Identifying the Intervening Variables in the Information Technology Investment and Organizational Performance Relationship

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ABSTRACT

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This study explores the evolution and development of research models which were developed in order to improve our understanding of the relationship between investment in information technology (IT) and the subsequent benefit (or loss) to an organization's performance. Due to the elusive nature and contradictory findings in much of the research in this field a newer, more complete model was developed and tested empirically. The proposed model incorporates the Technology to Performance Chain (Goodhue and Thompson, 1995) into the more basic model suggested by Smith and McKeen (1993)

Results of data analysis using the Partial Least Squares technique are presented and discussed. Findings suggest that the Technology to Performance Chain does act as an intervening variable in the IT investment / organization performance relationship. Limitations of the present study, as well as suggestions for future research are also discussed.

ACKNOWLEDGEMENTS

To those who provide opportunity.

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Introduction

Research focusing on information technology (IT) investment and the resulting impact on organizational performance is prevalent, yet inconclusive (Kauffman and Weill, 1989). For the past 18 years the measurement of the effectiveness of IT investment has been an issue of concern among information systems (IS) executives and managers (Niedelman et al., 1991; Brancheau et al., 1996). However, while there was a gradual decrease in the level of interest in IT effectiveness over those same 18 years Brancheau et al. (1996) reported a resurgence in interest in 1994. Brancheau et al. (1996) stated that the renewed interest in IT effectiveness may have been due to the need for IS executives to justify investment decisions. Evaluating any investment decision would typically involve making choices based on obtaining the best possible net benefit after having examined other alternatives. Corporate finance normally requires an analysis and decision making process using, for example, net present value (NPV) assessment in order to link an investment to the bottom line. It is this linking of the IT investment to bottom line performance indicators that has been elusive (Dixon and John, 1989) and as a result IT effectiveness continues to be of particular interest to researchers and practitioners alike.

This report reviews the existing literature, discusses the current models being used to evaluate the effectiveness of an IT investment, and identifies the need for and the development of a newer more complete model. The proposed model is tested empirically and the results are discussed.

Literature

Several studies have attempted to measure the effectiveness of an IT investment. Kauffman and Weill (1989) reviewed thirteen such empirical studies. The thirteen studies were selected for review as they each used high quality datasets that measured both the IT investment and relevant performance variables. Kauffman and Weill (1989) found that many of the studies showed little evidence that "IT investments created strong leverage on the value of the firm", i.e., net benefits did not appear to always exceed net costs. Figure 1 below is a model, which represents the essence of previous research cited by Kauffman and Weill (1989).

Figure 1. Initial IT Investment Research Stream

Measures and level of analysis used in IT investment research have tended to be focused on aggregate firm or industry level data (Loveman, 1988; Harris and Katz, 1988; Breshnahan 1989). Loveman (1988), in a manufacturing setting using aggregate secondary firm level data, was unable to show a positive relationship between IT investment and increased labor productivity. Breshnahan (1989) found that consumers of the financial service sector products benefited from IT investment, although due to the level of analysis it was not possible to capture the impact of the investment on an individual firm's performance. Other studies have demonstrated a significant positive relationship between

IT investment and organizational performance (Brynjolfsson and Hitt, 1996; Arun et al., 1997). Still others have found the relationship to be elusive (Banker and Kauffman 1988).

Arun et al. (1997), using secondary firm level data found several positive effects in their study of the impact of IT on organizational performance. However, in the same study they also noted only a weak relationship between software investment and labor productivity and recommended further research on this particular relationship. Arun et al. (1997) stated, contrary to Kauffman and Weill (1989), that "modeling performance effects at the level of specific technologies and activities ignores the strategic and bottom-line effects of a portfolio of investments" and were thus supportive of the level of analysis established at the firm. Arun et al. (1997) examined secondary firm level data consisting of IT spending between 1987 - 1991 by 497 public companies firms and found that "computers contribute significantly to firm level output".

What can be noted from the above studies was the focus on the high level of analysis. Specifically the use of aggregate firm or industry level data for measurement. Kauffman and Weill's (1989) main critique of research using aggregate firm or industry level data was that the effect of IT investment was "diluted" at the high level of analysis due to intervening variables that had not been identified and controlled for.

Kekre and Mukhopadhyay (1992) focusing on a lower level of analysis examined the impact of electronic data interchange (EDI) on performance variables which they identified as, inventory reduction programs, quality improvement programs and customer satisfaction. They were unable to provide proof of a link between EDI usage and the performance variables being studied.

Kelley (1994) studied the effect of IT on production operating efficiencies. Kelly (1994) had inconclusive results and noted that equal investments do not necessarily result in equal impacts on performance.

It should be noted that researchers have identified possible intervening variables in the IT investment and organizational performance relationship. Kelley (1994) noted in her study that the path between IT investment and organizational performance improvements appeared to be mediated by factors such as level of use of programmed automation, the newness of the implementation and certain organizational structures such as highly bureaucratic structure. Brynjolfsson and Hitt(1996) in their discussion of the "productivity paradox", i.e., spending on IT results in higher production costs (Brynjolfsson 1993), suggested that intervening variables such as "a period of learning, adjustment and restructuring" as well as "mis-measurement, lags, redistribution and mismanagement" could have accounted for the lack of evidence of IT investment having a positive impact on performance.

Inconsistent results of past research led Smith and McKeen (1993) to suggest the need for a better model with which to assess information technology impact on business value. Smith and Mckeen (1993) suggested that the effectiveness of IT was not considered in previous studies and as a result proposed a model (Figure 2) that introduced IT Effectiveness as the critical mediating variable. The Smith and McKeen (1993) model modified the fundamental research question from "what is the impact of *investment* in IT on an organization's performance to what is the *impact* of IT on an organization's performance". Smith and McKeen (1993) recommended a research program, which could be used to attempt to avoid the equivocal results experienced to date.

Figure 2. IT Effectiveness as Possible Mediating Variable

IT Investment

Smith and McKeen (1993) provided a summary of previous studies addressing the IT investment/organizational performance question. They reported a variety of IT investment measures used;

Non-Financial Measures

- Computer ownership
- Number of software capabilities
- Type of software
- Individual IT characteristics
- Number of computer applications
- Presence or absence of a system

Financial Measures

- IT expense as a percent of operating expenses
- IT budget
- Percent of IT investment in industry sector

Other studies have used non-financial measures for IT investment. Kekre and Mukhopadhyay (1992) represented IT investment by EDI usage in their study of steel producers and JIT delivery programs, while Kelley (1994) represented IT investment by the level of penetration of production automation equipment in various manufacturing facilities.

IT Effectiveness

Researchers have dealt with the difficult task of identifying objective measures of the impact of IT on an organization by developing surrogate measures of effectiveness. There are currently three approaches being pursued with respect to these surrogate measures. Technology Use (Davis, 1989; Taylor and Todd, 1995) and User satisfaction (Bailey and Pearson, 1983; Yves et al., 1983) represent the most popular choice for current research followed by Task Technology Fit (Goodhue 1988). Both use and task-technology fit have theoretical underpinnings while user satisfaction has been criticized for its lack of theoretical grounding (Melone, 1990). The following section will review the constructs use, user satisfaction and task-technology fit.

System Use

A definition of system users would be appropriate to begin the discussion of system use[1]. Whitten et al. (1994) define users as follows, "*...the people who use (and directly benefit from) the information system on a regular basis—capturing, validating, entering, responding to, and storing data and information...System users are the people for whom systems analysts develop information systems. System users define (1) the problems to be solved, (2) the opportunities to be exploited, (3) the requirements to be fulfilled....*" The above definition offers two key factors important to research into the successful investment in IT. They are that system users USE the information system on a

REGULAR basis to derive a benefit. The above definition also captures the idea of user involvement which researchers (Hartwick and Barki, 1994) found to be an important determinant of system utilization. By defining problems, opportunities and system requirements the system users become more involved in system development. This involvement was shown by Hartwick and Barki (1994) to be strongly correlated with a users attitude toward the system which in turn leads to behavioral intention and ultimately to system use. System use has been considered as one of the important intervening (mediating) variables in the IT effectiveness research (Lucas, 1975; Davis, 1989; Szajna, 1993; Smith and Mckeen, 1993). As described by Whitley (1996) a mediating variable is a variable which is found between two (2) variables in a causal chain, i.e., the mediating variable is found between the independent and dependent variable in a theoretical model. As a minimum requirement, if a system is not used to solve the business problems that it was designed to address, it cannot have an effect on organizational performance and as such system use takes on the role of mediating variable. This argument is essentially that of Smith and McKeen (1993) and their recommendation was that system use represented the key variable that linked IT investment and organizational performance. Stated simply, if a system is not seen to be effective by the user, it will not be used. Non-use of IT should then limit the impact that IT will have on organizational performance.

System Use - Measurement

Both objective and subjective measures have been used to determine system use with arguments developed for and against each method. The main concern against using subjective measures of system use is how little is known about the relationship between

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[1] The following discussion is based upon the assumption that system use is voluntary.

self-reported level of use and actual, objectively measured, system use (Davis 1989). Straub et al. (1995) found a significant difference between actual and self-reported usage, but suggested that there may be reasonable alternate explanations for their findings. Others have asserted that self-reported usage would tend to be less accurate than objective usage data (Szajna 1993). Of equal importance, the use construct appears to be more valuable as a surrogate measure of IT effectiveness when it is used to assess systems designed for voluntary end user usage. Mandatory system use presents a different set of measurement problems for the researcher that will be described in the following section of this report.

One final consideration of system usage leads back to the opening definition of system users and to an affirmation made by Likert (1967), " *Every aspect of a firm's activities is determined by the competence, motivation and general effectiveness of the human organization. Of all the tasks of management, managing the human component is the central and most important task, because all else depends on how well it is done.*" It is the voluntary human use of technologies that will enable organizations to derive the maximum benefits from IT and as such there seems sufficient support to include system use in any discussion of IT effectiveness.

User Satisfaction

Having previously defined the system user we need to determine why a user continues to use the information in a voluntary situation. This is essentially a question relating to behavior, which leads to psychology and organizational behavior theories. Ives et al. (1983) defined user information satisfaction (UIS) as " the extent to which users believe the information system available to them meets their information requirements."

They further stated that UIS is a surrogate measure for the change in organizational effectiveness that results from the use of an information system. The user satisfaction construct has played an important role in IT effectiveness research, yet along with supporters of user satisfaction (Gatian, 1994; Raymond, 1987; Doll et al., 1995) there are detractors, e.g. Melone (1990).

Bailey and Pearson (1983) developed an instrument to measure user satisfaction based on theoretical foundations in psychology, i.e., positive users attitudes held towards an information system would lead to behavior in the form of system use. Their work resulted in a widely sited and used instrument of user satisfaction.

Gatian (1994) found a relationship between user satisfaction and user behavior in a study of information system use in different universities. Gatian (1994) reported a high level of correlation between user satisfaction and two measures of performance: system affected decision-making and system affected user efficiency. Support of the reliability and validity of a shortened version of the Bailey and Pearson (1983) user satisfaction measurement instrument has been presented (Ives et al.; 1983; Raymond, 1987; Doll et al., 1995).

Melone (1990) provided several criticisms of the user satisfaction construct by suggesting that user satisfaction represented different constructs depending on the authors and that the construct was weak due to its lack of theoretical grounding. By concentrating their efforts on a directional link with attitudes antecedent to behavior Melone (1990) contends that MIS researchers have taken a biased approach in their research. Furthermore, Melone (1990) contended that the user satisfaction construct was modeled after theories of job satisfaction and can be criticized due to the lack of evidence that job satisfaction leads to performance. It is valuable at this moment to explore job satisfaction at a more detailed level in order to provide a framework within which one can consider Melone's (1990) critique.

Locke (1976), in his review of job satisfaction research, stated "...there is no direct effect of satisfaction on productivity." With Locke's (1976) well-supported conclusion in mind, let us first contrast the dimensions of user satisfaction and job satisfaction. The most apparent difference is simply one of scope. According to Locke (1976), job satisfaction research is concerned with employee attitudes along the following dimensions:

1. Work ,for example creativity, variety, difficulty, etc.
2. Pay
3. Promotion
4. Verbal Recognition
5. Working Conditions, for example equipment used environment, cleanliness, etc.

User satisfaction is concerned with one attribute of one dimension of job satisfaction, specifically equipment, which is included in the working conditions dimension. User satisfaction researchers attempted to determine user attitudes towards one of the many tools that they may use to perform a given task. Therefore, the scope of the user satisfaction construct is narrow relative to job satisfaction.

If a user is satisfied with an information system, use should continue. This assertion is based upon social psychology theory, where Lewin (1935), stated, "*behavior...involves moving form one activity to another in order to maximize satisfaction or minimize the frustration of a current need*". A user who has benefited from an information system will return to the information system in the future provided that superior choices of information gathering do not exist. Here lies some support for the link between attitude (satisfaction) and behavior (use). It is perhaps this narrow scope of user satisfaction and its possible link to use that has led to its continued usage as a surrogate measure of effectiveness.

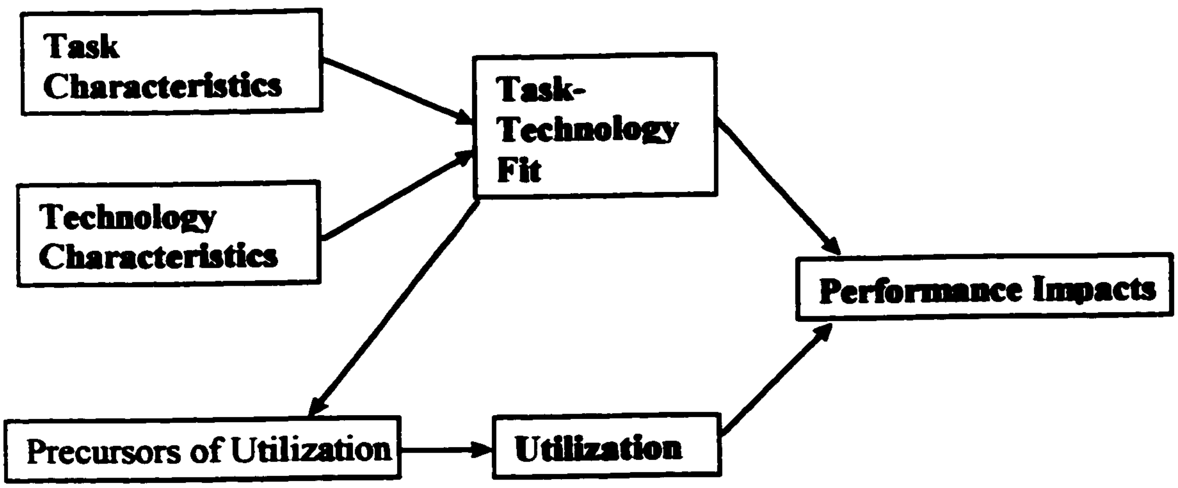
Melone (1990) further commented that user satisfaction, as measured by attitude lead to other concerns. If attitudes towards IT are non-existent, and only developed in a response to a questionnaire, we may conclude that the attitudes did not exist, prior to the subject being exposed to the questionnaire. As a result, if attitudes did not exist prior to a given behavior they therefore can not be used to explain behavior. A positive attitude towards IT may or may not have existed and therefore the behavior can not always be explained by user attitude. Melone (1990) also raised a fundamental question as to the direction of the attitude---behavior---performance relationship and what causes performance.

Finally Melone (1990) noted that user satisfaction has a role to play in IT research although it should not be used as "the" measure of IT effectiveness alone and can not be used to infer a direct and simple relationship between user satisfaction and organizational performance.

Task-Technology Fit

A more recent measure of IT effectiveness, Task-Technology Fit (TTF), was proposed by Goodhue (1988). Goodhue (1988) extended "fit" theory, which was originally conceptualized in the domain of individual decision-making performance (Benbasat et al., 1986), to apply to information system effectiveness research. The concept of "fit" reflects a primary objective of a systems analyst, which is to develop systems that provide the functionality that "fits" the requirements of the end-user. Goodhue (1988) suggested that correspondence between functionality and task requirements of users lead to positive impacts on individual performance. This new development was a needed addition to the MIS research field as it captured the essence and end result of high quality system development as well as provided a possible framework for performing post implementation system evaluation. TTF was also based on a solid theoretical grounding which addressed some previous criticism of IT effectiveness research (Melone, 1990).

Goodhue and Thomson (1995) incorporated the TTF into a new model of IT effectiveness, which they termed the Technology to Performance Chain (TPC) Model. The foundation of the TPC model, which combines models of utilization and fit, is reproduced in Figure 3.



From The Technology to Performance Model combining Utilization and Fit. (Goodhue & Thompson 1995)

Figure 3: TPC Model

Goodhue and Thompson, (1995) devised a model with the following premise: in order for IT to have an impact on individual performance the technology must both be utilized and support the tasks that it was designed to support. The constructs, which represent technology, tasks, utilization (use), individual characteristics, and individual performance, are combined to form the TPC Model. Goodhue and Thompson's (1995) underlying premise was consistent with, yet went beyond, the Smith and McKeen (1993) justification for including IT effectiveness when assessing the impact of IT on organizational performance. Smith and McKeen (1993) limited the definition of effectiveness by considering only system utilization. When system use is mandatory Goodhue and Thompson (1995) suggested that TTF will account for a greater proportion of performance impacts than will utilization.

One of the strengths, therefore of the TPC model was that it considered both utilization and appropriate "fit" of the technology to the tasks needed to be accomplished thus providing a more complete view of the precursors to individual impact. Rogers (1983) defined a construct, Compatibility, as " the degree to which the innovation fits with the potential adopter's existing values, previous experiences and current needs". This construct, while broader in scope was similar to Task-Technology Fit. Taylor and Todd (1995), in their investigation of the decomposed Theory of Planned Behavior model used this narrower definition of Compatibility which was consistent with Task-Technology Fit.

Individual Performance

The proposed research attempts to address the question of how IT affects the effectiveness of an organization. However, by entering the realm of organizational effectiveness one must address not only what, if any, valid measures of effectiveness exist, but also what are the predictors of effectiveness. The most comprehensive model developed to date concerning IT effectiveness (Delone and McLean, 1993) identifies individual performance as a predictor of organizational performance.

The individual has been considered by many researchers as one element in assessing IT effectiveness (Rushinek and Rushinek, 1986; Igbaria et al, 1995; Kramer et al., 1993; Vlahos and Ferratt, 1995). By establishing whether or not a system is used, if users are satisfied with the system and what level of "fit" a technology has with a particular task researchers have made inferences as to the successful deployment of IT.

Recall that users are thought to use an information system on a regular basis in order to derive a benefit (Whitten et al.,1994). If individual goals are aligned with organizational goals one may suggest that individuals will be satisfied with any work tool, i.e., IT, that assist them in meeting their goals. Once an individual has achieved their specific goals the organization is in turn closer to having achieved its' goals.

Organizations have many goals and improving effectiveness is only one. Managerial strategies have been found to have had significant relationships with changes in organizational effectiveness (Cameron 1986). A strategic decision to invest in IT can be expected to affect individuals and their abilities to perform their tasks and ultimately and organizations performance.

Organizational Performance

Referring once again to Smith and McKeen's (1993) review of IT investment/organizational performance studies, a number of previously used performance measures are listed below;

- Pretax Profits
- Sales
- Return on Investment
- Return on Assets
- Net income as a percent of total assets
- Return on Management
- Labor productivity
- Management productivity

Arun et al. (1997) further classified organizational performance measures as either output measures (sales), performance measures (ROA and ROI), and productivity ratios (labor and administrative productivity). Results from Arun et al. (1997) study indicated that IT investments can positively affect firm output as well as reduce costs although the effect on performance ratios was inconsistent. Arun et al. (1997) referred to the possibility that in order for business performance to improve there must be a " period of learning and adjustment" before IT impact is measurable. This assertion by Arun et al. (1997) supported the Smith and McKeen (1993) hypothesis of the existence of a mediating variable in the IT investment/organization performance relationship which Smith and McKeen (1993) defined as IT effectiveness.

The present study focuses on productivity as the dependent variable representing organizational performance. Studies carried out in a manufacturing setting can provide specific quantitative data measuring productivity and financial performance, but similar productivity measures, as defined by outputs/inputs, have not been available in the service sector. The use of productivity as a performance measure in the service sector is an important contribution of the present study. The measurement of organizational productivity will be discussed in an upcoming section.

Summary of Research Problem

Organizations allocate scarce resources towards IT investment with the objective of realizing a positive net benefit. Massive investments are being made in this area although little is known about *how* IT affects organizational performance. Researchers need to be able to explain the variables that intervene in the relationship between IT investment and organizational performance. IT value research is an important and growing area of academic research worthy of continued efforts. The main research questions are:

- Expanding of the Technology to Performance Chain (TPC) Goodhue and Thompson, (1995) to include organizational performance.
- Does the Technology to Performance Chain (TPC) represent an intervening variable explaining the possible positive effect of technology investment on organizational performance?

Justification of Current Study

To date researchers have had limited and varied success in the many attempts to measure what impact IT has on organizational performance. From the perspective of a practitioner the risks associated with investment in new IT projects are high, in particular risk associated with lack of quantifiable system benefits as discussed earlier. One may have established a clearly defined IT budget, clearly defined system requirements and clearly defined expectations of the impact of any IT system on an organization. However, as noted in earlier work (Kauffman and Weill, 1989; Brynjolfsson and Hitt, 1996; Arun et al., 1997) a gap between expectations and actual benefits derived from IT investment exists in many cases. Why this gap exists is as of yet unclear. The fundamental issue of what variable(s) has a mediating effect in the IT investment to organizational performance relationship remains unresolved. By further defining these mediating variables one is in a better position to minimize or reduce the risk associated with IT investment. As stated at the outset of this report, IS executives continue to be concerned with the issue of IT effectiveness, (proposed mediating variable in this study), since investment decisions need to be justified.

There has been a logical progression in IT research which has included IT effectiveness measures, which include system use (Lucas, 1975; Davis 1989; Straub, 1995), user satisfaction (Ives, Olson and Baroudi, 1983, Kettinger, 1994),and task-technology fit (Goohue,1995). Parallel, but independent of IT effectiveness studies were research initiatives focused on assessing the direct benefits that an organization accrued after having acquired and implemented IT (Lucas, 1975; Kekre and Mukhopadhyay, 1992; Arun et al., 1997). Subsequently, several researchers concluded (Delone and McLean, 1992; Smith and McKeen ;1993) that IT research should take a more comprehensive view, suggesting more complete models of how IT impacts an organization. This research continues in this vein by recognizing that it is insufficient demonstrating that IT users both use and are satisfied with their computer based information systems. Researchers must show how IT is having an impact on an organization and ultimately predicting what that impact may be. The research proposed in this study provides us with a comprehensive view of IT investment as a management strategy. This study includes the capturing of information relative to the initial investment in IT continuing through to the resulting measurable impacts that the investment had on organizational performance.

A further justification of this study concerns the fact that IT research has been criticized due to inadequate application of theoretical foundations, (Melone, 1990) ,lack of testable hypotheses and high level data aggregation that "dilute" evidence of a possible link between IT investment and organizational performance (Kauffman and Weill, 1989). Concerns have also been raised about the difficulties of measuring productivity in the service industries (Breshnahan, 1986; Oman and Ayers, 1988). More challenging is explaining effects of IT investment on organizational productivity. DeLone and McLean (1992) cautioned researchers against performing research into the effectiveness of IT without identifying and measuring the key causal variables along with the relevant dependent variable. This study will investigate the appropriateness of "task-technology fit", "utilization", and "individual productivity" as mediating variables in predicting organizational performance.

Complete and satisfactory research has not been performed on this area. Significant investment is at risk for the buyers, designers and implementers of IT who do not have a better understanding of the IT effectiveness variables affect organizational performance.

Research Model

For the purposes of this study a complete and a reduced research model will be tested. The reduced model is illustrated in Figure 4, while the complete research model follows in Figure 5

Compared to previous research where only a direct link between IT investment and organizational performance (i.e., organizational productivity) was investigated, the proposed model introduces a chain (TPC) of three mediating variables: 1 Task-technology fit, 2. Utilization and 3. Individual performance (i.e., individual productivity).

Figure 4...Reduced Model

The reduced model (figure 4) was developed in order to allow the isolation of the TPC when testing the research hypotheses which are central to this study. The reduced model includes both IT Investment and Organizational Productivity and is consistent with the incomplete models cited by Kauffman and Weill (1989).

Task-technology fit.

Task-technology fit (TTF) was defined by Goodhue and Thompson (1995) as "...the degree to which a technology assists an individual in performing his or her portfolio of tasks.". Goodhue and Thompson (1995) stated that TTF is expected to have

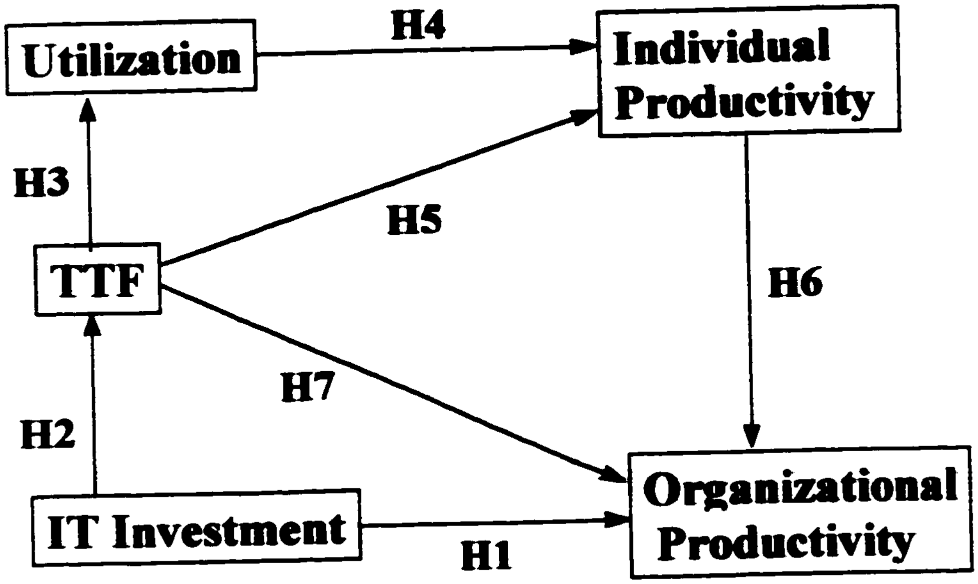


Figure 5...Complete Model

an impact on utilization since a user who believes that an information system is more useful, more important or provides more relative advantage is likely to utilize the system. This argument is relevant where system use is voluntary and is supported by previous research into the precursors of utilization such a work performed by Davis (1989). In situations where use in mandatory a system with high TTF will assist an individual in performing his duties.

Utilization

Goodhue and Thompson (1995) defined utilization as completing tasks by employing technology. The mere existence of an information system is insufficient means to provide individual or organizational productivity benefits. A system must be utilized in order for impacts to be realized.

Goodhue and Thompson (1995) noted that utilization alone may be a misleading indicator of whether or not a system has a positive impact on individual performance since poor systems may be the only systems available. Poor systems, i.e., systems with low TTF, which individuals are obliged to use will not provide the positive individual performance impacts realized through systems with high TTF. It is for these reason that both task-technology fit and utilization must be assessed simultaneously in order to determine whether or not system use has an impact on individual performance.

Individual Performance

No system can have an impact on organizational productivity if the system has no prior impact on an individuals performance. DeLone and McLean (1992) identified this relationship in their model of IS success. As noted previously both task technology fit and utilization are expected to have an impact on individual performance.

The above three variables, task-technology fit, utilization, and individual performance are presented here as the key mediating variables affecting the relationship between IT investment and organizational productivity. The complete Goodhue and Thompson (1995) TPC introduced five additional variables; Precursors of Utilization, Technology Characteristics, Individual Characteristics, Task Characteristics, and System Characteristics, which are described below.

Precursors to Utilization.

System use has been shown to be caused by antecedent variables whose origins are based on theories of attitudes and behaviors. These antecedent variables have been studied previously and consist of beliefs and attitudes (Davis, 1989), social norms

(Hartwick and Barki, 1994), habit and facilitating conditions (Goodhue and Thompson, 1995). Under conditions where system usage is voluntary researchers have been interested in determining why a user chooses to use a system. Where system use is mandatory precursors to utilization provide little insight into why a system has an impact on individual or organizational productivity. Hartwick and Barki (1994) take a contrary position concerning mandatory versus voluntary system use. They suggest that even in situations where usage is mandatory the level of usage is variable and as a result usage can be predicted. Further, Hartwick and Barki (1994) found that mandatory users' decision to use a system was affected significantly when other users felt that it was appropriate for them to use the system more frequently. In this case the antecedent variable(s) to utilization appeared to be important in the context of the work done by Hartwick and Barki (1994).

Despite the recommendation of Hartwick and Barki (1994), that more work needed to be done in the area of identifying and understanding the antecedent variables to voluntary or mandatory usage, this study did not assess precursors to utilization as they are of secondary importance. This approach is similar to that taken by Goodhue and Thompson (1995) in their evaluation of the Technology to Performance Chain. By measuring both utilization and TTF in order to predict individual performance the issue of voluntary versus mandatory system utilization becomes irrelevant. On a practical level investors, designers and finally end-users of a given system are interested in whether or not a technology has been successfully implemented into the workplace. Whether success is measured in economic, technical or operational terms one needs to address two important points; Is the technology being used (utilization) and does the technology assist the user in accomplishing their tasks (high Task-Technology Fit). Therefore precursors of utilization do not need to be assessed in investigating the relationship between IT investment and organizational productivity.

Finally, Goodhue and Thompson, (1995) describe three antecedent variables to Task Technology Fit. These three variables, technology characteristics, task characteristic and individual characteristic are considered to interact with a resulting impact on TTF. As the primary purpose of this study is to assess whether or not the TPC has a mediating effect in our proposed model and as such the antecedent variables will not be assessed.

Hypotheses

H1 There is a positive relationship between IT Investment and Organizational Productivity.

In determining whether or not the Technology to Performance Chain, TPC, (Goodhue and Thompson 1995) has a mediating effect on the IT Investment to Organizational Productivity relationship one needs to test the above hypothesis under two (2) conditions. A reduced model which consists only of IT Investment and Organizational Productivity and a complete model which contains all other latent variables. By testing this hypothesis in both the reduced and complete models we will be able to observe any mediating effect of the TPC. Earlier work as cited by Kauffman and Weill (1989) suggest that the above hypothesis has been found to be true. That is an investment in IT will have a positive relationship with organizational performance.

H2 There is a positive relationship between IT Investment and TTF

IT investment can be categorized into several dimensions. If one were to consider the complete system development life cycle IT investment dimensions would include costs associated with five main dimensions. New System Development (1) which includes all aspects of development beginning at defining the scope of a new system through to system implementation. Within the system development life cycle investments will also be made in Software (2) which may include off the shelf software i.e., operating system, networking, and communication software etc., required for the project. Hardware (3) investments may include desktop computers, servers, printers and accessories. Ongoing System Maintenance and Upgrades (4) investment is required to maintain or achieve higher task-technology fit. System Repair and Service (5) will be required to, once again, maintain or achieve higher levels of task-technology fit.

The level of IT investment made in the dimensions noted above will result in a system having more or less task-technology fit. More investment with good task-technology fit will lead to more utilization, more investment with poor task-technology fit will not have a similar effect.

H3 There is a positive relationship between Task-Technology Fit and Utilization

According to Goodhue and Thompson (1995) TTF is expected to be a direct determinant of utilization . As a result we expect that systems with high TTF will therefore predict utilization.

H4 There is a positive relationship between Utilization and Individual Performance.

System utilization will effect individual performance to a varying degree depending upon the level of TTF associated with the system being used. The higher the TTF the higher individual performance is expected to be regardless of whether or not system use is voluntary. Low TTF, indicative of a poor system, will not lead to individual performance improvements (Goodhue and Thompson, 1995) despite the fact that system use is mandatory.

H5 There is a positive relationship between Task-Technology Fit and Individual Performance.

As noted by Goodhue and Thompson (1995) task-technology fit will lead to performance impacts "when a technology provides features and support that fit the requirements of a task". Goodhue and Thompson (1995) remarked further that the quality or usefulness of a system will determine individual performance impacts. Where system use is mandatory individual performance will depend more upon TTF.

We can also expect that for the same level of utilization, more task-technology fit will lead to better performance. A better system, that is a system with appropriate features and functionality, will allow users to complete their tasks more efficiently or effectively.

Vessey's (1991), review of literature which summarized research concerning the relative advantages of presenting information in a tabular versus graphical format provided support for the above hypothesis. Vessey (1991) concluded that performance improvements are realized by individuals when the information needed to make a decision was available and presented in a way that "fit" with the specific problem under evaluation. Vessy (1991) identified several studies where the results showed that graphs where significantly better than tables or vice-versa for decision making. Whether graphs or tables was preferred was dependent upon the nature of the task to be accomplished. Finally, Vessey (1991) noted the " the paradigm of cognitive fit...suggests that decision makers will perform better when they receive the appropriate support for a specific task".

Jarvenpaa (1987), in an experimental study on the effect of task demands and graphical format on information processing strategies found that when there was a match between the graphical format and task demands that the "most efficient decision making strategy is selected". Here again we see evidence that a fit between technology and the task to be accomplished may have a significant effect on individual performance.

H6 Individual Performance has a positive relationship with Organizational Productivity.

Both the DeLone and McLean (1992) and Goodhue and Thompson (1995) models included individual impact as important variable in IT research. DeLone and McLean (1992) included individual impact as an antecedent to organizational impact while Goodhue and Thompson (1995) included individual impact as their dependent variable. Gains in individual effectiveness are expected to have positive impact on organizational performance.

H7 There is a positive relationship between TTF and Organizational Productivity.

Where system utilization is mandatory one would expect that TTF will impact on Organizational Productivity. High TTF having a positive effect while low TTF having little or no effect on Organizational Productivity.

Methodology

A questionnaire (see Appendix A for survey instrument) was distributed to employees in 15 Radiology departments that used a Radiology Information System. A total of 320 questionnaires were hand delivered to the department managers for distribution to all categories of end users in their respective departments. The 15 departments were selected as they met the criteria that they were using an information system to support their activities and they were located in a geographic region accessible to the researcher. The two (2) Departments that chose not to participate in the study did so due to lack of time (e.g. short questionnaire turn around time requested by the researcher) or non-availability (vacation) of the department manager during the data collection period. Therefore there does not appear to be any non-response bias at the organizational level. Department managers were in fact very interested in the research project and as a result provided excellent cooperation during the questionnaire distribution and collection phase of the study.

Surveys were hand delivered to the manager of participating departments with instructions that he or she was to distribute questionnaires to employees who happened to be on site during the work shift that researcher was present. The task of questionnaire distribution always occurred during a week day between 8:00 - 15:00 hours. The managers were instructed to ensure that questionnaires were distributed to all categories of employee, i.e., clerical, technical, supervisory as well as other management staff. Respondents were given 1 week to complete the questionnaire at which time the researcher returned to the participating departments to pick up any questionnaires. Questionnaires were to be returned to the department manager in a sealed envelope which was provided with the questionnaire. Participation in the survey was voluntary and respondents remained anonymous. It is felt that due to the active involvement of the department manager a very high response rate was achieved. A total of 274 of the 320 questionnaires were returned for a response rate of over 85%.

Measures

This section provides a description of the measures used to operationalize the constructs in the research model. A 7 point Likert type ordinal level scale was used for each of the items. The scale was anchored at 7 = Stongly agree to 1 = Strongly disagree with 3 = Indifferent at the midpoint. Three items which used different anchor labels will be identified in the following section. Table 1 provides a summary of the latent variables and their associated manifest variables which will be used to test the model empirically.

Table 1..Manifest Variable Description

Latent Variable	Number of Manifest Variables	Description of Manifest Variable	Source of Manifest Variable
IT Investment	6	Self report perceptive measures of investment in the following dimensions: 1. System Development 2. Hardware 3. Software 4. System Maintenance 5. System Repair and Upgrade	Based upon components of the System Development Life Cycle as per: Whitten, Bentley and Barlow (1994).
Task Technology Fit	3	Self report, perceptive measures adapted from "compatability", (Rogers,1983) to represent the fit of technology to the task.	Adapted from measures developed by Taylor and Todd (1995).
Utilization	2	Self report measures representing a users dependence on the information system.	Adapted from measures developed by Goodhue and Thompson(1995).
Individual Productivity	3	Self report measures representing a users perception of how their productivity and their work groups productivity is affected by using the information system.	2 items adapted from measures developed by Goodhue and Thompson (1995) 1 item developed by author for this research.
Organizational Productivity	3	2 Self report measures representing the users perception of how the information system affects organization productivity. & 1 Quantative measure of department productivity.	2 qualitative measures developed by the author for this study. 1 quantitative measure acquired through secondary source.(Association of Quebec Hospitals)

IT Investment

What is the amount of investment made in Radiology Information Systems. This value will be represented by 6 items which ask respondents to assess to what degree they believe that the amount of investment in information systems hardware, software, training, system maintenance and repair and new development is appropriate. An appropriate level of investment in all aspects of computer systems should positively impact the TTF. A limitation of this study is the lack of quantitative investment measures, but in order to test the model at a lower level of analysis this compromise was made. It is expected that department managers will be in a good position to assess the level of investment in the various IT investment dimensions.

Utilization

As it was not be feasible to obtain objective measures of system utilization this study used self report measures of system utilization. Similar to Goodhue and Thompson (1995) the users dependence on the system represented his or her level of utilization. The respondent was asked to respond to the statement " I am dependent on the Radiology Information System to perform my tasks." The respondent was also asked what proportion of their time is spent using the Radiology Information System to perform their tasks. Respondents were provided a chose of 10 categories, each having an 10% interval , from 0-10% to 91-100%.

Individual Performance

Two of the items were developed by Goodhue and Thompson (1995) and a third item was developed for this study to assess the impact of Utilization on group performance. This third item was necessary as the research model was expanded to include organizational impact. We wish to determine whether incremental improvements in individual performance alone are sufficient to lead to improvements in organizational performance or are improvements in the entire work groups' performance required.

Organizational Productivity

The dependent variable in this study is Organizational Productivity and represents how efficiently the organization is producing outputs. We are studying organizational productivity at a very low level. Rather than attempting to study the output of the entire organization the focus in on one specific department (Radiology) which has clearly identified IT resources and clearly identified outputs.

Two items will be used to measure organizational productivity. One item is represented by a quantitative measure of productivity known as the cost per provincial technical. (The definition of the provincial technical unit is found in the following section of this paper.) The value of this measure is obtained from a secondary source[2] independently of the original the survey instrument. The second item is based upon the individual's perception of how productive their department is. This second item is a self-report measure of perceived productivity and the data is obtained via the survey instrument, i.e., questionnaire.

Provincial Technical unit.

[2] Data obtained from the Association des Hopitaux de Quebec, Montreal, Quebec.

The Provincial Technical Unit is the standard quantitative measure of clinical work performed in a Radiology department in Quebec. The amount of time in minutes a medical imaging procedure, on average, should take is represented by the technical unit and is used by all hospitals throughout the province. As state funded organizations hospitals are required to report all clinical work volume using the Provincial Technical Unit of measure. Short of fraudulent reporting of technical units the measure is reliable. All costs incurred by the Radiology Department are also reported to the government along with the total number of technical units.[3] To arrive at an elementary measure of productivity of a Radiology Department one would simply divide the total number of technical units reported by a department with the total costs incurred to produce the units.

Perceptual Measures of Performance

Users of the systems will be asked to comment on their perceptions concerning how the computer based information system that they use has improved the performance (e.g. productivity) of their department.

Data Analysis

Data analysis will require an assessment of several factors. First, determining how well the individual measurement items relate to the various constructs is required to assess internal consistency and discriminant validity. Second, we want to determine if the relationships that were hypothesized hold. The analysis will be performed using the software package PLS-Graph version 2.91.02 . This statistical analysis software allows

[3] See Appendix B for a detailed list of cost categories reported by Radiology Departments.

researchers to use to the Partial Least Square (PLS) procedure which provides several unique advantages. With PLS one can model latent constructs, under conditions of non-normality and small sample size, and simultaneously analyze how well measures relate to each construct and test whether hypothesized relationships stated in the structural model (Figure 4) are empirically true (Chin, Marconi and Newsted, 1996).

In this study all measures are reflective representing the same construct of interest, and as a result path loadings from construct to measures are expected to be .70 or higher. Reliability of the measures will be assessed using Cronbach's alpha and results are expected to show minimum values of .6 as found by Goodhue and Thompson (1995) using a similar measurement instrument.

Results:

Using the PLS Graph software program two different latent variable models were developed in order to test the hypotheses identified for this study. Output from the PLS graph software, seen in Figures 6 and 7, the reduced and complete models respectivily, is in the form of arrow diagrams where boxes represent manifest variables and circles represent latent variables. The numbers specified inside the boxes in both models represent the measurement items that correspond to the individual item numbers on the survey questionnaire. See Appendix A for survey instrument. Directional arrows represent the hypothetical relationships between the various latent variables in the model. Arrows drawn between the latent variables and individual measurement items identify all measurement items as reflective. An asterisks besides the path coefficients linking latent variables indicates a statistically significant relationship between those 2 variables. PLS assigns either positive or negative values to the path coefficients and loadings. This assignation is arbitrary although interpretation of the results must take into account these positive or negative signs. The correct interpretation of the path coefficients and loadings are as follows:

- If the loadings of construct 1, (IT Investment in this case) are positive, while the loadings of contruct 2, (Organizational Productivity in this case) are negative, a negative path coefficient between the constructs implies a positive relationship between those constructs.

Results of both the Reduced and Complete Models require an interpretation as described above. All measurement models are satisfactory with loadings greater than .7 as significant (T-statistic > 1.65) (See Appendix C for data output)

Reduced Model Results:

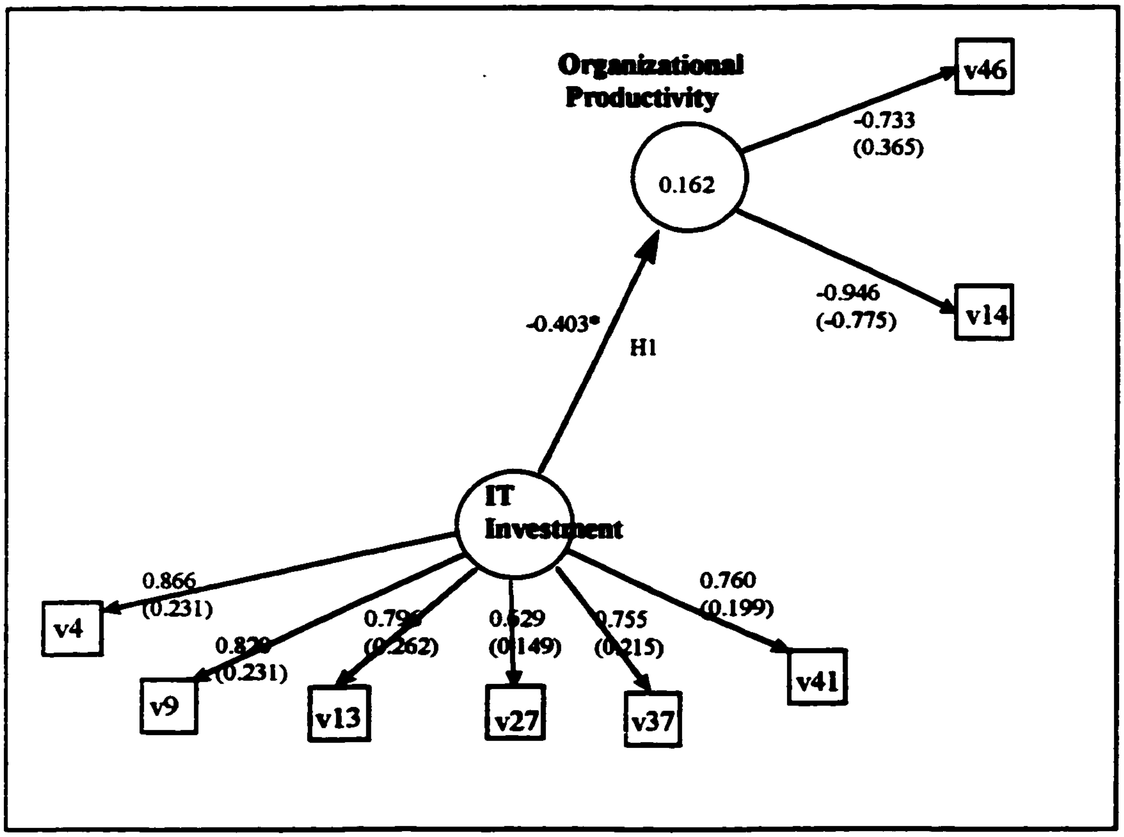


Figure 6...Reduced Model PLS Results

HI - IT Investment has a positive relationship with Organizational Productivity

The results indicate a positive relationship between IT Investment and Organization Productivity. This positive relationship is represented by the statistically significant link seen in the PLS output shown in Figure 6. We note that R square is low at 16%, indicative of a small effect of IT Investment on Organizational Productivity. This finding is consistent with other studies which have found IT investment to have had a positive impact on organizational productivity (Breshnahan, 1989; Brynjolfsson and Hitt, 1996). This finding, as we have seen in previous discussions, should be expected when IT design and implementation has been successfully undertaken. Nevertheless, the finding offers no insight into how the investment in IT has had an impact on organizational productivity. As noted earlier in this study, IT research should go beyond this limited view of IT success models and determine which variables, if any, mediate the above relationship. As a result we now proceed with an examination of the complete model in the next section.

H1 - IT Investment has a positive relationship with Organizational Productivity

After introducing the Technology to Performance Chain into the research model we found that the link between IT Investment and Organizational Productivity is no longer significant, however, R square has increased from 16% to 60%, and all other indirect links are significant. In this particular set of observations the mediating effect of the TPC is demonstrated.

H2- IT Investment has a positive relationship with TTF.

The results support the above hypothesis. The PLS program provides us with an aggregate measure the level of investment in IT. We previously specified the various components or dimension of IT investment as follows; investments in information system software, hardware, training , maintenance, repairs and upgrades. These dimensions are

Complete Model Results:

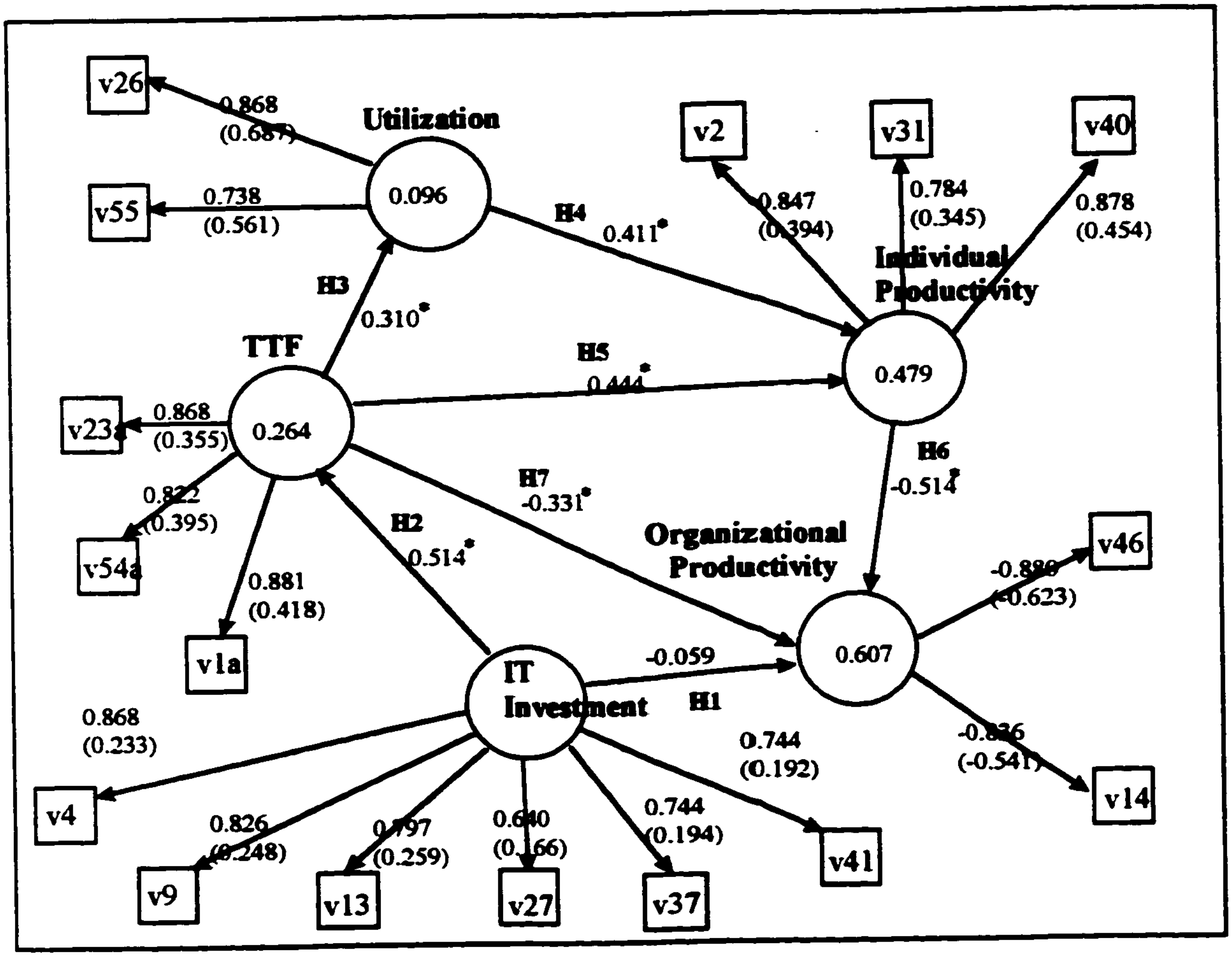


Figure 7...Complete Model PLS Results

combined to provide one overall measure of the level of investment. The above hypothesis does not list each component of IT investment and how it affects TTF, but as an aggregate or summary measure we do find evidence that IT investment has a positive relationship with TTF.

This result suggests that those Radiology departments who acquired, either through in-house development or out right purchase, a computer based information system did so in such a way as to meet the requirements of the various system end users. One is able to draw this conclusion since high TTF reflects a system that meets the needs of the end users in terms of assisting them in the accomplishments of their tasks. We see that appropriate levels of investment lead to high TTF systems. This finding responds to one of the main research questions that was established at the outset of this study; Does more substantial and appropriate investment in IT eventually lead to better task technology fit? Further we note that IT investment, as suggested by Kauffman and Weill (1989) and Smith and McKeen (1993), is critical to evaluate when attempting to assess the impact of IT on an organization.

To summarize, in those organizations where appropriate levels of investment in IT are made we find a correspondingly high level of TTF. It is important to note that IT investment alone is insufficient to have an impact on organizational performance, the IT investment must result in a system with high TTF in order to affect organizational performance in any significant way.

H3 There is a positive relationship between Task-Technology Fit and Utilization

Based upon these results we note that the theory holds true as we find a positive relationship between TTF and utilization. Previously, we defined utilization as completing tasks by employing technology. The findings here suggest that users will utilize a system in an environment characterized by high TTF. From a practical perspective this is significant under conditions where system utilization is voluntary. We previously noted that individuals tend to select the information or tool from the best possible choice among differing alternatives (Lewin, 1935). Once having had a positive experience with an information source an individual can be expected to return to the same source should similar needs for information arise in the future.

In situations where system use is mandatory we remain interested in the level of TTF of a system as this will indicate how appropriate a system is in assisting an individual in completing his or her tasks.

This finding also maintains the next critical link in the Technology to Performance Chain as specified in the research model.

H4 There is a positive relationship between Utilization and Individual Performance.

As one progresses through the model the hypothesis of a positive relationship existing between utilization and individual performance is supported by the results. Utilization has been consistently reported and supported as a critical variable in IT effectiveness research (Lucas, 1975; Davis, 1989; Szajna, 1993; Smith and McKeen, 1993). As a minimum requirement a system must be used in order for it to affect individual performance.

The result of this study suggest that within the research sample individuals felt that by using the information system available to them they perceived gaining significant performance improvements.

H5 There is a positive relationship between Task-Technology Fit and Individual Performance.

This hypothesis found support in the work performed by Goodhue and Thompson (1995) and we find a positive relationship between TTF and individual performance in this research study. When testing this hypothesis we find that for the same level of utilization TTF improves individual performance. A perception by the end user that the information system they use provides the features and support that they need to perform their tasks well is also perceived to improve their individual performance.

Better " fit" and better information leads to better performance, all else remaining equal. This finding parallels that of both Vessey (1991) and Jarvenpaa (1987) in their research on 'fit' and decision making respectively .

Gatien (1994) found a high level of correlation between user satisfaction and system affected decision making which in some respects parallels the findings of this study.

H6 Individual Performance has a positive relationship with Organizational Productivity.

Prior to interpreting the results to this hypothesis it was noted, that based upon their loadings, the items or manifest variables selected to represent organizational productivity did not all belong together. Specifically, objective measures of organizational productivity did not belong with perceived measures of organizational productivity. As a result of this discrepancy objective measure or organizational productivity was excluded from the PLS analysis.

The results indicate that individual productivity does have a positive effect on organizational productivity. This finding supports the argument of Delone and McLean (1993) that individual productivity must be considered in any model representing the impact of IT on organizational performance. Furthermore we have additional support indicating that there are mediating variables in the IT Investment/Organizational Productivity relationship.

H7 There is a positive relationship between TTF and Organizational Performance.

This research study used a model that had organizational productivity as the dependent variable. When measuring the overall or aggregate level of productivity of an organization it becomes apparent that the input of the individual i.e., individual performance in this case has an effect on organizational productivity which is insignificant when one considers the overall impact that the TTF of the system under evaluation.

When one considers organizations there appears to be synergy effects which are made possible through the acquisition and use of high TTF system. An individual perceives that his or her performance and contribution to an organization's overall productivity is significant. However, we find the overall TTF of the system under investigation also has a significant positive affect on organizational productivity in this particular research setting.

In summary the results of the data analysis support the above hypothesis. We find that the higher the TTF the greater the effect on organizational performance, holding individual performance constant. This significant result is once again consistent with the work performed by Goodhue and Thompson(1995).

Discussion

The purpose of this study was to determine whether the Technology to Performance Chain acts as a mediating variable in the IT investment / Organizational productivity relationship. Data from 274 end-users from 15 different Radiology departments were used to test the proposed model. The results of the study indicate that the Technology to Performance Chain explains 60 % of the variance in organizational productivity.

In the Complete model we noted that TTF had a significant effect on Utilization, Individual Performance and Organizational Productivity. IT investment also had a significant effect on TTF. Comparing this study to that performed by Goodhue and Thompson (1995) we found similar results. TTF's effect on Utilization is significant although R-square is low at .096. This is likely due to the fact that for the vast majority of system users, i.e., all users with the exception of managerial and supervisory staff, system use in mandatory. As a result whether or not a system has high TTF the overall effect on Utilization will be minimal in a mandatory use environment. As in the Goodhue and

Thompson (1995) study we expected to see TTF and Utilization to be significant predictors of Individual Performance. This is indeed what was found with both TTF and Utilization having a significant effect on Individual Performance and explaining 48% of the variance in Individual Performance.

This study extends Goodhue and Thompson's (1995) work by hypothesizing that TTF would have a significant effect on Organizational Productivity. In this particular set of survey results we find this to be true. The inclusion of organizational performance, defined as organizational productivity in this case is consistent with and strongly recommended by Delone and McLean (1992). This inclusion results in a more complete model of IT effectiveness. We expect TTF to have a positive significant effect on Organizational Productivity since TTF represents how well an information system meets the needs of end-users. Results from the study bear out this hypothesis and suggest, within the current research setting, that the level of TTF does have an effect on organizational productivity.

Limitations of the Study

A primary limitation concerns the fact that the study is cross sectional in nature. The impact of this limitation is essentially one which affects the internal validity of the study. Here we are concerned with which extraneous variables have a direct impact on department efficiency and ultimately department productivity.

Differing department size in terms of the number and types of clinical procedures performed as well as different clinical practices may well affect department productivity. Volume of activity may allow one department to be particularly efficient in one or more types of clinical procedures which will result in decreased cost per provincial technical unit, i.e., the dependent variable in this study. Clinical practice may also have a direct effect on department efficiency. While there are basic procedures for any given diagnostic exam in Radiology different physicians may either expand or limit the extent of a procedure based upon their experience and immediate needs of the patient. These decisions will affect a departments ability to optimize the cost per technical unit.

Other issues which affect department productivity lie in the departments mission and dedication to academic and research matters. Research and teaching may have a direct impact on department operating costs and ultimately cost per technical unit. Further still, differing levels of service provided to the patients will also affect operating costs. For example, it is possible for one department to make every effort, including incurring overtime costs, to ensure that patient wait times are kept to a minimum level. Another department may make no such effort and therefore incur no overtime costs. Whichever approach is preferred by the department will of course affect the cost per technical unit.

A second and important limitation of this study was the lack of quantitative data available to measure the investment in IT. Ideally one would want detailed data concerning actual amount of capital and labor used to provide IT infrastructure and support to a department. This type of data was not available for the present study.

A third, and perhaps less important limitation concerns the issue of reactivity and self report measures. To combat this threat to internal validity participants were informed that their responses were to be anonymous and they were to seal their completed questionnaires in a return envelope before returning them to the researcher.

One final comment concerning internal validity deals with the fact that department operating costs include expense items which are unaffected by IT technology and relate more to clinical practice, i.e., what type of exam is performed. We do not have adequate comparisons as to what one hospital pays as opposed to another for the supplies that they use. Economies of scale will benefit the operating costs of the larger departments and as a result cost per technical unit may be lower in a larger department versus a smaller department.

The above limitations will tend to affect the dependent variable in either a positive or negative direction. As a result, by performing a cross-sectional study comparing many different departments one may suggest that the present study exhibits low internal validity.

Future Research Suggestions

There is strong support (Goodhue and Thompson, 1995; Delone and McLlean, 1992; Smith and McKeen, 1993) for the continuation and refinement of IT effectiveness research. Researchers must focus on longitudinal studies in individual organizations in order to isolate the effects of IT on organizational performance (productivity in the present case). Longitudinal studies of individual organizations will allow the researcher to accurately track costs, identify and control for variables that effect performance.

Despite the limitations of the present study we must still consider our findings and reflect upon whether or not this type of research is worthy of continued efforts. To assist in the consideration of this basic question we may also ask can and should this research be extended to other settings.

The proposed model incorporates those constructs which, based on previous research, appear to effect the ability of IT to have a positive impact on an organizations performance, as measured by productivity in the present case. Utilization, which is intuitively obvious from a practical perspective has been the subject of numerous studies as previously discussed in this paper. Task Technology Fit, a more recent in addition to IT research, provides us with a theoretically sound framework to further develop and pursue research.

Definite practical applications may lie ahead based on continued research using the model proposed in this study. However, particular attention to the measurement of manifest variables as well as increasing the internal validity is required. IT investment needs to be quantified, and performance indicators must not be collected via the primary survey instrument.

The issue of cross-sectional versus longitudinal research is critical with respect to further validating the model. Longitudinal research will allow the evaluation of an organizations performance indicators both before and after the implementation of an information system. The systematic investigation at a low level of analysis will improve the internal validity of future studies and allow researchers to test the predictive ability of the model with pre and post implementation data.

Continued applied IT research using the proposed model should be carried out at the single organizational level and where possible focus on the narrowest boundary of the information system under investigation. This approach would be consistent with recommendations made by Kauffman and Weill (1989). We know that a successfully designed and implemented system must meet specific needs of specific user. It is only by verifying if the investment made meets the needs of specific end users and whether or not a material impact on the department or organizational unit has occurred as a result of using the system.

Conclusion

Within the current research setting the results of the study support the work of Goodhue and Thompson (1995) and provide evidence that the TPC model can be applicable in assessing how IT affects organizational productivity. High TTF was indicative of a more productive organization as well as having a positive affect on individual performance. Utilization, a construct well established in IS research, is shown to effect individual performance to a greater or lesser extent depending upon the level of TTF of the computer based information system. We found that for the same level of utilization TTF improved individual performance.

The Technology to Performance Chain, within the current research setting , appears to act as an intervening variable between IT investment and organizational productivity.

IT investment was positively and significantly related to TTF. This finding indicates that when appropriate levels of investment in the various components of system development and maintenance are made high TTF systems will be the resutlt.

Our initial research questions have been answered and provide us with strong indication that continued research in this area is a worthy effort.

Appendixes

A. Survey Instrument

Radiology Information System Questionnaire

INSTRUCTIONS

The purpose of this survey is to determine your perceptions regarding the Radiology Information System in use in your department. It is part of a research study being conducted at Concordia University.

Upon completion of the questionnaire insert it in the provided envelope and seal it before you return it to your Department Manager, Chief Technologist, or designated person.

The researcher will visit your department in **5 days** to pick up the completed questionnaires.

- Please answer all of the questions in the study.
- Your responses will be kept confidential.

ANSWER SCALE:

Circle the appropriate number on the answer scale beside each question.

Example 1.

	Strongly Agree			Indifferent			Strongly Disagree
1. I am most happy when we get over 40cm of snow fall in November.	7	6	5	4	3	2	1

Example 2.

	Strongly Agree			Indifferent			Stronlgy Disagree
2. I am very satisfied with the performance of the New York Jets.	7	6	5	4	3	2	1

The completion of this questionnaire would take 15-20 minutes.
Thank-you for taking the time to complete this questionnaire.

		Strongly Agree			Indifferent			Strongly Disagree
1a	Using the Radiology Information System fits well with the way I work.	7	6	5	4	3	2	1
		Very Good			Indifferent			Very Bad
1b	A computer system that fits well with the way I work is: (VeryGood/Very Bad)	7	6	5	4	3	2	1
		Strongly Agree			Indifferent			Strongly Disagree
2	The Radiology Information System has a large, positive impact on my effectiveness and productivity in my tasks.	7	6	5	4	3	2	1
3	It is easy to learn how to use the Radiology Information System.	7	6	5	4	3	2	1
4	The amount of investment in Radiology Information System hardware in my department is appropriate.	7	6	5	4	3	2	1
5	I am getting the training I need to be able to use the Radiology Information System effectively.	7	6	5	4	3	2	1
6	The information from the Radiology Information System is up to date enough for my purposes.	7	6	5	4	3	2	1
7	The Radiology Information System available to me is missing critical information that would be useful to perform my tasks.	7	6	5	4	3	2	1
8	It often takes too long for Information Services to communicate with me concerning my requests.	7	6	5	4	3	2	1
9	The amount of investment in Radiology Information System software in my department is appropriate.	7	6	5	4	3	2	1
10	Regular Information Services activities are usually completed on time.	7	6	5	4	3	2	1
11	Information Services deliver agreed-upon solutions to support my information needs.	7	6	5	4	3	2	1
12	Information Services take a real interest in helping me solve my information problems.	7	6	5	4	3	2	1
13	The amount of investment in new Radiology Information Systems development in my department is appropriate.	7	6	5	4	3	2	1
14	The Radiology Information System has improved the overall performance of my department.	7	6	5	4	3	2	1
15	Information that would be useful to me is unavailable because I don't have the right authorization.	7	6	5	4	3	2	1
16	Sometimes it is difficult for me to compare or consolidate information from different sources because the information is defined differently.	7	6	5	4	3	2	1
17	Information Services take my Radiology Information System problems seriously.	7	6	5	4	3	2	1
18	I frequently deal with ad-hoc, non-routine tasks.	7	6	5	4	3	2	1
19	The Radiology Information System I use is convenient and easy to use.	7	6	5	4	3	2	1
20	The exact definition of the information on the computer screens or reports relating to my tasks is clear to me.	7	6	5	4	3	2	1
21	I generally know what happens to my request for Information Services. (e.g. whether it is being acted upon.)	7	6	5	4	3	2	1
22	I can count on the Radiology Information System to be "up" (functioning) and available when I need it.	7	6	5	4	3	2	1
		Strongly Agree			Indifferent			Strongly Disagree
23a	Using the Radiology Information System fits into my workstyle.	7	6	5	4	3	2	1
		Very Good			Indifferent			Very Bad
23b	A computer system that fits into my workstyle is: (Very Good/Very Bad)	7	6	5	4	3	2	1

		Strongly Agree			Indifferent			Strongly Disagree
24	The tasks I perform frequently involve more than one department.	7	6	5	4	3	2	1
25	Based on my previous experience with Information Services, I will still rely on them.	7	6	5	4	3	2	1
26	I am dependent on the Radiology Information System to perform my tasks.	7	6	5	4	3	2	1
27	The amount of investment in Radiology Information System user training in my department is appropriate.	7	6	5	4	3	2	1
28	There are times when I find that supposedly equivalent information from different sources is inconsistent.	7	6	5	4	3	2	1
29	The information kept on the Radiology Information System is at an appropriate level of detail for my work.	7	6	5	4	3	2	1
30	Information production schedules such as report delivery and running scheduled jobs(e.g. period end reports) are completed on time.	7	6	5	4	3	2	1
31	The Radiology Information System has a large positive impact on my interactions with my co-workers or others in my work group.	7	6	5	4	3	2	1
32	I am satisfied with the level of service I receive from Information Services.	7	6	5	4	3	2	1
33	Getting authorization to access information useful in my job is time consuming and difficult.	7	6	5	4	3	2	1
34	The Radiology Information System I use is subject to unexpected or inconvenient down times which makes it harder to do my work.	7	6	5	4	3	2	1
35	I feel that Information Services personnel communicate with me in familiar terms that are consistent.	7	6	5	4	3	2	1
36	When it is necessary to compare or consolidate information from different sources, I find that there may be unexpected or difficult inconsistencies.	7	6	5	4	3	2	1
37	The amount of investment in Radiology Information System hardware service and repair in my department is appropriate.	7	6	5	4	3	2	1
38	Sufficiently detailed information is kept by the Radiology Information System.	7	6	5	4	3	2	1
39	It is easy to find out what information is kept in the Radiology Information System on a given subject.(e.g. patient)	7	6	5	4	3	2	1
40	The Radiology Information System is an important and valuable aid to me in performing my job.	7	6	5	4	3	2	1
41	The amount of investment in the maintenance/upgrades of the existing Radiology Information System is appropriate.	7	6	5	4	3	2	1
42	The Radiology Information System I use is subject to frequent breakdowns.	7	6	5	4	3	2	1
43	The Information Services people I deal with understand the day-to-day objectives of my work.	7	6	5	4	3	2	1
44	There is not enough training for me on how to use the Radiology Information System.	7	6	5	4	3	2	1
45	The information kept in the Radiology Information System is pretty much what I need to carry out my tasks.	7	6	5	4	3	2	1

46	The Radiology Information System has a large, positive impact on the effectiveness and productivity of my department.	7	6	5	4	3	2	1
47	I frequently deal with ill-defined tasks.	7	6	5	4	3	2	1
48	The exact meaning of the information on the Radiology Information System (e.g. on reports, screens) is obvious.	7	6	5	4	3	2	1
49	It is easy to locate information in the Radiology Information System on a particular subject, (e.g. patient), even if I haven't used that information before.	7	6	5	4	3	2	1
50	When I make a request for service or assistance, Information Services normally responds to my request in a timely manner.	7	6	5	4	3	2	1
51	I cannot get information from the Radiology Information System that is current enough to meet my needs.	7	6	5	4	3	2	1
52	The tasks I perform frequently involve dealing with more than one person.	7	6	5	4	3	2	1
53	Frequently the tasks I perform involve answering questions that have never been asked in quite that form before.	7	6	5	4	3	2	1

		Strongly Agree			Indifferent			Strongly Disagree
54a	The setup of the Radiology Information System is compatible with the way I work.	7	6	5	4	3	2	1
		Very Good			Indifferent			Very Bad
54b	A computer system that is compatable with the way I work is: (Very Good/Very Bad)	7	6	5	4	3	2	1

55 You use the Radiology Information System to perform the following proportion of your tasks.

- 0-10% ☐
- 11-20% ☐
- 21-30% ☐
- 31-40% ☐
- 41-50% ☐
- 51-60% ☐
- 61-70% ☐
- 71-80% ☐
- 81-90% ☐
- 91-100% ☐

56 What is your position in the Department?

- Managerial ☐
- Technologist ☐
- Clerical ☐
- Secretarial ☐
- Supervisory (Clerical) ☐
- Supervisory (Technical) ☐
- Other (please specify) ____________

57 Approximately how many years have you been using this Radiology Information System.

____________ years.

58 Sex: F ☐ M ☐

59 Age:

- < 20 ☐
- 20 - 30 ☐
- 31 - 40 ☐
- 41 - 50 ☐
- 51 - 60 ☐
- > 60 ☐

60 Number of years experience. ☐

Thank-you for participating in this study!

B. Provincial Technical Unit

Cost incurred in the production of technical units;

Costs include all activities related to;

Patient scheduling
Patient reception
Patient preparation
Preparation of necessary supplies for examinations
Production, development and verification of radiographs
Film library
Radioprotection of personnel
Planning, organizing, coordinating and controlling department activities.
In-Patient transport
Quality Improvement
Development of human resources.

Specific Cost Items;

Labor:	**Material:**	**Other:**
Salaries Fringe Benefits	Contrast Media Film and chemical solutions Medical and surgical supplies Radiation protection supplies Office supplies	Equipment rental Purchased services Travel expenses

Source: AHQ-Systeme Operationnel et Financier Informatise (SOFI)

C. PLS Data Output—Complete Model

PLS Output Complete model.

Number of cases in full model: 274
Number of cases per sample: 274
Number of good samples generated: 100
Number of good samples: 100
Outer Model Loadings:

	Entire sample estimate	Mean of subsamples	Standard error	T-Statistic
individu:				
v2	0,8472	0,8438	0,0328	25,8174
v31	0,7839	0,7879	0,0323	24,2371
v40	0,8780	0,8792	0,0198	44,2746
Utilizat:				
v26	0,8681	0,8711	0,0270	32,1654
v55	0,7383	0,7405	0,0434	17,0045
T/T fit:				
v23a	0,8682	0,8686	0,0289	30,0750
v54a	0,8221	0,8227	0,0257	31,9933
v1a	0,8814	0,8827	0,0185	47,5155
IT inve:				
v4	0,8682	0,8695	0,0163	53,4263
v9	0,8263	0,8228	0,0274	30,1559
v13	0,7966	0,8018	0,0385	20,6653
v27	0,6400	0,6213	0,0526	12,1659
v37	0,7441	0,7428	0,0366	20,3433
v41	0,7517	0,7513	0,0416	18,0719
Org. pe:				
v46	-0,8801	-0,8767	0,0230	-38,2016
v14	-0,8355	-0,8341	0,0295	-28,3202

Path Coefficients Table (T-Statistic)

	individu	Utilization	T/T fit	IT inve	Org. pe
individu	0,0000	10,0991	8,2095	0,0000	0,0000
Utilization	0,0000	0,0000	5,2111	0,0000	0,0000
T/T fit	0,0000	0,0000	0,0000	13,3159	0,0000
IT inve	0,0000	0,0000	0,0000	0,0000	0,0000
Org. pe	-8,4734	0,0000	-5,4173	-1,1393	0,0000

PLS Output - Reduced Model

Number of cases in full model:	274
Number of cases per sample:	274
Number of good samples generated:	100
Number of good samples:	100

Outer Model Loadings:

	Entire sample estimate	Mean of subsamples	Standard error	T-Statistic
individu:				
v2	0,8472	0,8438	0,0328	25,8174
v31	0,7839	0,7879	0,0323	24,2371
v40	0,8780	0,8792	0,0198	44,2746
Utilizat:				
v26	0,8681	0,8711	0,0270	32,1654
v55	0,7383	0,7405	0,0434	17,0045
T/T fit:				
v23a	0,8682	0,8686	0,0289	30,0750
v54a	0,8221	0,8227	0,0257	31,9933
v1a	0,8814	0,8827	0,0185	47,5155
IT inve:				
v4	0,8682	0,8695	0,0163	43,7493
v9	0,8263	0,8228	0,0274	27,5607
v13	0,7966	0,8018	0,0385	22,7728
v27	0,6400	0,6213	0,0526	10,0364
v37	0,7441	0,7428	0,0366	22,5567
v41	0,7517	0,7513	0,0416	16,6453
Org. pe:				
v46	-0,8801	-0,8767	0,0230	-9,4836
v14	-0,8355	-0,8341	0,0295	-43,1009

All coefficients and loadings significant t>1.65

Path Coefficients Table (T-Statistic)

	individu	Utilization	T/T fit	IT inve	Org. pe
individu	0,0000	10,0991	8,2095	0,0000	0,0000
Utilization	0,0000	0,0000	5,2111	0,0000	0,0000
T/T fit	0,0000	0,0000	0,0000	0,0000	0,0000
IT inve	0,0000	0,0000	0,0000	0,0000	0,0000
Org. pe	-8,4734	0,0000	-5,4173	-6,8332	0,0000

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