in the last 20 years. Much of the model building in this area has used Transaction Cost Economics (TCE) as a foundational construct.

Clemons and Row (1992) posited that TCE impacted interorganizational cooperative relationships in the following ways:

1. Increased levels of explicit coordination with parties not owned by the firm can increase resource utilization and create value.
2. Level of explicit coordination is limited by transaction cost.
3. Transaction costs have two components- coordination cost and transaction risk.
4. By reducing costs and risks associated with explicit coordination, IT can facilitate the development of [value added] relationships among firms.

Specifically, Information Technology can reduce transaction (coordination) costs among non-related firms by facilitating "...tighter interfirm links through information sharing and mutual monitoring" (Gurbaxani and Whang, 1991). Such monitoring may also mitigate risk of cooperation. Williamson (1975) clarifies this inherent risk. He explains that ownership of a highly specific asset leads to greater need for contracting with outside parties to ensure full utilization. These external parties may act opportunistically if contracts are not completely specified (as market conditions change, for example).

Risks of opportunism and transaction cost have historically led to vertical integration by firms. Such integration can be a source of inefficiency

due to lack of management expertise and underutilization of assets (Malone, Yates, and Benjamin, 1987). Information Technology, by virtue of its ability to mitigate risk and transaction cost, can lead to a restructuring of value added processes needed to create a finished product or service. Stated differently, it is possible through IT, to create a "Virtual Value Chain" (Benjamin and Wigand, 1995). Such an arrangement creates value for all members of the chain by more fully utilizing specialized expertise and assets.

Virtual value chains do have a limit, however, as transaction cost and risk are only reduced, not completely erased by IT (Clemons and Row, 1993). It is simply not possible from a simple economic standpoint to increase reliance on an external supplier without giving that supplier some additional bargaining power (ibid). Another significant effect of virtual value chains is that the most profitable and least profitable firms in an industry will "move to the middle" (Clemons, Reddi and Row). This happens because the inefficiencies of lower profit firms are mitigated while industry leaders lose advantages due to size or strategic alliances.

Business cooperation and the benefits that accrue from it are an important factor in any business value study where the specific technology of interest has interfirm communication capabilities. Venkatraman (1994) identified four specific functional areas where benefits may accrue to firms undergoing "Business Network Redesign".(BNR) They are summarized below:

Table 2.7

Benefits of Business Network Redesign

Scope/Functions	Potential Benefits
Transaction Processing	Administrative Efficiency Enhancements
Inventory Movement	Operational Efficiency Enhancements
Process Linkage	Potential for Differentiation in the Marketplace through Greater Coverage of Sources of Competencies
Knowledge Leverage	Enhanced Learning-Potentially Valuable Under Highly Uncertain Conditions

Venkatraman (1994) points out that simply adopting a technology that has inter-organizational linkage features (such as EDI) does not guarantee the realization of benefits shown above to all users. Rather, " Effective business network redesign calls for coordinating distinct strands of relationships through a common IS platform" (ibid). Formulation of a model showing measurable benefits accruing to adopters of BNR-enabling technology-enabled must, therefore, consider which specific business are intended to be altered and what processes are shifted from inside the organization to external parties.

IT and Bargaining Power

Most IS research concerning organizational bargaining power use either Porter's Competitive Forces model or the Value Chain construct as an organizing framework. Bakos and Treacy (1987) combine these two approaches into three major factors linking IT to bargaining power. They are: Search cost, Unique Product Features and Switching Cost. Literature

dealing with Information Technology and bargaining power of the firm can be efficiently organized under this framework.

Electronic Marketplaces were predicted by Malone, Yates and Benjamin (1987) to have a profound impact on organizational form. They felt that the "electronic brokerage effect" would be of even greater significance than the "electronic integration effect" of electronic hierarchies. Bakos (1991) also felt that Electronic Marketplaces would be of significant impact due to IT's ability to reduce search costs and give customers more bargaining power. Rolf and Wigand (1995) suggest the possibility of a complete disappearance of wholesalers and retailers due to shifting information and bargaining power to consumers.

Hess and Kemerer (1994), however, determined that technological advances in the banking industry did not lead to Electronic Marketplaces, specifically because true EM's would have impacted certain revenue generating processes too much. Although Computerized Loan Origination Systems (CLOS) had the potential to create a large scale EM in mortgage instruments, they were resisted by much of the industry to the point that only a few limited implementations survived. Those that did survive more closely resembled Electronic Hierarchies than Electronic Marketplaces.

Several factors were cited by Hess and Kemerer as possible explanations for the failure of CLOS's to dramatically change the structure of the market in home mortgages. First, as Clemons, Reddi and Row (1993) suggested, transaction risk increases might outweigh coordination cost

reductions. Secondly, economic benefits may flow more to buyers than sellers (Seidman and Wang, 1993). Finally, adopters may have to make certain 'non-contractible' investments, that is, investments which cannot be explicitly linked to future benefits to participate in the EM (Bakos and Brynjolfsson, 1993). Concentration of benefits sufficient to encourage EM participation would exist if only a few firms participated.

On a micro level, firms can use Information Technology to enhance the features of a product or service. Sometimes the product itself is information related (software, on-line information services, etc.), in which case IT completely defines the product. In other product types, IT can impact product attributes in two ways – lowering cost and enhancing differentiation (Porter and Millar, 1985). Cost reduction issues have been addressed in a previous section.

The use of IT to differentiate a product from its competition is a significant factor in the relationship between IT and business value (McFarlan, McKenney and Pyburn, 1983). Differentiation strategies listed by Shank and Govindarajan (1992) include: Brand loyalty (data mining / customer centered marketing), superior customer service (on-line support, expert systems), dealer network (wide area networks/distributed databases), product design and features (CAD/CIM), and product technology (modeling/simulation) [examples added by this author]. Banking examples of product differentiation include Automated Teller Machines and direct links to the institution (via home PC) for certain transactions.

"Electronic marketplaces can impose significant switching costs on their participants" (Bakos, 1991). Suppliers and buyers may both be required to make significant investments in time, money and technology in order to reap the benefits of Electronic Data Interchange and other EM technologies. Jelassi and Fignon (1994) documented a successful EDI implementation at Brun Passot that effectively imposed switching cost on its customers by requiring a large technology investment.

IT and Business Scope Redefinition

Information Technology, by virtue of its ability to shift feasible boundaries of profitable enterprise, "..can cause a shift in the structure of entire industries (Bakos and Treacy, 1986). Firms can exploit IT catalyzed changes in two different ways:

They may find new opportunities for profit in the changed marketplace, utilizing existing technologies.

They may re-mine the existing marketplace for opportunities that have become feasible due to the adoption of innovative competencies. These strategies often overlap, and will both impact the firm's eventual 'portfolio' of business activities as it attempts to maximize organizational (financial) performance (ibid.).

Industry structure may change due to shifts in buyer power, barriers to entry or substitution (Porter and Millar, 1985). New opportunities will arise as commonly available technology changes the economics of internal

and external coordination (Clemons and Row, 1992). Capitalizing on these opportunities requires that the firm engage in Systems Planning methodologies that are designed to align IT with organizational strategy (Lederer and Sethi, 1988)

Firms that predominantly use the second strategy have been termed 'prospectors' (Miles and Snow, 1978). Prospectors' IT-implementations are expected to be decentralized and adaptable, facilitating capitalization on market opportunities as they are found (Das, Zahra and Warkentin, 1991). In prospector organizations, exploitation of IT related opportunities is expected to be driven not by the IS function, but rather by IT users in various functional areas (ibid.).

At the level of Portfolio Strategy, organizational changes would be described as Business Scope Redefinition by Venkatraman (1994). Actually acquiring or divesting productive functionalities as a result of IT driven shifts in feasible boundaries would fall into this category of transformation. Modifying business scope creates "Opportunity to leverage information processing capabilities to create a more flexible and effective business entity..". (ibid.) The implication for empirical model building is that research subjects (firms) that have undergone business scope transformation due to IT are expected to report quantitatively and qualitatively that substantial improvements in organizational performance have been realized.

Linking Inputs and Outputs: Modeling the IT/Business Value Relationship

The findings reviewed in the prior section will support a general research model and specific hypotheses to be described hereunder. Independent and dependent variables are operationalized. Specific questions to be used and format of the questionnaire are discussed in Chapter 3.

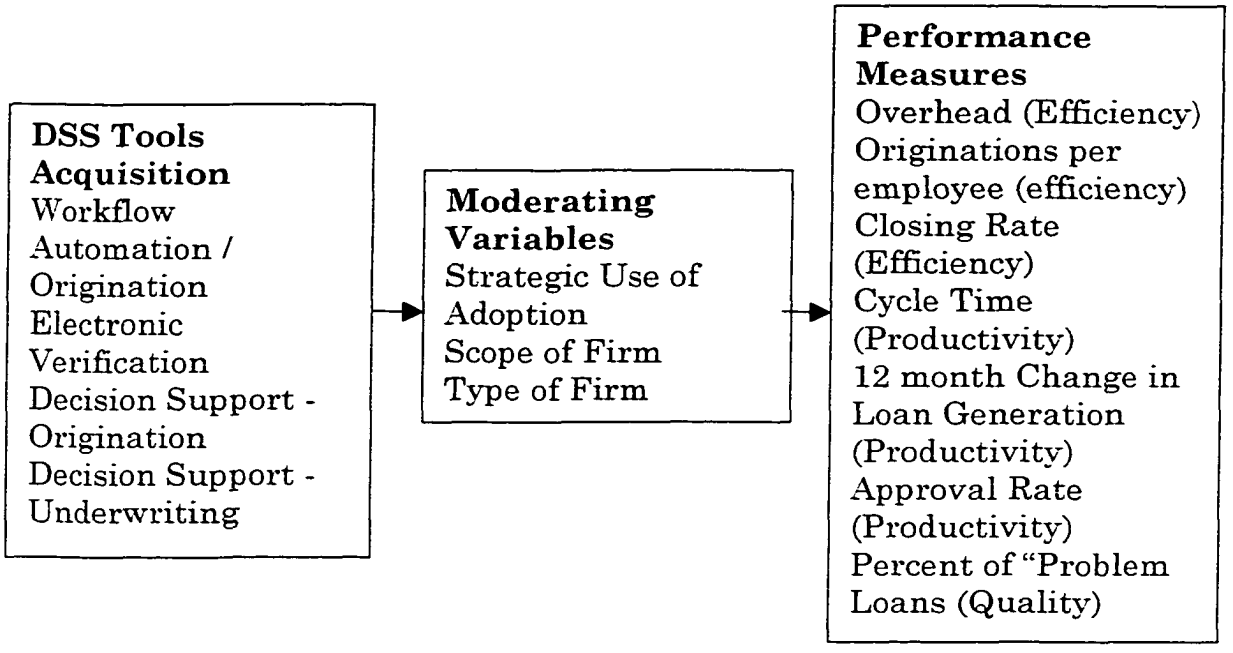

Figure 2.1

General Research Model for Business Value of Automated Underwriting Systems

Explanation of the Independent Variables

Adoption of DSS tools are gauged by determining adoption of each of four technologies independently. Responses are coded as 0/1 based on whether respondents answered affirmatively to questions based on features

and brand names of the technologies in question. Survey items to establish adoption of each technology and the analysis employed to finalize the scales is established in Chapter 3.

Workflow / Loan Origination Tools

Adoption of Workflow / Loan Origination tools are expected to impact loan operations at a tactical level. By the nature of the functionalities associated with AW/LO applications organizational benefits are measurable in cycle time and labor hours required to process the application. Moving toward the elimination of paper flow is a primary factor in overhead reduction. According to one industry observer, lenders "...will not be able to position themselves as low cost/high quality competitors without moving to paperless processing". (Portner, 1995)

Mortgage lending is subject to dramatic shifts in volume in response to interest rate fluctuations. When interest rates drop sharply, borrowers flood the origination process to renegotiate loans at the more favorable rate. Since lenders cannot hire and train lending officers quickly, they must maintain extra staff to cope with peaks. Workflow automation systems obviate this need for higher staffing levels by allowing existing staff to become more highly leveraged in times of peak demand. In order to secure higher profits, mortgage originators must "...Use supplemental information systems to optimize the tradeoff between volume and price...". (Toevs and Ziska, 1994).

"Making production costs more variable" is a priority in mortgage lending according to Thinakal (1996).

Electronic Verification Tools

The evaluation of creditworthiness of loan applicants in all lending sectors is largely dependent on obtaining data from credit reporting agencies (credit bureaus). Origination software may or may not use direct links to credit bureaus through Value Added Networks or the World Wide Web. The traditional vehicle for credit reporting in the mortgage industry is the Residential Mortgage Credit Report. This approach usually requires two business days to complete and costs the originating institution between $50 and $60 (Kunkel, 1995). By using a new vehicle - a streamlined process combining information from three largest repositories of credit data-, originators can spend only $15 to $20 and complete the process in about a minute (ibid). Such cost savings are quantifiable not only in dollars per loan but in diminished cycle time.

Mortgage Electronic Registry System (MERS) is a loan identification system, where a universally recognized numbering system is used to follow a loan from origination to completion, no matter how many times it changes hands (Noe, 1997). While most benefits accruing to users of MERS have to do with servicing and selling into the secondary market, originators can use the system to help diminish fraud by searching for existing mortgages against a

specific property (ibid). Saving time in the origination / underwriting phase of a loan is an additional benefit of the system (Walker, 1997).

Both online credit checks and the use of MERS are considered 'Electronic Verification' for purposes of this study. In each case, one or more antecedent processes to loan approval are impacted. Whether the actual data link is by way of a value added network (VAN) or via the World Wide Web is not functionally significant. Respondents will simply be asked if they use direct data links in either area as an alternative to paper/telephone approaches.

Origination Decision Support Tools

Origination Decision Support is defined as DSS elements which specifically aid in the choice phase of lending decisions including:

1. Choice of product
2. Whether to require mortgage insurance
3. Whether to lend
4. Pricing
5. Loan Portfolio Management

Operationally, these elements will include origination software employing:

1. Rule bases derived from the institution's own data
2. Rule bases purchased from vendors based on industry-wide data

3. Rule bases programmed explicitly by in-house personnel
4. Management support features designed to aggregate and/or analyze lending unit data.
5. Other software functionalities designed specifically to provide suggested solutions/decisions based on input about mortgage applicants

Underwriting Decision Support Tools

Underwriting decision support is commonly referred to as Automated Underwriting [AU] (Blose and McElwee, 1998). For the purpose of this study, AU is defined as real-time evaluation of underwritability based on underwriters' scoring models. Access to these scoring models may be via electronic linkage (EDI) or software licensed by the Underwriter (Fannie Mae or Freddie Mac) and resident on the lender's computer system. Automated Underwriting systems, known as Desktop Underwriter (Fannie Mae) and Loan Prospector (Freddie Mac) can improve cycle times significantly, and even serve as de facto origination DSS as underwritability may be a key element in the lending decision (Johnson and Berg, 1996).

Automated Underwriting systems, in addition to improving cycle time and efficiency, also have the capacity to improve loan quality via several mechanisms. First, AU allows lenders to process more loans, thereby enabling greater selectivity and greater conformity to acceptable parameters. Secondly, the use of an 'Expert System' such as AU has a training effect on

users over time (Byrd, 1993). Finally, the underwriter's decision rules can serve as validation of the originator's internal rules. Where judgements of loan quality do not agree, the lender is prompted to re-evaluate and perhaps modify its decision rules or scoring models.

Dimensions of Lending Performance:

Dependent variables to be used in this study are stated below. They are measured in two ways, using primary and secondary data. All are related to organizational performance at a department level. In the case of firms that engage only in mortgage lending, this is equivalent to measuring the variable at the firm level. In other cases, these variables are sub-firm level.

Actual Default Rate

Hard data on loan assets outstanding and recent default rates is available through federally mandated reports. By computing the ratio of defaults to total mortgage loan assets, the default rate can be computed.

Self Reported Buyback Rate

Many lenders do not keep their own mortgages, but sell them into the secondary market. However, if the loan becomes non-performing, it often must be bought back. Self-reports of buyback rates are expected to be reasonably accurate, especially if anonymity is guaranteed. The questions are posed in terms of ranges, which are based on published industry

distributions. Such ranges will facilitate treatment of this variable as interval data.

Self Reported Overhead Related to Mortgage Operations

Overhead rates related to mortgage lending are measured primarily in two ways - dollars of overhead per loan originated and loan originations per employee. Again, these figures are known to managers in lending institutions. Means and distributions of this variable among industry participants are published by a trade organization. This will facilitate posing the question as a series of ranges, and asking each respondent to indicate which most accurately represents the firm. This variable will also be treated as interval data.

Self Reported Measures of Volume of Originations

Each respondent is asked to report volume of loan generations both in dollar volume and in number of loans generated over the prior two completed years. Growth will be calculated from these responses.

Pipeline Dropouts

Loan applications that are accepted but drop out of consideration prior to final disposition are a burden on the firm. The degree to which dropouts can be avoided is a reasonable performance measure. Again, ranges are offered to respondents based on published industry norms. The responses are treated as interval data.

Cycle Time for Closing a Loan

Each respondent is asked to report the average number of days between initial applicant contact and final disposition of the application.

Measured Loan Volume Held change from 1998 to 1999

Industry performance data available from the Chicago Federal Reserve is used to compute percent change in volume of loans held between 1998 year-end and 1999 year-end

Moderating Variables

Often, relationships between predictor and criterion variables are impacted by other phenomena, generally called 'Moderator Variables' (Sharma, Durand and Gur-Arie, 1981). Moderator variables may impact IV/DV relationships in four ways, depending on the degree of interaction with predictor and criterion variables (ibid). Specifically, four distinct classes of 'specification' variable (Rosenberg, 1968) relationship may be inferred by crossing "Interaction with Predictor Variable" and "Relationship to Criterion and/or Predictor" as shown below (Sharma, Durand and Gur-Arie, 1981):

Table 2.8

Expected Interactions

	Related to Criterion and/or predictor	Not Related to Criterion and Predictor
No Interaction With Predictor	1. Intervening, Exogenous, Antecedent, Suppressor, Predictor	2. Moderator (Homologizer)
Interaction With Predictor	3. Moderator ("Quasi"-Moderator)	4. Moderator ("Pure" Moderator)

These four classes of specification variables are expected to impact predictor / criterion relationships in the following ways:

- Influences the predictor and/or the criterion variable, but does not interact with the predictor (Rosenberg, 1968).
- 'Homologizer' - Identifies subgroups of the sample based on the proportion of total variance due to error. This effectively breaks the sample into subsets with higher R^2, or predictive validity (Ghiselli, 1964)
- 'Quasi' Moderator variables modify the form of the relationship and are predictors themselves.
- 'Pure' Moderator variables modify the form of the relationship but are not related to the criterion or predictor variables.

In the following discussion of specification variables to be included in the study, the foregoing typology will be referenced.

Strategic Use

Venkatraman (1994) compresses his five levels of business transformation into two macro levels based on (intended) degree of organizational impact, as shown below:

Table 2.9

Generalized Levels of Transformation

Evolutionary Transformation	Localized Exploitation Internal Integration
Revolutionary Transformation	Business Process Redesign Business Network Redesign Business Scope Redefinition

Questions posed to respondents will serve to classify them at one of Venkatraman's five levels. At the very minimum, respondents will have planned localized exploitation of the technology. Therefore, having no option to indicate complete absence of business transformation is reasonable.

Strategic use is again expected to modify the relationship between adoption of the technology of interest (AU) and measurable benefit. As in origination DSS, AU has the capability to provide a range of benefits from slight to dramatic, based on whether adoption is part of a strategic plan to exploit innovative technology to modify or replace a key business process. Strategic use, for purposes of analysis, can be viewed as 'evolutionary' or 'revolutionary' (Venkatraman, 1994).

The use of origination decision tools may yield benefit levels from slight to dramatic, depending on the strategic use of the adopter. By simply reducing the time and manpower needed to make decisions, measurable improvements in cycle time and management overhead could be realized. More dramatic improvements however, will likely only come about if adopters make radical changes to the lending process in response to new technologies. "The main challenge ahead for management is to adapt their companies to [technological innovations] by reengineering their scope, objectives and procedures.". (Weimer, 1994). Acquiring the technology does not ensure that such transformations will occur. In order for process re-engineering to occur, acquisition of IS tools must be part of a purposeful effort to exploit technological innovations to restructure key processes (Hammer and Champy, 1993).

Loan quality, gauged by rates of late, non-performing, and charged off loans as percentage of total loans is also expected to be impacted by adoption of decision support tools. As is the efficiency indices, quality metrics are expected to vary between adopters with 'evolutionary' strategic vision and those with 'revolutionary' use for the project. It is widely observed across all organizations that technology innovations are not fully exploited as agents of change when it adopted (Davenport, 1993). In the mortgage industry specifically, while many report that some process reengineering was attempted concomitant with technology adoption, far fewer began the project with a clear strategic use (Blose and McElwee, 1998). Those who do begin

the process with a clear and purposeful plan for modification of business processes to exploit new technologies are more likely to achieve 'spectacular' performance results (Tapscott and Caston, 1993).

Strategic use of adoption is posited to be a quasi moderator variable, based its relationship to predictor and criterion variables. Strategic use would occur prior to or concomitant with adoption. It could therefore be a predictor of adoption as well as impacting the relationship between adoption and criterion variables. This interaction is mentioned frequently by authors in industry journals as well as refereed academic proceedings and journals (Sampler and Short, 1994, Blose and McElwee, 1998).

Size of Firm

Size of the lending institution may be directly related to both adoption of IT and output measures. Some existing literature suggests that larger firms are more likely to adopt IT innovations since they can spread their investment over a larger volume of business (Post, Kagan and Lau, 1995). However, other studies suggest an inverse relationship between IT adoption and firm size (Brynjolfsson et al, 1994).

Interaction between firm size and IT adoption's impact on the output variables is implied by Clemons, Reddi, and Row (1993) in their investigation of the impact of IT on internal and external coordination costs. Larger firms with more complex administrative infrastructures should experience significant benefit (lower overhead) when utilizing IT to coordinate the

origination process. Therefore, firm size is posited to be a quasi-moderator variable, and will be positioned in the data analysis as such.

Type of Firm

Several different types of firms are allowed under U.S. banking regulations to originate mortgages (Koch, 1995). For purposes of this survey, the types are defined as:

- Commercial Bank
- Savings and Loan
- Mortgage Bank
- Mortgage Broker
- Credit Union
- Other

Investigation of the relationship between firm type and output variables are exploratory in nature, since nothing in the literature would suggest an association. However, since this information is easy to capture and categorize, it is added to the research model as a moderating variable.

Expected Relationships

Based on the foregoing review of IT and business value relationships, the following relationships are expected to be found:

Table 2.10

Moderating Variables and Expected Interaction Effects

	Productivity Impact	Efficiency Impact	Asset Quality Impact
Loan Origination /Workflow Adoption	Yes (moderated by scope, SU)	Yes (moderated by scope, SU)	No
Electronic Verification Adoption	Yes (moderated by scope, SU)	Yes (moderated by scope, SU)	Yes (moderated by SU)
Origination Decision Support Adoption	No	No	Yes (moderated by SU)
Underwriting Decision Support Adoption	No	No	Yes (moderated by SU)

Hypotheses

Testing several specific hypotheses will validate the foregoing empirical model. These hypotheses will relate the predictor variable to the output variables, and measure any moderating or direct impact of the constructs posited to be moderators.

H1a: Adoption of Loan Origination / Workflow tools are associated with higher levels of productivity and efficiency.

H1b: The impact of Loan Origination / Workflow tools adoption on productivity and efficiency are greater for respondents whose strategic use of adoption is "revolutionary"

H1c: The impact of Loan Origination/ Workflow tools adoption on productivity and efficiency is greater for respondents who have a wider scope of operation

H2a. Adoption of Electronic Verification tools is associated with higher levels of productivity and efficiency.

H2b: The impact of Electronic Verification tools adoption on productivity and efficiency are greater for respondents whose strategic use of adoption is "revolutionary"

H2c: The impact of Electronic Verification tools adoption on productivity and efficiency is greater for respondents who have a wider scope of operation

H3a: Adoption of Origination Decision Support tools is associated with higher levels of asset quality.

H3b: The impact of Origination Decision Support tools adoption on asset quality is greater for respondents whose strategic use of adoption is "revolutionary"

H4a: Adoption of Underwriting Decision Support tools is associated with higher levels of asset quality.

H4b: The impact of Underwriting Decision Support tools adoption on asset quality is greater for respondents whose strategic use of adoption is "revolutionary"

Chapter Three

Research Methodology

This chapter addresses research design issues relating to this study, for which the unit of analysis will be the mortgage lending function. A Cross sectional study using a survey instrument will be employed to test the hypotheses listed in the previous chapter and to validate the constructs proposed as predictor, criterion, and moderating variables. Respondents will be asked to answer survey questions either on a paper instrument or on a web page with fill-in fields. The data collected will be analyzed using procedures available in a PC-based statistical package. The primary technique will be multiple regression with comparisons to identify moderating variables.

Survey Design

A field study (sample survey) approach is being used for this research due to the importance of the complexities and contextual interactions associated with the actual process (Mason, 1989), This assertion is also supported by Locke (1986) who also cited perceived expectations ("demand characteristics) by subjects in lab studies which contaminate results. Sample

subjects are readily available through professional associations and published directories. Time span available for the current research and potential difficulties with longitudinal studies (Campbell and Stanley, 1963) do not favor this approach.

Survey instruments often suffer from "...weak linkages between units of analysis and respondents (Pinsonneault and Kraemer, (1993). Therefore, the introduction and explanation pages in the survey instrument will explicitly explain the unit of analysis concept. Additionally, the survey instrument itself will ask some questions about the size and scope of the business unit that the respondent is representing in answering the questions.

The Sample

A mailing list of 1000 banking members of the Mortgage Bankers Association of America (MBAA) was provided to the author by that organization. The Arizona Mortgage Lenders Association provided an additional sample of 120 names. The Arizona list was crosschecked against the national list to ensure that no duplicates existed. After removing duplicates, the Arizona list contained 90 names. The total sample mailing was 1090. The original format of delimited ASCII text in both lists was converted to a Microsoft Acess™ database. Fields available (consolidated for brevity) are:

- Name (Prefix, First, Middle, Last, Suffix)
- Label Name

- Degree
- Company Name, Title
- Address (Street, City, State, Zip, Country)
- Personal Sort
- Company Sort
- Bad Address Date
- Phone
- Fax
- E-Mail (not available in Arizona Sample)
- Entity ID (Internal MBAA Use)
- Primary Company (Internal MBAA Use)

These fields are sufficient for the multi-media instrumentation approach that will be described in this chapter. Electronic mail addresses are not available for every member of the database, but will be employed for reminders and follow-ups where they exist.

Instrumentation

A paper questionnaire will be mailed to each sample member with a cover letter explaining the value and purpose of the study. A pre-addressed envelope will be included in each mailing to facilitate mailing the instrument back. Respondents were encouraged to submit their reply by way of a web presence maintained by the author, the address of which will be supplied in the cover letter. The web will reside on a server accessible to the author and

will be monitored and maintained by the author. The research department of the Mortgage Bankers of America constructed a page with links to the actual survey and endorsing the study as a joint project between the MBAA and the principal investigator's institution. The investigators website contained an introduction page as well as pages for definitions of terms and respondent protections.

The survey page consisted of a fill-in field corresponding to each question on the paper instrument. Respondents who use the web page for responding will have the additional benefit of hyperlinks back to the definitions page for review if needed. No hyperlinks to websites not under the author's control were included in the page.

The web page for data collection was developed using Microsoft Front Page 2000™. This application tool facilitates the creation of 'fill-in' fields. These fields capture user responses and save them into a tab delimited ASCII file on the same server where the web form is hosted. As data came in, the author periodically retrieved new file records and added them to a master response file maintained in Microsoft Access™ format. Any paper surveys submitted were hand keyed into the Access™ file.

Scaling and Measuring the Independent Variables

In this study, adoption of innovative technologies related to the lending process is the key input variable. Four distinct technologies will be defined and targeted. Respondents will either have adopted or not adopted each

technology, based on responses to survey questions. A hierarchical four level construct, with some technologies necessarily antecedent to others, has face validity, but has not been validated by prior research. Cooper and Zmud (1990) measured level of adoption in such a fashion in their study of MRP systems. In their case, however, a pre-existing definition of the construct existed in the form of a formal framework established by the dominant professional organization in that field. No such framework exists in mortgage lending.

Table 3.1

Input Variable Definitions

Variable Name	Variable Description	Variable Type
Using Origination/ Workflow aids	Does the subject use software aids to generate and process new loan applications	Nominal
Using Electronic verification	Does the subject use direct computer links to external databases to verify input or provide additional input	Nominal
Use Origination Decision Support	Does the respondent use in-house computerized decision aids such as scoring models, rule bases or neural networks	Nominal
Use Underwriting Decision Support	Does the respondent use Underwriters' computerized decision aids	Nominal

Since a hierarchical construct cannot be justified at this point, the inputs will be coded as four dichotomous variables. For each of the technologies, respondents will be coded as 'adopters' or 'non-adopters'. A

separate set of questions will determine each respondent's 'strategic use' of the technology in question.

Loan Origination / Workflow Management Tools

Adoption of loan origination and workflow management (LO/WM) software will be treated as dichotomous variable. Measuring adoption of LO/WM software will be based on a brief description of the functionality of such software and a representative example based on a survey of popular commercial offerings. While many such systems are in use, there is no universally recognized categorization scheme whereby respondents could simply indicate whether they were using a particular category of technology or not. While "Automated Underwriting" is a widely recognized term (Clayton, 1998), many would take it to include other technologies which are treated separately in this study.

General characteristics of LO/WM software include:

- Computerized input forms for applicant data
- Prompts to ask for necessary data
- Performs computations such as payment amount
- Manages / generates correspondence
- Generates 'to-do' lists for lending personnel
- Generates summaries of loans in progress and their status
- Generates mandated government reports
- Maintains or provides access to regulations

Highly representative examples of Loan Origination / Workflow software are Desktop Originator™ from Fannie Mae / MORNET and Loan Manager™ from Dynatek (Clayton, 1998). These two trade names will be referenced in the question regarding adoption of LO/WF. The web form that collects responses to this question will offer a quick link to a more detailed description of LO/WF software.

Automated Verification Tools

Adoption of automated verification will be simpler to measure than LO/WM, as simple, unambiguous questions can be used. The questions will be:

1) Does your lending unit use direct electronic links such as EDI or the World Wide Web to communicate with credit bureaus?
2) Does your lending unit direct electronic links such as EDI or the World Wide Web to communicate with mortgage registries (MERS)?

If either answer is 'yes', the respondent will be classified as an adopter of automated verification. A more detailed definition of direct electronic linking and listing of several brand name products will be hyper-linked to a button beside the question. The products will include the "Interfaces/EDI" feature of MorVision™ and ePass™ from Genesis 2000.

Automated Origination Decision Support Adopter Tools

Automated Origination Decision Support (ODS) Adoption will be defined for the purposes of this study as the use of decisional guidance at the point of origination stored in the form of computer software. ODS is different from Underwriting Decision Support (UDS) in that it does not relate directly to marketability or underwritability of the potential loan. UDS will also be measured using different criteria.

Specific software features which characterize ODS include the following:

- Guidance in suggesting specific products to applicants once applicant information is entered
- Risk characterization of applicant (low-moderate-high, for example)
- Accept / Refer decision ('Refer' meaning to pass process on to human)
- Compare applicant data against lending unit's internal rules, policies, and guidelines
- Ability to be programmed with lending unit policies
- Assess impact of potential new loan on lending unit's existing loan portfolio

- Uses a rule base which has been either programmed in-house or purchased from a software vendor (often referred to as 'expert system')
- Emulates the decision of an experienced lending officer

A brief description of ODS will be presented to respondents along with representative examples of well known commercially available systems. The examples will be DecisionXchange™ from COGENSYS and the Prequalification feature of Genesis 2000 and similar packages

Underwriting Decision Support Tools

Underwriteability is a key issue in the lending process. If a loan conforms to an underwriter's standards, it can be sold into the secondary market. While some lenders specialize in 'nonconforming' loans (Glass, 1996),

Automated underwriting "...allows for implementation of the internal modules that check for loan quality based on the lender's and the secondary market's qualification requirements" (Weimer, 1994). The two largest mortgage underwriters, Federal National Mortgage Association ("Fannie Mae") and Freddie Mac offer the service of evaluating loans online if the originator's software captures the necessary data in a compatible format. The software link at both organizations links with most popular mortgage

software packages. A simple question will be used to classify respondents as adopters or non-adopters of UDS:

> "Does your institution use linkages to underwriting support software such as Desktop Underwriter® or Loan Prospector® to pre-qualify or classify loan applications?"

It is expected that any respondents using AU will recognize the product names of these two packages, since they account for virtually all of the AU market.

"The major problem with ... previous studies is that they failed to address two fundamental issues that are essential to [IT Value] research: (1) adoption of a conceptual framework to define IT investment and organizational performance and, (2) identification of relevant and accurate measures to operationalize these concepts." (Mahmood and Mann, 1993). Building on the basic research model established in Chapter 2, this section will identify and operationalize the constructs that are expected to impact organizational performance measures of interest.

Software used by mortgage lenders is not limited to that which provides decisional support and guidance during the origination process. Some applications exist solely or primarily to support secondary marketing - selling loans to other institutions and investors after they are originated.

Scaling and Measuring the Dependent Variables

Performance constructs in lending generally and mortgage lending specifically are simple and straightforward. The domain of performance constructs (Sethi and King, 1994) in this study is operational efficiency and effectiveness of the mortgage lending function. Operational efficiency is operationalized as dollars spent per unit of production. Other metrics are loan production volume per employee, cycle time, and dropout rate. Operational effectiveness will be taken as the quality of output of the lending departments products. Output quality refers to the performance of loans that are made. Specific output variables to be measured are summarized below:

Table 3.2

Output Variable Definitions

Variable Name	Variable Description	Var. Type
Volume Increase Percent- 1 yr	The loan volume increase will be calculated from two input variables: Loan volume 1999 and Loan volume 1998. Figures obtained by self-report.	Ratio
Percentage of Problem Loans	The total loan volume held by the institution as well as volume of late and non-performing loans are available from the Federal Reserve database	Ratio
Originations per employee	This will be derived from two of the input variables: Loan originations in 1999, and number of employees	Ratio
Overhead exp. per loan	Banks that calculate dollars of overhead expense per loan generated will be asked to report it.	Ratio
Cycle time	Average number of days to reach a final disposition on a loan application.	Ratio
Dropout Rate	Proportion of applications that voluntarily drop out of consideration prior to final disposition.	Inter val
Approval Rate	Proportion of Loan Applications processed by system that are eventually approved.	Inter val

Volume Increase - 1Year

Total loan production (originations) for 1998 and 1999 will be self-reported. As explained in the prior section, volume on the bank's balance sheet at year end (available from Federal Reserve) may not be indicative of total volume of originations due to differing policies regarding selling loans into the secondary market (Johnson and Berg, 1996). One-year percentage volume increase will be the incremental increase of loans generated in 1999 over 1998.

Loan Volume 98 and Loan Volume 99 will be defined as the dollar volume of new loans generated by the respondent in 1998 and 1999, respectively. Ranges will not be needed for this input, since the dollar volume should be available to most respondents. The input form will specify that the number be given in millions rounded to the nearest million. These variables will be treated as continuous, ratio inputs for pre-processing and analysis purposes. It is plausible that some banks may have negative changes due to general economic trends such as higher interest rates (Maselli, 1994).

Percentage of problem loans

Total mortgage loans for each respondent institution that is covered in the Federal Reserve database (www.frbchi.org/rcri) are reported in Item 1410 - "LOANS SECURED BY REAL ESTATE". Problem loans can be taken as the total of Item 1422 "LOANS SECURED BY REAL ESTATE - PAST 90 DAYS OR MORE AND STILL ACCRUING" and Item 1423 "LOANS

SECURED BY REAL ESTATE - NONACCRUAL". Dividing problem loans into total loans will yield an effective measure of loan quality.

There are several potentially confounding factors, which cannot be measured, and therefore must be assumed to be randomized across all respondents. These factors are:

1. Banks may have different policies on which loans they keep and which they sell. Some institutions may sell all loans that qualify into the secondary market, keeping only the poorer ones, which may have been priced higher.
2. Some banks may have problem loans that were generated prior to implementation of new technology but still on the books. This problem is mitigated by the likelihood that banks will charge off loans that have not performed for several years.

Percentage of problem loans is expected to go down as general level of IT adoption increases. This variable is expected to show a particularly high degree of association with Automated Underwriting and Automated Origination adoption. The value of knowledge imparted to decision makers by way of extracting it from data (Weiss and Kulickowski, 1991) or transferring it from other domain experts (Turban, 1993), will be most evident in this variable. Strategic intent of adoption is expected to have a moderating effect, since adopters who are willing to change their business

practices have been identified as experiencing the highest benefit (Davenport, 1993).

Loan Originations per Employee

Respondents have been asked to indicate total volume of loans and total number of loans generated in their business unit 1n 1999 as well as the average number of employees in that unit during the year. A simple ratio will be calculated from these two inputs. Loan volume per employee is and efficiency measure, and is expected to vary directly with level of adoption. A high strength of association is expected between this variable and Loan Origination / Workflow and Automated Verification based on simple task realignment/consolidation and the value of management information (Post, Kagan, and Lau, 1995). When adopters expressly intend to exploit IT innovations to restructure business processes (as captured in the 'Strategic Intent' variable) the association should be even stronger. Strategic Intent is, therefore, expected to interact with the predictor variable in its impact on this criterion.

Each respondent will be asked to estimate the average number of employees in the lending unit for which he/she is responding during 1998. Ranges will not be used, as respondents are expected to be able to accurately report the number of employees. The survey instrument will explain that the number is to represent all professional, managerial and clerical employees in

the business unit who deal directly and predominantly with mortgage lending.

Total Cost per Loan Originated

Many banks calculate and carefully monitor overhead dollars per loan processed. Overhead dollars per loan is an efficiency measure and is expected to correlate negatively with level of adoption. That is, technology adopters are expected to experience lower overhead dollars per loan than non technology adopters (Portner, 1995). Size of the institution (West, 1994) and strategic intent of adoption (Tapscott and Caston, 1993) may moderate the impact of technology adoption on overhead rates.

Cycle Time

Respondents will be asked to indicate, in days, how much time elapses on average between original applicant contact (data collection) and final disposition of the loan. Cycle time is a generally understood concept in mortgage lending. Therefore, it is reasonable to expect a high response rate without posing pre-defined ranges. Whoever fills out the form (web or paper) will simply state an integer estimate of the number of days. The web form will not allow unreasonably high estimates or negative estimates as a safeguard against blunders.

Cycle time is expected to be shorter as level of adoption is higher. A particularly strong negative association with cycle time is expected for Automated Workflow and Verification adoption. Firm size and type and

strategic intent of adoption may moderate the impact in all cases. Numerous sources cite a willingness to restructure critical processes as a deciding factor in the 'success' of innovative IT adoption (Davenport and Short, 1990, Stoddard and Jarvenpaa, 1995).

Dropout Rate

After initial contact, not all applicants remain interested in following through with the application. When an applicant terminates consideration and further processing of the loan voluntarily, it is termed a 'dropout'. Dropout rate is expected to be correlated positively, but not perfectly with cycle time, as it is reasonable to expect that long waiting times would lead people to look elsewhere or change their minds about the transaction.

The rate of dropout is primarily a productivity measure, and is expected to correlate negatively with adoption (lower dropout rates will be associated with higher levels of adoption). For that reason, a high level of association is expected between Workflow and Verification adoption and this measure. The effect once again may be moderated by firm size and type, and by strategic intent of adoption. Institutions who are willing to re-engineer the loan origination process should see the most dramatic improvements in time and efficiency (Venkatraman, 1994), and therefore fewer dropouts.

Some variables have a very straightforward meaning and will be solicited directly (example: Volume of new loans generating in past 12 months). Other variables will require indirect measurement using several

questions from a previously validated scale, where possible (example: Degree of organizational transformation concomitant with technology adoption). Where new scales must be developed, several questions will be proposed based on face and content validity.

Scaling and Measurement of Moderating Variables

Three possible moderating variables included in the research model must be captured and scaled with the survey instrument. The variables are: Type of institution, scope of institution, and strategic intent of adoption.

Type of Institution.

Respondents will be offered choices to respond to this question. The major types of lenders are:

- Commercial Bank
- Savings and Loan
- Credit Union
- Mortgage Broker
- Mortgage Banker
- Other

Since financial institutions are required by law to declare which type they are, this question can be answered directly by respondents. A 'radio button' technique will be used in the input form to eliminate the possibility of the respondent marking multiple choices. For purposes of analysis, type of institution will

Scope of Institution

Whether the respondent is reporting for a single branch or multiple branches will be solicited by the instrument. A single branch would by definition be a local institution. Multiple branches within a local radius (50 miles) is the next level of scope. Multiple branches within 250 miles and multiple branches with a radius of more that 250 miles are the final options. The data is justifiably ordinal, but not interval or ratio.

Strategic Use of Adoption

Venkatraman's (1994) five levels of organizational transformation will serve as the foundation of the construct 'Strategic Use of Adoption'. While no developed scales based on this framework have been published, a closely related scale was developed by Mirani and Lederer (1998). This work is a compilation and organization of previous works in business value of IS projects. The authors group questions into three dimensions of organizational benefit: Transactional, Informational and Strategic. An analysis of content of Venkatraman's levels of transformation and Miriani and Lederer's dimensions of benefit yields the following common elements:

Table 3.3

Operationalization of Strategic Use Level

Content Elements	Venkatraman (Original)	Mirani/ Lederer	Venkatr-Aman (Condensed)
• Provide New Products or Services to customers • Provide Better Products or Services to Customers • Enhance competitiveness or create strategic advantage	Business Scope Redefinition	Strategic Dimension	Revolution-ary Use
• Establish useful linkages with other organizations	Bus. Network Redesign		
• Change the way the organization does business • Enable the organization to respond more quickly to change	Bus. Process Redesign		
• Improve management information for strategic planning • Improve information for operational control • Improve information for managerial control • Enable easier access to information •	Information Integration	Informatio nal Dimension	Evolutionary Impact (Use)
• Save money by reducing the work force • Save money by reducing communication costs • Save money by reducing system maintenance costs • Speed up transactions • Facilitate organizational adherence to government regulations	Localized Exploitation	Transactio nal Dimension	

The instrument will pose five 'benefit groups' corresponding to Venkatraman's five levels of transformation. Each group will have 1-3 specific benefits (from the above table) that characterize the level. Respondents will be asked to check all benefit groups that apply to their intentions in recent technology adoptions. The highest category in which any benefits are checked will signify the level of this variable. For purposes of data analysis, levels of this construct were reduced to two: Evolutionary Use and Revolutionary Use.

Administering the Instrument

The instrument will be administered via web page. Lending institutions will be contacted by letter, phone and, where practical, by e-mail to solicit co-operation. At the time of contact, subjects will be informed of the nature of the study, and its significance in establishing measurable relationships between technology adoption and value. A paper form of the questionnaire will accompany the solicitation for respondents who do not have web access or would rather respond on paper. Pre-addressed labels will be included in the solicitation packet.

A running log of paper surveys returned and responses transmitted over the World Wide Web was kept and compared to the original mailing weekly. After the first two weeks, either an e-mail or phone follow up will be done every other week for the next six weeks. At the end of that time, follow

up will cease, and data analysis will begin, assuming that enough responses are in hand for statistical analysis.

List of Questions

Table 3.4

List of Questions to be Included in the Instrument

CONSTRUCT	QUESTION	CHOICES
Loan Volume 1998	To the closest thousand, what was the volume of loans generated by your business unit in 1998?	Will type in number directly
Loan Volume 1999	To the closest thousand, what was the volume of loans generated by your business unit in 1999?	Will type in number directly
Institution Type	Indicate the type of institution you are representing in your responses	• Commercial Bank • Savings and Loan • Mortgage Bank • Credit Union • Other
Scope of Operation	Indicate the focal market area for the institution you are representing in your responses. The focal market area is where you plan to do 80% of new loans this year.	• Single Branch • Multi-Branch / Single Metro Area • MultiBranch / Multi Metro Area
Number of Employees	Give the number of loan officers and support personnel in your business unit directly involved with mortgage lending	Will type in the number directly
Origination/Workflow Adopter	Has your institution implemented Automated Loan Origination / Workflow Management Software such as Desktop Originator™ or Loan Manager™? (Hyperlink to more detailed description/definition provided)	Yes/No

Electronic Verification Adopter	Does your lending unit use EDI or other electronic links to communicate with credit bureaus or title registries?	Yes/No
Origination Decision Support Adopter	Has your institution implemented Origination Decision Support Software such as DecisionXchange™ or the Prequalification feature of GENESIS 2000™? (Hyperlink to more detailed description/definition provided)	Yes/No
Cycle Time	Please estimate the average number of days which elapses between intake of application data and final disposition of loan applications in the business unit for which you are responding	Enter number of days directly
Dropout Rate	Please estimate the percentage of loan applicants who drop out of consideration voluntarily before final disposition of the application is determined	Enter percentage directly
Overhead Expense Per Loan	If your business unit computes overhead dollars spent per mortgage application processed, please indicate that dollar figure. Additionally, please type, in the space provided, a brief description of expense categories included in this figure	Enter dollar amount directly Enter text directly in separate input box

Pretesting

The survey web page was reviewed, and questions responded to by industry experts drawn from lending institutions and banking organization staffs. Currency of the technology definitions and appropriateness of performance ranges were validated. Each respondent was asked for a critical review of the questions asked, ease of understanding, and appropriateness to the construct of interest to the researcher. Of particular interest are performance indices

using self-report. Any indication of inappropriate wording or implication will be addressed prior to execution of the full survey.

Data Analysis

Analysis of Variance (ANOVA) and Multiple Analysis of Variance (MANOVA) will be used to test the relationships among the variables specified in the hypotheses. Additionally, this technique can highlight any unexpected classification power of a variable or group of variables. ANOVA and MANOVA are well suited to this research design, as all of the output variables are metric, and almost all of the inputs are inherently categorical. Several dependent variables will be captured, each derived from multiple questions. When this is the case, and all other characteristics of the research design call for the use of Analysis of Variance, MANOVA has an inherent advantage over ANOVA. Specifically, when separate ANOVA's are performed for each dependent variable, no significant differences between groups may be discovered, while the same set of DV's may form a linear combination which does distinguish between groups (Hair, et al, 1992). When properly applied through SAS or a similar statistical package, MANOVA will report not only the discriminant power individual outputs, but their (optimal) combined power to differentiate between treatment groups.

Transformation of Adoption Construct

Asking respondents to report strategic purpose for each technology adoption creates a problem for ANOVA / MANOVA application in testing

main effects. If a respondent has not adopted a technology, they will not answer the related question about strategic purpose. If adoption and strategic purpose are used to construct a 2-way ANOVA, for example, the cells for "Not Adopt" and all levels of the "Strategic Use" dimension will be empty. The remedy for this problem will be to combine the adoption and intent questions into a single dimension with three levels:

1. Not Adopted
2. Adopted with 'Evolutionary' Use
3. Adopted with 'Revolutionary' Use

When 'between group' differences were found along this dimension, specific post-hoc contrasts were be requested for hypothesis testing.

Testing the Factor Structure

A factor analysis of all dependent variable is included in the analysis. The results of this analysis impacted hypothesis testing and interpretations of findings. Orthogonal rotation was used toward parsimonious assignment of specific variables to factors.

Loan Origination / Workflow Tools Adoption

As discussed in Chapter 2, Adoption of Loan Origination / Workflow tools is expected to have an impact on Production and Efficiency, but not necessarily on Asset Quality. Moderating effects should be scope and strategic purpose of adoption. To test the hypotheses (and to explore whether

an unexpected impact on quality exists, all three output variables will be included in a MANOVA design, as indicated below:

Table 3.5

Analysis of Variance – Adoption of Loan Origination / Workflow Tools

		Scope of Operation		
		Single Branch	Multi-Branch / Single Metro Area	Multi Branch / Multi Metro Area
Adoption and Strategic Purpose	Not Adopted	Production Efficiency Asset Quality	Production Efficiency Asset Quality	Production Efficiency Asset Quality
	Adopted / Evolutionary Purpose	Production Efficiency Asset Quality	Production Efficiency Asset Quality	Production Efficiency Asset Quality
	Adopted / Revolutionary Purpose	Production Efficiency Asset Quality	Production Efficiency Asset Quality	Production Efficiency Asset Quality

Specific null hypotheses to be tested are:

1. Adoption of Loan Origination / Workflow tools has no impact on production or efficiency measures. An F-test will be used to determine whether between-group variance along this dimension is significantly greater than can be accounted for by overall variance.
2. Among adopters, no differences exist in levels of the dependent variables between groups with 'evolutionary' and 'revolutionary' purpose. A post-hoc test for difference between these two groups tested the null.
3. Among adopters, no differences exist in levels of the dependent variables between groups with single branch, multi-branch / single

metro, and multi branch / multi metro scope of operation. By including an interaction term in the ANOVA model specification (model y_1 y_2 y_3=a b a*b) the null was tested.

Electronic Verification Tools Adoption

Adoption of electronic verification tools is posited to have an impact on Production and Efficiency, and on Asset Quality. Moderating effects are scope and strategic purpose of adoption. To test these relationships all three output variables are included in a MANOVA design, as indicated below:

Table 3.6

Analysis of Variance – Adoption Electronic Verification Tools

		Scope of Operation		
		Single Branch	Multi-Branch / Single Metro Area	Multi Branch / Multi Metro Area
Adoption and Strategic Purpose	Not Adopted	Production Efficiency Asset Quality	Production Efficiency Asset Quality	Production Efficiency *Asset Quality*
	Adopted / Evolutionary Purpose	Production Efficiency Asset Quality	Production Efficiency Asset Quality	Production Efficiency Asset Quality
	Adopted / Revolutionary Purpose	Production Efficiency Asset Quality	Production Efficiency Asset Quality	Production Efficiency Asset Quality

Specific null hypotheses tested were:

1. Adoption Electronic Verification tools has no impact on production or efficiency measures. An F-test was used to determine whether between-group variance along this

dimension is significantly greater than can be accounted for by overall variance.

2. Among adopters, no differences exist in levels of the dependent variables between groups with 'evolutionary' and 'revolutionary' purpose. A post-hoc test for difference between these two groups tested for support of the null.
3. Among adopters, no differences exist in levels of the dependent variables between groups with single branch, multi-branch / single metro, and multi branch / multi metro scope of operation. By including an interaction term in the ANOVA model specification (model y_1 y_2 y_3=a b a*b) the was tested.

Origination Decision Support Tools Adoption

Adoption of Origination Decision Support tools has an impact on Asset Quality but not necessarily on Production and Efficiency. Moderating effect is strategic purpose of adoption. All three output variables were included in a MANOVA design, as indicated below:

Table 3.7

Analysis of Variance – Adoption of Origination

Decision Support Tools

Adoption and Strategic Purpose		
Not Adopted	Adopted / Evolutionary Purpose	Adopted / Revolutionary Purpose
Production Efficiency Asset Quality	Production Efficiency Asset Quality	Production Efficiency Asset Quality

Specific null hypotheses to be tested are:

1. Adoption of Origination Decision Support tools has no impact on asset quality. An F-test was used to determine whether between-group variance along this dimension is significantly greater than can be accounted for by overall variance.
2. Among adopters, no differences exist in levels of the dependent variables between groups with 'evolutionary' and 'revolutionary' purpose. A post-hoc test for difference between these two groups tested the null.

Underwriting Decision Support Tools Adoption

Adoption of Underwriting Decision Support tools is posited to have an impact on, Asset Quality but not necessarily on Production and Efficiency. Moderating effect should be strategic purpose of adoption. To test the hypotheses (and to explore whether unexpected impacts on production and

efficiency exist , all three output variables were included in an ANOVA design, as indicated below:

Table 3.8

Analysis of Variance – Adoption of Underwriting Decision Support Tools

Adoption and Strategic Purpose		
Not Adopted	Adopted / Evolutionary Purpose	Adopted / Revolutionary Purpose
Production Efficiency Asset Quality	Production Efficiency Asset Quality	Production Efficiency Asset Quality

Specific null hypotheses to be tested are:

1. Adoption of Underwriting Decision Support tools has no impact on asset quality. An F-test was used to determine whether between-group variance along this dimension was significantly greater than can be accounted for by overall variance.
2. Among adopters, no differences exist in levels of the dependent variables between groups with 'evolutionary' and 'revolutionary' purpose. A post-hoc test for difference between these two groups tested for the null.

Other Exploratory Tests

No theoretical basis for hypothesizing a relationship between bank type and performance variables or interaction effect with adoption variables could be constructed. However, since institution type is being reported, it is convenient and useful to construct separate ANOVA's to test for these effects. Adoption of all four technologies will be included in final models as main effects. Bank type will be a the other main effect. The following model specification will be used: model $y_1y_2y_3y_4y_5y_6y_{73}$=a b a*b .

Chapter Four

Data Collection and Analysis

This chapter presents actual data collection, coding, pre-processing, and analysis. First, distribution of the surveys and collection of responses are related. Response rate and efforts to enhance it will be covered. Second, coding and storing responses electronically are explored. Third, preprocessing procedures, such as excising inappropriate and incomplete responses are explained. Finally, aggregation, summary, and analytical techniques used, as well as their results, are presented.

Distribution of Surveys and Collection of Responses

The mailing list provided electronically by the Mortgage Bankers Association of America (MBA) was converted from ASCII text into a Microsoft Access table and used to mail-merge cover letters. Surveys went out with personalized envelopes and cover letters to the list in October. Several follow ups were conducted and a second mailing of new subjects was sent later. Simultaneously, a website was constructed and activated which had the capability of collecting responses on line. Web collected responses were

imported directly into a Microsoft Access table, while paper responses had to be hand keyed.

Respondents who took the survey on line went to a web page hosted by the Mortgage Bankers' Association of America. The page contained an endorsement of the study by the MBA and a link to the actual survey page hosted at Indiana State University. In the course of establishing the link, the survey instrument was screened for format and content by the research department of the MBA. The President of Mortech, LLC, a Mortgage Technology Consulting firm, also reviewed the instrument for content and scaling of questions.

Survey Mailing

A mailing of 1000 surveys was sent from Indiana State University on October 20, 2000. Each mailing contained the following:

- Cover letter explaining the purpose of the survey, rights and protections of respondents, and the address of the link to the on-line instrument
- The instrument itself, printed on both sides
- An addressed and postage paid envelope for returning paper survey, if used

Each cover letter was personalized, using mail merge. Envelopes were addressed using pressure sensitive labels. All envelopes were stuffed by hand to ensure that personalized letters matched the mailing labels on the

envelopes. Approximately 85% of the sample had e-mail addresses indicated. For these sample points, three e-mail reminders were sent. The first reminder was sent one week after mailing, the second three weeks after, and the last four weeks after.

In addition to the e-mail reminders, phone calls were made to state Mortgage Banking Association directors to encourage them to support the survey among their membership and encourage response. One director (Arizona Mortgage Bankers Association) offered her membership list in electronic format. Once this list was checked for duplications, ninety additional mailings were prepared and sent. No e-mail follow ups were possible, as e-mail addresses were not included.

Response Rate

Within a few days of the initial mailing, responses began to come in, although slowly. Each e-mail reminder resulted in a few additional responses. The final cutoff for inclusion was December 15, 2000. At that time, 103 paper responses and 77 web responses had been collected. Two responses came after the cutoff, but neither was usable so were not included in the analysis. The total response rate, including the second mailing, was 16.5%.

Data Coding and Cleaning

All survey response data was stored in Microsoft Access™ tables. Three tables were created with identical structures. One table was generated

for paper responses, one for web responses, and one for combined results. Data cleaning was done at several stages in the coding process. Calculated fields were generated with the use of Microsoft Access™ update queries.

Data Coding

All responses from both paper surveys and the online data repository were merged into a common Microsoft Access 2000™ table. Responses on paper were hand keyed by the investigator. Paper surveys that indicated that they were from commercial lenders were excluded from coding.

When no response was given, the field was left blank. Occasionally, respondents who used paper instruments gave a range, where a point estimate was asked for. Most often this was done with the variable Cycle Time that estimates the turnaround time for a loan application. In these cases, the midpoint of the range was entered as the point estimate. When loan volume was obviously given in dollars instead of millions of dollars, the investigator made the correction as the response was keyed in. The criteria used to determine when this type of error had been made were: Comparison to number of loans, type of institution, and origination cost.

Responses made on the web page were captured in the form of a text file on the host server. The investigator is an administrator of the server and was thereby able to directly access this file. The file has now been copied to a backup tape and removed from the server for security purposes. Through the Microsoft Access Import procedure, the text file was brought into a Microsoft

Access™ table of identical structure to the file described above. Since ranges were not possible, this error did not have to be corrected. Dollar estimate coding error were corrected in the same manner as with coded paper forms. Once data was imported into a Microsoft Access™ table, both the paper response table and the online response table were appended into a combined table with identical structure.

The approval rate problem loan variables had an option of '7' to indicate that these fields were not applicable. Any place a '7' was entered, it was excised prior to analysis and shown as a missing value. In the original response database, the actual response was retained.

Calculated Fields

Two variables of interest for the calculation had to be computed from raw data given by respondents. These fields are summarized below:

Table 4.1

Calculated Fields to be Used as Dependent Variables

Variable Name	Data Type	Computation
Loans Per Employee	NUMERIC	Total Number of Loans 1999 / Number of Employees
Growth	NUMERIC	(Loans 1999 – Loans 1998) / Loans 1998
Adoption of Workflow Tools	NUMERIC	Level of Adoption: **0** – WF=0 (WF adoption) **1** – WF1=1 or WF2=1 (Evolutionary Intent) **2** – WF3=1 or WF4=1 or WF5=1 (Revolutionary Intent)
Adoption of Electronic Verification Tools	NUMERIC	Level of Adoption: **0** – EV=0 (EV Adoption) **1** – EV1=1 or EV2=1 (Evolutionary Intent) **2** – EV3=1 or WF4=1 or WF5=1 (Revolutionary Intent)
Adoption or Origination Decision Support Tools	NUMERIC	Level of Adoption: **0** – ODS=0 (ODS Adoption) **1** – ODS1 =1 or ODS2= (Evolutionary Intent) **2** – ODS3=1 or ODS4=1 or ODS5=1 (Revolutionary Intent)
Adoption of Underwriting Decision Support Tools	NUMERIC	Level of Adoption: **0** – UDS=0 (UDS Adoption) **1** – UDS1=1 or UDS2=1 (Evolutionary Intent) **2** – UDS3=1 or UDS4=1 or UDS5=1 (Revolutionary Intent)

These fields were added to the table by creating new fields with the characteristics shown. Values were computed with update queries.

Final Cleaning

After all surveys were entered and coded, a final effort to excise surveys that would not meaningfully contribute to data analysis. Reasons for excision were as follows:

- Reasonable inference that the respondent was a commercial lender. The most obvious cue was that average loan size was over $1 million. Additional cues were cycle times in excess of 1 month, loans per employee of less than 5, and origination cost of over $10,000. If any of these conditions was found, the sample point was excluded.
- Non-responsiveness. If the respondent gave essentially no data about loan volume, number of employees, cycle time or origination cost, the sample point was excluded.
- Ambiguity of loan volume. When it could not be reasonably ascertained whether loan volume was being given in dollars or millions of dollars, the sample point was excluded.

No sample point was found to have unreasonable responses after the above mentioned cleaning steps were executed. A high degree of variability was noted on some variables, but none were implausible.

Tests for Response Bias

Bias is always a possibility in survey research, so sources of bias should be explored where possible (Hufnagel and Conca, 1994). Two possible sources of response bias were identified and tested for – Serial positioning of response and modes of response. Serial positioning refers to whether a response came early in the time window allotted for response or late. Mode of response refers to whether a subject responded by way of a paper survey or by way of a web form.

Since the source of a response was already included in the dataset, group counting for categorical variables and group averages for continuous variables across response mode was straightforward. For continuous variables, one-way ANOVA was used to detect significant differences across response modes. The following tables summarize results of this analysis:

Table 4.2

Comparison of Responses for Paper and Web Responders – Categorical Variables

Characteristic	Level	Percent of Responses Paper	Percent of Responses Web
Workflow Tools Adoption	Non - Adopter	18	28
	Adopt - Evolutionary	15	5
	Adopt - Revolutionary	66	67
Elect. Verification Adoption	Non - Adopter	25	18
	Adopt - Evolutionary	19	4
	Adopt - Revolutionary	56	68
Origination DSS Adoption	Non - Adopter	78	73
	Adopt - Evolutionary	2	5
	Adopt - Revolutionary	20	22
Underwriting DSS Adoption	Non - Adopter	12	10
	Adopt - Evolutionary	10	5
	Adopt - Revolutionary	78	85
Scope	One Branch	37	44
	Multi Branch <50 mi	23	15
	Multi Branch <250 mi	11	5
	Multi Branch > 250 mi	29	36
Institution Type	Commercial Bank	17	14
	Savings and Loan	6	5
	Mortgage Bank	50	49
	Mortgage Broker	14	10
	Credit Union	8	5
	Other	5	17

Table 4.3

Comparison of Responses for Paper and Web Responders – Continuous Variables

Characteristic	Average for Paper Responders	Average for Web Responders	Difference Pr. > F
Loans per Employee	42.19	48.82	.3169
Growth	1%	19%	.4248
Cycle Time (days)	14.45	15.39	.6237
Dropout Rate	3.38	3.60	.4440
Problem Loans	1.28	1.60	**.0233**
Approval Rate	4.48	3.39	**.0397**
Origination Cost	$1291	$1437	.3603

Most characteristics are comparable in value and distribution across response type. However, some interesting differences show up in the areas of Problem Loans and Approval rates. While these findings may stimulate future research on survey instrumentation and execution, when many ANOVA's are performed, the possibility of a Type I error goes up (Hair, et al, 1992). This could partially explain the differences.

To test differences based on serial position of responders in the response set. the data was divided in to three groups. The earliest third, for each response mode were labeled 'Early Responders', the last third for each mode was labeled 'Late Responders' Group counts, group means, and significant differences for continuous variables are listed below.

Table 4.4

Comparison of Responses for Early and Late Responders – Categorical Variables

Characteristic	Level	Percent of Responses Early	Percent of Responses Late
Workflow Tools Adoption	Non - Adopter	20	25
	Adopt - Evolutionary	15	13
	Adopt - Revolutionary	65	72
Elect. Verification Adoption	Non - Adopter	28	18
	Adopt - Evolutionary	17	15
	Adopt - Revolutionary	55	67
Origination DSS Adoption	Non - Adopter	83	65
	Adopt - Evolutionary	5	3
	Adopt - Revolutionary	12	32
Underwriting DSS Adoption	Non - Adopter	15	8
	Adopt - Evolutionary	8	5
	Adopt - Revolutionary	77	87
Scope	One Branch	40	38
	Multi Branch <50 mi	13	27
	Multi Branch <250 mi	17	0
	Multi Branch > 250 mi	30	35
Institution Type	Commercial Bank	18	18
	Savings and Loan	0	5
	Mortgage Bank	52	50
	Mortgage Broker	18	7
	Credit Union	5	8
	Other	7	13

Table 4.5

Comparison of Responses for Early and Late Responders – Continuous Variables

Characteristic	Average for Early Responders	Average for Late Responders	Difference Pr. > F
Loans per Employee	38.59	58.89	**.0245**
Growth	-3%	10%	.1811
Cycle Time (days)	17.4	14.05	.1753
Dropout Rate	3.54	3.44	.7772
Problem Loans	1.37	1.64	.1359
Approval Rate	4.24	4.13	.7501
Origination Cost	$1367	$1358	.9605

Again, a significant difference across groups, this time based on serial position in the response set, has been found for Loans per Employee. This phenomenon may also be due to the increased risk of Type I error when repeated ANOVA's are performed, but provide incentive for further study nonetheless.

No impact on the study is seen, as the preponderance of variable values are similar across groups, making it plausible that the paper responders and web responders represent the same population. Similarly, early and late responders have quite similar responses on the majority of characteristics. The external validity of findings in this study will not be impacted by response biases in the methods of survey. However, the differences that were found will be mentioned in Chapter 5 under 'Implications for Future Research'.

Secondary Data – Chicago Federal Reserve

The original research design called for corroboration of self reported loan quality data with hard data available through the Chicago Federal Reserve. All banking institutions are required under law to report financial results to their regulators in order to verify that they are conducting their operations in a sound manner, thus imposing minimal risk on state and federal banking insurance funds (Koch, 1995).

As results came back, however, it became apparent that there was insufficient data to match respondents with the appropriate reporting entity whose data would be obtained from the Chicago Federal Reserve. The problems with matching were as follows:

- Only about half of all respondents included the full name of the institution
- Many institutions are owned by larger enterprises which report their results in aggregate form
- Some branches of larger institutions reported as branch operations only

For these reasons, quality of assets (which are used here as a proxy for quality of decisions) must be gauged by self reported data only.

Distributions and Summary Statistics

Presented here are various aggregate and descriptive statistics of dependent variables for purposes of preliminary insight into the data as well as selection of statistical procedures and their results. Many statistical procedures are influences by distribution of inputs (Tabachnik and Fidell, 1996). Inequality of sample size across treatment effects also influences selection of analytical techniques (SAS /STAT User's Guide, 1992).

All dependent variables are continuous, numeric entities, consistent with the requirements of Analysis of Variance and Multiple Analysis of Variance techniques (Hair, Tatham, Anderson and Black, 1992). Presented below are characteristics of the variable distributions, as produced by PROC UNIVARIATE in SAS v. 6.12:

Table 4.6

Univariate Statistics for Dependent Variables

Variable Name	Mean	Std. Dev	Min	Max	Missing Values	Skew-ness	Kurto-sis
Loans / Employee	45.44	33.61	5	92	12	4.02	23.68
Growth	.0986	1.09	-.71	10.29	15	8.24	76.51
Cycle Time	14.92	10.08	2	30	3	1.91	7.40
Dropout Rate	3.53	1.56	1	5	2	-.31	-1.28
Problem Loans	1.50	.89	1	4	11	3.00	13.69
Approval Rate	4.35	1.49	1	7	5	-.47	-.18
Origination Cost	1368	782	100	3500	19	.72	.20

Table 4.7

Sample Points for Three Levels of Independent Variables

Classification Variable	Count for Not Adopted (0)	Count for Adopted / Evolutionary (1)	Count for Adopted / Revolutionary (2)
Workflow Tools	26	12	78
Electronic Verification Tools	25	19	72
Origination Decision Support	89	3	24
Underwriting Decision Support	12	8	96

The final pre-analysis summary statistics compiled were group means. Transferring all data to a Microsoft Excel™ Spreadsheet and using the subtotaling feature computed the mean of each dependent variable for each cell. Results have been transcribed into the following tables:

Table 4.8

Group Means of Dependent Variables – Adoption of Workflow Tools

	Three Levels of Adoption			Grand Mean
Variable Name	0 *(n=26)*	1 *(n=12)*	2 *(n=78)*	*(n=116)*
Loans per Employee	41.47	35.41	48.23	45.44
Growth	45%	10%	-1%	10%
Cycle Time	22.52	14.55	12.51	14.92
Dropout Rate	3.65	3.67	3.46	3.53
Problem Loans	1.67	1.17	1.51	1.50
Approval Rate	4.41	4.17	4.36	4.35
Origination Cost	1586	1732	1258	1368

Table 4.9

Group Means of Dependent Variables – Adoption of Electronic Verification Tools

	Three Levels of Adoption			Grand Mean
Variable Name	0 *(n=25)*	1 *(n=19)*	2 *(n=72)*	*(n=116)*
Loans per Employee	38.37	39.27	49.62	45.44
Growth	-2%	1%	17%	10%
Cycle Time	15.36	22.89	12.71	14.92
Dropout Rate	3.16	3.17	3.75	3.53
Problem Loans	1.29	1.50	1.58	1.50
Approval Rate	4.64	4.50	4.23	4.35
Origination Cost	1294	1566	1332	1368

Table 4.10

Group Means of Dependent Variables – Adoption of Origination Decision Support Tools

	Three Levels of Adoption			Grand Mean
Variable Name	0 *(n=89)*	1 *(n=3)*	2 *(n=24)*	*(n=116)*
Loans per Employee	43.95	51.79	50.23	45.44
Growth	1%	-8%	43%	10%
Cycle Time	15.26	25.00	12.83	14.92
Dropout Rate	3.49	3.67	3.63	3.53
Problem Loans	1.49	1.00	1.61	1.50
Approval Rate	4.44	4.67	4.00	4.35
Origination Cost	1379	2000	1263	1368

Table 4.11

Group Means of Dependent Variables – Adoption of Underwriting Decision Support Tools

	Three Levels of Adoption			Grand Mean
Variable Name	0 *(n=12)*	1 (n=8)	2 *(n=96)*	*(n=116)*
Loans per Employee	28.38	35.86	48.10	45.44
Growth	-7%	0%	13%	10%
Cycle Time	21.50	12.25	14.40	14.92
Dropout Rate	3.50	3.00	3.56	3.53
Problem Loans	1.55	1.25	1.51	1.50
Approval Rate	5.30	4.50	4.23	4.35
Origination Cost	1535	1737	1316	1368

Based on the preceding four tables, it is instructive to look at the general shape of functions before proceeding to hypothesis testing:

Table 4.12

Observed Relationships Between Each Adoption Level and Each Dependent Variable (Statistical Significance Not Established)

	Workflow	Electronic Verification	Origination DSS	Underwriting DSS
Loans per Employee	∪	/	/	/
Growth in Number of Loans	\	/	∪	/
Cycle Time	\	∩	∩	∪
Dropout Rate	---	/	---	∪
Problem Loans	∪	/	∪	∪
Approval Rate	∪	\	∩	\
Origination Cost	∩	∩	∩	∩

Key */-direct linear* \-*inverse linear* ∪*-non-linear, minimum in middle* ∩*- non-linear, minima at ends* --- *no observed relationship*

It should be noted that some cells, particularly in Origination Decision Support Adoption and Underwriting Decision Support Adoption, have very low *n*. This will make main effects and particularly interaction effects very difficult to find, even though they may exist in the general population of institutions that is of interest in this study (Hinkle, Wiersma and Jurs, 1988.

In order to determine what underlying constructs were supported, factor analysis, using SAS PROC FACTOR was performed on the six dependent variables. Results from this procedure determined the MANOVA designs that were tested. A correlation matrix suggested several factors that were supported by the factor analysis.

Proposed Constructs - Investigating Relationships among Dependent Variables

In Chapter 2, it was posited that three constructs were being measured by the seven dependent variables of interest. Two constructs were represented by three questions or computed variables each, and one by a single question. These constructs are as follows:

Table 4.13

Proposed Constructs Underlying Dependent Variables

Decision Efficiency:	Productivity	Decision Quality
• Loans Per Employee • Origination Cost • Approval Rate	• Growth • Cycle Time • Dropout Rate	• Rate of Problem Loans

As a preliminary test these constructs, a correlation matrix was computed using SAS PROC GLM with a CORR specification in the print statement. The following matrix resulted.

Table 4.14

Correlation Matrix for all Dependent Variables

	Loans / Emp	Growth	Cycle Time	Dropout	Prob. Loans	Approval	Orig. Cost
Loans / Emp	1.000	.0199	**-.3004****	.1259	.1082	.0982	**-.2558***
Growth		1.000	-.1241	.1322	.0799	-.0487	.0235
Cycle Time			1.000	.0712	-.0708	.0616	**.2548***
Dropout				1.000	**.2846****	-.1463	.0360
Prob. Loans					1.000	-.0155	**.1734***
Approval						1.000	-.0847
Orig. Cost							1.000

Notes: * Prob > |T| = .10 ** Prob > |T| = .05

This matrix suggests that constructs relating to several variables may be supported. In order to further investigate the support for such constructs, a factor analysis was performed using SAS PROC FACTOR. The Principal Components method and VARIMAX orthogonal rotation were employed toward a parsimonious and meaningful list of factors (Hair, et al, 1992). Results of the analysis are shown here:

Table 4.15

Factor Analysis of Dependent Variables Using Principal Components and VARIMAX Orthogonal Rotation

	Factor 1	Factor 2	Factor 3
Loans / Employee	**-.71306**	.32122	.18304
Growth	-.13633	.19949	**-.54027**
Cycle Time	**.72574**	.02540	.29297
Dropout Rate	.02209	**.71647**	-.20780
Problem Loans	.02112	**.80499**	.02164
Approval Rate	-.13247	.03584	**.81629**
Origination Cost	**.69533**	.26220	-.07417

When compared to the originally proposed constructs (Table 4.10), the new factor structure suggests a considerably different set of constructs. This finding is significant for future research, and will be discussed in Chapter 5. For the present study, however, it will be most efficient and instructive to analyze individual variables, discussing each individually as it relates to hypotheses.

Since not all factors hypothesized in Chapter 2 were fully supported, and since some factors consisted of one variable only, individual one-way ANOVA's were run on each Independent Variable and for all Dependent Variables. In addition to these tests a one-way MANOVA was performed on each Independent Variable using all seven Dependent Variables. While not grounded in the original constructs, this test was used to detect any differences across levels of adoption based on a full combination of variables that was not predicted. As shown below, a combination of all seven

dependent variables did not vary across adoption levels for any of the technologies.

Table 4.16

Results of One-Way MANOVA Using all Dependent Variables for Workflow Tools Adoption

Independent Variable	Deg. of Freedom	Pr > F (Wilk's Lambda)
Adoption of Workflow Tools	14	.2119
Adoption of Electronic Verification Tools	14	.3741
Adoption of Origination Decision Support Tools	14	.8282
Adoption of Underwriting Decision Support Tools	14	.7190

Wherever a significant difference across three groups was identified, using one-way ANOVA, contrasts were run with both the Tukey procedure, which defaults to a 5% alpha, and the Waller-Duncan test, set at an alpha of .10 using the KRATIO option (SAS/STAT User's Manual, 1992).

Hypothesis Testing and Related Analyses

The primary analytical tool for testing hypotheses stated in Chapters 2 and 3 was Analysis of Variance (ANOVA). Since all independent variables are categorical, and all dependent variables are continuous. (Hair, et al, 1992). PROC GLM procedure in SAS v. 6.12 was employed to execute the ANOVA's due to unequal cell counts (SAS/STAT User's Guide, 1992).

In this section, results of statistical analysis will be discussed, primarily toward supporting or failing to support the specific hypotheses listed in Chapter 3. Additionally some exploratory efforts not related to

specific hypotheses are explored toward deeper understanding of the problem domain and directions for future research. Analytical results are discussed in the order of and grouped by the four technologies shown in the general research model: Workflow Tools, Electronic Verification Tools, Origination Decision Support Tools, and Underwriting Decision Support Tools.

Effects of Adoption of Workflow Tools

Because of the localized nature of Workflow Tools, their adoption was expected to impact efficiency and productivity. Adoption of this technology was not expected to impact asset quality.

H1a: Adoption of Loan Origination / Workflow Tools is associated with higher levels of productivity and efficiency.

In order to test Hypothesis H1a, one-way analysis of variance was employed to detect the impact of adoption of Workflow Tools on any of the dependent variables.

Table 4.17

Results of One-Way ANOVA'S for Adoption of Workflow Tools

Dependent Variable	DF (source/error)	Pr. > F
Loans / Employee	2/101	.4157
Growth	2/98	.2418
Cycle Time	2/110	**.0001**
Dropout Rate	.2/111	.8186
Problem Loans	2/102	.2847
Approval Rate	2/108	.8968
Origination Cost	2/94	**.0938**

Individual dependent variables were tested with one-way ANOVA to detect differences in group means across adoption levels. The variables Origination Cost and Cycle Time were found to differ significantly across levels. Origination Cost was originally listed as a component of the efficiency construct. While that overall factor was not confirmed exactly as expected, Origination Cost may still be plausibly used as a proxy for the construct. Given that, the null hypothesis of no impact of adoption on efficiency is rejected. Directionality of the relationship may be inferred from group means. The variable Cycle Time was originally specified as a component of the productivity construct. Again, while a general factor including this variable was not supported as expected, Cycle Time may plausibly be considered as a proxy for the construct. Given that there was a highly significant difference in this variable across adoption levels, a relationship is inferred.

Given the above findings, the null hypotheses that adoption of Workflow Tools has no impact on productivity or efficiency are rejected.

H1b: The impact of Loan Origination / Workflow tools adoption on productivity and efficiency are greater for respondents whose strategic use of adoption is 'revolutionary'

In order to test this hypothesis, Tukey and Waller-Duncan Ratio contrast procedures were applied to all pairs of adoption levels for the output variable Cycle Time.

Table 4.18

Significant Group Contrasts Using Tukey Procedure

Independent Variable	Dependent Variable	Contrasting Groups (alpha=.05)	
Workflow Tools	CYCLE	0	2

Table 4.19

Significant Group Contrasts Using Waller-Duncan Ratio Procedure

Independent Variable	Dependent Variable	Level 0*	Level 1*	Level 2*
Workflow Tools	CYCLE	A	B	B

** Classes Belong to Common Groups by Letter (alpha = .05)*

The variable Cycle Time, which most strongly differed across adoption levels, showed some specific contrasts that were identified with the Tukey procedure. However, only levels 0 (non adopters) and 2 (adopters with

'revolutionary use') showed a significant contrast. The Waller-Duncan ratio test showed groupings only of non-adopters and adopters at a high significance level. The null hypotheses of no impact of Strategic Use among adopters on the dependent variables of productivity and efficiency are not rejected.

H1c: The impact of Loan Origination / Workflow tools adoption on productivity and efficiency is greater for respondents who have a wider scope of operation.

In Chapter 2, it was hypothesized that the impact on output variables of adoption of workflow tools would be moderated by the size of the firm. As a proxy for firm size, the geographic range and number of branches are subsumed in the variable Scope of Operations. The levels of this variable correspond to the following four scenarios from which respondents choose:

1. Single Branch
2. Multiple Branches / Locations up to 50 miles
3. Multiple Branches / Locations 51-250 miles
4. Multiple Branches / Locations more than 250 miles

Table 4.20

Results of Two-Way ANOVA for Adoption of

Workflow Tools by Scope (3 Levels of Adoption / 4 Levels of Scope)

Dependent Variable	Pr. > F Listed Effect	Pr. > F Scope	Pr. > F Listed Eff. * Scope
Loans / Employee	.4397	.7955	.9906
Growth	.2363	.4244	.2395
Cycle Time	**.0001**	.9450	.5114
Dropout Rate	.7988	**.0062**	.1401
Problem Loans	.2989	.9673	.5745
Approval Rate	.8945	**.1773**	.6288
Origination Cost	**.0926**	.1171	.7472

No interaction effect was found between any of the variables comprising the 'efficiency' construct and SCOPE relative to adoption of Workflow tools. The null hypothesis of no interaction is not rejected. It is reiterated that small cell populations would make relationships of this type very hard to detect even if they existed.

Effects of Adoption of Electronic Verification Tools

Electronic Verification tool adoption was expected to impact productivity and efficiency for the same reasons as stated above. Benefits accruing to adopters will be largely localized and related to labor savings.

H2a: Adoption of Electronic Verification Tools is associated with higher levels of productivity and efficiency.

In order to test Hypothesis H2a, one-way analysis of variance was employed to detect the impact of adoption of Electronic Verification Tools on any of the dependent variables.

Table 4.21

Results of One-Way ANOVA'S for Adoption of Electronic Verification Tools

Dependent Variable	DF (source/error)	Pr. > F
Loans / Employee	2/101	.2774
Growth	2/98	.7437
Cycle Time	2/110	**.0005**
Dropout Rate	.2/111	.1531
Problem Loans	2/102	.4325
Approval Rate	2/108	.4799
Origination Cost	2/94	.4878

The impact of adoption of Electronic Verification Tools on productivity may be ascertained by testing how well it differentiates groups with varying adoption levels on the variable Cycle Time. As mentioned earlier, Cycle Time is a reasonable proxy for productivity in the absence of a validated multi-variable construct. As shown above, this variable (Cycle Time) does, in fact vary quite significantly across adoption levels. Therefore the null hypothesis of no impact of adoption of Electronic Verification Tools on productivity is rejected.

None of the variables posited to be related to the efficiency construct was found to vary significantly across levels of adoption. Therefore, the null hypothesis of no impact of adoption of Electronic Verification Tools on efficiency is not rejected.

H2b: The impact of Electronic Verification tools adoption on productivity and efficiency are greater for respondents whose strategic use of adoption is 'revolutionary'

Table 4.22

Significant Group Contrasts Using Tukey Procedure

Independent Variable	Dependent Variable	Contrasting Groups (alpha=.05)	
Electronic Verification Tools	CYCLE	0	1
Electronic Verification Tools	CYCLE	1	2

Table 4.23

Significant Group Contrasts Using Waller-Duncan Ratio Procedure

Independent Variable	Dependent Variable	Level 0*	Level 1*	Level 2*
Electronic Verification Tools	CYCLE	A	B	B

** Classes Belong to Common Groups by Letter (alpha = .05)*

Tukey contrasts were performed for all variables in relation to Electronic Verification adoption. On the variable Cycle Time, contrasts were significant between non-adopters and adopters with 'evolutionary' use (adoption levels 0 and 1). This finding lends additional support to the

rejection of the productivity portion of H2a. Additionally, a contrast between adopters with 'evolutionary' use and adopters with 'revolutionary' use was found. Therefore, the null hypothesis pertaining to productivity in H2b of no moderating effect of strategic use is rejected.

Since no variance across adoption levels in any variable related to efficiency, the portion of the null hypothesis (H2b) relating to efficiency is not rejected.

H2c: The impact of Electronic Verification tools adoption on productivity and efficiency is greater for respondents who have a wider scope of operation.

Two-way ANOVA was used to test for interaction effects between level of adoption and all output measures. As in the previous set of hypotheses, small cell sizes made detection of any such effect unlikely, even if it existed in the general population.

Table 4.24

Results of Two-Way ANOVA's for Adoption of Electronic Verification Tools by Scope (3 Levels of Adoption / 4 Levels of Scope)

Dependent Variable	Pr. > F Listed Effect	Pr. > F Scope	Pr. > F Listed Eff. * Scope
Loans / Employee	.2917	.5513	.8499
Growth	.7569	.6467	.9915
Cycle Time	**.0005**	.9534	.1970
Dropout Rate	.1452	**.0300**	.8009
Problem Loans	.4519	.8390	.8267
Approval Rate	.4632	.1509	.1910
Origination Cost	.4987	.1940	.9684

No interaction effect was found between any of the variables comprising the 'efficiency' construct and SCOPE relative to adoption of Electronic Verification tools. The null hypothesis of no interaction effect on productivity or efficiency is not rejected.

Effects of Adoption of Origination Decision Support Tools

Origination Decision Support is a technology which implements business rules on decisions that, by their nature, have an impact on organizational performance. Origination Decision Support applies lending criteria uniformly across lending officers, branches, and time. Such tools are constructed to implement 'best practice' decision criteria, and are therefore expected to affect asset quality (Problem Loan Rate) positively. For understanding of the results summarized below, it should be noted that

overall adoption rate of Origination Decision Support was very low. Only 27 of 116 respondents were adopters. Of that 27, only 3 had 'evolutionary' use.

H3a: Adoption of Origination Decision Support tools is associated with higher levels of asset quality.

Impact of adoption of Origination Decision Support Tools on Asset Quality was tested by running an ANOVA on levels of ODS adoption versus all output variables.

Table 4.25

Results of One-Way ANOVA'S for Adoption of Origination Decision Support Tools

Dependent Variable	DF (source/error)	Pr. > F
Loans / Employee	2/101	.7114
Growth	2/98	.2671
Cycle Time	2/110	.2106
Dropout Rate	.2/111	.9256
Problem Loans	2/102	.6144
Approval Rate	2/108	.4182
Origination Cost	2/94	.4365

The variable Problem Loans was the sole variable originally posited to measure asset quality. For convenience, and for reference in Chapter 5, all other variables have been included in the above table. None of the variables, including Problem Loans, showed any significant differences across levels of adoption. The null hypothesis of no effect of adoption is not rejected.

H3b The impact of Origination Decision Support tools is greater for respondents whose strategic use of adoption is 'revolutionary'

Given that no differences across groups in the area of decision quality were found, there are no contrasts to test for. The null hypothesis of no impact of strategic use is not rejected

Effects of Adoption of Underwriting Decision Support Tools

Underwriting Decision Support is similar to Origination Decision Support in that it implements business rules on management decisions. The functional difference between Origination Decision Support (ODS) and Underwriting Decision Support (UDS) is that UDS implements a rule base maintained by a third party while ODS reflects the lenders own business rules. The third party rules for UDS are, however, very important, as they determine the marketability of a loan once it is originated.

The distribution of adopters and non-adopters of UDS is even more skewed than the distribution of ODS adoption levels. However, the skewness is in the opposite direction – only 12 of 116 respondents did not adopt UDS. Again, this unevenness of distribution may have made it difficult for the ANOVA procedure to identify differences with a high level of confidence.

H4a: Adoption of Underwriting Decision Support tools is associated with higher levels of asset quality.

Analysis of Variance was used to test for impact of adoption of Underwriting Decision Support on each output variable.

Table 4.26

Results of One-Way ANOVA'S for Adoption of Underwriting Decision Support Tools

Dependent Variable	DF (source/error)	Pr. > F
Loans / Employee	1/105	.1457
Growth	1/103	.8679
Cycle Time	2/110	**.0479**
Dropout Rate	.2/111	.6089
Problem Loans	2/102	.7028
Approval Rate	2/108	**.0963**
Origination Cost	2/94	.3313

Analysis of variance was performed on all variables, including Problem Loans. Significant differences across adoption levels were found for the variables Cycle Time and Approval Rate, but not for Problem Loans. The null hypothesis of no relationship between adoption and decision quality is not rejected. Findings not directly related to H4a will be discussed in Chapter 5 under the heading of 'Implications for Future Research.

H4b The impact of Underwriting Decision Support tools will be greater for respondents whose strategic use of adoption is 'revolutionary'

Given that no differences across groups in the area of decision quality were found, there are no contrasts to test for. The null hypothesis is not rejected.

Summary

Some of the findings in this chapter, particularly in the areas of Workflow Tools and Electronic Verification tools were consistent with stated hypotheses. A brief summary of these findings is shown below:

Table 4.27

Summary of Hypothesis Testing

Hypothesis	Relationship	Finding
H1a	Adoption of Workflow Tools Leads to Higher Productivity	Supported
H1a	Adoption of Workflow Tools Leads to Higher Efficiency	Supported
H1b	Strategic Use Interacts with Adoption in impacting Productivity among adopters	Not Supported
H1b	Strategic Use interacts with Adoption in impacting Efficiency among adopters	Not Supported
H1c	Scope of Operation Interacts with Adoption in impacting Productivity among adopters	Not Supported
H1c	Scope of Operation Interacts with Adoption in impacting Efficiency among adopters	Not Supported
H2a	Adoption of Electronic Verification Tools Leads to Higher Productivity	Supported
H2a	Adoption of Electronic Verification Tools Leads to Higher Efficiency	Not Supported
H2b	Strategic Use Interacts with Adoption in impacting Productivity among adopters	Supported
H2b	Strategic Use Interacts with Adoption in impacting Efficiency among adopters	Not Supported
H2c	Scope of Operation Interacts with Adoption in impacting Productivity among adopters	Not Supported
H2c	Scope of Operation Interacts with Adoption in impacting Efficiency among adopters	Not Supported
H3a	Adoption of Origination Decision Support Impacts Asset Quality	Not Supported
H3b	Strategic Use Interacts with Adoption in impacting Asset Quality among adopters	Not Supported
H4a	Adoption of Underwriting Decision Support Impacts Asset Quality	Not Supported
H4b	Strategic Use Interacts with Adoption in impacting Asset Quality among adopters	Not Supported

Chapter Five

Conclusions and Implications for Future Research

The preceding chapter used survey techniques and statistical analysis to detect significant relationships is the data that would address the general research questions of this research. In this chapter, the significance of the foregoing findings will be explained, particularly as they relate to stated hypotheses Additionally, incidental findings not directly related to the hypotheses will be shown and briefly discussed toward their usefulness to related research areas. Overall contributions to theory and practice will be stated. Finally, limitations of the study and overall implications for future research will be explored.

Summary of Research Findings

Analysis of the 116 survey responses that remained after data cleaning yields the results of this research. As a preliminary analysis step, group aggregates (count and mean) were computed for all groups and clusters of groups where differences might be of interest. Next, rigorous analytical techniques were performed to determine whether group means represented different underlying populations beyond a reasonable doubt. A minimum standard of .10 probability that group means came from the same underlying

population was applied where techniques permitted. A stricter standard of .05 is shown where it is found.

Adoption of Loan Origination and Workflow Tools

Adoption of Workflow Tools was found to have a significant impact on Cycle Time and Origination cost. The diminution of Cycle Time concomitant with technology adoption is consistent with Hess and Kemerer's (1994) finding that Information Technology will benefit the adopting organization by time-compression of value-adding activities. Therefore, finding a concurrent relationship with origination cost is reasonable, and confirmatory of established research.

Finding differences in Origination Cost across adoption levels as an efficiency measure is consistent with Sampler and Short's (1994) conclusion that even localized technologies can yield measurable benefits. While post hoc comparisons did not support the hypothesis that strategic use made a difference in outcome among adopters, simple inspection of group means (table 4.8) suggests that some relationship exists, and might be detected with further study, perhaps on a larger sample. Specifically, adopters with 'revolutionary' use had the lowest mean origination cost ($1258), the group that adopted Workflow Tools with only 'evolutionary' use had the highest cost ($1732). Evolutionary adopters were outperformed even by the non-adopters ($1586).

Declining rate of growth across increasing levels of adoption is a pattern that bears further investigation. While the ANOVA procedure (table 4.16) did not detect a significant relationship, the differences in means across groups (table 4.8) are large enough to warrant clarification by additional study. The low or negative absolute rate of growth of many firms may be partially explained by the increase in average mortgage interest rates from 7.06% in 1998 to 7.55% 1999 (30 year fixed rate, as reported by HSH Associates, 2001).

Adoption of Electronic Verification Tools

Similar to Workflow Tools, the adoption of Electronic Verification Tools was found to impact Cycle Time. A comparable impact on origination cost was not found. In addition to an overall effect of adoption, though, a significant difference was found between adopters with 'evolutionary use' and adopters with 'revolutionary use. When adopters are willing to change their business processes to exploit the new technology, they usually experience much better results than adopters who simply superimpose new technologies over existing processes. This is consistent with a large body of literature suggesting that large performance benefits are far more likely when adopters are willing to adapt their business operation to take maximum advantage of innovations (Davenport and Short, 1990, Hammer and Champy, 1993, Venkatraman, 1994).

Origination Cost follows virtually the same pattern across adoption levels as in the prior example (Workflow Tools). The one difference is that non-adopters actually have the lowest cost. This unexpected finding my be spurious, as ANOVA did not find a general relationship between cost and adoption level (table 4.20). It still bears further study, however, specifically relative to interaction effects with contextual variables. The pattern of greatest cost across all groups of the adopters with evolutionary purpose (table 4.9) is repeated from the example above.

Adoption of Origination Decision Support Tools

Problem loans as a proportion of total loans did not vary widely across adoption levels. No significant relationship was detected using statistical techniques. Based on simple observation of group means, however, the fewest problems existed among adopters with 'evolutionary use'. There is no widely reported precedent for this finding in the literature, but it could indicate that the traditional loan decision-making process is very effective, and any changes to it will impact decision quality negatively. The finding here could serve as a catalyst for a future study on this question alone.

As was the case with Workflow Tools, the poorest cost performance was found among the group of adopters who had the technology but whose use was evolutionary (table 4.10). Their cost per loan was $2000, while the adopters with revolutionary use only spent $1263 per origination. Non-adopters were in the middle with a cost of $1379. A significant relationship

was not detected with the ANOVA procedure (table 4.24). However, the power of this technique was limited due to small cell populations.

Adoption of Underwriting Decision Support Tools

The only hypothesized impact of Underwriting Decision Support is on Asset Quality, and this was not found. A plausible explanation could be similar to the one above – that the integrity of the decision making process in mortgage lending is so well established and firmly controlled that adoption of technology does not improve decision quality, but only speeds decisions up. The significant group differences found in Cycle Time across adoption levels (Table 4.25) indicates that the use of UDS does in fact have the effect of speeding up loan processing. This is certainly plausible, as approval of underwriters is a critical step that almost no lenders skip. Making the process virtually instantaneous would certainly impact cycle time.

The other significant relationship found in this analysis was between Underwriting Decision Support Adoption and Approval Rate (Table 4.25). Approval rate was originally posited to be a component of a general construct of efficiency (Table 4.13). As above, efficiency improvement was not originally hypothesized to be related to adoption of Underwriting Decision Support. However, such a finding is not inconsistent with established literature. A decision tool designed to improve the quality of managerial decisions will eventually impact the firm's overall performance. Gurbaxani and Whang (1991) look at the issue from the opposite perspective, positing

that "decision information costs" are the result of sub-optimal management decisions due to lack of necessary information.

For the fourth time, adopters of the technology of interest who had evolutionary intent had the highest total origination cost (Table 4.11). For the third time, adopters with revolutionary intent had the lowest total cost. While a significant relationship was not detected between adoption of Underwriting Decision Support and Origination Cost (Table 4.25), the power of the ANOVA technique is diminished due to small cell populations.

Findings not Related to the General Research Model

As stated in Chapter 1, certain data would be convenient to collect and of interest to both industry and academia, but which would not be directly tied to the basic research model and related hypotheses. These data will be shown and very briefly discussed as an exploratory exercise and as a foundation for further research.

Observations About Institution Type

Since 'Institution Type' was very easy to collect and of potential future interest, it was included on the questionnaire. Values of dependent variables averaged by institution type are shown below. A one-way ANOVA summary highlights where differences were found.

Table 5.1

Mean Values of Dependent Variables by Institution Type

	Loan/ Emp	Grow-th	Cycle	Drop-out	Prob-All	Ap-prove	Orig/ Cost
Commercial (n=19)	42.20	-15%	16.39	3.67	1.50	4.00	$1427
Savings & Loan (n=5)	50.69	23%	13.00	3.80	1.00	3.60	$1154
Mortgage Bank (n=59)	47.50	20%	13.76	4.00	1.72	4.19	$1440
Mortgage Broker (n=13)	29.76	-8%	21.77	2.46	1.00	5.25	$1053
Credit Union (n=7)	57.64	29%	10.14	1.71	1.14	5.14	$938
Other (n=13)	47.82	-1%	14.50	3.15	1.36	4.58	$1460
Average (n=116)	45.44	10%	14.92	3.53	1.50	4.35	$1368

Table 5.2

Group Differences in DV's across Institution Type

Dependent Variable	**Differences Across Institution Types** Pr > F
Loans per Employee	.6014
Growth	.8590
Cycle Time	.1088
Dropout Rate	**.0003**
Problem Loans	**.0520**
Approval Rate	.2475
Origination Cost	.5526

Significant differences were found only the variables Dropout Rate and Problem Loans. No explanation is offered for these findings, but they are worthy of further study due to their importance to lending practice. Rate of

problem loans is a particularly important criterion of lending performance (Koch, 1995).

Observations About Institution Scope

Institution Scope was used as a moderating variable in two groups of hypotheses. While no interaction effects were detected, a main effect showed up in some of the two-way ANOVA's. These effects are summarized in group means and a one-way ANOVA table summary for Scope by itself:

Table 5.3

Mean Values of Dependent Variables by Institution Scope

	Loan/ Emp	Grow-th	Cycle Time	Drop-out	Prob-All	Ap-prove	Orig/ Cost
Single Branch (n=48)	47.95	-1%	15.96	3.21	1.55	4.67	$1457
Multi Branch 50 mile radius (n=22)	45.13	-3%	14.68	3.09	1.5	4.55	$966
Multi Branch 51-250 mile radius (n=9)	33.55	-5%	14.50	3.56	1.33	4.22	$1318
Multi Branch 251+ mile radius (n=37)	45.40	31%	13.74	4.23	1.50	3.86	$1483
Average	45.44	10%	14.92	3.53	1.50	4.35	$1368

Table 5.4

Group Differences in DV's across Scope

Dependent Variable	**Differences Across Institution Types** Pr > F
Loans per Employee	.7509
Growth	.5588
Cycle Time	.8027
Dropout Rate	**.0011**
Problem Loans	.9352
Approval Rate	**.0971**
Origination Cost	.1228

The variable Scope, when analyzed as a main effect, shows significant impact on the output variables Dropout Rate and Approval rate. While differences do not appear large from inspection of the group means table, these findings should nonetheless be of interest to the financial services community and the IT research community.

Contributions to Theory and Practice

Contributions of this study fall primarily into the areas of academic interest (theory) and business interest (practice). At least some knowledge has been added to both domains. Academic interest will primarily be in the areas of: Business value research, process reengineering research, and Information Systems Research Methods.

Business Value Research

Several previously acknowledged relationships between technology adoption and production efficiencies have been validated. Mitra and Chaya (1996) found that higher IT investment led to lower production costs but higher overhead. The one variable that showed the most consistent shape was Origination Cost. Adopters of all four technology types had lower origination cost than non-adopters. Similarly, Loans per employee were largely higher among adopters.

Determining an efficiency factor is a contribution to Business Value Theory, as it will be useful in scale development for future studies. The other factors discovered ('Effectiveness', 'Competitive Pressure') are somewhat less useful since they did not differ in amount across adoption levels. Still, finding the factors may prove useful for future instruments or basic value research. Any additional foundation for such scale development is responsive to the "need for more grounded models..." (Brynjolffson and Hitt, 1993).

The strong relationship between levels of adoption and mean cycle time reinforces the concept that IT has the potential to benefit adopters by time-compressing value-adding activities (Hess and Kemerer, 1994). While the shape of the function varied somewhat across technology types, Cycle time was largely less for adopters than non-adopters. This is particularly significant in light of the impact on asset utilization that is a central influencer of organizational performance (Clemons and Row, 1991). With

Loans per Employee largely higher for adopters as a group than for non-adopters, the link between time compression and asset utilization is further supported.

The use of Decision Support Systems has been posited to bring value to adopters by effecting better management decisions. The benefits of IT in general are realized through 'manipulation of other resources' (West and Courtney, 1993). Lost value to the firm from poor decisions has even been called 'decision information cost' (Gurbaxani and Whang, 1991). A strong relationship between adoption level and problem loans would have been a significant finding to reinforce this stream of literature.

Finding very little relationship may, however be significant from another perspective. El-Najdawi and Stylianou (1993), as well as others, characterize Decision Support Systems as being most useful for 'semi-structured' problems. Lending decisions tend to be very highly structured. Therefore, lack of improvement in decision-making may be indicative of a poor 'fit' between DSS and such a structured problem. Adequate access to decision rules may be available to lenders with or without computerized decision support.

Process Reengineering Research

A widely held belief among process reengineering researchers is that the greatest benefit of adoption of a technology will accrue to those adopters who are willing to change their business practices to exploit it (Hammer and

Champy, 1993). Finding non-linear relationships between adoption and various business value measures lends significant support to this view. Origination cost is the most obvious instance of this phenomenon, as the functional relationship has the same exact shape across all technology types. Adopters with 'revolutionary' use invariable have lower cost per origination than adopters with 'evolutionary use'. In every case, the highest origination cost was among adopters with only 'evolutionary' use.

The fact that adopters with evolutionary intent (not willing to change business practices) fared more poorly even than non-adopters may be explained several ways, all of which are consistent with existing literature. As mentioned earlier, adoption of IT often increases production, but does not diminish labor cost and adds to overhead (Mitra and Chaya, 1996). Firms which adopt new technologies but do not fully exploit them may be taking on too much extra overhead to be offset by what little production gains they will realize without reengineering.

Another possible explanation is that failing to restructure business processes or business networks to exploit a new technology will leave transaction costs at their old levels. Some posit transaction cost savings to be at the heart of the relationship between IT and business value (Clemons and Row, 1992). If a new technology is adopted and its cost absorbed by the firm, failure to use the technology to reduce transaction costs will yield negative economic value to the firm. Whatever the explanation for differences in

results across adopters based on level of concomitant organizational transformation, it is clearly present.

Information Systems Research Methods

A focus on specific functional levels of organizations for measuring impact of IT adoption is responsive to the criticism of only 'blunt instruments' (Brynjolffson and Hitt, 1993). While the most critical measure of organizational success and viability might be Return on Investment, it is exceedingly difficult to isolate the impact of a single variable on this indicator. The present study demonstrates that a narrower focus and more granular unit of analysis is a productive avenue for future 'Organizational Impact of IT' studies.

The 'Quest for the Dependent Variable' (DeLone and McLean, 1992) has also been pursued in a meaningful way. By researching academic and industry literature for context-specific performance measures, the research has been able to yield conclusions useful within that context and similar contexts. The strategy of using functional level criteria for success has been fruitful. This technique brings the researcher closer to measuring true organizational value than simply whether the technology was adopted or not.

A further contribution to research practice is in the use of the World Wide Web to capture responses in survey research. Almost half of the usable responses in this study came via the web page, even though the entire originally identified sample had pre-paid return envelopes and paper

questionnaires. It is quite plausible that some of the web respondents would not have filled out the paper survey. Additionally, when sample sets for use in survey research have e-mail available, a very effective follow up technique is enabled. When the e-mail reminder is sent, an active link to the response page can be embedded in the message, making it very easy for readers to respond. The few differences that did show up in the variables will be of interest to those considering conducting web-based research and those interested in the study of research methodologies for the social sciences.

Mortgage Banking Practices

Practical value will accrue to mortgage originators from several aspects of this study. Simply documenting levels of adoption is of significant interest. While the industry periodically performs technology surveys (Lebowitz, 1998) the current study adds levels of detail that were not previously available. In areas that are comparable, previously obtained estimates have been validated. Specifically, the rate of adoption of Underwriting Decision Support Systems has been confirmed at approximately 90%. New information about strategic use and performance results have now augmented that knowledge.

The relationship between strategic use and performance should be of interest to both lenders and technology vendors. Industry trade journals have chronicled both the changes in business practices and business

partnerships concomitant with technology adoption (Lebowitz, 1996). However, hard data linking performance to these phenomena has been lacking. The results shown earlier in this study should serve as a catalyst for analyzing business practices and engaging in Strategic Information Systems Planning.

Limitations of Study

Primary limitations of this study are: Sample size, the survey / self report approach, and generalizeability.

Sample Size

A total of 1090 surveys was sent out with a response of 180. After data cleaning, 116 surveys remained. Approximately half were from the web page and the other came back as completed paper instruments. While some relationships were documented others could not be confirmed with an acceptable level of confidence. Some cells simply had such low counts that ANOVA lacked sufficient power to detect relationships that may actually exist in the population sampled. Had the sample size been larger, some of the relationships that appeared obvious upon simple inspection of group means could have been supported more strongly. This would have added to the value of the research.

Survey / Self Report Approach

Respondents were trusted to accurately estimate performance parameters and report them honestly. Since anonymity was offered, it is reasonable to assume that respondents who offered performance data did so fairly. To the greatest extent possible, sound practices of survey research were followed, such as soliciting respondents in their normal setting and soliciting only information describing current or recent phenomena (Pinsonneault and Kraemer, 1993). However, there remains the possibility that self-reported data was less than a perfect representation of reality (Hufnagel and Conca, 1994). The current study did attempt to corroborate self reported performance data with existing hard data, but this attempt was not successful due to inadequate ability to match database data to the appropriate identity and scope of the respondents.

External Validity

The use of context specific performance criteria such as dropout rate and proportion of problem loans makes this study useful within the context of mortgage lending and to a slightly lesser extend within the lending area in general. This also limits the generalizeability of the findings outside of lending institutions. To the extent that some of the performance variables may be characterized in a broader sense, though, they could become more useful. Cycle time, for example, is a plausible proxy for the more general criteria of decision speed and information velocity. Origination cost is a

viable measure of production cost. The processing of a mortgage loan application is simply a unit of production.

Some findings are useful to all organizations that have or will use innovative technology as a tactical or strategic business too. The link between adoption of technology and the strategic use to which it is applied has importance across many organization types, scopes, and locations. Decision Support Systems as a source of organizational value is also explored in this study, with results being applicable to a broad range of organizations considering them.

Implications for Future Research

Researchers interested in business value will find in the present study a number of catalysts for future research projects. Primarily, findings that showed interesting characteristics but could not quite pass statistical analysis for significance may be redone with some refinements or larger samples, if they can be obtained. Most interesting will possibly be the relationship between strategic use and adoption, relative to business performance. This relationship actually was confirmed in one case, but not in some others where it was strongly suggested.

As described in Chapter 4, a few significant differences in the outcome variables did show up across response modes. While these differences may simply be the result of increased risk of Type I errors with multiple ANOVA's, they are worthy of further study on the use of web-based research.

With this methodology becoming more attractive due to increased availability of web-enabled PC's, even minor anomalies are noteworthy.

The factor matrix (replicated below with suggested construct names) should be of interest to the IT business value research community and bears further study.

Table 5.5

Factor Analysis of Dependent Variables Using

Principal Components and VARIMAX Orthogonal Rotation

	Factor 1 ('Efficiency')	Factor2 ('Effectiveness')	Factor 3 ('Competitive Pressure')
Loans per Employee	**-.71306**	.32122	.18304
Growth	-.13633	.19949	**-.54027**
Cycle Time	**.72574**	.02540	.29297
Dropout Rate	.02209	**.71647**	-.20780
Problem Loans	.02112	**.80499**	.02164
Approval Rate	-.13247	.03584	**.81629**
Origination Cost	**.69533**	.26220	-.07417

It is seen that two of the original three factors posited to be related to efficiency are, in fact, strongly related (Loans per Employee and Origination Cost). An "Efficiency" factor consisting of these variables plus Cycle Time is strongly supported. Approval rate did not load on this factor, as was originally expected. Cycle Time and Origination Cost loaded positively, while Loans per Employee loaded negatively. Opposing signs would be expected,

since lower values of Origination Cost and Cycle time show better efficiency, while higher values of Loans per Employee may be so characterized.

A second factor emerged very strongly consisting of the variables Dropout Rate and Problem Loans. They both had a positive weighting, indicating that they varied together. This factor may be termed "Effectiveness" since both of these variables may be seen as indicative of decision quality.

Dropout rate refers to how many applicants remove themselves from the application process before a final decision is made. This variable was hypothesized to covary with Cycle time and Growth to represent a construct of 'productivity'. However, no such co variation was found, so it is plausible that dropout rate is influenced by quality of the decision making process, along with rate of problem loans.

The third and final factor to emerge in the factor analysis consists of Approval Rate and Growth. Both factors load strongly, but in opposite directions. It might be expected that approval rate would covary directly with growth, indicating that banks which are interested in growing. However, it is also plausible that banks experiencing poor or negative growth would increase acceptance rates as a reactive response while banks enjoying high growth would have the flexibility to become more selective.

The foregoing view is supported by inspection of the highest and lowest growing bank types (Table 5.1) Savings and Loans as a group experienced the

highest growth rate in number of loans (23%), and also had the lowest approval rate (3.60/6.00). Conversely, Mortgage Brokers had the second poorest growth (-8%) and the highest approval rate (5.25/6.00). The factor is therefore termed 'Competitive Pressure' to indicate the level to which a respondent was under pressure to improve productivity.

Replication of this research approach in other contexts is also suggested by these results. Common phenomena such as decision speed and production cost can be easily operationalized in other settings to discover whether the relationships found herein are present on a broader scope. More specific measures, such as default rate will make finding a corollary more challenging, but still possible. The imperative for further business function level IT value research is clearly established.

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APPENDICES

November 9, 2000

«SALUTATION» «FIRST» «LAST»
«COMPANY»
«ADDRESS»
«CITY», «STATE» «ZIP»

Dear «SALUTATION» «LAST»:

The enclosed questionnaire represents a valuable data input for my research and doctoral dissertation. Presently, I am on the faculty at Indiana State University, and in the final stages of my doctoral work at Southern Illinois University. My area of study is business impact of electronic workflow and decision support tools commonly used by mortgage originators.

If you would be so kind as to spend 15-20 minutes filling out the questionnaire, either on paper or by visiting my website where the questionnaire is available as an on-line form, I would be most appreciative. The website address is: http://www.mbaa.org/technology/research/isusurvey.htm. You may remain confidential, or fill in your name, mailing address, and/or e-mail address to receive summarized results of the survey when it is finished. All returned questionnaires will be kept in a locked file accessible only to me. If you do provide your name, it will be kept separate from the rest of the data set. All reasonable care will be exercised in the handling of names and other responses to ensure confidentiality. I *would* like the name and location of your institution as part of the your response. Please respond at your earliest convenience.

Your name was provided by the Arizona Mortgage Lenders Association. AMLA is cooperating with, but not a sponsor of my study.. No incentives are being offered other than copies of final results when they become available. Your participation is, of course, completely voluntary. This project has been reviewed and approved by the SIUC Human Subjects Committee. Questions regarding your rights as a participant in this research may be addressed to: Committee Chairperson, Office of Research Development and Administration, Southern Illinois University, Carbondale, IL 62901-4709. Phone: (618) 453-4533. The Human Subjects Committee may also be reached by e-mail at siuhsc@siu.edu.

If you are willing to complete the survey, please read over the instructions carefully before responding. They are provided on the paper copy enclosed with this letter as well as on the website. If you have questions or concerns about the survey or the research it supports, or if you wish to have your name removed from any future mailings, you may contact me at (812) 237-2280. You may also contact Dr. Suresh Tadasina, the supervising faculty member at Southern Illinois University at (618) 435-7888.

Sincerely,

Joseph T. Harder
Assistant Professor

Please take a few moments to fill this out if you don't have immediate access to the World Wide Web or you would simply rather do it this way. A stamped, self addressed envelope is provided. Read all questions carefully. If you are not sure of an exact figure, give the closest approximation you can instead of leaving the field blank.

Your scope of responsibility may be one branch or many branches. As you answer the questions, please be consistent once you have chosen the scope of the business unit represented by your responses. I sincerely appreciate the time you are taking to help me with my research.

Demographics / Business Volume

My position in the business unit for which I am responding is:

- ❑ President
- ❑ Vice President
- ❑ Branch Manager
- ❑ Senior Lending Officer
- ❑ Lending Officer
- ❑ Technology Manager
- ❑ Other _____

The name of the business unit for which I am responding is: _____

My location (closest metropolitan area) is: _____

The business unit I am responding for is a(n):

- ❑ Commercial Bank
- ❑ Savings and Loan
- ❑ Mortgage Bank
- ❑ Mortgage Broker
- ❑ Credit Union
- ❑ Other _____

The Scope of the Business Unit I am responding for is:

- ❑ One Branch / Location
- ❑ Multiple Branches / Locations up to 50 miles
- ❑ Multiple Branches / Locations 51 - 250 miles
- ❑ Multiple Branches / Locations more than 250 miles

What was your business unit's origination volume in **1998?**
Number of Loans _____ Dollar Volume (Millions) _____

What was your business unit's origination volume in **1999?**
Number of Loans _____ Dollar Volume (Millions) _____

How many persons are employed in your business unit (mortgage operations only) _____

If you would like a printed copy of the results of this study, please provide the following:
Name / Title: _____
Organization: _____
Address: _____

Technology Adoption
Has your business unit implemented Automated Loan Origination / Workflow Management software such as Desktop Originator™ or Loan Manager™? Yes / No

If the answer above is "Yes" please indicate the benefits you intend to realize from its use (check all that apply)

- ❑ Localized Labor Savings
- ❑ Improved Access to Information
- ❑ Redesign Key Processes
- ❑ Establish Useful Linkages (Partnerships) with Other Organizations
- ❑ Make Fundamental Changes in Products Offered or Markets Served

(over)

Brand of Software, if applicable: _____ Number of Years in Use: _____

****

Has your business unit implemented Electronic Verification Systems such as computerized links to Credit Bureaus or Electronic Title Registries (MERS)? Yes / No

If the answer above is "Yes" please indicate the benefits you intend to realize from its use (check all that apply)

- ☐ Localized Labor Savings
- ☐ Improved Access to Information
- ☐ Redesign Key Processes
- ☐ Establish Useful Linkages (Partnerships) with Other Organizations
- ☐ Make Fundamental Changes in Products Offered or Markets Served

Brand of Software, if applicable: _____ Number of Years in Use: _____

****

Has your business unit implemented Origination Decision Support tools such as DecisionXChange™ or the Prequalification™ Feature of Genesis 2000? Yes / No

If the answer above is "Yes" please indicate the benefits you intend to realize from its use (check all that apply)

- ☐ Localized Labor Savings
- ☐ Improved Access to Information
- ☐ Redesign Key Processes
- ☐ Establish Useful Linkages (Partnerships) with Other Organizations
- ☐ Make Fundamental Changes in Products Offered or Markets Served

Brand of Software, if applicable: _____ Number of Years in Use: _____

****

Has your business unit implemented Underwriting Decision Support Tools such as Loan Prospector™ or Desktop Underwriter™? Yes / No

If the answer above is "Yes" please indicate the benefits you intend to realize from its use (check all that apply)

- ☐ Localized Labor Savings
- ☐ Improved Access to Information
- ☐ Redesign Key Processes
- ☐ Establish Useful Linkages (Partnerships) with Other Organizations
- ☐ Make Fundamental Changes in Products Offered or Markets Served

Brand of Software, if applicable: _____ Number of Years in Use: _____

Lending Experience

Please estimate the average time to process a loan (days) at your business unit. _____

Please pick the range closest to your business unit's pipeline dropout rate: ☐ 0-2% ☐ 3-4% ☐ 5-7% ☐ 8-9% ☐ 10%+

Please pick the range closest to your business unit's problem loan rate: (*'problem loan' is defined for use in this instrument as the percent of originated loans which become slow paying or default in the first two years – use your most recent two years' experience)*

Conforming Loans: ☐ 0-1% ☐ 2-3% ☐ 4-5% ☐ 6-7% ☐ 8-9% ☐ 10%+ ☐ N/A

Non-Conforming Loans: ☐ 0-1% ☐ 2-3% ☐ 4-5% ☐ 6-7% ☐ 8-9% ☐ 10%+ ☐ N/A

Total Loans: ☐ 0-1% ☐ 2-3% ☐ 4-5% ☐ 6-7% ☐ 8-9% ☐ 10%+

What Percent of all loans processed by your Automated Underwriting System are initially recommended for approval?

☐ <50% ☐ 51-60% ☐ 61-70% ☐ 71-80% ☐ 81-90% ☐ 91%+ ☐ N/A

Please estimate (in dollars) the direct and overhead (combined) cost for your business unit to originate a mortgage loan.

_____

THANK YOU !

Please use the envelope provided to mail back the instrument at your earliest convenience.

The Survey

Home

Please read all questions carefully. If you are not certain of an exact figure, give the closest approximation you can instead of leaving the field blank.

Your scope of responsibility may be one branch or many branches. As you answer the questions, please be consistent once you have chosen the scope of the business unit represented by your responses.

I sincerely appreciate the time you are taking to help me with my research.

Demographics / Business Volume

I have reached this page as a result of:

- (•) Receiving a Survey in the Mail
- ( ) Finding the Link in the MBA Web Site
- ( ) Other (*i.e. Told about the site by a colleague*)

The name of the business unit I am responding for is:

My location (closest metropolitan area) is:

The business unit I am responding for is a(n): Commercial Bank

If you specified "other" above, give institution type:

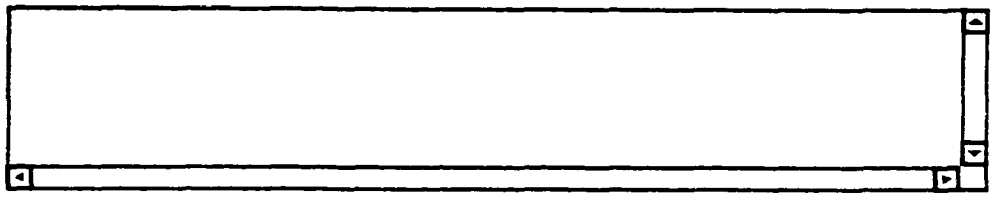
The scope of the business unit I am responding for is:
One Branch / Location

What was your business unit's origination volume in **1998**?
Dollars (Millions): *Number of Loans:*

What was your business unit's origination volume in **1999**?
Dollars (Millions): *Number of Loans:*

How many persons are employed in your business unit (mortgage operations only):

If you would like a printed copy of the results of this study, enter your name and address here



Technology Adoption

Has your business unit implemented Automated Loan Origination / Workflow Management software such as Desktop Originator™ or Loan Manager™ ○ Yes ◉ No

If the answer above is 'Yes' please indicate the benefits you intend to realize from its use (check all that apply)

- ☐ Localized Labor Savings
- ☐ Improved Access to Information
- ☐ Redesign Key Processes
- ☐ Establish Useful Linkages (Partnerships) with Other Organizations
- ☐ Make Fundamental Changes in Products Offered or Markets Served

Brand of Software, if Applicable:

Number of Years in Use: 1

****

Has your business unit implemented Electronic Verification Systems such as computerized links to Credit Bureaus or Electronic Title Registries (MERS) ○ Yes ◉ No

If the answer above is 'Yes' please indicate the benefits you intend to realize from its use (check all that apply)

- ☐ Localized Labor Savings
- ☐ Improved Access to Information
- ☐ Redesign Key Processes
- ☐ Establish Useful Linkages (Partnerships) with Other Organizations
- ☐ Make Fundamental Changes in Products Offered or Markets Served

Brand of Software, if Applicable:

Number of Years in Use: 1

****

Has your business unit implemented Origination Decision Support tools such as DecisionXchange™ or the Prequalification Feature of Genesis 2000™? ○ Yes ○ No

If the answer above is 'Yes' please indicate the benefits you intend to realize from its use (check all that apply)

- ☐ Localized Labor Savings
- ☐ Improved Access to Information
- ☐ Redesign Key Processes
- ☐ Establish Useful Linkages (Partnerships) with Other Organizations
- ☐ Make Fundamental Changes in Products Offered or Markets Served

Brand of Software, if Applicable:

Number of Years in Use: 1

****

Has your business unit implemented Underwriting Decision Support tools such as Loan Prospector™ or Desktop Underwriter™? ○ Yes ○ No

If the answer above is 'Yes' please indicate the benefits you intend to realize from its use (check all that apply)

- ☐ Localized Labor Savings
- ☐ Improved Access to Information
- ☐ Redesign Key Processes
- ☐ Establish Useful Linkages (Partnerships) with Other Organizations
- ☐ Make Fundamental Changes in Products Offered or Markets Served

Brand of Software, if Applicable:

Number of Years in Use: 1

Lending Experience

Please estimate the average time to process a loan (days) at your business unit

Please pick the range closest to your business unit's pipeline dropout rate 0%-2%

Please pick the range closest to your business unit's problem loan rate: (*'problem loan is defined for use in this instrument as the percent of originated loans which become slow paying or default in the first two years - use your most recent two years' experience*)

Conforming Loans: 0-1%

Non-Conforming Loans: 0-1%

All Loans 0-1%

What percent of all applications processed by your Automated Underwriting System are initially recommended for approval? < 50%

Please estimate (in dollars), the direct and overhead (combined) cost for your business unit to originate a mortgage loan

Don't Forget to 'Submit'

Submit

SIUC HSC FORM A

REQUEST FOR APPROVAL OF RESEARCH ACTIVITIES INVOLVING HUMAN SUBJECTS

This approval is valid for one (1) year from the approval date. Researchers must request a renewal to continue the research after that date. This approval form must be included in all Master's theses/research papers and Doctoral dissertations involving human subjects to be submitted to the Graduate School.

PROJECT TITLE: An Investigation of the Business Impact of Automated Underwriting Systems on Mortgage Lenders

CERTIFICATION STATEMENT:

In making this application, I(we) certify that I(we) have read and understand the University's policies and procedures governing research activities involving human subjects, and that I(we) shall comply with the letter and spirit of those policies. I(we) further acknowledge my(our) obligation to (1) accept responsibility for the research described, including work by students under my(our) direction, (2) obtain written approval from the Human Subjects Committee of any changes from the originally approved protocol **BEFORE** making those changes, (3) retain signed informed consent forms, in a secure location separate from the data, for at least **three** years after the completion of the research, and (4) report immediately all adverse effects of the study on the subjects to the Chairperson of the Human Subjects Committee, Carbondale, Illinois, (618) 453-4533, and to the Director of the Office of Research Development and Administration, Southern Illinois University at Carbondale, (618) 453-4531.

Joseph T. Harder — 9/1/00

RESEARCHER(S) or PROJECT DIRECTOR(S) — DATE

Please print or type name below signature

Dr. Suresh Tadisina — 21st Sept '00 ~~9/1/00~~

RESEARCHER'S ADVISOR (required for all student projects) — DATE

Please print or type name below signature

The request submitted by the above researcher(s) was approved by the SIUC Human Subjects Committee.

Anthony J. Carpo — 10/2/00

CHAIRPERSON, SOUTHERN ILLINOIS UNIVERSITY HUMAN SUBJECTS COMMITTEE — DATE

VITA

Graduate School
Southern Illinois University

Joseph T. Harder Date of Birth: January 18, 1952

701 West Candlewick Circle, West Terre Haute, Indiana, 47885

Purdue University at West Lafayette
Bachelor of Arts, Psychology, December 1974

Southern Illinois at Carbondale
Master of Business Administration, August 1983

Special Honors and Awards:
The Honor Society of Phi Kappa Phi

Dissertation Title:
An Investigation of the Business Impact of Automated Underwriting Systems on Mortgage Lenders

Major Professor: Arkalgud Ramaprasad

Publications:

Buffington, James, **Joseph Harder** and Jeffrey Harper, "An Exploratory Study of the Factors Contributing to MIS Student Organization Effectiveness" Proceedings of the 2000 Annual Conference of the International Academy for Information Management

Harder, Joseph, "An Assessment of the use of a Practical System Analysis Project in Introductory MIS Courses", Proceedings of the 1999 Annual Conference of the International Academy for Information Management

Harder, Joseph, "Isomorphic Models for Financial Decision Making", Proceedings of the 1996 Midwest Business Administration Association Annual Conference

Harder, Joseph, and Jack Sterrett, "Information Technology and Organizational Reengineering: A Small Business Perspective", Proceedings of the 1996 Midwest Business Administration Association Annual Conference

Ho, Wei-Xiong and **Joseph Harder**, "Hybrid Expert Systems: A Marketing Application", Proceedings of 1993 Decision Sciences Institute National Conference.