An Exploration of the Factors Affecting Consideration of Usage of Open Source Databases in Organizations

by

Pindaro Epaminonda Demertzoglou

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ABSTRACT

The literature suggests that research on technology adoption in organizations is fragmented and inconsistent. In addition, a comprehensive framework is missing to guide research for academics and decision making for managers. Adding the late advent of open source software with high interest for commercial applications the situation becomes even worse. Being even more specific and narrowing our scope to open source databases we can readily conclude that such research is practically non-existent. Databases constitute the cornerstone of information systems in organizations at the basic transactional-operational level and further up at the tactical and strategic levels with OLAP and data mining applications. The aim of this paper is to take the TOE framework, expanded with new constructs, and enrich it to produce a model that can be used both for further research and by practitioners. In doing so, a comprehensive view of the key issues in the literature is presented with details about pitfalls and points of focus that the researcher should not overlook.

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INTRODUCTION

This thesis focuses around three major notions: technology adoption in organizations, open source software (OSS), and database servers. Technology adoption is the research area which we try to illuminate working in the neglected open source area, narrowing the research to open source databases.

Assimilation of innovations in organizations is a big research stream by itself. Considering the fact that this stream of research goes back to the 40s, one would assume that by now a well-defined research framework exists. Unfortunately, this is not the case; fragmented and inconclusive results are still occurring phenomena.

In addition, the student of technology adoption in organizations cannot simply start examining the topic by using the organizational level of analysis. A comprehensive understanding of user acceptance models should exist before a researcher can delve into more complex models at the organizational level. This is all the more valid since whatever the level of analysis is - individual, unit, organizational, specific industries, aggregate economic sectors, the whole economy or any other macro-economic level- it is a question of whether the individuals in that unit of analysis will finally adopt and use the technology. Consequently, starting at the individual level we have identified two fundamental lines of research that try to explain user adoption of innovations. The first uses Behavioral Intention (BI) as the predicting factor and the models are usually derived from the fields of social psychology and sociology. The second and most known one is based on Roger's (1983) Diffusion of Innovations Theory (DOI) which paradoxically has been used with mixed results in research where the unit of analysis is not the individual user. Finally, it is natural for some researchers to try to combine BI and DOI like Taylor and Todd (1995), (Venkatesh et al. 2003), Franz and Robey (1984), Markus (1983). Models highly cited in the literature for individual acceptance of innovations include: the theory of reasoned action (TRA), the technology acceptance model (TAM), the resource extended technology acceptance model (R-TAM), the theory of planned behavior (TPB), the decomposed theory of planned behavior(D-TPB), TAM and TPB combination, the motivational model (MM), the model of PC utilization (MPCU), the diffusion of innovation theory (DOI), the social cognitive theory (SCT), the unified theory of acceptance and use of technology (UTAUT). All these models are examined and depicted in this thesis in chapter 3 and their strong and weak points are exposed.

Given the prevalent reference of the above models in the literature, one would expect that a basic research framework has been formulated. However, there are some authors like Seligman (2000) who suggests that these models follow a rational and sequential process to innovation adoption and the adopter is viewed as a black box. He rather suggests the concept of sense-making as the deciding factor of adoption which is retrospective and concentrates on the person itself and not on the activities or behaviors of that person. Other authors tried to understand the phenomenon better by studying pre-adoption and post-adoption beliefs like Karahanna et al. (1999). Other authors try to see the adoption of technology as a continuum from the organization to the individual distinguishing between primary and secondary adoption and thus implicitly combining the two levels of analysis (Fichman and Kemerer 1999), which is a fact that received considerable criticism from the literature.

Proceeding to the organizational adoption of innovations, we see a variety of models trying to theorize on the phenomenon. However, at this level, research is fragmented and inconclusive lacking a general framework that can constitute the basis for future research and a guiding point for decision makers in the industry. A multitude of problems at this level is reported in chapter two in this thesis and all the existing models are examined in chapter three. In addition in chapter three all the major issues in technology adoption in organizations are discussed. Organizational models that appear in this thesis include: McFarlan and McKenney's Model (1982), Roger's Five Stage Model (1983), Kwon and Zmud's Six Stage Model (1987), Zmud and Apple's Six Stage Model with Post-Implementation Considerations (1989), Gatignon and Robertson (1989), Cooper and Zmud (1990), Daugherty, Germain, and Droge (1995), Fichman and Kemerer (1997), Lai and Guynes (1997), Chau and Tam Model on Adoption of Open Systems (1997), Premkumar Roberts (1999), (Chengalur-Smith, Duchessi 1999), Zhu, Kraemer, Xu, Dedrick, Lee and Runge (2001), Kendall, Tung, Chua, Hong, Critical Mass Marcus (1987), Absorptive Capacity Theoretical Model, Organizational Learning Attewell (1992), Charles R. Franz, Daniel Robey (1984), and Bridging Theory by Yetton et al. (1997).

Though research is fragmented, each model serves as a foundation pillar for future research and enhances the understanding of technology adoption in organizations. In addition, no matter how fragmented research is in this field, it is obvious that some basic frameworks can be derived. We conduct the data analysis in chapter three and in chapter four we present all the details and comparisons among research methods. Some basic clusters are quite obvious from the literature: First, models can be categorized in stage and factor models with different research designs and allowable conclusions for each. Actually, we followed this approach and in chapter three we categorize models this way. The other major finding is that there is a strong division in the literature according to the unit of analysis. Consequently, there is a stream for the individual level and a stream for the organizational level. Of course there are studies which span industry sectors and other efforts to construct a research framework but the above constitute the two basic partitions in the literature.

In this thesis we try to understand the factors affecting the adoption of open source databases by organizations. Consequently, we need to use a factor model with cross-sectional data to do this. The literature at this point is quite consistent: in chapter four we report on the research design and methods of similar studies to ours and there are some consistent conclusions. First, most authors use factor analysis to test the proposed factors and then since the independent variable is in the vast majority a categorical one, a PROBIT or LOGIT model is used. Also, almost all the studies are cross-sectional in nature as it is the norm in factor models. In our data analysis we stay away from regression and instead we use partial least squares.

Narrowing the research area, we have identified an area which is practically unexplored by the academic community and highly investigated by managers in commercial organizations. This is the area of open source software. Researchers like Chau and Tam (1997) talk about the lack of research in this area and at the same time underline the fact that a myriad of open source articles exist in practitioner magazines. But even the little bits of existing research consist of mostly vertical studies or in other words they focus on highly successful and widespread programs like Apache or Linux Capiluppi et al. (2003). Other authors like Crowston and Scozzi (2002) correctly point out that if we consider the stream of open source adoption in organizations, then the situation is even worse in terms of number of studies. These authors also point out the limited scope of research which in general investigates factors contributing to successful open source systems. Simple interest or a successful OSS program does not mean automatic adoption from organizations.

Finally, we narrow our research even more by examining the factors affecting the adoption of open source databases in organizations. Research on adoption of open source databases in organizations is almost non existent. Open source databases have evolved and can practically compete at par with the commercial giants in the industry. Moreover, they are already used by commercial organizations. In addition, the author is a database administrator by profession, and the penetration of open source databases in the market is meteoric and cannot be ignored.

Open source databases like Berkeley DB, Cloudscape/Derby, Ingres, MySQL, and PostgreSQL are products well established in commercial applications and a Forrester Research Survey of 140 big companies in north-America revealed that 52% of them plan to use or are already using open source databases. (Yuhanna 2004, p. 2) Databases, whether open source or commercial, and whether relational or hierarchical constitute the backbone of transaction processing in every corporation and in most cases the cornerstone of the decision support processes as well. Consequently, big changes in this software area cannot be ignored. The current share of open source databases is estimated by Forrester Research at $120 million out of a total market of $10 billion. The slice might seem small but the rate of adoption is dazzling and the share is expected to go up to 1 billion by 2008 (Yuhanna 2004, p. 2).

Given the fact that open source databases are around for two decades and their high current penetration in commercial applications, it is hard to believe that research is practically non-existent. The main purpose of this thesis is to illuminate a little bit this shady area. Furthermore, open source databases are not used by small, obscure companies but by names like Associated Press, Yahoo, NASA, Suzuki, Google, Daimler-Chrysler, Ericsson, and others (Bloor 2005), (Yuhanna 2004), (MySQL website 2005).

Finally, in chapter four of this thesis we present the results of our research and in chapter six we conclude by reporting the limitations and future research avenues.

CHAPTER 1 PROBLEM STATEMENT

Introduction

A careful review of the technology adoption literature would reveal a multitude of problems. First, the choice of the unit of analysis is problematic with many authors choosing to examine the topic at the individual level, leaving out the departmental and organizational ones since collection of data and identification of constructs is much easier for the individual rather than the organizational level.

Second, even at the organizational level, models tend to be highly parsimonious, thus decreasing the value of the model for practitioners.

Third, it seems that some researchers do not fully understand the technology they are examining which leads to omission of factors and indicators or specific features of a technology otherwise crucial for the model they are building.

Fourth, some researchers try to capture all the stages of technological introductions in organizations, from adoption to diffusion with little data to support such an enormous scale of research with of course anecdotal results. Actually, the author has noticed in the literature journal articles where cross sectional data has been used for stage models which process by itself is impossible.

Fifth, it is common knowledge that the technological environment changes over time and the nature of change is not only the evolution of technologies but rather the whole approach of developing and disseminating the technology as is the case in open source software.

Sixth, it looks like there is not a coherent stream of research at the individual level and the situation is even worse at the organizational level. In the case of the latter it seems that authors simply choose a technology they feel comfortable with, a number of factors are thrown in, and a model is built.

Seventh, a vast majority of research on this topic is based on Roger's work and his book now in its fifth edition (2003) which is forced to serve as the basis for all kinds of individual or organizational models whether they are based on Behavioral Intention (BI) or on the theory of Diffusion of Innovations (DOI) or whether they are stage or factor models.

Eighth, the research literature is very biased towards adoption of innovations and change that it ignores resistance and focusing to a disproportionate degree on factors affecting adoption and not on factors affecting rejection of innovations.

Ninth, the problem becomes more accentuated when we look at technologies like open source software with great dynamics but little diffusion in the industry yet and consequently mostly ignored from researchers.

Tenth, a comprehensive theoretical framework that organizes current research and provides future directions seems to be missing from the literature.

Eleventh, there is a continuum problem with theory building and introduction of new technologies to organizations. That is, for theory building processes, researchers focus on a specific set of constructs. However, and irrespectively of the model (DOI, TOE) used the theoretical base might change due to the introduction of new technologies and their interaction with the intra and inter organizational environments of the corporation.

If we take the subject further and try to understand the factors affecting adoption of open source databases in organizations, we will quickly realize that such research is nonexistent. At the same time it is very important because no matter the intended use of the database (transaction processing or decision support system) we know that a database system comprises the backbone of the information system of any corporation.

1. The Unit of Analysis Problem

The literature strongly suggests that technology diffusion has been studied much more extensively at the user level of analysis (Kendall et al. 2001, p. 227). The reason is that researching at the individual level is more attainable and less complicated than at the organizational level. (Taylor and Todd) (p. 144).

Chau and Tam (1997, p. 3) criticize authors who use traditional models of innovation diffusion for individuals like Roger's and try to adopt them at the organizational level. Such adaptations are problematic because of "failure to recognize the differences in unit of analysis, environment, and technology characteristics." Other authors express the same opinion (Lai and Guynes 1997, p.147). The above is an indication that there does not exist a comprehensive theoretical basis on which researchers can rely for a sound starting point for their research.

2. The Level of Abstraction Problem

As Fichman and Kemerer (1997, p.1349) point out, organizational innovation using IT technologies is a problematic area because researchers work on highly parsimonious and abstract models which fail to encompass the particular factors affecting the introduction of a technology. Building abstract models is not a problem at all since they constitute the basis for research and the establishment of theory but maybe they need to be complemented by additional models taking into account the peculiarities of a technology as is the case in open source databases. This approach of dual models of theory and application will also help bridge the gap between the academic community and industry professionals.

Chau and Tam (1997, p. 3) complaint that too much research is done on individual technologies. As a result the theoretical power of models obtained with application specific research would not be so strong and could not function as the foundation for future research. Other authors complain that research is done on a general level and results might vary from industry to industry (Kunnathur et al. 1996, p. 16).

3. Research Instruments are not Well Developed.

As Zhu et al. (2004 p. 45) suggests, the research instruments for technology adoption in organizations are not well developed. More research is needed to understand existing technologies and at the same time research instruments should evolve to account for additional leaps in technology. Grover et al. (1993, p. 2) recognizes that substantial research has been made on the topic but this research stream "has also been limited both conceptually and methodologically.

4. Analyzing Stages of Technology Adoption with Little Data

Fichman and Kemerer (1997) conducted a study involving the IT departments of 608 medium and large organizations. The technology in focus was object-oriented programming languages and they were trying to identify the factors affecting the assimilation of such languages in organizations. Assimilation is defined as "the process spanning from an organization's first awareness of an innovation to, potentially, acquisition and widespread deployment." (Fichman and Kemerer 1997, p. 1346). Having a look at the research design on page 1353 we can see that they used a survey instrument and collected cross-sectional data. The question is how is it possible to obtain reliable results from cross sectional data when actually longitudinal data is needed to assess the progress of technology assimilation from adoption to implementation.

Another striking example in the literature is the work by Cooper and Zmud (1990) where they researched all stages and all factors within each stage in MRP implementations. Questions arise about the validity of the study since results are based on a cross sectional survey only and moreover a host of authors have underlined the importance of time when building or researching stage models (Gallivan 2001, p. 55, p.58), (Rogers 2003, p. 127), (Fichman and Kemerer, 1997, p.1342) (Lai and Guynes 1997, p.155).

5. New Research is Needed for Emerging Technologies

An emerging technology is evaluated for introduction into the organization for multiple reasons. For example, reducing cost, increase speed of operations, provide competitive advantage, increase revenues and a host of other reasons. However, the change is not only technological in most cases. New technologies would in some cases change existing processes (Attewell 1992, p. 6) and in other cases redefine the operations of an organization altogether as it is the case with ecommerce technologies where a new sales channel is created (Gatignon and Robertson 1989, pp. 35-36). These kinds of technologies are termed by Fichman and Kemerer (1997) as Software Process Innovations (SPIs) and in the 80s and 1990s were technologies like CASE tools, relational databases, and object-oriented technologies to name a few (p. 1348). Recently, this has been the case with open source software. Research should require the development of new models to account for the new approaches and characteristics of open source applications. While older models do not lose their value and actually formulate the basis for research yet they need to be improved and potentially expanded to accommodate these advances. Model parsimony while always important should not keep researchers back from developing models to capture the particular characteristics of technology innovations.

The problem of the specificity of the technology being researched is very well captured by Daugherty et al (1995, p. 311) who claims that even less is known about technology adoption about particular technologies. Obviously, these are indications that the theoretical framework on this research stream is not there yet.

Chau and Tam (1997, p. 3) go a step further when they claim that "many conflicting results on organizational innovation reported in the literature could be attributed to the contextual differences of these studies. Thus, innovation adoption decisions must be studied within appropriate contexts and with variables tailored to the specificity of the situation." Thus the question becomes if and to what extent we can build general adoption models or should we derive conclusions based on the organizational, environmental, and technological context.

Grover et al. (1993, p. 10) ponder on the same issue and they were surprised to find that more decentralized organizations tend to be more effective in adopting and using innovations than centralized organizations. They claim that "while surprising, this result might be an artifact of the nature of the technologies being discussed." However, the nature of the technology in Grover's study was communications which actually helps a corporation to decentralize. Studying a different technology might have yielded different results.

6. Confusing and little Research at the Organizational Level

Examining the factors affecting organizational innovation is a problematic area in IT research and it is not a new problem. Going back to the 1970s, 1980s, and 1990s, organizational innovation using IT has always been a problematic area for researchers. Specifically, results from research were not consistent and comprehensive and definite findings were rare (Fichman and Kemerer 1997, p. 1349) (Lai and Guynes 1997, p.147) (Lee and Kim 1998, p. 287). Up until the mid 1990s this topic received very little attention from researchers (Swanson 1994, p. 1072).

To the justification of Fichman and Kemerer's point of inconsistent results let us take as an example the factor of centralization. Gatignon and Robertson (1989, p. 43) and (Lai and Guynes 1997, p.154) claim that the degree of centralization of a corporation is insignificant as a factor for predicting adoption outcomes. However a host of other authors (Gordon 1993, p. 153), (Chengalur-Smith and Duchessi 1999, p. 79) (Lai and Guyness 1997 p. 148), (Daugherty et al 1995, p. 312) claim that the opposite is true.

At the same time Chengalur-Smith and Duchessi (1999, p. 87) and Grover et al. (1993, p. 11) concluded that organizational size does not have any impact on the adoption process of a new technology. Yet authors like Premkumar (1999, p. 480) and Lai and Guynes (1997, p.154) clearly state that size is a critical factor for the adoption of technology innovations with other authors feeling rather ambiguous about this relationship postponing conclusions for future research (Daugherty et al. 1995, p. 321). Research becomes more confusing if we take into consideration that size as a factor is reported as a structural dimension by some authors and as a contextual dimension by some others. For instance, Daugherty et al. (1995, p. 311) consider size a contextual dimension which is a questionable choice by itself.

However, one factor where the vast majority of authors agree is that of the relative advantage resulting from the introduction of the technology (Chengalur-Smith and Duchessi 1999, p. 87) (Kendall et al. 2001, p. 235) (Daugherty et al. 1995, p. 311) with some authors going so far as to claim that relative advantage was the only significant factor that would differentiate adopters from non adopters (Premkumar 1999, p. 480).

(Lee and Kim 1998, p. 287) sagaciously point out that "the term 'innovation' has been used in three different contexts: 'an invention', 'a new object', and 'a new process'." Moreover they distinguish between general organizational innovation and IT-based organizational innovation with the latter demanding more attention in the literature. Finally, they refer to what they call "interrelated IT innovation" or in other words the research stream that should be generated when two or more IT technologies interact within the organization.

Actually, (Gallivan 2001, p. 56) explains that "one other scenario where traditional models appear to fit least well is one that combines both organizational mandates to use innovation and complex technologies requiring coordination among users." Research findings are very inconsistent in this research stream and the opinion of this author coincides with that of Lee and Kim (1998).

However, there are some constructs for which the literature is consistent. For example technological complexity is such a construct and authors agree that it inhibits organizational innovation. (Cooper and Zmud 1990 p. 128) (Chengalur-Smith, Duchessi 1999, p. 80) (Premkumar 1999, p. 471).

A notable point comes forward from Premkumar (1999, p. 468) when he stresses that most research on organizational adoption of innovations is based on data from big businesses. The literature supports his point and actually the significance is high if we consider that the economy runs on the output of small businesses and not large corporations. If we also consider the fact that small businesses do not have the resources to acquire high-end technologies, then it is obvious that a study examining the consequences of open source databases is very relevant.

Grover et al. (1997, p. 274) claims that

> "...most IS innovation work studies specific IS innovations, using contextual factors from other innovation studies. This implicitly presumes that that all IS innovations are homogenous in their property to be adopted or diffused and can be modeled using a set of common constructs."

This is of course not possible as the nature of the technology seems to constitute a factor. The same rationale has been presented by Swanson (1994) when he extended Daft's (1982) dual-core model. Practically, authors are striving to model situational phenomena pertaining to individual technologies.

Authors like Fichman and Kemerer (1999, p. 256) criticize the concept of adoption of innovations and rightly so since adoption should be followed by implementation. This is a valid point but outside the scope of research of this paper. Assimilation gaps should be identified but with longitudinal data and not cross-sectional studies. It looks like that practical problems in conducting research limit the validity of the studies. For example, assimilation gaps might be wide for the first six months or a year after adoption but then knowledge barriers go down assimilation gaps narrow.

7. Confusion Between Stage and Factor Models

Cooper and Zmud (1990, p.125) claim that previous research does not encompass all the stages and factors involved in organizational adoption. This means that there is a lack of understanding of the stages and the factors involved in each stage. These authors created a matrix of stages and factors but recent research indicates that not all factors are applicable to all stages. The bottom line is that there is not yet a clear idea of the factors and stages involved in organizational innovation.

A significant view is that of Gallivan (2001, p. 58) however when he explains the differences between stage and factor models. He clearly indicates that stage (process) models are well suited to explain how phases in IT adoption unfold, in what context, and "... the causal linkages and temporal relationships among context, behavioral processes, and outcomes."

8. Literature Is Biased Towards Organizational Innovation

Gatignon and Robertson (1989, p. 36) claim that current research on organizational innovation focuses too much on the adoption outcome ignoring factors that predict rejection. Gatignon and Robertson's model is one of the exceptions where rejection is considered as the dependent variable. However, there are other authors like Lai and Guynes (1997, p.152) whose study examines the reasons for rejection of ISDN technologies by organizations.

9. No Research on The Adoption Of Open Source Systems

Chau and Tam (1997, p. 2) refer to the fact that from 1989 to 1992 no research on open source software was done by the academic community while during the same period more than a 1000 articles appeared in professional publications.

Chau and Tam (1997, p. 4) claim that the Tornatzky and Fleischer framework constitutes an excellent foundation on which research about open source software can be based at the organizational level. The reason is that this framework takes into consideration the organizational, environmental and technological context within which the technological innovation occurs. This is indeed a powerful starting point and it often constitutes the basis for studying technology adoption. However, it is not enough; having a look at the literature we can see that another couple of factors do play a critical role. Those are the characteristics and perceptions of the primary decision maker, i.e. the individual who will be making the decision and the technology-task fit. Both factors complement the TOE framework.

While open source software is a tiny fragment in the ocean of academic research, both private and public organizations use open source software to achieve their objectives. The Science Activity Planner, NASA's analysis tools for data collected through the two rovers on Mars, consists of eight open source packages. Castor, MySQL, HSQL, and other packages are used by NASA in its SAP package. One would notice immediately that seven out of the eight packages are database-related. For example, MySQL is a database server, Castor a database depository when connection from the client to the server is non-existent. Castor is the tool used to move data between XML files and databases, or in other words between hierarchical and relational formats, an occurrence common in everyday business scenarios. What is the reason for which NASA chose to use open source software and not one of the commercially available and tested database packages like MS SQL server which is a tested product and can provide the same functions through its MSDE database, DTS services, database server, XML add-ons etc? (Norris, 2004 p. 42 and p. 44).

Crowston and Scozzi (2002) p. 3 claim that the "small number of organizational studies" on open source software require additional investigation by the research community. Also, most of the studies on open source fall under two categories: what are the factors that create interest in open source and what are the factors for open source success. However, any organizational study is highly contextual as it has been suggested repetitively and, for instance, open source software for game development over the internet will differ from open source transactional databases.

Other authors like Capiluppi et al. (2003) correctly point out that the existing empirical studies on open source projects are highly scattered and around highly visible products like the Apache web server. They also claim that most of the studies are vertical in nature with a noted lack of horizontal studies. That is, most research papers investigate thoroughly a single product instead of investigating the characteristics of numerous OSS packages.

Kshetri, (2004 p. 74) conveys yet another truth about OSS: For the last two decades software development was concentrated in Europe and America. However, with the advent of open source and its accessibility due to cost and nature, any economy around the world can develop tools having full access to the source code of a package. Thus, corporations have access to a much greater number of choices, custom built solutions, and at a lower cost which are factors that cannot be ignored for competitive purposes.

Feller and Fitzgerald (2000, p. 58) claim that the "software crisis" term first appeared in 1968, almost 40 years ago. It means long development cycles, non compliance to specifications, high cost, and inflexibility. These are still common problems and continue to plague the software industry today. Some see open source as an answer to these problems but others are very skeptical. Feller and Fitzgerald cannot simply see open source as the "silver bullet" that will solve all problems underlining the fact that OSS research is scattered and usually about high profile success cases with packages like Linux, Apache, and MySQL. It is obvious that more research is needed across a great variety of available software.

10. Lack of a Comprehensive Research Framework

Cooper and Zmud (1990, p.124) argue that there is little progress in organizational research in both progress and direction and attribute the phenomenon on a lack of appropriate frameworks to direct research.

Prescott and Conger (1995, p. 20) tried to put together such a framework by using the Locus of Impact and the research approach as criteria. That is, the first criterion has been whether the study is at the unit, organizational, or inter-organizational level. The second criterion is whether the model is a factor or stage model. Among their findings is that environmental and contextual factors play a bigger role in inter-organizational studies, whereas at the individual unit of analysis organizational influences diminish in importance.

Research like that of Prescott and Conger is of the outmost importance and extremely useful. However, I have yet to see an article or study which examines in detail the theoretical foundations of organizational innovations and of course the case becomes even worse if we look for a theoretical framework to expand theory on open source software. In this study we try to solve both these problems.

11. Continuum Problem with Theory Building

Agarwal and Tanniru (1992, p. 196) note that organizations are continuously looking to acquire new information technologies to reduce cost, improve processes, and thus obtain a competitive edge. Information Technology is recognized as a major factor driving change in organizations. However, technology changes not only in terms of improvements in particular software and hardware but in its nature as well. For example from MRP now we discuss about ERP software that encompasses all the internal functions of the organization and from a sales force automation system we moved to discuss the ramifications of CRM systems. By the same token from commercial transactional databases like MS SQL, Oracle, and IBM DB2 we are seeing the emergence of open source databases like MySQL and Postgress SQL which are redefining the plans of CIOs in organizations due to different development processes, cost, and license basis.

12. Two Competing Theories of IS Innovation

Innovation Characteristics Theory and Implementation Process Theory are practically competing to explain the same phenomenon with the first focusing on the characteristics of the innovation and the second focusing on the correctness of the implementation process. Consequently, it is important to integrate the two theories and build a common framework so that stronger theory can be developed and practitioners can really use the framework. However, on page 4 Yetton et al. (1997) admit that innovation characteristics theory is applied at the individual level of analysis while implementation process theory applies to group or organizational settings. Consequently, I have my reservations in integrating two theories that apply to different levels of analysis. This is a real concern knowing already that the unit of analysis is already a big concern in innovation theory in general and the recipient of considerable criticism.

Research Questions

1. What are the organizational characteristics indicating a company is prone to adopt open source databases?

2. What are the technology characteristics that prompt a corporation to adopt open source databases?

3. What are the environmental factors facilitating or inhibiting the adoption of open source databases by corporations?

4. What are the task-technology matches that will facilitate adoption of open source software?

5. What are the characteristics of individual decision-makers at the senior management level that will affect the adoption of open source databases?

Chapter Summary

In this chapter we presented the problematic areas of research for the adoption of technology innovations from organizations. Practically, we have identified twelve major areas as they follow from the current literature. There are problems with: the unit of analysis, the level of abstraction, the research instruments, data scarcity, time lag between emerging technologies and produced research, confusing results, misapplication of research models, biases towards factors of adoption with little research on rejection, very little research on open systems vertically in general and horizontally in particular, lack of comprehensive research frameworks, continuum problems due to the changing nature of technologies, and separate research streams trying to answer the same questions.

CHAPTER 2 LITERATURE REVIEW

Individual Adoption of Information Technology

For the user acceptance of information technology research area many different models exist for explaining usage and usage intention and drawing from a variety of related disciplines such as sociology and psychology. There are many levels of analysis at which the adoption, usage, and value of IT are examined. Some authors prefer to study the phenomenon at a macro-economic level, examining the economy, aggregate economic sectors, and specific industries (Panko, 1991) while other authors focus on a micro-economic or firm level. Finally, a very strong and important stream of research focuses on the adoption and usage of technology by individuals (Taylor and Todd) (p. 144).

At the individual level per se there are two basic lines of research that assess adoption and usage of technology. The first line of research focuses on behavioral intention (BI) as a predictor of IT adoption and derives its models from the fields of social psychology and sociology. The second line of research examines technology adoption and usage using Roger's Diffusion of Innovations Theory (DOI). Finally, there have been combinations of BI-based and DOI-based theories in an ever-increasing stream of models that try to explain individual technology adoption in organizations Taylor and Todd (1995 p. 145), Venkatesh et al. (2003), Franz and Robey (1984), Markus (1983).

There has been considerable research on diffusion of innovation and adoption of technology at the individual level or in other words where the individual has the choice or autonomy to accept or reject a technology solution or innovation. In 0 the basic concept underlying all models explaining individual acceptance of information technology is presented (Venkatesh, 2003). The models discussed in this paper are nine general ones including sub-models when the author felt necessary to include the ones that enhance understanding of theory.

1. **The Theory of Reasoned Action Model (TRA)**
2. **The Technology Acceptance Model (TAM)**
3. **The Resource Extended Technology Acceptance Model (R-TAM)**
4. **The Theory of Planned Behavior (TPB)**
5. **The Decomposed Theory of Planned Behavior**
6. **TAM and TPB Combination Model (C-TAM-TPB)**
7. **The Motivational Model (MM)**
8. **The Model of PC Utilization (MPCU)**
9. **The Innovation Diffusion Theory (IDT)**
10. **The Social Cognitive theory (SCT)**
11. **The Unified Theory of Acceptance and Use of Technology (UTAUT)**

Figure 1: List of Technology Acceptance Models at the Individual Unit of Analysis

The model of the Theory of Reasoned Action (TRA) was introduced by Fishbein and Ajzen in 1975 and it is a model that comes from the field of social psychology. This model itself has only two constructs that predict behavioral intention (BI) which in turn will predict the actual behavior of the individual. This actual behavior for the purposes of the adoption of IT will become usage behavior of a technology in accordance with the other models presented here. A thorough review of the model is presented by Sheppard et al. (1988) and reviewed and applied by Davis et al. (1989) and Venkatesh et al. (2003). The model appears in 0 and it shows the relationship of the two constructs of attitude and subjective norm to behavioral intention and usage behavior. According to this model:

$$BI = A + SN$$

Attitude Toward Behavior: An individual's attitude toward the adoption of a behavior will be defined by the person's perceptions about the consequences of the behavior whether positive or negative (Davis et al. 1982).

Subjective Norm is defined by two factors in this model. First, the individual will take into consideration self-perceived expectations of other individuals and groups about the adoption of a behavior. Second, the adoption of a certain behavior will depend on the individual's motivation to comply with perceived expectations (Davis et al. 1982).

A very strong point of the TRA model when applied to adoption of IT is that any factor that affects the adoption and usage of technology will do so through one of the two constructs of the model. According to Davis et al. (1989), variables like system design, organizational structure, user characteristics, implementation procedures, and even organizational politics will affect usage behavior (UB) through attitude or subjective norm making the model highly applicable and parsimonious in this respect. All these variables were called "external variables" by Ajzen and Fishbein (1975) and any of their effects will ultimately pass through the two TRA constructs of attitude and subjective norm.

Throughout the years of application of the Theory of Reasoned Action, it has been proved that the model holds strong in predicting human behavior. For example, Sheppard et al. (1988) refer to the fact that in more than half of the studies till 1988 the TRA model has been used outside its intended boundaries and still to their surprise demonstrated consistent and strong predictive power in choices of goals and alternatives. Consequently, the TRA model has very strong predictive ability and it is also parsimonious in its application thus expanding its ability to be used in multiple fields of study (Davis et al., 1982), (Mulaik et al. 1989), (Venkatesh et al., 2003), (Sheppard et al., 1988).

The Technology Acceptance Model

The Technology Acceptance Model was first formulated by Davis (1986) as a PhD Thesis at the Massachusetts Institute of Technology. Practically, it is a spin-off of the Theory of Reasoned Action and it has attracted major attention in the IS literature both in studies that provide extensions of the basic model and comparison studies with other models such as The Theory of Reasoned Action (TRA) and The Theory of Planned Behavior (TPB). As an advancement from TRA, Davis et al. (1989) claimed that TAM better predicted IT adoption than TRA. TAM is a model specifically developed for assessing information technology adoption. Unlike TRA the basic TAM model does not include subjective norm as one of its two basic constructs thus deviating from TRA in this respect and not explaining the influence of social factors (peers, supervisors) in technology acceptance. However, later studies put subjective norm back into the TAM model as we shall see below in detail. (Taylor and Todd, 1995), (Davis et al., 1982), (Davis, 1989) (Venkatesh et al., 2000), (Mathieson, 1991).

TAM appears in 0 and it contains two basic constructs: perceived usefulness and perceived ease of use.

Perceived Usefulness is defined as the extent to which an individual considers that the adoption of an information technology package will result in increased job performance. Davis (1989) stresses the word useful as the notion of "capable of being used advantageously." Thus the result is that individuals might consciously choose to use IT packages that they do not particularly like but which they perceive will enhance their work opportunities for raises and promotions (Davis et al., 1982), (Davis, 1989).

Perceived Ease of Use is defined as the perception of an individual that usage of a package will not result in tremendous effort by the part of the individual. That is the person using the new technology will be able to do so rather easily in terms of effort and the relationship between effort and perceived benefits should be a positive one for the technology to be adopted (Davis, 1989).

TAM also suggests that actual usage of a technology will increase performance in using this technology since perceived usefulness is a direct determinant of behavioral intention. This is also a major divergence between TAM and the Theory of Reasoned Action. The reason for such deviation is that the TAM model explains the case in which an individual might dislike a system but still use it since it is perceived that using the system might result in increased job performance (Davis, 1989).

Davis et al. (1989) suggests that any factors not explicitly included in the TAM model will ultimately affect ease of use and usefulness which are the two primary factors in the TAM model and through which all other external factors will impact intention and usage of IT.

According to Davis et al. (1989) a really useful model is the one that has both prediction and explanatory powers. Thus, TAM has been developed so that external factors can be linked to the individual's internal perceptions and determine the influence of external factors on these beliefs.

Consequently, following the rational of the TAM model, the easiest a technology is to use, the higher the perceived benefits and finally the highest the adoption of the technology. Thus, the TAM model is both simple and inclusive in its application for determining adoption of IT technology (Taylor and Todd, 1995), (Davis, 1989).

TAM does not include Subjective Norm and consequently excludes all social variables that might affect the attitude and behavioral intension of the user in the adoption of a system. However, Davis (1989) argues that social pressure is not independent from perceptions of outcomes and thus any such variables have already accounted for in the TAM model. Other researchers however like Mathieson (2001) argue that there might still exist some unique social variables that are not directly connected to job performance and outcomes and thus need to be taken into consideration.

Also, TAM is applying behavioral intention in a different, more restrictive way than other models. Specifically, TAM advocates through the "Ease of Use" construct that only the skill of the individual and ease of use of a technology will determine eventual usage of a system. However, Mathieson (2001) suggests that there might be factors such as limited corporate resources, limited access to the system and other variables external to the user's control that might prevent the individual from using the technology even if that individual believes that he or she has the skills to use the technology and also perceives that important job benefits will come from its use. Regardless of the rationale, Mathieson found that TAM outperformed TPB during the testing of the two models and concludes that TAM is inexpensive and easily applicable whereas TPB can be used to provide additional information about the factors individuals take into consideration in deciding to adopt and use a system. The same conclusion can be drawn from the comparative testing of eight models by Venkatesh et al. (2003) where the TAM and TAM2 models outperform TPB and DTPB models in predicting intention.

One of the most important contributions of the TRA and TAM models however is that they prove that usage behavior is affected by behavioral intention (BI). Thus BI as we have already noted, becomes a central and major predictor for the adoption and actual usage of IT and subsequently other models use BI as the major predictor of usage behavior (Davis et al., 1982).

In summary, the relative strengths of the TAM model are its focus on IS usage, its reliability, its validity, and its parsimony (Mathieson, 1991).

The Resource Extended Technology Acceptance Model (R-TAM)

As we have seen in the overview of TAM, some researchers expressed concerns that TAM excludes factors that might be important in predicting usage behavior of IT systems. Practically there are two areas of concern: The first is that TAM does not include a construct of user resources. In this sense, individuals might perceive that the system in consideration is both easy to use and with considerable perceived benefits for work performance but access to the system is limited due to time or capital, or other resource limitations. The second omission of TAM, that the literature is concerned about, is that it does not include any social variables. Both of these concerns led to the development of two extensions of the TAM model. The first extension by Mathieson (2001) creates a new construct, that of “Perceived Resources”, and the second by Davis himself and Venkatesh (2000), who added social variables in the model. It would be interesting to see what would happen to the TAM if both “Perceived Resources” and “Social Effects” were to be added to TAM at the same time but such study does not appear in the literature. On the other hand if both these factors were to be added to TAM, then it would assimilate to a high degree the Decomposed Theory of Planned Behavior Model (DTPB), which we will examine right after the basic TPB model. Consequently, we will look in the two extensions of the TAM model as separate cases.

The Resource Extended Technology Acceptance Model (R-TAM) appears in 0 and the major difference from TAM is that it includes one additional construct, that of perceived resources.

Perceived Resources is defined as the degree to which an individual perceives as having the personal and organizational resources to adopt and use the IS system in consideration. These resources can be hardware, software, capital, documentation, time, etc. (Mathieson, 2001).

The construct "Perceived Resources" (R) directly affects Perceived Ease of Use (EOU) and Behavioral Intention (BI), is unrelated to perceived usefulness (U), unrelated to attitude (A), and is related to usage behavior (UB) under certain conditions. R will affect EOU since R includes personal resources such experience and expertise which will affect the perception on the ease of use of the system in consideration. The relationship between R and BI should be positive and makes immediate sense since availability of resources would positively predisposition an individual towards the adoption of the system since there is a formed perception that the resources to use the system are available. There should not be a relationship between R and A or between R and UB. We know that attitude expresses the desirability of an individual to use a system and this desirability might not translate to intention (BI) if the necessary resources are not present. The relationship between R and UB is a very complicated one and adds undue complexity to the model. Practically, it represents the situation in which an individual has the resources to use a system and will either use it successfully when the relationship is existent or use it unsuccessfully because that individual overestimated his or her own intention (BI) to actually use the system in which case R is present but A is problematic.

For this reason some researchers differentiate between intention to try and intention of actual usage of a system. Actually, Bagozzi and Warshaw (1990) examine the models of The Theory of Goal Pursuit (TGP) and The Theory of Planned Behavior (TPB) and they propose a new theoretical model which distinguishes between intention of trying and actually using. They name this model The Theory of Trying (TT) and claim that it added considerably to the explanatory power of both TGP and TPB (Adams and Nelson, 1992).

Mathieson and Chin (2001) examined meticulously the introduction of the new construct of Perceived Resources (R) in the basic TAM model. First, they report that the TAM's constructs refer to situations where an individual makes a choice of IT adoption regarding a single system and at a single point in time. They claim that R follows the same rational of examining the perceptions about available resources for a single system at a single point in time. Second, the TAM constructs are task specific; performing specific system actions, and similarly R is task specific referring to perceived resource availability for the task or tasks in question. Third, Ease of Use, Perceived Usefulness, and Perceived Resources examine the same object in which case it is an IT system. Constructs such as peer and supervisor pressure differ (Social Norm) from EOU, PU, and R in the sense that they take a perspective internal to the individual. Finally, R should be at the same level of abstraction with EOU and PU. Mathieson and Chin (2001) developed an instrument based on Churchill (1979) procedure of developing measures at a high abstraction level as are the other two basic constructs of TAM. Churchill (1979) takes a very practical and useful approach for measurement and instrument development that make it particularly applicable in measuring perceptions in IT adoption models.

Maybe this is because his study referred to marketing research which is much related in trying to understand consumer perceptions and intentions.

The Theory of Planned Behavior Model (TPB)

The Theory of Planned Behavior (TPB) is an extension of the Theory of Reasoned Action (TRA) in the sense that it takes into consideration situations in which individuals do not have complete control over the adoption of information technology.

The basic TPB model appears in 0 and states that attitude, subjective norm, and perceived behavioral control determine behavioral intention which in turn determines usage behavior. In this model, usage behavior is a function of behavioral intention and perceived behavioral control. Behavioral intention in turn is formed by attitude, subjective norm, and perceived behavioral control. Attitude as a factor reflects the individual's favorable or unfavorable stance towards the technology introduced. Subjective norm refers to pressures from other groups or peers that the individual perceives are existent for the adoption of the technology.

Finally, perceived behavioral control (PBC) refers to internal and external factors that inhibit or facilitate technology adoption (Taylor and Todd, 1995) such as resources, favorable situation, opportunities, etc. The Perceived behavioral Control construct is of particular importance because it constitutes the main difference and extension from the TRA model. As Ajzen (1991), the founder of the TRA and TPB models explains, there was a necessity to extend the TRA model to deal with its limitation in occasions where a user does not have unlimited control over his or her choices. Then, the decision of a person to adopt or reject a technology will depend on the perceived control of actions, situations, resources, and outcomes. The concept of perceived behavioral control is very close to the concept of self-efficacy used in the Social Cognitive Theory Model and in the Decomposed Theory of Planned Behavior Model.

The Decomposed Theory of Planned Behavior Model (DTPB)

The extended TPB model appears in 0 and it has the advantage of incorporating many additional factors than the traditional TPB or even TAM models, making it much easier to understand behavior intention and usage of IT. For example, the "Subjective Norm" factor in the simple TPB is extended to include the influences of peers and supervisors which represent specific cases of pressure from the social environment and can also be studied more effectively. Social determinants of IS use have been explored extensively by authors like Robertson (1988) in his award winning article in JMIS. Also, detailed models such as the DTPB can be used from practitioners more effectively since they present more specific and understandable factors than the broader TPB and TAM models.

Taylor and Todd (1995) report that the TRA and TPB models did not perform as well as the TAM model in comparative studies till 1995. Specifically, the TAM model outperformed the Theory of Planned Behavior Model in the prediction of Behavioral intention which is the cornerstone and common factor in TAM, TPB, and DTPB. However, Taylor and Todd proved that TPB provides a slightly better prediction of Behavioral intention than TAM. Specifically, it was found that subjective norm, has a very strong effect on behavioral intention, thus making TPB and DTPB in particular very strong candidate models for explaining usage behavior (DTPB in particular because it breaks down subjective norm in two specific factors of peer and superiors' influence).

While the DTPB model sacrifices parsimony and becomes more complex than TAM and TPB, it provides however increased explanatory power and understanding of its constructs. The DTPB model is also stronger in diagnostic power since the researcher or the practitioner can go back and analyze the structure and constructs of the model and are able to better determine why usage and adoption of the technology is not at the level required. Consequently, the DTPB provides a better model in the systems implementation area, while TAM in systems design and DTPB also provides a better understanding of the antecedents of the usage behavior of IT (Taylor and Todd, 1995).

The TAM-TPB Model

This model is a combination of constructs from the TAM and TPB models. Actually, there is no extension of any of the two models; simply Taylor and Todd (1995a), combined constructs from the two existing models to come up with a new model. The model appears in 0 and it practically appends the constructs of "Subjective Norm" and "Perceived Behavioral Control" from the TPB model into the TAM model. A discussion of the nature about the constructs will not be included here since these constructs have been already discussed above in the TAM and TPB models. However, the reasoning behind this combination will be discussed.

Taylor and Todd (1995a) argue that it was unclear that technology acceptance models would be predictive for inexperienced users since most of the work done to that point was based on systems that the users were familiar with. Also, the same authors argue that IT usage determinants might not be the same for users with experience and users without any experience. Also, the TAM model does not include, as we discussed, the influence of external factors such as social pressure, level of control, and others that might affect the eventual adoption of a technology. That is why Subjective Norm and Perceived Behavioral Control from the TPB model are included to extend the useful applications of the TAM model. An experiment including 430 users with prior experience and 356 users with no prior experience was conducted to test the validity of the combined TAM-TPB model.

The results of this study indicate that the TAM-TPB model fits the data for both experienced and inexperienced participants (Taylor and Todd 1995a, p. 564). However, when it comes to the path coefficients there were noticeable differences among the groups. For example, experienced users showed a stronger "Behavioral Intention" while surprisingly "Perceived Usefulness" was stronger in inexperienced participants. Of course "Ease of Use" was stronger (stronger predictor) for inexperienced users (Taylor and Todd 1995a).

One of the most important conclusions of the TAM-TPB model is that it can be used in situations where users did not have any direct experience with the system or in other words TAM-TPB can predict future usage behavior which makes it a diagnostic tool for systems before they are actually implemented (Taylor and Todd 1995a).

The second important conclusion from this model is that experienced users who show strong behavioral intention are expected to show strong usage behavior; for inexperienced users however the link between intention and behavior is not as strong. Consequently, management should expend the effort to inform and train inexperienced users about the system to strengthen this link (Taylor and Todd 1995a). The role of managers and its importance as perceived by end users is documented well in the literature as in the work of Leonard-Barton and Deschamps (1988).

Finally, the work of Taylor and Todd (1995a) suggests that a static view of the process of technology adoption is not enough but rather the related models should be able to capture the change in user experience as they become more familiar with the introduced technologies (Taylor and Todd 1995a).

The Motivational Model

Motivation theory suggests that there are two fundamental sources of motivation for an individual to perform a task: extrinsic motivation and intrinsic motivation.

Extrinsic motivation: "refers to the performance of an activity because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself, such as improved job performance, pay, or promotions." (Davis et al., 1992, p. 1112)

Intrinsic Motivation: "refers to the performance of an activity for no apparent reinforcement other than the process of performing the activity per se." (Davis et al., 1992, p. 1112)

Davis et al. (1992) found that an individual's intention to use a computer at work is mainly influenced by its perceived usefulness towards job related tasks. In other words, extrinsic motivation is the number one factor in the choice to use a technology. Intrinsic motivation and the liking of a technology play a secondary role in technology adoption at work settings. This empirically deduced conclusion makes the author of this paper reflect that many of the studies reporting results on individual models of technology adoption were not conducted in work settings. Some of them employed students while others were conducted through surveys away from work pressures. One would wonder if the balance of choice would further shift towards extrinsic motivational factors under pressing working conditions. Nevertheless, Davis et al. (1992) captures this fact in essence making the weights of extrinsic and intrinsic motivation towards individual technology adoption a secondary consideration for the time being.

Taking the above into consideration, one would argue that making a system more user-friendly or more "enjoyable" would increase its use. This is correct but there exist two pitfalls for organizations: First, attention might be driven away from mission critical systems that are not user friendly to systems of secondary or marginal importance that are enjoyable. Second, research indicates that if a system does not deliver work related benefits, its adoption rate will decrease no matter how enjoyable it is (Davis et al., 1992, p. 1125).

In a separate study, Venkatesh and Speier (1999) accept Davis' et al. (1992) model of motivation being a key determinant of acceptance and use of technology and try to assess the underlying principle that affects motivation. Specifically, they examine how mood affects an individual's motivation towards a task. They found that positive mood at the time of the initial training on a technology increases the level of intrinsic motivation for the short term with a leveling of this type of motivation in the long term. However, negative mood at the initial training will affect and decrease the level of intrinsic motivation both at the short and long terms. While this study is useful, the basic underlying factor is that the fundamental motivational type at the working environment is extrinsic motivation.

The Model of PC Utilization (MPCU)

This model has its roots on Triandis theory of human behavior back in 1977. Thompson worked on this model and adjusted it for use in computer utilization. The original model proposed by Triandis appears in 0 and the expanded model proposed by Thompson appears in 0. Thompson (1991) claims that while the Theory of Reasoned Action (TRA) is used widely in IS literature, the MPCU model includes many of the same constructs and elaborates and expands on them. Specifically, Thompson (1991) suggests that the TRA theory is based on "all beliefs" a person has towards a behavior while the MPCU model differentiates between perceptions for the actual use of the information technology and beliefs about future consequences from the use of the technology. The model consists of six constructs:

Long-Term Consequences of PC Use: Defined by Thompson as "outcomes that have a pay off in the future." For some users the long term outcomes might be more significant than the tasks of the actual and current PC tasks and operations. (Thompson (1991, p. 129).

Job Fit With PC Use: This construct refers to the short term benefits that an individual believes might get from using a PC. It relates to the current job performance of the individual and it measures benefits such as time and effort of performing a task at the present. For example, completing a task faster or obtaining the same results with less effort will lead to beliefs that the current PC use improves that person's job performance Thompson (1991, p. 129).

Complexity of PC Use: Thompson (1991) uses the definition of complexity offered by Rogers and Shoemaker (1971) where complexity is defined as "the degree to which an innovation is perceived as relatively difficult to understand and use". Thompson suggests that the more complex the PC utilization, the lower the utilization rate and consequently there should be a negative relationship between this construct and PC Utilization Thompson (1991, p. 128).

Affect Towards PC Use: Based on Triandis (1971) definition of Affect, this construct refers to "the feelings of joy, elation, or pleasure, or depression, disgust, displeasure, or hate associated by an individual with a particular act" and Thompson

(1991) suggests there should be a positive relationship between Affect and PC Utilization (p. 127).

Social Factors Influencing PC Use: According to Thompson (1991) this construct refers to the beliefs and opinions of others that affect what a person should do. Specifically, Thompson uses the definition provided by Triandis (1971) for social factors which is "the individual's internalization of the reference groups' subjective culture, and specific interpersonal agreements that the individual has made with others, in specific social situations" Thompson (1991, p. 126). Thompson suggests there should be a positive relationship between this construct and PC utilization.

Facilitating Conditions for PC Use: Thompson (1991) refers to the definition of facilitating conditions as given by Triandis (1971) stated as "objective factors 'out there' in the environment, that several judges or observers can agree make an act easy to do" Thompson (1991, p. 129). The idea is that environmental factors are critical and a behavior from a user cannot be exhibited if the right conditions are not present or do not facilitate the user intended behavior and of course it is expected that this construct shows a positive relationship with PC Utilization.

From the above constructs, Thompson (1991) found that there was no evidence that affect or facilitating conditions influenced PC Utilization while the rest of the constructs were found to influence PC utilization either positively or negatively as suggested.

Also, Venkatesh et. Al. (2003) suggests that this model measures usage rather than intention which is the focal point of the rest of the models. Consequently, this model needs to be adjusted for behavioral intention measurement if it is to be compared to the models presented in this paper.

In any event, a strong implication from this model is that some factors are more controllable than others. Consequently, practitioners should focus on the factors that are easier and feasible to control to affect the PC utilization and adoption of technology Thompson (1991).

The Diffusion of Innovations Theory (DOI)

The DOI model is based on the field of sociology and in particular on the work of Rogers (1983). Moore and Benbasat (2001) wanted to test the validity and reliability of Roger's constructs and consequently they developed an instrument to test the operationalization of the variables and the validity of the instrument itself. These authors paid particular attention to the generalization of the instrument to other types of information technology and not only to their specific study involving the adoption of personal workstations (PWS).

Also, Moore and Benbasat (2001) made a point in distinguishing between primary and secondary attributes of information technologies. They argue that primary attributes are intrinsic to the specific information technology and should not be used for the development of constructs or theory. For example, these authors refer to the cost of a specific technology which is a primary attribute. However, it is the perception of cost to the individual buying the technology that constitutes the secondary attribute from which constructs can be generated since what might be expensive for one individual might be considered relatively inexpensive for another. Also, this is the reason for which technology adoption models use perceptions instead of primary attributes of the particular technology. Based on the work of Rogers and the innovation diffusion theory, Moore and Benbasat (2001) came up with the following constructs:

Relative Advantage: Taken directly from Roger's original model, this construct refers to "the degree to which an innovation is perceived as being better than its precursor." (Moore and Benbasat 2001) (p. 195)

Compatibility: Again coming directly from Roger's model, it is defined as "the degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters." (Moore and Benbasat 2001, p. 195)

Ease of Use: This construct is the same as the one named "Complexity" in Roger's model and refers to "the degree to which an innovation is perceived as being difficult to use." (Moore and Benbasat 2001, p. 195)

Trialability: this is again one of Roger's original constructs and is defined as "the degree to which an innovation may be experimented with before adoption." (Moore and Benbasat 2001, p. 195). One important note here is that Moore and Benbasat decided to reduce the complexity of their model by leaving out this construct since its importance in an organizational context was significantly lower than the other constructs. The same authors note however that this construct becomes significant at the individual level for "those who would adopt an innovation at their own risk" as for example in studies of consumer behavior. (p. 210)

Image: defined as "the degree to which use of an innovation is perceived to enhance one's image or status in one's social system." (Moore and Benbasat 2001, p. 195)

Results Demonstrability: defined as "the tangibility of the results of using the innovation, including their observability and communicability..." (Moore and Benbasat 2001, p. 203). It is important to note that this construct came from a split of the original Roger's construct of "Observability." The other construct that came from the split is "Visibility".

Visibility: this construct measures the degree to which one can see other individuals using the system in the organization. (Moore and Benbasat, 2001).

Voluntariness of Use: defined as "the degree to which use of the innovation is perceived as being voluntary, or of free will. (Moore and Benbasat 2001, p. 195)

The Social-Cognitive Theory Model

The Social Cognitive Theory (SCT) is based on the work of Bandoura (1986) and its fundamental principle is that observing others performing a task affects an individual's perception about performing the same act. In particular, an individual's perception of own ability or self-efficacy will be shaped and performance strategies will be formed. SCT has been proven empirically sound and it has been widely accepted as a model of individual behavior (Compeau, 1995), (Compeau, 1999), (Compeau and Higgins, 1995).

There are two major dimensions of cognitive theory: The first dimension is the cognitive influence on behavior: There are two components making up this dimension and which will ultimately influence individual behavior: The first is the expectation of outcomes where individuals are prone to assume behaviors leading to positive and valuable outcomes while rejecting behaviors they perceive will lead to unfavorable results. The second component in an individual's behavior is the belief about "self-efficacy" or the perception of own ability to manage and perform a particular task. Expectation of outcomes and self-efficacy as described by cognitive theory will determine the effort, persistence, performance, and ultimate adoption of behaviors towards the use of information technology (Compeau and Higgins, 1995a).

SCT has been adopted by Compeau and Higgins (1995a) to explain individual behavior towards the adoption and usage of information technology. A model of four constructs (prior performance, self-efficacy, behavior modeling, and future performance) is used to assess the usage of computers by individuals and it appears in 0. Later, in 1999, Compeau and Higgins conducted an additional study and developed a new model that assesses "the linkages between cognitive factors" (p.147) but this model is a subset of the original one that is reported here. Thus, in this paper we present the basic, generic model of SCT as applied to adoption of IT. The basic constructs proposed by Compeau and Higgins appear below:

Prior Performance: If an individual has been able to perform a task successfully in the past, then the outcome expectations from future similar tasks would be expected to be positive as well. As Compeau (1995a) puts it "Enactive mastery, or successful execution of a behavior, is held to be the strongest source of information about self-efficacy." (Compeau and Higgins 1995, p. 122)

Self-Efficacy: this construct refers to the opinion or perception of one's own ability to achieve an outcome. As defined by Bandura (1986), self-efficacy is "People's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses (Compeau and Higgins (1995a, p. 191). Self-efficacy does not affect perceptions only but it will actually influence expected outcomes. A positive relationship has been found between self efficacy and outcome expectations.

In fact, self-efficacy is such an important construct for technology adoption, and in general in social psychology that Compeau and Higgins (1995a) devoted a whole study to assess it validity and reliability. In this study, three dimensions of self-efficacy had been identified:

a. Magnitude: referring to "the level of task difficulty one believes is attainable" (p. 192). Consequently, the higher the magnitude the higher the belief that one can accomplish difficult tasks.

b. Strength: referring to "the level of conviction about the judgment." (p. 192). In this respect, one with higher levels of self-efficacy will not be easily disappointed by difficulties and set backs in the adoption of a behavior.

c. Generalizability: referring to "the extent to which perceptions of self-efficacy are limited to particular situations." (p. 192). Thus, an individual might strongly believe that he or she can perform a behavior under some specific circumstances and not in the absence of them while someone else might believe they can perform the behavior under any circumstances.

Behavior Modeling: Cognitive theory suggests that observing others performing a task functions as a learning mechanism. Actually, by watching a task performed an individual's perception of being able to perform the same task increases. Indeed, modeling has already been used in teaching new behaviors and skills to individuals such as mathematics, leadership skills, and selling techniques (Compeau and Higgins, 1995).

Through this model it has been demonstrated that: First, behavior modeling can have a significant effect on self-efficacy, and self-efficacy influences performance with computers. Second, behavioral modeling can be used as a learning mechanism to alter self-efficacy perceptions and affect subsequent performance.

<u>Outcome Expectations</u>: individuals who expect favorable or positive results from the adoption of computers are more likely to learn and use computers. This construct refers to the evaluation of the consequences of an action, in this case the adoption of IT and computers. Positive expectations will lead to adoption of technology while negative expectations will slow adoption. Actually, outcome expectations affect both choice and performance in that individuals with positive outcome expectations will choose the technology and will exert a higher effort to attain the expected benefits (Compeau and Higgins, 1995).

The essence with Social Cognitive Theory as applied to the adoption of information technology is that though outcome expectations are important, there is a self factor, that of self-efficacy, that critically affects an individual's decision for adoption of the technology and subsequent performance of its use. Also, SCT promotes the consideration of environmental factors, such as the opinion of others, that will model the behavior of the individual.

The Unified Theory of Acceptance and Use of Technology (UTAUT)

One of the most impressive studies on technology adoption comes from Venkatesh et al. (2003) where eight previous models are compared and synthesized to arrive at a new model with substantially increased explanatory power. Practically, Venkatesh et al. combined elements from the TRA, TAM, MM, TPB, C-TMA-TPB, PCU, DOI, and SCT models to arrive at a model with four key constructs as it appears in 0. These four core constructs directly affect behavioral intention and appear below: It is important to emphasize that the model includes an additional four moderators that do not directly affect behavioral intention.

Performance Expectancy: is defined as "the degree to which an individual believes that using a system will help him or her to attain gains in job performance." (Venkatesh et al., 2003, p. 447). This construct is the result of the combination of five constructs from individual models and specifically, perceived usefulness from TAM, extrinsic motivation from MM, job-fit from MPCU, relative advantage from DOI, and outcome expectations from SCT. It should be noted that the above constructs represent the strongest predictors of behavioral intention in their respective individual model and regardless of obligatory or voluntary settings. Venkatesh et al. (2003) suggest that performance expectance will be moderated by age and gender.

Effort Expectancy: is defined as "the degree of ease associated with the use of the system." (Venkatesh et al., 2003, p. 450). This construct is formulated from three constructs from the individual models: perceived ease of use (TAM), complexity (MPCU), and ease of use (DOI). Venkatesh et al. (2003) suggest that effort expectancy will be moderated by gender, age, and experience.

Social Influence: is defined as "the degree to which an individual perceives that important others believe he or she should be able to use the new system." (Venkatesh et al., 2003, p. 451). The constructs from the individual models that represent social influence are subjective norm (TRA, TPB), social factors (MPCU), and image in DOI.

One key point about social influence models in the individual models is that they are not significant in voluntary settings but become significant in mandatory ones. Moreover, the construct of social influence is moderated by gender, age, voluntariness, and experience in the UTAUT model.

Facilitating Conditions: are defined as "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system." (Venkatesh et al., 2003, p. 453). This construct is based on the following constructs from the individual models: perceived behavioral control (TPB), facilitating conditions (MPCU), and compatibility (DOI). Furthermore, facilitating conditions is a construct moderated by age and experience.

The strongest point of the UTAUT model is its combination of constructs from the various individual models and the resulting increased explanatory power. Moreover, UTAUT introduces moderators such as sex and age which are usually not taken into consideration in technology adoption models. Furthermore, this model clarifies the gaps in the research literature among behavioral intention, usage, and outcomes. For example, while the link between intention and usage has been validated, the link between usage and success is not. For example, there might be an organizational scenario in which a technology has been accepted and used but this will not necessarily lead to successful organizational outcomes; more research on the firm level is needed at this point (Venkatesh et al., 2003).

We also need to make a reference to the goodness of fit of a model regarding its overall fit and parsimony. Mulaik (1989) refers to those characteristics of a model and challenges its goodness of fit when only a portion of the model can be validated. This is the case with extended models like DTPB where numerous factors are inserted and they are considerably expanded. Consequently, some researchers believe that we should strive for parsimony in model building where the best model is the one with the most predictive power and the fewer factors (Taylor and Todd, 1995), (Mulaik et al., 1989).

However, other researchers like McDonald and Marsh (1990) argue that general models will not fit and will not predict the population but the nature of the sample in the specific situation. Consequently, such models tend to approximate the phenomenon investigated and do not test the hypothesis on hand. Actually, McDonald and Marsh report that goodness of fit and parsimony are conflicting concepts and parsimony is not something we should strive for as researchers. In this sense, some complex models might be interpretable and some simple ones cannot be interpreted and thus of decreased value for applying them in practical situations. Actually, while parsimony is desirable in model building, it should be kept to the extent that makes the model useful and understandable. Consequently, a degree of parsimony might be sacrificed to make a model more applicable and understandable (Taylor and Todd, 1995), (McDonald et al., 1990).

Individual Adoption Summary

In this chapter, we examined in total eleven models that try to explain technology adoption and usage at the individual level. Nine of these models are practically based on Behavioral Intention (BI), one on Diffusion of Innovations (DI), and one is a hybrid model of the two lines of research. However, the above list is not by any means exhaustive. There exist additional models based on different principles than the ones we examined in this chapter. For example, Seligman (2000) suggests the concept of sense-making as the deciding factor of adoption, a concept based on the work of Karl Weick

(1995) in his book *Sensemaking in Organizations*. Seligman suggests that the models we examined above follow a rational and sequential process to innovation adoption and the adopter is viewed as a black box. Instead, the theory of sense-making concentrates on the person itself and not on the activities or behaviors of that person as other models do p. 362). Additionally, since sense-making is retrospective which means someone can reason about a fact that has already happened, behavioral intention seems to be a very poor measure of innovation adoption (Seligman, 2000, p. 364)!! This claim renders the models we discussed above questionable in their predictive power since most of them use behavioral intention as the critical predictive factor. Moreover, there is research that examines pre-adoption and post-adoption beliefs, attitudes, and behaviors like the study by Karahanna et al. (1999) but in this chapter we concentrated practically on models that try to predict technology adoption.

Organizational Adoption of Information Technology

Daft (1978, p. 197) defines organizational innovation as "the adoption of a new idea or behavior by an organization." Swanson (1994, p.1072) defines information systems innovation as "innovation in the organizational application of digital computer and communications technologies (now commonly known as information technology). I would agree with Swanson since today by IT we mean hardware, software, and telecommunications and consequently the definition given by Swanson still holds.

Technology adoption at the individual or organizational level is a topic being researched since the 1940's (Lai and Gayness 1997, p.147) and though the majority of the research to this point has been done at the individual unit of analysis, a shift is being happening to study the phenomenon at the organizational level.

Issues in Technology Adoption and Diffusion/Infusion in Organizations

1. Definition of Infusion

"This notion of depth of usage and level of impact is labeled technology infusion, where the infusion metaphor refers to the innovation penetrating down into the organization." (Gallivan 2001, p. 59)

"Embedding an IT application deeply and comprehensively within an individual's or organization's work systems" (Saga, 1994, p. 37)

"The extent to which an innovation is used completely and effectively and improves the organization's performance" (Lee and Kim 1998, p. 289)

2. Factors of Production

The neo-classical model of economic theory tries to explain the impact of innovation by the effect that it has on the prices of factors of production, namely labor and capital. According to the model, innovation will reduce the prices of labor or capital and it will induce changes in the choice of one factor over another. If innovation results in lower prices of capital, then labor becomes a more expensive factor and more investment will be diverted towards capital. Though models like these are acceptable for general conclusions, they are very general and cannot explain situational factors. Consequently, less parsimonious models are needed for explaining the role of innovation in organizations (King et al., 1994, p. 142).

3. Social Factors

Social and cultural factors will make a difference in the introduction of innovation and need to be accounted for when building models and defining the model scope. An innovation adapted in one country or one corporation will not necessarily be adopted the same way in a different social environment (King et al., 1994, p. 142).

4. Organizational Learning

Fichman and Kemerer (1997) take the view that technology diffusion in organizations is inhibited by knowledge barriers. That is, technology adoption and diffusion can be seen as an organizational learning process. This concept of linkage between technology adoption and organizational learning was first introduced by Attewell (1992) who suggested that organizations will adapt technologies with lower learning requirements or they will adopt a technology once the necessary knowledge exists in the corporation at a satisfying level. Fichman and Kemerer assert that for a technology to be introduced and used in an organization, a satisfactory knowledge level need to be attained for that technology (p. 1347). Daft (1978, p. 206) concurs that the adoption of an innovation will depend on the skill or knowledge level of the employees in the corporation. This means that organizations will innovate when they can afford the cost of the introduction and use of the new technology including all the training and re-organization costs associated with such introduction. The conclusion is that cost is a factor in innovation adoption and organizations will find many ways to mitigate this cost either with savings from current commercial technologies by adopting open source software or with expected savings over a certain period of time resulting from the adoption of an IT innovation (p. 1348). Finally, we see that Fichman and Kemerer (1997) primarily concentrate on object oriented technologies. The rational is that a model should be parsimonious but at the same time applicable. Other authors followed the same route like for example Agarwal and Tanniru (1992) who concentrated on expert systems.

5. Innovation Initiation: Who and How

It is usually thought that scientific experiments and research drive innovation in the industry but it is usually the other way around. Research and development in industrial laboratories are the initiators of innovation and the factors that drive science. It is economic factors, competition, and other pressing corporate factors that will lead to innovation for the most part (King et al., 1994, p. 143).

6. The Risk Factor

Innovation is a magic word associated with leaps in technology advancement with serious consequences to society. The fact is that in every technology innovation and diffusion process there is a certain degree of risk involved. (King et al., 1994, p.144). This risk is not only manifested in the introduction of technology into organizations but also in implementing the technology after it has been introduced.

7. Supply-push and Demand-pull Types of Innovation

King et al. (1994) makes an excellent point in distinguishing IT innovation based on demand or supply factors. First, an innovation might materialize because suppliers push the innovation into the market. This might be the case for example with customer relationship management software where suppliers had the idea of creating a software package to integrate channels of communication and make the corporation a customer-centric organization, which means getting away from the product-centric model of operations. In other situations, the customers themselves might want a specific innovation to appear because they think it will help them be more efficient. However, as King suggests for an innovation to appear, both supply and demand factors must exist. This is really the case since as the customers experience an innovation, they become smarter and they ask for more features while the supplier of the IT innovation might anticipate further needs which result into a cycle of push and pull innovation (King et al., 1994, p. 149).

8. Technological Frames and Cognition

Orlikowski and Gash (1994) introduce the concept of technological frames in organizations or in other words social cognitions of what a technology might mean to different groups of people. In this respect, they suggest that an IT initiative will take different meaning for users, managers, and other groups in the corporation as a car has a different meaning for drivers, mechanics, and designers (p. 179). A technological frame constitutes the "assumptions, expectations, and knowledge they use to understand technology in organizations." (p. 178)

Orlikowski and Gash (1994) argue that the concept of technological frames is a very useful means to understand user behavior from the introduction of information technology and moreover predict outcomes that cannot be captured by traditional models (p. 199). Also, since technological frames constitute a process perspective rather than a factor model, they can be very useful in tracking organizational changes over time along the many phases of IT adoption and diffusion in organizations (p.200).

9. A Stage Process of Innovation Introduction

Organizational innovation is viewed as a stage process. That is, there is a series of steps or stages through which an innovation is introduced to an organization and in general those steps are distinguished as initiation, adoption, and implementation. Research might focus on any of those stages but usually the most important are the adoption and implementation processes. Initiation is a decision to evaluate a new technology due to own decisions or pressures from the outside environment. Adoption involves the decision to actually allocate the resources for the innovation, and implementation to take the necessary steps that the technology is actually diffused and used in the organization to realize the benefits for which it was adopted (Grover et al. 1993, p. 2).

10. Primary and Secondary Stages of Innovation Adoption

Other authors distinguish between only two stages in technology adoption: a primary adoption phase and a secondary adoption phase: In primary adoption, management makes the decision for the organization to adopt the technology and provides the financial resources to acquire it. Secondary adoption involves the technology actually being used in the organization. A study that aims to explain the introduction of a technology to an organization needs to take into consideration time as a factor since different stages of adoption occur (Gallivan 2001, p. 55, p.58), (Rogers 2003, p. 127), (Fichman and Kemerer, 1997, p.1342). Thus, there is a cumulative adoption process that includes primary and secondary adoption that needs to be studied as well as the extend of the assimilation gap between the two stages. (Fichman and Kemerer 1999, p.256).

11. Synchronization Issues for Adoption of Complex Technologies

Organizational adoption of complex technologies might deviate from traditional adoption models. This is because a number of users should adopt the technology in synchronization rather than individual users accepting the innovation independently. In this case, traditional adoption models might not work and new theoretical frameworks might be needed to explain the adoption process. Such new models might be based on the theory of critical mass, absorptive capacity, and organizational learning (Gallivan 2001, p.56)

Wesley and Levinthal (1990) define the concept of absorptive capacity as "the ability of the firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends. (p. 128)". The authors emphasize that the firm should be able to effectively use the information it acquires, not just acquiring it (p. 131). Also, new information and technologies will be adopted by the organization if there exists similar know how in the organization per se. This of course means that the organization needs to be connected to the outside environment with appropriate communication systems. It is actually suggested that companies should consciously work on developing their absorptive capacity which at this point the authors identify with the corporation's knowledge base.

12. Public domain spillovers

A very strong conclusion from the research model of Wesley and Levinthal (1990) is the explanation of why some firms might devote resources to conduct ground level or "basic research", even though the results of this research might go to public domain. The answer is that corporations are willingly engaging to acquire the fundamental knowledge of new technologies that they expect to become very useful in the future and they need the knowledge base to engage in these technological innovations. Companies in this way want to reply to competitive edges gained by other corporations who have already engaged in these technologies. Consequently, firms are practically enlarging their absorptive capacity (p. 148).

13. Organizational Complexity

Daugherty, Germain, and Droge (1995) explore the connection of technology adoption to organizational complexity in a study of EDI systems. The authors found that organizational complexity tends to drive technology innovation and adoption because the organization needs to simplify its complex tasks. This is true when the corporation has either operational complexity or informational complexity. In this sense, if the corporation has multiple and intricate manufacturing operations and/or relies heavily in complex information systems it will certainly try to adopt new technologies to simplify and streamline its processes.

14. Technology Typology

Adler and Sbenhar (1990) developed a technology typology that will help in understanding the technological base of the corporation. In each corporation, the authors argue, there might be a multitude of different technologies in various departments and in various stages. The usual classification schemes like those provided by academia like IT technologies, mechanical engineering, electrical engineering and others do not work; nor does it work the usual simplistic classification between hardware and software. Instead there has to be a typology that it is not very detailed or very general and at the same time it should not be overly skewed by functional or product based classifications. The classification that the authors defined is distinguishing among "base", "key", "pacing", and "emerging" technologies. According to the definitions they gave:

> "Base Technologies are those that are common to everyone in the industry, but that do not provide competitive advantage because all the industry players have equal access to them. Key technologies can provide competitive advantage in the current state of the industry. Pacing technologies are those that, while not currently deployed in the industry, can reasonably be assumed to have the potential to displace one of the key or base technologies. And emerging technologies are on the horizon, as yet unproven, but potentially important."

Corporations need to assess the state at which the technology they are considering adapting and replacing is and evaluate the strengths and weaknesses of doing so (p. 28)

15. Rational vs. Fashion choices in organizational innovation

Bandwagon Phenomena

Abrahmson and Fairchild (1999) refer to bandwagon phenomena, a behavior occurring during innovative processes where managers introduce innovation to organizations out of fashion rather than rational thinking. This is a "me too" behavior where innovation is introduced because it is fashionable at that particular point in time. As an example, Swanson and Ramiller (2004, p. 554) refer to the "fashion" of ERP systems in the latter half of 1990s. Organizations would engage in ERP projects because everybody else in the industry did and an ERP initiative became a must.

Mindfulness in Organizations- A Strategic Choice

Swanson and Ramiller (2004, p. 555) introduce the concept of mindfulness in organizations where an organizational entity adopts innovative technologies based on rational processes. In this case "mindfulness concerns the adaptive management of expectations in the context of the unexpected." (p. 555) Mindfulness and rational choice in this context might as a result inhibit the introduction of IT innovations in the organization if the IT technology does not comply with the needs of the corporation. This is especially true in HROs (High Reliability Organizations) such as aircraft carriers or air traffic controllers (p. 557)

Mindlessness in Organizations – A Strategic Choice

Organizations following this approach do not usually understand the importance of IT for competitive advantage and they do not take a conscious approach to researching and understanding upcoming IT innovations. Thus, they usually fall in the bandwagon phenomenon and they will consider an innovation popular in the industry already. This means that they are practically followers of IT applications rather than leaders of IT innovations. Also, what they get might not be a fit with the specific organizational environment since these organizations do not have the ability to detect what they need. Having a strategy based on mindlessness is sometimes a strategy of choice with benefits such as waiting for standards to be established before adopting the technology or waiting to adopt a technology that really works. Having a mindlessness strategy produces benefits but these benefits are marginal with respect to an early rational adoption.

16. Research Approach

Orlikowski and Baroudi (1991) identify three research approaches in studying information technology in organizations: positivist, critical, and interpretive. The dominant approach is the positivist one which originates from research in the natural sciences. Following a dominant approach restricts the scope of research and limits the phenomena that can be studied. More research orientations should exist to open new perspectives in the study of IT in organizations.

The positivist approach

The positivist perspective follows the next precepts reported in Orlikowski and Baroudi (1991, p. 9) as adapted from Lincoln and Guba (1985, p.36):

- The phenomenon of interest is single, tangible, and fragmental, and there is a unique, best description of any chosen aspect of the phenomenon.
- The researcher and the object of inquiry are independent, and there is a sharp demarcation between observation reports and theory statements.
- Nomothetic statements, i.e., law-like generalizations independent of time or context, are possible, implying that scientific concepts are precise, having fixed and invariant meanings.
- There exists real, uni-directional cause-effect relationships that are capable of being identified and tested via hypothetic-deductive logic and analysis.
- Inquiry is value free.

The positivist approach is criticized however because it ignores historical and contextual factors. Especially for information technology studies in organizations, a rigid research framework might not be appropriate since a number of situational factors play their role such as geographic location, culture, historical perspective, and organizational politics. It is therefore advisable to consider other research approaches that can account for context around the focal point of research (Orlikowski and Baroudi 1991, p. 12). In the positivist approach research methods follow the classical approach of developing hypotheses and then through collection of data instruments and constructs are verified.

Interpretive Research Approach

The interpretive research approach on the other hand stresses that the perception of reality and knowledge is heavily influenced and tightly coupled by the social context in which the research is implemented. Consequently, interpretive research welcomes the subjectivity of the social phenomena and it studies how social groups in social systems interact, how this interaction evolves over time, and what is the resulting meaning of such interactions. Therefore, the quest for the discovery of objectivity in social phenomena is abandoned and instead the causes and effects of subjectivity are studied. In the interpretive approach the research methods involve mainly field studies where the researcher does not show up with a list of assumptions or hypotheses but rather the model or theory is derived from exposure in the social phenomenon itself. (Orlikowski and Baroudi 1991, p.13). The interpretive approach has been criticized as well. Some of its deficiencies include its failure to explain historical change, conflicts among social groups and social entities in general, external conditions that affect the social group studied, and unintentional consequences of actions of individuals although the initiators did not have any intention to cause (Orlikowski and Baroudi 1991, p.18).

The critical approach

The main premise of the critical approach is that the researcher actually takes a critical approach towards the social phenomena he or she studies and then tries to improve these social phenomena through his or her input. This is in sharp contrast to the positivist and interpretive approaches which only study the phenomena and do not intervene. The critical approach takes the view that social phenomena are based on historical origins and reality is not stable but social actors such as humans and organizations will try to change the realities in which they exist. However, to change these realities is not easy since there are constraints such as economical and political. The critical approach also claims that there are no isolated factors or situations in studying phenomena. The interdependence of factors in social phenomena is based on historical development and contextual circumstances. Consequently, one cannot isolate a factor or construct and study it in isolation of these historical and contextual perspectives. Critical studies need longitudinal data to be effective and research methods include long ethnographic studies of organizations. Studies following the critical approach are very situational and contextual in nature which makes any generalizations difficult to assert and any models difficult to validate or invalidate for that matter (Orlikowski and Baroudi 1991, p. 20)

Larsen (2003) conducted a very detailed study about the direction of MIS research and organized research papers into three groups: The first group is the **IS Journal Group** and it includes the following journals: Communications of the ACM, Information & Management, Information Systems Research, Journal of Management Information Systems, and MIS Quarterly). The second is the **Technical Journal Group** and it includes Decision Sciences, Decision Support Systems, and Management Science). The third is the **Organizational Journal Group** and includes the Academy of Management Journal, Administrative Science Quarterly, and Organization Science.

Models

Most of the models for adoption of technology by individuals are factor models based on cross-sectional data. However, in organizational adoption of technology we see both factor and stage models.

Stage Models

Practically, stage models are a sub-category of process models and as such require longitudinal studies for data collection. The strength of process models is that they also recognize and account for the context of the phenomenon studied (Gallivan 2001, p. 58).

Stage models focus on the effects of specific factors across all the phases of adoption and diffusion processes unlike factor models which look at the impact of factors within a particular phase. Prescott and Conger (1995) found that though stages are similarly defined among various authors, the definitions of the stages vary wildly. Thus, there is some conceptual ambiguity in defining the stages (p. 29).

1. McFarlan and McKenney's Model (1982)

McFarlan and McKenney developed the first stage model to theorize technology adoption and diffusion in organizations. The model was subsequently tested by Raho et al. (1987). A schematic representation of the model appears in 0. There are four stages in the model:

Identification and Investment: In this first stage the corporation decides on the particular technology and also makes a decision to invest in it. Training of users in the new technology is included in this phase.

Adaptation and Implementation: In this phase the organization and its staff members are aware of the new technology but it is not more than an installed application for them. Every effort is made to introduce the users to the technology and actually use (implement) it and incorporate it in the processes of the organization.

Operations, Management, and Control: In this phase the technology has been introduced in the organization and the focus is on the tactical and operational decisions about the technology unlike the first stage where the decision to implement the technology was strategic. The organization at this point is trying to find the best way to use the technology.

Technology Diffusion: In this stage the technology is well implemented within the organization. However, the diffusion process continues with the technology being actually used in additional parts in the corporation.

McFarlan and McKenney managed to distinguish among stages in technology adoption and diffusion in organizations in the early stages of this kind of research. Their model was tested by Raho et al. in 1987 and was found to work consistently with the sample testing. However, Raho et. al (1987) found some discrepancies with the model especially with phases two and three and they suggest that additional phases are needed (p. 54). It is no surprise then that Roger's 1983 includes additional stages for technology adoption and diffusion.

2. Roger's Five Stage Model (1983)

Roger's model was the first process[1] model of organizational adoption of technology dating back to 1983 and his book is used as a reference in mostly all adoption articles. The five stages of the model include: knowledge, persuasion, decision, implementation, and confirmation. The model appears in 0 as it was adapted by Rogers (2003, p. 170). The stages of this model are discussed below:

Knowledge Stage:

The innovation-decision process starts with a knowledge stage which is the time when exposure to the technology's existence occurs. At this stage an idea of the technology's functions is developed either through active search because of a need or accidental exposure from participation in communication channels. Research at this point does not provide a clear answer on whether exposure is the result of a need for the technology, or the exposure to technology creates the need (Rogers 2003 pp. 173-174).

Persuasion Stage:

This is the stage where a positive or negative idea towards the technology is developed. Individuals or organizations or other decision-making units will actively search for more information on the technology and try to determine the consequences from an eventual adoption of the technology. Estimating future results brings uncertainty and social reinforcement enters the play where individuals will ask for confirmation from

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[1] In this paper no distinction is made between the terms process and stage.

social groups and peers. The bottom line in this stage is that uncertainty for the consequences of using the technology should be reduced (Rogers 2003 pp. 174-176).

Decision Stage:

This is the stage where the decision is made as to the adoption or rejection of the innovation. If adopted, the technology will usually be tried on a smaller scale than its actual purpose, usually in pilot programs. On the other hand, the technology might not be adopted at all in which case we refer to active rejection. However, there is also the case of passive rejection in which case the technology has been adopted but it is not used. (Rogers 2003 pp. 177-178)

Implementation Stage:

This is the stage where the technology will be put into practice. The literature suggests that implementation will follow the decision stage fairly quickly unless there are problems with the availability of the technology due to supply shortages, logistics, geographical remoteness and others. In organizations implementations are not always smooth processes since culture, structure and the degree of change required might slow or even stop the process of implementation. An important concept during the implementation process is re-invention and it is defined as "the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation." (Rogers 2003, p. 180). Rogers gives a full list of eight reasons why re-invention might occur during the implementation stage (Rogers 2003, p. 186):

1. Complex innovations are more likely to be re-invented.
2. Lack of detailed knowledge about the innovation from the adopter.
3. Innovation is a technology with multiple applications.

4. Innovation tries to solve a multitude of user problems.
5. Modification of a technology to present it as one's own.
6. Pressure to change an innovation from a change agency.
7. Innovation must adapt to the organizational structure.
8. Late adopters change the innovation following lessons from early adopters.

Confirmation Stage:

This is the stage where the organization or individual will seek confirmation of a correct decision to adopt a technology. Even at this stage the introduced technology may still be dropped if there are negative messages. Dissonance and discontinuance stages may follow the adoption of a technology. Dissonance is an uncomfortable state about the innovation adopted and individuals and organizations will try to eliminate it by acquiring more knowledge, changing behaviors, and adopting new attitudes. Discontinuance means that the innovation is rejected after being adopted and it comes in two forms: replacement or disenchantment as Rogers names them. Replacement means that a better technology choice is available and the innovation is replaced by a different one. Disenchantment means that the innovation is rejected due to performance. The innovation does not cover the adopter's expectations and a technology in such a case does not offer a distinct advantage over alternatives.

3. **Zmud and Apple's Six Stage Model with Post-Implementation Considerations (1989)**

This model is a stage model taken from a reference to an article by Cooper and Zmud (1990) since it is based on an unpublished manuscript (p. 124). It is based on Kwon and

Zmud's (1987) model but it enhances that model by encompassing several activities that appear after the adoption stage. The model appears in 0 and its various stages are explained below:

Initiation: During this stage the needs and opportunities for the organization are evaluated and matched against alternative solutions. The identification of an IT product belongs in this stage too.

Adoption: In this stage the organization goes through a logical, rational, and political process through which arguments are made for and against the solution. If the decision is positive the resources required to purchase the technology are made available.

Adaptation: This is the stage where the new technology is put into practice. An IT solution will be implemented and training for the users starts. The technology is now ready for use by the corporation.

Acceptance: users are now committed in using the technology and the innovation is introduced for use in organizational operations.

Routinization: Usage of the technology is considered as normal in the corporation.

Infusion: The technology is expected to show its benefits for the corporation since at this stage it is used in the fullest degree.

Factor Models

4. Gatignon and Robertson (1989)

The basic premise of this model is that innovation produces changes in factors of production and consumption. In addition, this model is a factor model and as such examines these potential changes at a single point in time. What is of great value in this model is the inclusion of supply factors in the sense that the model will take into consideration the efforts of suppliers of technology to push and sell the technological innovation to potential adopters. Another strong point of this model is its inclusion of competitive factors or in other words the pressure to adopt a technological innovation by taking into account the competitive environment of the corporation, not only perceived internal needs. A final point of interest of this model is that it incorporates the study of rejection along with adoption of technology, something that most other models omit. Actually the dependent variable in this model is a categorical variable that accepts two values: one for adoption and the other for rejection (Gatignon and Robertson, 1989, p. 36). A visual representation of the model and its factors appears in 0. Below the four factors of the model are explained:

Supply-Side Competitive Environment: The existence of a highly innovative supplier will bring changes throughout the supply chain and this change will be proportionate to the degree of integration between participants in the supply chain.

Adopter Industry Competitive Environment: Competitive initiatives constitute a primary drive for innovation according to Gatignon and Robertson. Technical innovations are more likely to occur in industries with fewer competitors or in oligopoly scenarios. Their rationale is that companies in these industries pay close attention to their competitors' initiatives. Also, the same authors claim that technological innovations constitute a barrier to entry for competitors, thus maintaining a competitive edge over them.

Organization/Task Characteristics: Gatignon and Robertson (1989) theorize that organizational centralization is an enabler of technological innovation when the company strives for standardization. Also, the same authors suggest that in corporations with highly complex administrative processes, technical innovation is more likely to be adopted.

Decision Maker/ Information-Processing Characteristics: These are individual characteristics and Gatignon and Robertson (1989) claim that such characteristics are key to the diffusion process or the secondary adoption of the innovation as some other authors call it. The authors suggest that decision makers with high tolerance for ambiguity will exhibit higher degrees of tolerance and acceptance for innovations. Also, individuals with higher levels of access to information will exhibit higher adoption rates of technological innovations.

Gatignon and Robertson (1989) suggest that more research is needed on the supply side adoption of information technology. The current literature is mostly concentrated on demand-side initiations for adoption of innovations. Also, more research is needed on rejected innovations.

5. Cooper and Zmud (1990)

Cooper and Zmud (1990) focus their study on two stages of IT adoption in organizations. Actually, there is a problem with terminology since they call the whole process of IT adoption and diffusion, the implementation process. In any event the study is very interesting since they use factors to build their model and they explore the interaction of these factors within these two stages (p. 129). A schematic of this model appears in 0. The authors found that task-technology compatibility is a very important facilitator in the technology adoption phase. On the other hand, the task-technology compatibility does not seem to be important in technology infusion (p. 134). Cooper and Zmud (1990) emphasize the role of politics in technology infusion vs. technology adoption. Actually, the authors suggest that politics is the single determining factor for a successful implementation phase. Rational arguments about the benefits and rewards of the technology come a distant second with respect to political decisions. The net conclusion from these findings is that there is a difference between deciding to adopt and actually implement an IT innovation. Thus, the researcher of technology acceptance in organizations should study these stages separately and derive any conclusions in the context of a particular stage. Moreover, a researcher of IT innovation should absolutely consider the political environment of the corporation since the development of any models based purely on rational factors will be inadequate to explain technology implementation. For practitioners the net conclusion is that deciding to adopt the technology does not automatically mean usage of technology. There is a big difference between installation and implementation and to take advantage of a technology a successful implementation process is a must.

6. **Daugherty, Germain, and Droge (1995)**

The model by Daugherty et al. (1995) contains two factors, structure and context using adoption as the independent variable and examines EDI adoption in organizations. A depiction of the model appears in 0. Structure and context are over-researched in the literature but with confusing results. Actually, the results of the study do not seem to justify the setup of the model as the authors themselves reveal on page 321.

7. **Fichman and Kemerer (1997)**

Fichman and Kemerer developed a three-factor model to examine the assimilation of information technologies in organizations. The model appears in 0 and the descriptions of the constructs follow:

Assimilation Stage: The assimilation stage as defined by Fichman and Kemerer (1997) includes all the activities on adoption and diffusion of an innovation in the corporation. What is of striking interest is that the assimilation stage of this model encompasses all the stages of Roger's model of innovation adoption and diffusion. Simply, in Fichman and Kemerer's model the stages have different names and somewhat different scope: (1) awareness, (2) interest, (3) evaluation, (4) commitment, (5) limited deployment, (6) general deployment (p. 1349).

Learning-related scale: It is defined as "the scale of activities over which learning costs can be spread" (p. 1350). The authors retain that this construct is positively related to assimilation and as a result corporations with a bigger learning scale are more likely to introduce innovations than others with a lower learning scale.

Related Knowledge: It is defined as "the extent of abstract knowledge, know-how, and skills possessed by the organization in areas related to the focal innovation." (p. 1351). Related knowledge is positively related to assimilation.

Diversity of Knowledge and Activities: It is defined as "the degree of heterogeneity of organizational knowledge and activities in areas related to applications development." (p. 1352). In simple words, diversity of related knowledge means that the organization possesses a certain extend of IT related knowledge and it would be able to adopt new IT innovations more smoothly than other corporations with less IT related knowledge. This concept is positively related to assimilation.

The net result of the work of Fichman and Kemerer (1997) is that organizational learning factors play a pivotal role in the adoption of an IT innovation. The parsimony of the model and the definition of the constructs make it a very useful model for explaining complex IT innovations in organizations.

8. Lai and Guynes (1997) Model

Lai and Guyness focus their study on the characteristics of the organization only, leaving out the characteristics of the innovation and the management process since they claim adequate research has been done on the last two factors. Their model appears on 0 and it clearly shows the three constructs of the model and their relationship to the dependent variable which is "The Decision to Adopt." They identify three major factors within the characteristics of the organization which are contextual effects, structural effects, and strategy effects. Within each factor there exist a number of sub-factors which the authors identify in their model. Strategy and structure are two organizational concepts overwhelmingly explored in the literature. The contextual effect factor in this model consists of four building sub-factors which are openness (of the organization to its external environment), norms encouraging change, organizational size, and the availability of slack resources (p. 148). The role of the external environment of the corporation as a crucial factor of innovation adoption has been emphasized by Tornatzky and Fleischer (1990).

9. Chau and Tam Model on Adoption of Open Systems (1997) [180]

The model by Chau and Tam is a modern model and an evolution of the Tornatzky and Fleiscer (1990) framework. The model is depicted in 0 and it contains three constructs that affect the decision to adopt: the external environment, the organizational technology, and the characteristics of the open source technology. Of the seven items in the three constructs, all are supposed to have a positive relationship with the decision to adopt except the perceived barriers item which shows a negative relationship. The model seems to be a natural evolution towards the TOE framework. It is not there yet but definitely it has come long ways from the more limiting Tornatzky and Fleiscer framework. As we will see in later articles this notion of an organization, technology, and environment framework gains ground in the organizational innovation research.

10. Premkumar Roberts (1999)

Continuing with our previous reasoning we see that Premkumar's model is practically the TOE framework as it has been termed by Zhu et al. (2004) much later on. It consists of three constructs, the organization, environment, and innovation characteristics. What is striking about this model is that it presents relative advantage as the most important pre-requisite for a decision to adopt. This is consistent with other organizational studies as well as user acceptance models. Premkumar "borrows" two terms from sociology: vertical and horizontal linkages. Vertical linkages refer to corporations whose units are linked with the parent company while horizontal linkages refers to the connection among departments in the corporation and it helps more with diffusion of technology. We see from this study that vertical linkages are negatively related with adoption of technology, yet this relationship might not be valid in general since Premcumar used the Internet as the technology in question. We see that the nature of the technology is a factor as we have reported in our problem statement chapter. The same is valid for other authors like Chengalur-Smith and Duchessi (1999) where they use client server systems. If for example the technology in question was a new transaction processing system, the results might have been different.

11. (Chengalur-Smith, Duchessi 1999)

Chengalur and Duchessi have formulated a model that is practically the TOE framework but not named so. They examine organizational, technological and environmental factors for technology initiation and adoption of client-server technologies. A depiction of the framework appears in 0. The formulation of the model in this paper is an exception from the rest of the factor models where the dependent variable is usually of binary nature and consists of a single item. Also, it deviated from previous factor models in that it uses MANOVA for data analysis instead of a LOGIT/PROBIT model encountered usually in the literature. It is also of interest to note that in this article were mentioned (p. 78) but not examined two additional contextual factors: user characteristics and task related characteristics. I think the rationale of putting these two additional factors is in the right direction; personal preferences play a role but not at the user level but at the decision-maker level at the primary (organizational) adoption stage. User and task related characteristics will play a role but at the diffusion stage, not the adoption process.

12. Lee and Runge (2001)

This model is a deviation from the rest of the literature in the sense that it focuses on small businesses while the vast majority of the rest of research focuses on large corporations. One key difference with other studies is that it considers the owner's individual characteristics as the key factor for adoption of IT technologies. This is one of the very few studies that consider a key decision maker as an important factor for adoption at the corporate level albeit in small businesses. In addition, a surprising result of this study is that adoption of classic IS systems such as accounting software and inventory systems differs from adoption of Internet Technologies. Classic IT applications are based on the company's drive to innovate while Internet adoption is based on a perceived advantage for the corporation. A depiction of the model appears in 0. In this model we notice the appearance of social expectations as a factor or in other words small businesses tend to innovate looking at what the peers and competitors are doing in the industry. While this point is valid Lee and Runge try to justify it basing their references on individual models like that of DOI and TPB, both explained in detail earlier in this paper. While the justification has a basis since the owner and decision maker is an individual, we should pay extra attention when we take user acceptance models and try to apply them at a different unit of analysis. Consequently, from the three factors in the model two apply to the individual level and only one to the organizational level. It would be useful for the authors to have referred to Abrahmson and Fairchild (1999) and the bandwagon phenomena they explain.

13. Kendall, Tung, Chua, Hong, Ng, Tan Model of Innovation Adoption (2001)

Having a look at this model we can safely say that it deviates from the established research framework on two bases: First, it uses Roger's DOI model to construct a model of adoption and second it deviates from the TOE framework that researchers have so painfully established. The basic model appears in 0 and practically it contains five factors: relative advantage, compatibility, complexity, Trialability, and Observability while the dependent variable is the firm's willingness to adopt. The results of this study indicate that relative advantage is by far the most important factor with compatibility coming second. The remaining three factors were not important for the firm's willingness to innovation adoption. Once again however, and though this is a factor model we cannot but notice the application of a user model at the organizational level of analysis.

14. Zhu, Kraemer, Xu, Dedrick (2004)

This model is based again on Tornatzky's and Fleischer TOE framework. The TOE framework is based on technology, organizational, and environmental factors of the organization as an entity. In this respect, the technological context includes technologies existing in the firm as well as those available outside. The organizational factor contains firm characteristics such as size, structure, centralization, formalization etc. Finally, the environment factor contains the factors pertaining to the external environment such as competitors, government, suppliers and others. The TOE framework has been studied considerably by researchers and evidence indicates it has received solid empirical support (Zhu et al. 2004, p. 21).

The model prepared by Zhu et al. is depicted in 0. We notice that the dependent variable is not technology adoption but e-business value. It would seem that this model is out of context since we are exploring technology adoption factors but on a second thought it is not since the creation of value and the relative advantage obtained by the introduction of a technology is what drives business decisions. Furthermore, this is a very comprehensive study which we cannot leave out of the literature review.

From the findings of Zhu et al. it follows that technology readiness – the capability of the firm to effectively use and create value from Internet technologies – is the most important factor for the creation of e-business value. From the other factors that appear in the model only global scope, financial resources, and regulatory environment seem to have a significant weight for value creation. What is really surprising from the findings of Zhu et al. is that competitive pressure – a significant factor in previous studies – does not appear to be significant in this study. In other words, the value e-business technologies create seems to be linked to the internals of the corporation like financial resources and technology readiness than competitive pressure. In addition, firm size shows a negative relationship with e-business value creation meaning that e-business technologies are working less effectively for large corporations. One would expect the opposite but as we have shown before this is a controversial topic in the literature and at the same time highly dependent on the technology used. That is, results might differ if the technology in question is voice over IP or back-end integration systems. Finally, this study revealed and confirmed that managers should get ready for process reengineering with the introduction of new technologies and also integrate "islands of information" (Zhu et al. p. 44) in the corporation.

Other Models

Gallivan (2001) and Fichman (1992) suggest that in scenarios where the complexity of the technology and the complexity of the implementation are high, traditional innovation theories should be integrated with other theories such as critical mass theory, absorptive capacity, organizational learning and others. This is not the first time such a point has been made. Other authors like Yetton et al. (1997) have tried to bridge the gap between innovation and implementation theories to augment the application of theoretical frameworks.

15. Critical Mass

We start by examining the critical mass theory from an author who tried to integrate innovation theory and critical mass theory to explain the introduction of smart card technology. Critical mass theory is an encompassing theory that explains "the notion that an individual's benefit derived (or denied) from using an innovation is dependent on the size of the participating community" (Truman et al. (2003). Network externalities according to the same author represent an aspect of critical mass theory.

Though the results of this study indicate that relative advantage was a factor in accepting the new technology, the overall acceptance rates were low because critical mass thresholds were not reached. The conclusion seems to be that no matter how apparent the relative advantage of the technology is, a critical mass or initial supporting threshold would need to exist before the innovation is widely accepted.

16. Absorptive Capacity (ACAP)

Cohen and Levinthal (1990) define absorptive capacity as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (p. 128). Practically, the authors are discussing the firm's previously accumulated knowledge and its ability to exploit it for assimilation of new innovation technologies. As a concept this is not a novelty because many authors have talked about the significance of knowledge barriers and the importance of an existing knowledge base Premkumar Roberts (1999), Fichman and Kemerer (1997).

However, Cohen and Levinthal (1990) go a step beyond and they claim that for the organization absorptive capacity is not just previous knowledge but also the capability of the firm to exploit new innovations (p. 131). This is a unique statement and in the literature appears in models like those of Lai and Guynes (1997) when they refer to slack resources that might be available from the corporation for exploration of new technologies.

An organizational unit might assimilate knowledge from the internal or external environment of the corporation. Cohen and Levinthal suggest that imbalance from one or the other source will result in dysfunctional acquisition and poorer organizational learning. A model of the firm's sources of technical knowledge appears in 0. The most important point from this statement is that the authors refer to organizational learning through absorptive capacity though these two are supposed to be two different research streams. We have thus seen to this point that organizational innovation adoption, system implementation, absorptive capacity, and organizational learning are all related and not different research streams.

Cohen and Levinthal (1990) also talk about cross functional absorptive capacities arguing that overlapping of knowledge among corporate functions like R&D, marketing, and manufacturing are beneficial for the overall corporate knowledge acquisition.

One of the most important points about corporations as presented by Cohen and Levinthal (1990, p. 148) is that corporations should engage in basic, fundamental research even if part of the knowledge created becomes public domain. The advantage is that companies generate knowledge in multiple areas which allows them to respond quickly and take advantage of technology changes to attain a better competitive position.

Absorptive capacity in a recent article by Shaker and Gerard (2002) which summarizes the timeline of research on absorptive capacity at various levels of analysis from multiple authors (Table 1, p. 187). These authors conclude that ACAP manifests itself in two modes: potential and realized absorptive capacities. "Potential capacity comprises knowledge acquisition and assimilation capabilities, and realized capacity centers on knowledge transformation and exploitation" (p. 185).

The conclusion from our discussion on absorptive capacity is that it relates to organizational learning for the purpose of competitive advantage and it integrates well with comments from authors in the technology adoption stream who have already claimed that the adoption literature should integrate with the organizational learning research stream.

17. Organizational Learning Attewell (1992)

Attewell claims that organizational learning can be a barrier to adoption of technological innovations. Also, classical diffusion research does not take the knowledge barriers into consideration, an issue that generated similar responses from other authors like Gallivan (2001) and Fichman (1992).

Attewell (1992, p. 4) makes a point that adoption theories do not separate the duality of processes involved in communication procedures. First, there is a signaling process which means that corporations need to be aware that the technology exists before they can even think of adopting it. Second, there is the technical side and corporations need to possess related know-how to be able to adopt the technology, a point that was practically brought forward by Cohen and Levinthal (1990) and was repeated in studies by Shaker and Gerard (2002) later on when they studied absorptive capacity.

One strong point of Attewell's comments is that classical diffusion theories see adoption of technology as an oversimplified process that is closer to signaling than that of complicated adoption. In fact, though the receiver can buy any technology available in the market, the actual adoption and usage of the technology is not automatic (p.5). Of course someone would argue that now we get into implementation theory territory but if we take into consideration articles like that of Yetton et al. (1997) we might conclude that either innovation theories and implementation theories compete for the same result or for our discussion might need to be bridged.

On pages 7 and 8 of his article Attewell provides his Knowledge-Barrier Institutional-Network Approach putting together a theoretical basis for organizational learning. His theoretical approach appears in 0. Attewell borrows Tornatzky's terms and describes complex production technologies as "demanding, fragile, and lumpy-the antithesis of a reliable commodity" (p. 15). Such comparisons of reliability between operating systems and automobiles have been a common theme in practitioner magazines.

Attewell also implies that in the past, suppliers of manufacturing equipment provided comprehensive services to their customers such as "installation, operational, programming, and repairing services." (p. 16). However, those services were very expensive and the solution with the provision of information technologies today is that the customers are self-served instead of being serviced. Providers try to decrease learning barriers by standardization and hiding complexity from the user interface. However, even this is not enough since it is not only the introduction of new technology that matters but learning to operate under the new proposed processes and even worse eliminating existing ones.

18. Political and process. Franz and Robey (1984)

Franz and Robey bring into the literature two rare research concepts. First, they use longitudinal research methods which are very infrequent in all other studies. Usually, the two research methods most encountered are cross sectional surveys and in some instances interviews. The examination of the research phenomenon over time means that results are stronger in terms of construct validity and also multiple interpretations and points of view are possible.

In addition, Franz and Robey (1984) make a distinction between the rational and political approach in implementation research and examine both. Specifically, the outcome of the usage of the technology becomes a function of both. In contrast, the literature in general assumes that all technology decisions are rationally made ignoring the political process. However, these authors claim that "organizations may also be viewed as arenas for political activity where actors engage in conflict and negotiate for their private interest (p. 1203). This is quite true since the introduction of new information systems changes the balance of power in the corporation to the point that some jobs or whole units are threatened with termination of operations. The authors underline however that adoption decisions do not become "overly political" (p. 1203) and the rational approach does play its role.

Franz and Robey (1984, p. 1203) in addition provide a couple of terms that I never encountered in the literature and which I think are extremely useful for MIS research. They introduce us to the Nomothetic and Idiographic terms which were first sculpted by Dr. Gordon W. Allport in 1937. Dr. Allport (p. 22) stated that "The Nomothetic approach seeks only general laws and employs only those procedures admitted by exact sciences... The idiographic sciences endeavor to understand some particular event in nature of society." (p. 1203 in Franz and Robey article). As a result scientists believe that the correct and respectable type of research is Nomothetic research ignoring in my opinion phenomena and research directions for which Nomothetic research might not apply. For idiographic research to occur the scientist needs first to understand the phenomenon really well and in this case the organization and the technology involved instead of trying to immediately build a research framework that would be scientifically acceptable.

The conclusions that Franz and Robey draw are really powerful and absolutely logical and in accordance with my own experience in the industry. First, organizational actors compete for control of the technology introduced. Second, they maneuver to maintain their power basis at least. Third, political actors navigate so that they can escape blame from potential failures. Fourth, political interests and consequent behavior are not isolated behaviors in organizations from people who are "too political" and act like that in isolation throughout the otherwise rational process. Franz and Robey state that "It is the other way around. The rational elements are tools used by participants to gain new ground or to protect ground already won. They also serve as 'facades' to mask political motives and legitimize self-interest." (p. 1208).

If we can assume that the above is true and why not since it is based on scientific research with longitudinal data, then we need to re-evaluate the perspectives and the state of research as it is right now in the literature.

19. Bridging Theory

Yetton et al. (1997) make a very interesting claim in that there are practically two theories that try to assess technology adoption in organizations: the innovation characteristics theory and the implementation process theory. These two theories have been rarely examined together and most importantly they generate general "non-contingent" models. Yetton et al. (1997, p. 2) claims that technology adoption and implementation are two highly contingent processes and contextual factors must be taken into consideration.

Yetton (1997, p. 2) explains that each of the two theories weighs differently according to the implementation context. Thus, innovation characteristics theory has a bigger impact in technology adoption at the individual level whereas implementation process theory weighs more in technology adoption by groups such as organizations. Consequently, when the unit of analysis in technology adoption is the organization, we need to pay more attention to implementation theory and processes.

Moreover, Yetton suggests that a bridging of the two theories will help managers make better decisions in selecting technologies and also allocate resources more efficiently. This is because innovation characteristics theories force managers to focus on the characteristics of the technology for the most part while implementation process theories engulf managerial thought in a standard implementation process. Managers need both theories to make the best of decisions in selection and implementation.

We present the model by Yetton et al. (1997) in 0 and as its author explains, it is an adaptation from (Leonard-Barton and Deschamps, 1988). We need to warn the reader however that Yetton et al. (1997, p. 3) focus only on characteristics from the individual models of technology adoption namely relative advantage (Rogers 1962) and perceived usefulness from Davis (1989) and as a result there is no reference to organizational models.

One conclusion from Yetton et al. (1997, p. 4) is highly debatable: it is claimed that innovation characteristics theory applies at the individual level of analysis while implantation process theory applies at the group level of analysis. This is an overstatement in my opinion and probably is due to the fact that models about organizational adoption were not well developed yet. Technology adoption in organizations does take into consideration the implementation phase which is most often referred to as the diffusion phase. Not only that, but today theory is so expanded that both diffusion and infusion of technology have different meanings as we have seen in this thesis. However, there is no denial that the two theories can work together in applied research to give managers better tools to make their decisions.

Technology Adoption In Open Source Databases

Key Facts about Open Source Databases

Open source databases made their appearance in the early eighties (Yuhanna 2004, p. 4). Though they lacked some key features early on like support for transactions, triggers, and stored procedures, today they offer all that and they also entered the game of very high end features like support for replication and distributed databases (Cox, 2003) (Krill, 2002), (Hicks, 2002), (Babcock, 2004).

According to Forrester Research the market share of open source databases as of December 2004 was $120 million out of a total market of $10 billion. However, it is expected that by 2008 the open source database market will go up to $1 billion. As it has been said before databases have become a commodity and related services for support and consulting are expected to increase (Yuhanna 2004 p. 3).

For example, MySQL has about five million installations worldwide and it is used by small, medium, and large enterprises (Bloor, 2005).

Today, most of the adoption of open source databases is for non-mission critical applications. It is expected however that by 2006 35% of deployments of open source databases will support mission critical applications (Yuhanna 2004, p. 6)

The same is reported by AMR Research which indicates that open source databases will be used "routinely" for mission critical applications in 2006 (Babcock, 2004).

Forrester Research estimates that open source databases will be part of the IT strategy of corporations and 30% will be using them in production by 2008 (Yuhanna 2004, p. 13).

However, some analysts estimate that open source databases will not get the same level of support like the one given for operating systems and web servers. Projects like Linux and Apache have been given wide support from IBM and Oracle and the reasoning was quite obvious. They contributed in an effort against Microsoft and its windows operating system and Internet Information Services web server. Oracle already offers its own very expensive commercial DBMS and the same is true for IBM with its IBM DB2 database server.

IBM itself through Doug Heintzman, director of IBM software group, however denies that open source databases compete for the same customers as its DB2 database (Babcock, 2004). At the same time IBM's director for data management solutions, Jeff Jones, said two year earlier that open source databases do not have the same strength to support users, large data sets, and connectivity options that commercial databases provide and so they cannot penetrate the enterprise market (Krill, 2002). Of course all this has changed now and actually we see some commercial databases going open source.

The year 2004 was a turning point in open source software in general and open source databases in particular. Specifically, before 2004 open source programs are characterized as generation 1 while after 2004 some of the leading examples proceeded to be categorized as generation 2. Generation 1 products are characterized as products developed and supported by a developer community and while some enterprises tried their hands on them, they did so at their own risk since any kind of support would come from the developer community. However, after 2004 open source databases increased their offerings in functionality and most importantly commercial companies started providing support for a fee. Consequently, the new model is free open sourced code with professional support for a fee. (Bloor, 2005).

Adoption Reasons for Open Source Databases

There are several reasons for which open source databases came to the foreground in the beginning of the new millennium:

1. **Reduction of Operational Costs**

First, in their never ending quest to reduce operational costs, enterprises adopt open source databases with the primary aim to reduce licensing costs which end up being the most expensive part of the purchasing cost of a commercial database (Yuhanna 2004, p. 2). In a series of interviews by Forrester Research, customers indicated that the major reason of adoption of open source databases is cost reduction since for commercial databases the acquisition cost is on average $25,000. However, research indicates that over the long term, the maintenance, support, and other administration costs are not lower from commercial databases. Consequently, a total cost of ownership analysis should be conducted for the life of the project before any final decisions are made (Yuhanna 2004, p. 4). A comparison of database licensing costs appears below:

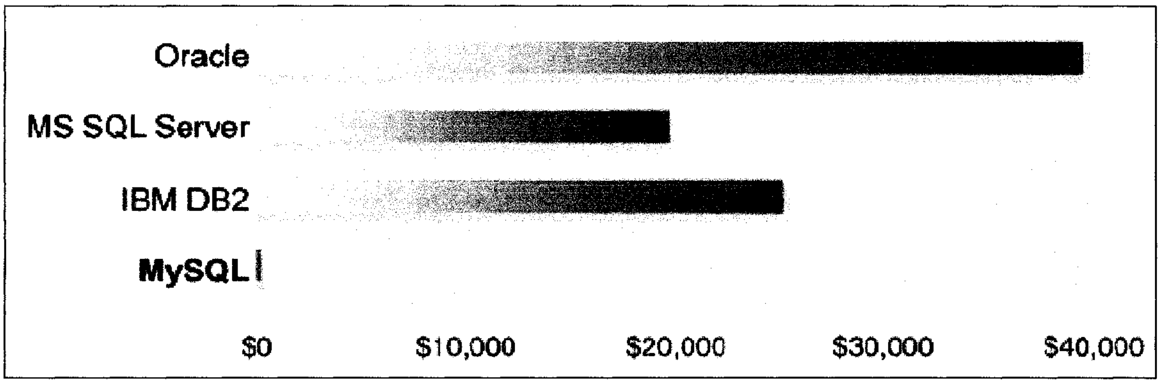


Figure 2: Database Licensing Costs. Source: IDC

Jeffrey S. Norris from the NASA Jet Propulsion Laboratory reports that for their Science Activity Project they were able to take 50% budget cuts and still be able to deliver superb software made from open source components. This happened as they had to abandon their in-house half-made data connectors and instead use open source data components instead (Norris 2004, p. 44). A summary of the components used by NASA for their SAP is listed below in Figure 3:

Open Ops

The Science Activity Planner uses the following eight open source components for critical mission operations tasks, ranging from writing rover activity plans to calculating resource usage:

- *Castor* (http://castor.exolab.org), a data-binding framework that lets SAP move data between XML files, Java objects, and SQL databases. Castor is the core of SAP's input and output functions.
- *Java Expression Parser* (JEP, www.singularsys.com/jep), a system for parsing and evaluating mathematical expressions that SAP uses to process resource formulas from the mission activity dictionary.
- *Xerces-J* (http://xml.apache.org/xerces-j/index.html), a validating XML parser that SAP uses with Castor to read and write all official mission formats.
- *MySQL* (www.mysql.com), a database application SAP uses to synchronize data between multiple program instances.
- *MySQL Connector/J* (www.mysql.com/products/connector-j/index.html), a middleware component that converts Java Database Connectivity calls in SAP to the SQL network protocol.
- *HSQL Database Engine* (http://hsqldb.sourceforge.net), a Java SQL database embedded in SAP to give the application a local database when a shared MySQL database isn't available.
- *Virtual Reality Modeling Language*, or VRML97 (www.web3d.org/technicalinfo/specifications/vrml97), a geometry loader SAP uses for 3D spacecraft models.
- *Skaringa* (http://skaringa.sourceforge.net), a data-binding framework similar to Castor. SAP uses its time-formatting functions.

Figure 3: Science Activity Planner components. Source: IEEE Software

It follows that it is important to understand the total cost of ownership of operating a database server. According to IDC research, the TCO by category for an Oracle 8i database appears below. We immediately note that 28% of the cost comes from downtimes of the database server. The explanation is that commercial software like Oracle8i, IBM DB2, and MS SQL are so complicated and full of features that it makes it very hard for administrators to operate and administer (MySQL AB, 2005).

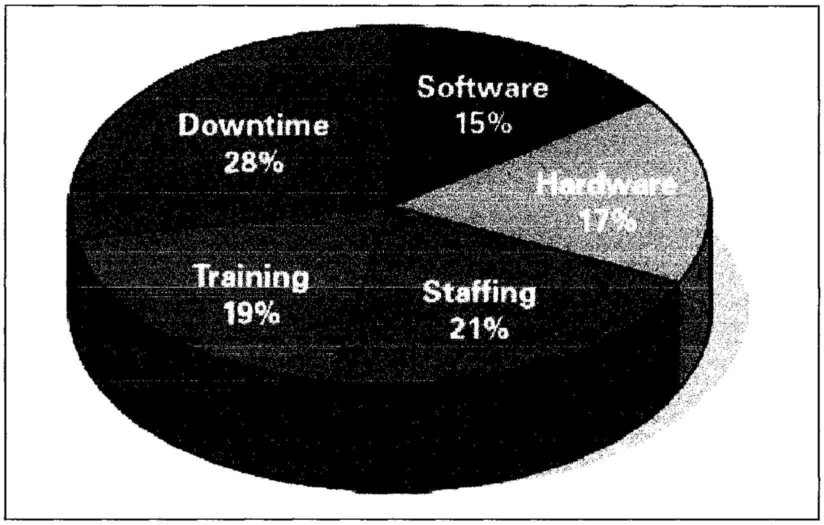


Figure 4: Oracle 8i Total Cost of Ownership

To provide some specific numbers for MySQL, according to an IDC study, on average MySQL provides the following cost savings (MySQL AB, 2005):

- Reduces licensing costs by more than 90%
- Reduces system downtime by 60%
- Reduces hardware expenditure due to lighter footprint by 70%
- Reduces administrative costs by up to 50%

2. Open Source Databases Provide Required Functionality

Second, databases have matured and the organizational customer is aware of the specific features needed to run a transaction processing system. Additional features such as data extraction, transformation, and loading (ETL) tools, or Online Analytical Processing tools (OLAP) or Data Mining Tools (DM) are not at all necessary in running a database server for day to day operations. These are features that might be useful when the database is used as the basis for a decision support system but the commercial database customer ends up paying for both anyway. Let us take the case of MySQL and MS SQL. MySQL is an open source database while MS SQL is a commercial database from Microsoft. I have tried and worked with both for years and the ease of use is almost the same. When it comes to processing data and in extension transactions both databases stand at the same level. They both support all the basics like constraints, transaction processing, triggers and stored procedures. The only difference is that the first one is free while the second will cost some thousands of dollars for a company with a few licenses. However MS SQL Server contains tremendous data analysis features that MySQL simply does not have.

3. No Vendor Lock-In

Third, some organizations want to avoid a lock-in with a particular vendor. The reason is that the use of a certain commercial database server as the back-end system will often translate in the purchasing or forced use of peripheral software as well. For example, data access tools, query clients, development suites, and even operating systems might need to be from a specific vendor for a smooth operation. In certain cases even the office production suites used by individual users will better co-operate with a database back-end from the same vendor which means that in the end all the IT software needs of the corporation will depend on the same supplier. In this case according to the Porter's model of competitive forces the bargaining power of the customer goes away completely.

4. Presence of Support Community

Fourth, especially with popular packages, support is available in abundance from the community and free. Database administrators can rely on a big collection of past cases as they are reported by other DBAs who encountered the same issues before. However, since support has been a main negative issue of open source databases in the past – due to the mission critical applications they support – today companies like mySQL offer professional support for a fee.

AMR research reports that although open source database adopters were concerned about technical support, they found that support contracts are available for open source databases as well (Babcock, 2004).

Jeffrey S. Norris from NASA's Jet Propulsion laboratory reports that the biggest difference they noted between open source and commercial software they used was support feedback times. Responses for problems with open source software would come very fast and in some cases resolved during the day. Moreover, those responses were from the developers themselves. Instead with commercial software there was no access to developers and responses for problems were delayed and sometimes they were fixed in the next release of the software which might have been months away.

5. Ability to Customize Source Code

Fifth, as with all open source software, corporations can expand the functionality of their open source database server at will. This occurs at the most basic level by developing and adding data access modules or meddle with the engine itself. They can do this while enjoying the same level of encouragement and help from the open source community. Consequently, they can tailor the functionality of the database to their own particular needs without waiting for general releases and updates as it happens with commercial databases.

6. Fast and Efficient Solutions of Problems

Sixth, according to Forrester Research organizations are reporting that by having access to the source code, their IT staff can resolve issues and problems faster and most efficiently than having to deal with a commercial DBMS which is practically a black box for them (Yuhanna 2004, p. 10).

7. Top Quality Products in Existence in the Market

Seventh, in 2004 two established database engines, Clouscape from IBM and Ingres from Computer Associates went open source. In this case the benefit for organizations is two-fold: they obtain a free open source database and at the same time this database has proven itself in the market as a commercial DBMS. As Forrester Research indicates more commercial databases might be open sourced in the future (Yuhanna 2004, p. 8)

Other open source databases have proved themselves as well. For example, MySQL is downloaded 30,000 times a day and it has five million installations worldwide. It has rightly become the open source database of choice (MySQL AB, 2005).

Most Popular Open Source Databases Today

Practically, we can distinguish between three general groups of open source databases. The first group consists of mature databases that have been in the market for a long time and have proved their value in commercial environments. This is the case for example with mySQL. Second, there are several less well known open source databases which however have been used by for-profit and non-profit organizations. For example, at NASA's Jet Propulsion Laboratory they test the Mars Exploration Rover (MER) for a 2009 mission to Mars. The software that will be used for uploads and downloads of data is called Science Activity Planner (SAP) and it uses eight open source software components. From those five are database products and while mySQL is used, we can see the use of HSQL which is a database product available from sourceforge.net and it is the least known to the IT community. Finally, we have the third category of open source databases and this includes databases servers which used to be commercial packages and have been converted to open source packages. Examples include ingres and cloudscape which were open-sourced in 2005. Table 1 provides the major open source database products and the respective URLs for more information. Also, in 0 we can see a timeline of the appearance of open source databases and in Figure 5 we can see their market presence.

Table 1: Major Open Source Database Servers

NAME	URL
Berkeley DB	www.sleepycat.com/
Derby	http://db.apache.org/derby/
Firebird	http://firebird.sourceforge.net/
Ingres	http://www3.ca.com/Solutions/Product.asp?ID=1013
MaxDB	http://www.sapdb.org/
MySQL	www.mysql.com
PostgresSQL	http://www.postgresql.org/

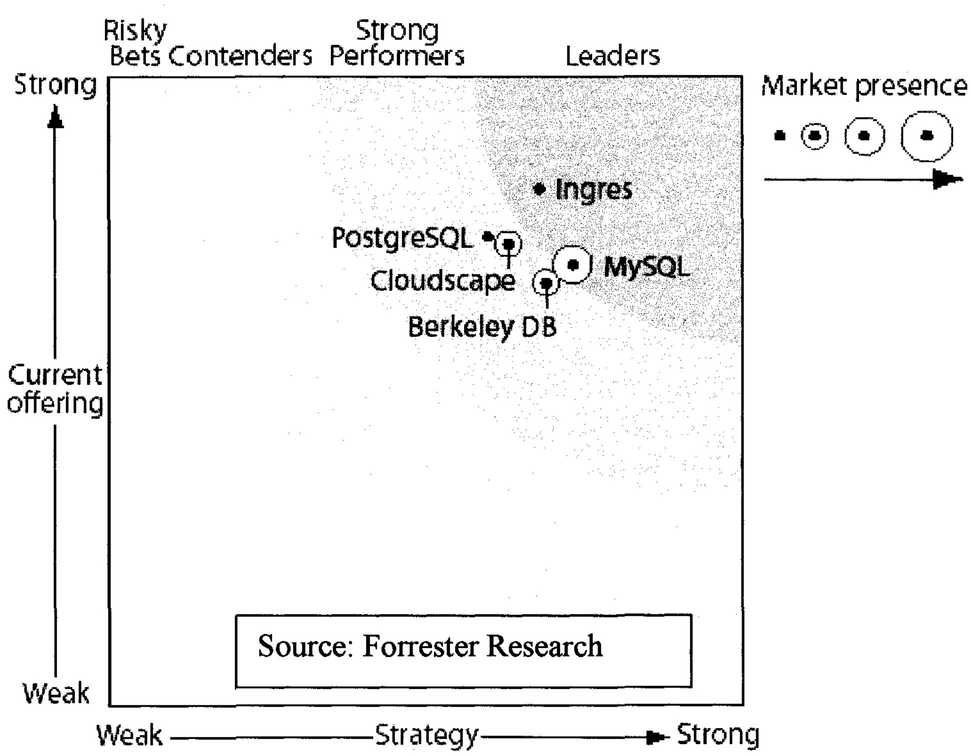


Figure 5: Market Presence of Open Source Databases.

Non-Adoption Reasons of Open Source Databases

1. **Support Availability**

The most popular reason of concern for open source software is support availability, quality, and promptness. Organizations are used to a 24X7 customer support lines from commercial database vendors. The same is not true for open source databases where most of help would come from the community through emails and forums. In most cases, there is no line to call here and now. However, lately there is a tendency for companies to provide support for open source databases. For example, as is the case with mySQL, the actual software is free but there is a fee for professional support and also there is a huge knowledge base for the DBA to refer to if he needs help.

2. **Product Quality and Maturity**

Second, there is a concern about product quality and maturity. It looks odd to organizational decision makers to choose a database server as the back-end for mission critical applications which was developed by a group of developers around the globe. This concern manifests itself in the business world where most open source DBMSs are used for non mission-critical applications and are tested extensively before they are put in any kind of production. Even this trait however is being changing lately because some of the open source databases are in the market for a long time with multiple releases and others were commercial DBs that were recently open-sourced.

For instance, at NASA's Jet Propulsion Laboratory they found that the quality of open source components they used for their Science Activity Planner Software exceeded the quality of commercial applications with fewer bugs, better documentation, and easier to understand code (Norris 2004, p. 44).

3. Third Party Applications

The third concern is the availability of third party software for open source databases. For example, for commercial databases one would find a n endless amount of applications ranging from front-end editing tools, performance monitoring, data access etc. In the open source market this abundance is not there yet but this does not mean that the situation will stay the same. For well-known open source databases like mySQL the availability of packaged software is increasing rapidly and this trend is expected to continue into the feature.

This reason is so important that even Marten Mickos, CEO of mySQL said back in 2002 that he did not expect enterprises to adopt MySQL before it enjoys the support of application vendors (Hicks, 2002).

For MySQL however this support is beginning to manifest itself in that many application vendors like SAP, Novell, Veritas, and many more are supporting MySQL in their applications (Bloor, 2005).

4. Security Concerns

Fourth, there is a concern about security since the source code of an open source database is exposed for everyone to see. If one knows the internals of the database engine, i.e. the way its defenses are structured, then it would be easier to stage an attack. This security concern is real and only way to offset it is through rigorous development and testing.

Fifth, one of the requirements of open source software is that once changes are made to the source code, the developer or the organization must release those changes to the public. Some corporations might feel that such a restrictive strategy is against their interests since they will be knowingly delivering to their competitors know how about their business processes and operations in general.

Chapter Summary

In this chapter examined a range of individual models of user acceptance of technology. Then we proceeded to report on organizational adoption of technology in which case we were faced by two different model types: Stage models which examine all the phases of technology adoption and infusion in the organization. Also, we examined factor models which examine one particular phase of technology introduction to organizations. Some of these models examine only adoption, some implementation, and some infusion to the end users. We chose to concentrate on factor models that examine technology adoption. We used the Technology, Organization, Environment (TOE) framework as a starting point for our research and in our next chapter we refer to our two newly theorized constructs through which we try to expand TOE.

CHAPTER 3: METHODOLOGY

Introduction

In this chapter we present the expanded TOE model (ETOE) and present our hypotheses in great detail. We also present our survey instrument so that the reader can easily understand the transitions from indicators to constructs. We also explain our data collection methods, pilot studies, and issues of factor models that a researcher should pay attention to. Finally, we also give an extensive literature review of similar factor model instruments used by other authors along with sample sizes, instrument types, and response rates.

Theoretical Foundations

In the effort to develop a new model for organizational adoption, we summarized previous work in the literature as it is shown below. We notice at once that most authors focused on the TOE framework. Authors like Cooper and Zmud (1990) and Lee and Runge (2001) who included additional constructs are not using TOE as their basis.

	Technology	Organization	Environment	Individual Characteristics	Technology-Task Compatibility
Gatignon and Robertson (1989)		✓	✓	✓	
Cooper and Zmud (1990)	✓				✓
Daugherty, Germain, and Droge (1995)		✓			
Fichman and Kemerer (1997)		✓			
Lai and Guynes (1997) Model		✓			
Chau and Tam Model on Adoption of Open Systems (1997)	✓	✓	✓		
Premkumar Roberts (1999)	✓	✓	✓		

(Chengalur-Smith, Duchessi 1999)	✓	✓	✓		
Lee and Runge (2001)		✓		✓	
Kendall, Tung, Chua, Hong, Ng, Tan (2001)	✓				
Zhu, Kraemer, Xu, Dedrick (2004)	✓	✓	✓		

Figure 6: Previous Organizational Adoption Research for Factor Models

Research Model And Hypothesis

The Research model is illustrated in Figure 7. There are seven sets of antecedent factors that are affecting open source technology adoption is organizations. Note that organizational learning, contextual dimensions and structural dimensions are all constructs referring to the organizational part of the TOE framework. Consequently, this model includes the TOE framework of Technology, Environment, and Organization and is enriched by two additional constructs: technology-task compatibility and the characteristics of the individual who acts as the decision maker.

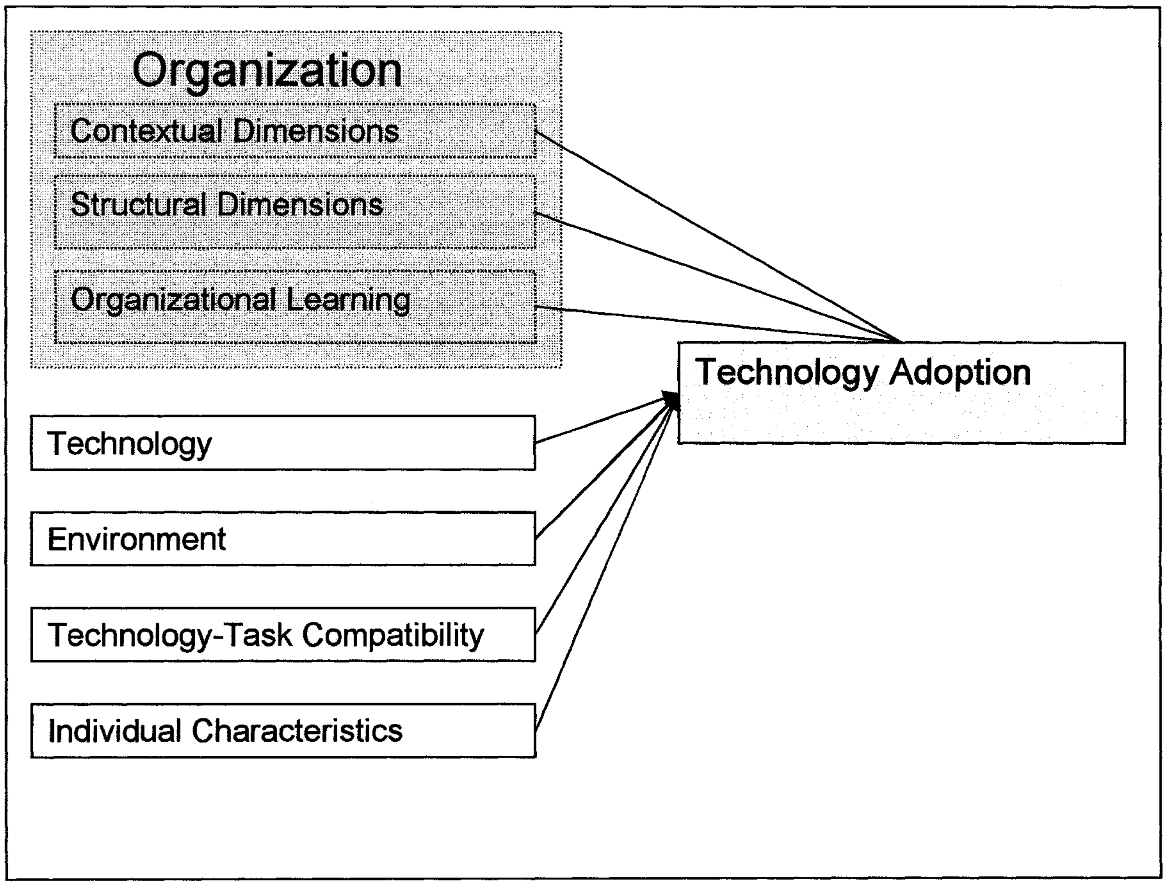


Figure 7: Proposed Model of Technology Adoption

Organizational Characteristics

Organizational dimensions (characteristics) are divided into two major types: contextual Dimensions and structural dimensions (Daugherty et al. 1995, p. 311). When it comes to structural dimensions we refer to formalization, specialization, decentralization, and integration. Many authors consistently refer to structural dimensions in organizational adoption studies (Daugherty et al. 1995, p. 311), (Lai and Guynes1997, p.147) (Chengalur-Smith and Duchessi 1999, p. 80), (Kendal et al. 2001, p.227-228). Contextual dimensions refer to organizational characteristics like size, number of sites, the history of the corporation, and others (Daugherty et al. 1995, p. 311). In our study we examine one contextual dimension (size) and four structural dimensions (formalization, specialization, decentralization, and integration). Consequently our organizational construct will include:

Structural Dimensions
- Formalization (+)
- Specialization (+)
- Decentralization (+)
- Integration (+)

Contextual Dimensions
- Size (+)

We expect a positive relationship between technology adoption and size, formalization, specialization, decentralization, and integration.

Our final inclusion in the organizational construct is Organizational Learning. Authors argue that corporations who have in place mechanisms to absorb learning will be in a better position to adopt new technologies. Also, corporations with related knowledge with respect to the technologies to be adopted will be in superior position to absorb new technologies Fichman and Kemerer 1997 p. 1351). Moreover, adoption can increase if technologies can be applied into multiple departments and/or applications within the corporation. In this case the cost per application will decrease since it will be shared within the company obtaining scale effects (Fichman and Kemerer 1997 p. 1350). Finally, the degree of diversity defined as "… the degree of heterogeneity of organizational knowledge and activities in areas related to application development." (Fichman and Kemerer 1997 p. 1350) will facilitate technology adoption in organization. We have considered organizational learning theory to play a pivotal role in technology adoption and this is why we have incorporated organizational learning indicators in the model. The organizational learning items are:

Organizational Learning
- Learning Related Scale (+)
- Related Knowledge (+)
- Diversity (+)

Consequently our hypotheses are:

H1: Organizational size is positively related to technology adoption.

Measured by: Total Revenues, Number of Employees.

H2: Structural Dimensions are positively related to technology adoption.

Measured by Top Management Support, Formalization, Specialization, Decentralization, and Integration.

H3: Organizational Learning is positively related to technology adoption. Measured by Learning Related Scale, Related Knowledge, Diversity.

Technology Characteristics

The characteristics of the particular technology that is considered for adoption is a construct included in the majority of research studies (Lai and Guynes, 1997), Cooper and Zmud (1990), Roger (1983).

Technologies highly **compatible with existing systems** will have a higher adoption rate in organizations (Chau and Tam 1997, p. 7) (Cooper and Zmud1990 p.126) (Premkumar 1999, p.471).

Technology Readiness is the ability of the firm to make use of existing and new technologies (Zhu et al. 2004, p. 27)

Relative Advantage is defined as the degree to which a technology is better than the one it replaces (Premkumar 1999, p.471)

Technologies that are more **cost effective** are more likely to be adopted by organizations (Premkumar 1999, p.471).

Less **complex technologies** are more likely to be adopted by organizations (Premkumar 1999, p.471) (Chengalur-Smith and Duchessi 1999, p. 80).

Availability of **Technology Characteristics** (support for SPs, transactions, clustering, unicode, sub-select, load balancing, triggers) will lead to higher rates of adoption.

Trialability: Open source technologies will have a higher adoption rate if they can be deployed and tried without high cost.

Highly mature open source software will more readily be adopted by organizations.

- **Extensibility**: Open source databases that are flexible and can accommodate an organization's changing needs will be more easily adopted by organizations.

Hypothesis 4: Technology factors are positively related to organizational technology adoption as measured by:

- Degree of Compatibility with Existing Systems (+)
- The Relative Advantage of the technology (+)
- Cost Effectiveness of the Technology (+)
- Degree of Complexity of the Technology to be Adopted (+)
- Range of Open Source Database Characteristics (+)
- Degree of Trialability of the Technology (+)
- Degree of Flexibility of the Technology (+)

Environment Characteristics

The environment of a corporation is comprised from entities external to the corporation such as customers, suppliers, partners, competitors, and governmental institutions. There are many environmental factors that will entice or preclude organizations from adopting open source databases.

A high degree of **demand uncertainty** entices organizations to be more open to technological adoptions (Gatignon and Robertson, 1989, p. 37) (Chau and Tam 1997, p. 4) (Premcumar 1999, p.469).

IS Integration Level: Corporations are prone to adopt new technologies when their information systems are more integrated to external information systems (Gatignon and Robertson, 1989, p. 37).

High **vertical coordination** among suppliers and customers prompts organizations to adopt information technologies for coordination (Gatignon and Robertson, 1989, p. 38) (Premcumar 1999, p.469).

It has been found that **competition intensity** entices organizations to be very open to adoption of new technologies. (Chau and Tam 1997, p. 4) (Zhu et al. 2004, p. 29).

A rapidly **changing industry** stimulates organizations to adopt new technological innovations ((Chau and Tam 1997, p. 5).

Government regulations will bring rapid adoption of new technologies by organizations (Chengalur-Smith and Duchessi 1999, p. 78) (Zhu et al. 2004, p. 29).

Hypothesis 5: Environmental Factors are positively related to technology adoption as measured by:

- Demand Uncertainty (+)
- Degree of IS Integration (+)
- Degree of Vertical Coordination (+)

- Competition Intensity (+)
- Changing Industry Environment (+)
- Degree of Government Regulation (+)

Technology-Task Compatibility

Task complexity will affect adoption decisions for open source software. It might be positively or negatively related (Cooper and Zmud 1990, p. 128).

Technology-Criticality of mission fit. Will open source databases be adopted for mission critical applications? (Yuhanna, 2004).

Technology-Current Processes fit will positively affect the adoption of open source databases (Kendall 2001, p. 227).

Expected Increase in Market Share will positively influence the decision from an organization to adopt open source databases (Kendall 2001, p. 227).

Expected Increase in Revenues will have a positive adoption effect (Kendall 2001, p. 227).

Expected decreases in cost will entice organizations for adoption of open source systems (Kendall 2001, p. 227).

Hypothesis 6: Technology – Task Compatibility is positively related to technology adoption as measured by:

- Degree of Task Complexity (+)
- Criticality of Mission (+)
- Technology Fit with Current Processes (+)
- Expected Increases in Market Share (+)
- Expected Increases in Revenues (+)
- Expected Decreases in Cost (+)

Decision Maker Characteristics

We claim that the attitude of a key decision maker toward open source will affect adoption of such systems considerably.

For a decision maker, "**exposure to personal information**" is the experience and know-how by the decision maker himself or herself and will affect the decision process for adoption of open source databases.

"**Exposure to impersonal information**" such as magazines, advertisements, and brochures will positively affect a decision maker. (Gatignon and Robertson 1989 p. 39 , p41).

Preference for Information heterogeneity means that the decision maker is interested in sources of information both within and outside his or her own industry (Gatignon and Robertson 1989 p. 39 , p41).

Word of mouth about the technology is important for decision makers and faced with positive or negative feedback they usually pay more attention to the positive one. (Gatignon and Robertson 1989 p. 39, p41).

"**Attitude toward open source**". The decision makers' attitudes toward open source systems will affect the adoption of such technologies.

Hypothesis 7: Individual Characteristics are Positively Related to Technology Adoption as measured by:

- Exposure to personal information (+)
- Exposure to impersonal information (+)
- Preference for Information heterogeneity (+)
- Positive word of mouth about the technology (+)
- Positive attitude toward open source systems (+)

A Parsimonious model

The utopian goal of any researcher who is building a model would be to build a comprehensive one including all the variables that possibly exist. In the adoption of technology in organizations field some researchers tried to build such models only to realize that such an endeavor is not feasible because of limitations of data. In this sense we are trying to build a model which is comprehensive enough that includes all the major variables and parsimonious enough to be understood and used by researchers and professionals (Lai and Guynes 1997, p. 147).

A Factor model

There are two main research approaches for studying adoption of innovations: factor and stage research. The choice of one of the approaches will dictate research design and data collection methods. Data collected for a factor model refers to a particular point in time and of course the outcome is a cross-sectional analysis of it. On the other hand, stage research involves the collection of data over subsequent periods of time resulting in longitudinal data. The focus of this type of a research is on unfolding the processes or the stages leading to adoption of innovations in an organization. Of course, mixed studies exist too where researchers identify the factors affecting innovation adoption and then they use these factors to study the adoption process in various stages (Prescott and Conger 1995, p. 24). The model in this study is a factor model since we are interested only in the factors affecting the adoption of open source databases by organizations.

Using the Key Informant Method

Gallivan (2001) reports that traditional research studies of technology adoption models rely on the "key informant" method. In this type of research a single respondent is selected from each organization and this person usually holds a senior position. Then, a questionnaire is presented and completed by this person and the data is collected into a database. The questionnaire asks about whether a particular technology was introduced to the organization and this categorical variable is used as the dependent variable. Then, through the questionnaire or other research methods, additional data is gathered for other characteristics of the corporation such as company size, structure, and design. Then, through regression analysis, the adoption dependent variable is linked to the other characteristics of the organization and a model emerges (p. 57).

However, some researchers criticized the "key informant" method arguing that conclusions about whole organizations are made based on the opinion of a single person. The problem is not the dependent variable but the quantification of independent variables since a senior manager is giving numbers and opinions without any validity tests from other staff within the organization. This method becomes less reliable in the cases where no triangulation is possible (Gallivan 2001, p. 57) (Rogers 2003, p. 127).

In this model, we are not interested so much in the successful implementation of technology but rather in the decision to consider and decide to adopt a database coming from the open source area. Any subsequent failures or successes resulting from the implementation of this technology are outside the scope of this study.

The Need for Causality

Orlikowski and Robey (1991) criticize the approach that many researchers take in exploring technology adoption in organizations. Often, researchers focus on a very specific area such system acceptance or failure, successful implementation, user resistance, or a specific aspect of the organization such as design, centralization, decentralization, and others. The resulting problem is that there is little evidence of theoretical frameworks that are encompassing enough to include factors and variables that would be of value to researchers and practitioners. Though model parsimony is important, there should be a clear distinction of the level of analysis, and attention to causality, and emphasis on usefulness of research instead of on the variables of the model (p. 144). This point was a major issue of interest in this study because we would like to provide a model that can actually be used by other researchers and practitioners. Consequently, though we pay attention to the parsimony of the model, yet we provide so many sub-factors of the major constructs that the model can become a tool at the hands of the business manager to base an adoption or non adoption decision.

Research Methodology

Measurement

Variables are measured in the form of multi-item indicators on a seven point likert scale and what we are trying to achieve is the aggregation of scores of surrogate variables that will constitute each factor. (Premkumar 1999, p. 473), (Lai and Guynes 1997, p. 150), (Chau and Tam 1997, p. 9), Gatignon and Robertson (1989). Some authors like Moore and Benbasat (1991) discussed the poor operationalization of constructs. In our study we made sure that we followed previous theory and research instruments to form the indicators with excellent results in the phase of data analysis.

Data Collection

Instrument Development

For our instrument development we did not just write survey questions that we thought might apply but rather we based our questionnaire on previous theory and we contacted previous authors like Kendall (2001), Gordon (1993), and Chengalur and Duchessi (1999) who worked on organizational adoption and the TOE framework to sent us their own questionnaires. Then, we added only the indicators for the TOE model expansion that we theorized.

Pilot testing.

Step 1: Contacting Previous Authors.

The first step for creating the questionnaire for this model was to look at the literature for authors who did similar work in the past and in particular for authors who worked on factor models. A table with those authors appears below:

Chau (1997)	**Logistic regression**
Lai (1997)	**Logistic regression**
Cooper and Zmud (1990)	**Logistic regression**
Fichman and Kemerer (1997)	**Partial Least Squares and OLS regression**
Chengalur-Smith, Duchessi (1999)	**Multivariate analysis of variance (MANOVA)**
Kendall (2001)	**Factor analysis, Linear Regression**
Premkumar (1999)	**Multivariate Discriminant Analysis**
Gordon (1993)	**Logistic Regression**

Table 2: Authors with Factor Technology Adoption Models

I have personally emailed some of the above researchers and professors Chengalur, Gordon, and Kendall replied and their questionnaires were used as a starting point.

STEP 2: Developing the questionnaire

To develop the questionnaire we practically followed an iterative approach. First, we based the questions on the survey questionnaires of previous authors who did research on technology adoption in organizations. Then, we created a table of the constructs that previous authors used and checked to see if there are any gaps in current research. Following that, we theorized a new model with two additional constructs as an expansion to current research. Even this proposed addition to current theory came from examining practitioner magazines, talking to companies that work with open source products like MySQL and Hewlett Packard, and also by having a look at the current open source literature. The questionnaire appears in 0.

STEP 3: Getting Data and comments from subjects

The author used a sample of managers and database professionals working on campus at Rensselaer Polytechnic Institute to get the data for the pilot survey. The goal was not just to fill out the questionnaire. The procedure involved the author setting up meetings with every professional and then go to their offices where they will fill out the questionnaire. Before, during, and after the completion procedures the author will listen to comments about the format and most importantly the content of the questionnaire. As a result the questionnaire has improved dramatically especially in terms of semantics so that the subjects understand the questions thoroughly.

Finally, before finalizing our survey instrument, we had a look at the instruments, methods, response rates, and usable indicators from other authors. This information helped us a lot to finalize our research methodology:

1. Lai and Gaynes (1997): Sent a **thousand** surveys to the MIS directors of the business week 1000 companies. Took names from directory of top computer executives and the corporate technology directory. Used follow up mail in six weeks. **161** usable questionnaires.

2. Chau and Tam (1997): Used a list of **300** senior executives responsible for managing the corporate IT functions compiled from the names of a major IT vendor and the Hong Kong section of the Asian Computer Directory of 1992. **89** senior executives were personally interviewed and analysis was based on those 89 records.

3. Cooper and Zmud (1990): Used a random sample of American Production and inventory control society members from the US. They targeted **100** members for a telephone interview from which they were able to use **52** questionnaires.

4. Fichman and Kemerer (1997) sent **1,500** survey questionnaires (in disks) to names they obtained through International Data Corporation (IDC) from 40,000 sites through probability sampling. They had **608** usable responses.

5. Gatignon and Robertson (1989). They used a survey that they sent to senior sales officers of companies of more than 200 employees across a range of industries. **900** questionnaires were sent with **146** responses from which **125** were usable.

6. Daugherty, Germain, and Droge (1995, p. 314). A mail survey was used. The survey was pre-tested with logistics practitioners and then sent to a **1000** persons from the Council of Logistics Management. They received 217 questionnaires from which they used **183**.

7. (Chengalur-Smith, Duchessi 1999, p. 82) sent a survey of **4593** questionnaires and received **350** usable responses. They also made a random call back to 160 non-respondents.

8. (Kendall 2001, p. 227): Used a survey which they sent to **400** members of the Association for Small and Medium enterprises in Singapore. **58** responses were received.

9. (Gordon 1993, p. 153): sent 484 surveys and received 95 usable responses.

CHAPTER SUMMARY

The key point the reader should retain from this chapter is that the model is a continuation of previously established research. We have not created a new model from scratch; we expanded an existing one to accommodate the latest developments in technology and in particular open source databases. Also, we have not developed our questionnaire from scratch; rather, we used indicators from previous authors as much as possible and we only used new indicators to verify the newly proposed constructs. As such we had the opportunity to retest the TOE framework and of course assess the validity of the theoretical framework we propose.

CHAPTER 4: DATA ANALYSIS AND RESULTS

DATA EXPLORATION

Groupings, Response Rates, and valid answers

Data was collected from four different groups. The first group consisted of Hewlett Packard clients from various industries. For this group an email was sent to potential participants and contained the URL of the online survey. Then, the users would visit the survey web site and would answer the questions on their own time. In total 55 emails were sent and 20 answers were received.

The second group consisted of Executive MBA professionals from SUNY Albany, that is, people who are working full time and are students part time. For this group, the survey questionnaire was distributed in class and the participants answered the questions on paper. The total students in class were 24 and 11 answers were received.

The third group consisted again from SUNY EMBA executives in a different class and again questionnaires were distributed and answered during class time. It is of interest to note that not all students were willing or able to take the survey. So a questionnaire was distributed to all of them but only those who felt comfortable with the questions responded. This group consisted of 25 students and 7 responded to the survey.

The fourth group consisted of Rensselaer Polytechnic Institute (RPI) EMBA students. This group was diverse in the time and taking of the survey and also the medium that was used. Some of them completed printed questionnaires and some of them completed the survey online. In total about 30 people were approached to answer the survey from which 11 did.

In total, out of 130 participants we received 49 responses, a response rate of 37%.

Three of the questionnaires were not usable because they had too many missing answers and we had to leave them out. Consequently, we remained with 46 cases to work with.

Below, we present several breakdowns of the characteristics of the respondents in a graphical way.

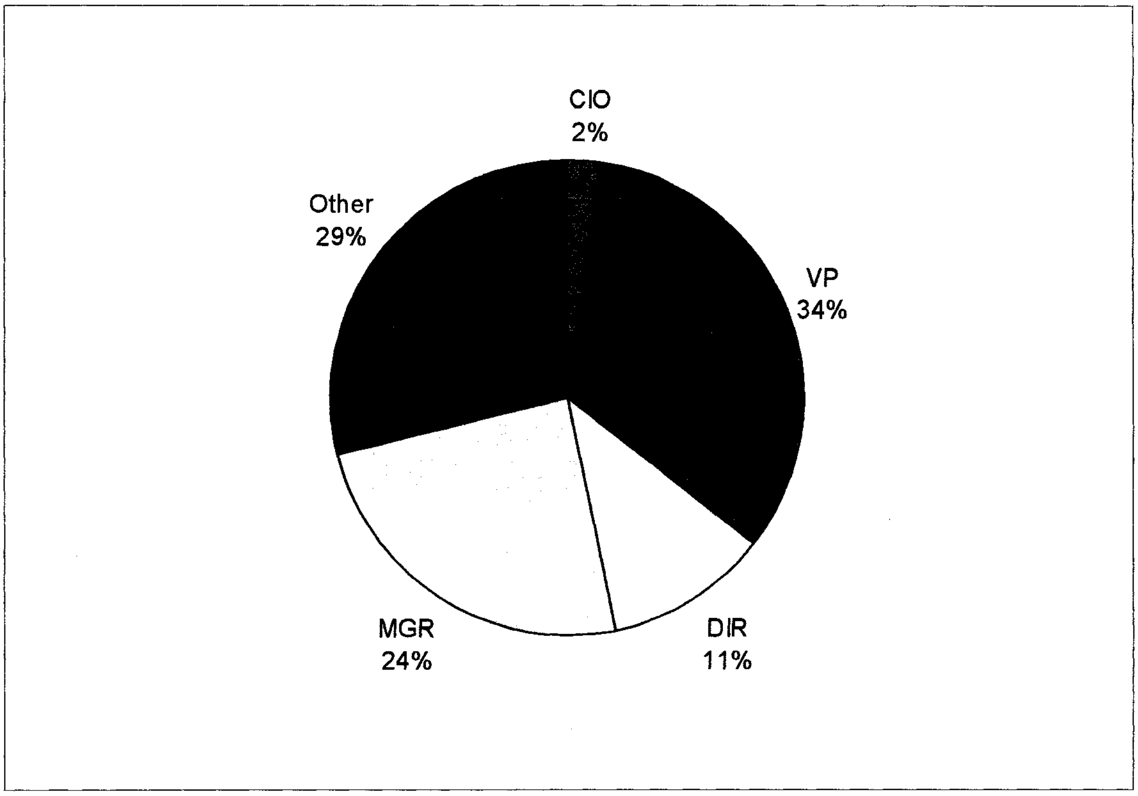


Figure 8: Survey Respondents by Job Function

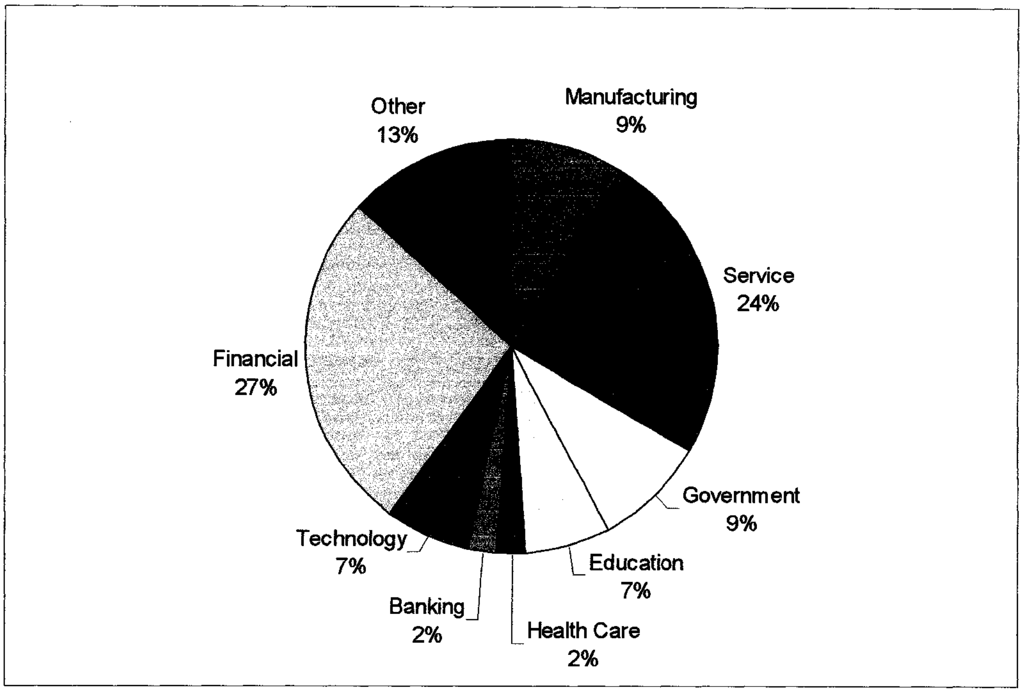


Figure 9: Survey Respondents by Industry

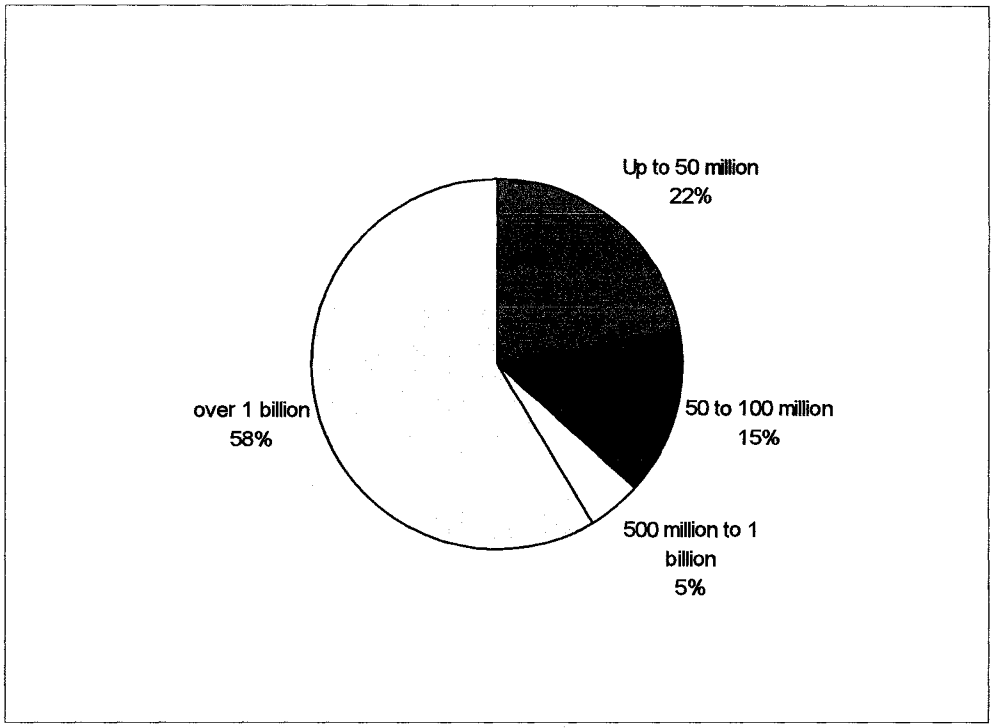


Figure 10: Survey Respondents by Company Revenue

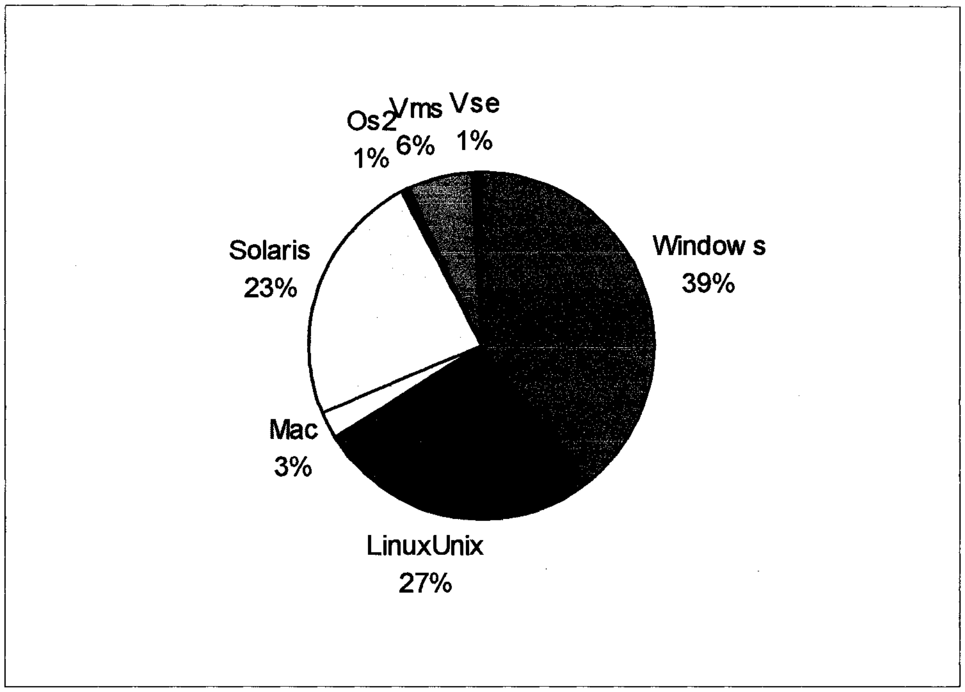


Figure 11: Usage of Operating Systems in Respondent's Corporations

VMS = Open Virtual Memory System. Developed by DEC and now owned by HP.

VSE = Virtual Storage Extended. Operating system from IBM for mainframe computers

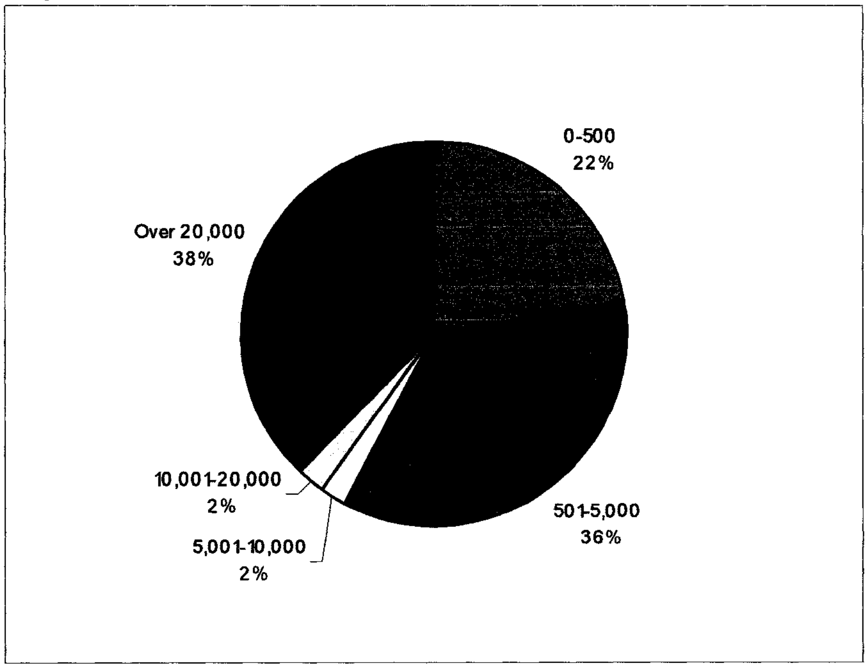


Figure 12: Employee Numbers and percentages

MANOVA Analysis

We used MANOVA analysis to check if there are any significant differences between the two main groups that we used. That is, EMBA students (working professionals) and Hewlett Packard customers who are full time working professionals. As we can see from Figure 13, revenue, employees, and budget, are significant differences between the two groups. These variables are all related to size and we can definitely justify such differences since we do have in the sample both big and small companies. In any case, as we shall see later on we do check for size in our SEM analysis and it comes up indignificant.

Choices in MANOVA Analysis

- **Group Field**: The categorical variable on which we test variation of dependent variables is the ID2 field.

Multivariate Tests

We see that all multivariate tests are coming to be non-significant.

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	1.000	931.171[a]	13.000	1.000	.026
	Wilks' Lambda	.000	931.171[a]	13.000	1.000	.026
	Hotelling's Trace	12105.223	931.171[a]	13.000	1.000	.026
	Roy's Largest Root	12105.223	931.171[a]	13.000	1.000	.026
id2	Pillai's Trace	.993	11.149[a]	13.000	1.000	.231
	Wilks' Lambda	.007	11.149[a]	13.000	1.000	.231
	Hotelling's Trace	144.943	11.149[a]	13.000	1.000	.231
	Roy's Largest Root	144.943	11.149[a]	13.000	1.000	.231

a. Exact statistic

b. Design: Intercept+id2

Figure 13: MANOVA Multivariate tests.

Univariate Tests

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
id2	Revenue	15.764	1	15.764	44.200	.000
	Employees	17.024	1	17.024	8.542	.012
	Budget	11.206	1	11.206	14.976	.002
	OSForCriticalApplications	118.788	1	118.788	1.919	.189
	OSForNonCriticalApplications	99.297	1	99.297	1.419	.255
	PlanningToAdopt	.438	1	.438	1.727	.211
	PurposeOfOpenSource	1.024	1	1.024	1.118	.310
	PlannedNextYear	266.002	1	266.002	1.423	.254
	PlannedFiveYears	22144.438	1	22144.438	3.499	.084
	O1	.341	1	.341	.067	.799
	O2	1.456	1	1.456	.505	.490
	O3	.024	1	.024	.007	.935
	O4	3.068	1	3.068	.929	.353
	O5	.055	1	.055	.017	.898
	O6	.000	1	.000	.000	1.000
	O7	3.491	1	3.491	1.058	.323
	O8	.024	1	.024	.007	.933
	T1	1.024	1	1.024	.514	.486
	T2	.733	1	.733	.502	.491
	T3	.733	1	.733	.636	.440
	T4	.024	1	.024	.013	.912
	T5	.388	1	.388	.165	.691
	T6	1.650	1	1.650	1.682	.217
	T7	3.491	1	3.491	1.230	.288
	T8	1.456	1	1.456	.505	.490
	T9	1.856	1	1.856	.644	.437
	T10	5.097	1	5.097	2.314	.152
	T11	6.206	1	6.206	3.550	.082
	T12	1.188	1	1.188	.447	.515
	T13	2.547	1	2.547	1.479	.246
	T14	5.097	1	5.097	1.715	.213
	E1	2.933	1	2.933	1.362	.264
	E2	7.424	1	7.424	3.458	.086
	E3	1.274	1	1.274	.465	.507
	D1	1.364	1	1.364	.380	.548
	D2	8.983	1	8.983	3.798	.073
	D3	1.752	1	1.752	.527	.481
	D4	.014	1	.014	.006	.938
	TT1	.256	1	.256	.065	.803
	TT2	.668	1	.668	.348	.565
	TT3	.123	1	.123	.035	.854
	TT4	.038	1	.038	.013	.910
	TT5	2.933	1	2.933	1.004	.335
	TT6	2.547	1	2.547	.863	.370
	TT7	1.105	1	1.105	.251	.625

Figure 14: Univariate Tests

From the univariate tests we see that revenue, number of employees, and budget (all measures of size) are significant. Consequently, we need to control for size.

CORRELATION ANALYSIS

Singularity

Having a look at the correlation R-matrix we have not identified any singularity problems, that is, variables that perfectly correlate.

Elimination of Variables that do not correlate with others

At this point we have not found any variables that do not correlate with the others and so we did not take out additional variables.

Multicollinearity

We do not want our variables to highly correlate with each other. Having a look at the determinant of the correlation analysis, it is obvious that we might have some multicollinearity problems. The value of the determinant of the R matrix is less than .00001 which suggests multicollinearity problems. Here, we might want to have a look at the Variance Inflator Factor (VIF) and Eigen values of the variables to test for multicollinearity.

Organizational Variables

	O1	O2	O3	O4	O5	O6	O7	O8
O1	1							
O2	0.290	1						
O3	0.037	0.532	1					
O4	0.402	0.274	0.192	1				
O5	0.131	0.368	0.672	0.097	1			
O6	0.302	0.532	0.507	0.076	0.372	1		
O7	0.555	0.082	0.098	0.490	0.067	0.032	1	
O8	0.203	0.420	0.573	0.167	0.473	0.288	0.171	1

Figure 15: Bivariate Correlations of Organizational Variables

Technology Variables

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
T1	1													
T2	0.643	1												
T3	[redacted]	0.659	1											
T4	0.758	0.623	0.648	1										
T5	[redacted]	0.442	0.756	[redacted]	1									
T6	0.689	0.677	0.785	[redacted]	[redacted]	1								
T7	0.706	0.590	0.680	0.772	0.760	[redacted]	1							
T8	0.715	0.314	0.651	0.710	[redacted]	0.724	0.727	1						
T9	0.633	0.322	0.586	0.705	0.800	0.768	0.789	[redacted]	1					
T10	0.696	0.560	0.715	[redacted]	[redacted]	[redacted]	[redacted]	0.795	[redacted]	1				
T11	0.660	0.503	0.679	0.732	0.724	0.787	[redacted]	0.663	0.713	[redacted]	1			
T12	0.584	0.386	0.640	0.672	0.757	0.748	0.758	0.793	[redacted]	[redacted]	[redacted]	1		
T13	0.690	0.439	0.714	0.744	[redacted]	[redacted]	0.797	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	1	
T14	0.562	0.346	0.618	0.647	0.720	0.761	0.713	0.798	[redacted]	[redacted]	0.784	[redacted]	[redacted]	1

Technology Task Match Variables

	TT1	TT2	TT3	TT4	TT5	TT6	TT7
TT1	1						
TT2	0.336	1					
TT3	0.243	0.621	1				
TT4	0.259	0.569	[redacted]	1			
TT5	0.394	0.495	0.591	0.587	1		
TT6	0.138	0.495	0.504	0.546	0.476	1	
TT7	0.362	0.635	[redacted]	[redacted]	0.612	0.574	1

Figure 16: Bivariate Correlations of Task-Technology Variables

Decision Maker Variables

	D1	D2	D3	D4
D1	1			
D2	0.421	1		
D3	0.434	0.103	1	
D4	0.544	0.129	0.542	1

Figure 17: Bivariate Correlations of Decision Maker Variables

Environmental Variables

	E1	E2	E3
E1	1	[redacted]	0.758
E2	[redacted]	1	0.782
E3	0.758	0.782	1

Figure 18: Bivariate Correlations of Environmental Variables

MISSING VALUE ANALYSIS

When a survey instrument is used to collect data, the existence of missing data is a normal phenomenon. In software packages like SPSS, when we perform factor analysis, we have three choices of handling missing data.

Exclude Cases Listwise

This option will leave out all the cases for which there is even one missing value of the variables participating in the analysis. Andy Field (2005) supports this method as the best of the three provided in SPSS. This is true because it is a very clean method. However, deleting cases with missing data might influence the size and nature of our sample since a lot of cases will be eliminated.

Exclude Cases Pairwise

This option is not suggested by Andy Field (2005) because it can distort the analysis results.

Replace with Mean

It implies that a missing value will be substituted with the mean of the observed values from that variable. It is a method not suggested by Shafer and Graham (2002) because it will distort estimated variances and correlations.

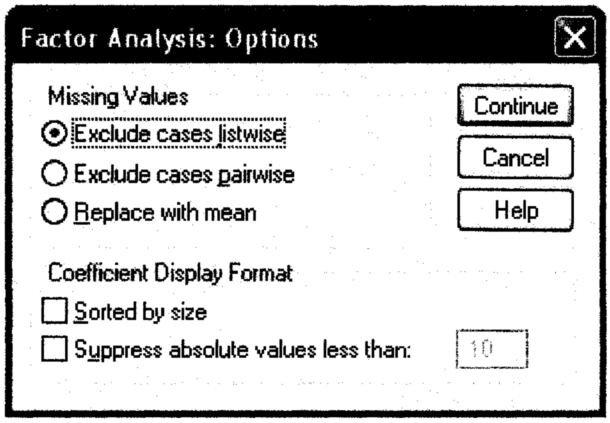


Figure 19: Missing Values Handling in SPSS

Imputation Discussion

Consequently we need to consider imputation options when we perform missing values analysis. An imputation method will replace missing values with high precision items without the need of deleting any cases. However, we need to pay attention to the imputation method used:

Single Imputation

There are four different ways to perform single imputation, that is substitute the value of a variable based on the rest of the values of that variable.

Imputing Unconditional Means

This is the case where missing values for a variable are replaced by the average of the values for that variable. The average values are ok but the variable might loose its initial distribution and variance (Shafer and Graham, 2002, p. 159).

Imputing from Unconditional Distributions

In this case, instead of computing and keeping the mean of the variable, we keep its distribution. That is, the focus is not generating valid mean values but rather keeping the distributional shape of the variable.

Imputing Conditional Means

In this case a regression model is used to substitute missing values. First, a regression model is developed based on actual values for the variable and then this regression model is used to estimate the values for the missing cases for this variable. However this method is not recommended by Shafer and Graham (2002, p. 159) because it might lead to distortion of covariances and correlations.

Imputing from Unconditional Distributions

This is a method that can avoid. However, it is still a single imputation method. (Shafer and Graham, 2002, p. 159)

Maximum Likelihood Estimations (ML)

Maximum Likelihood Estimation (ML) is a modern method for missing data estimation and it should be preferred over pairwise deletion or any single imputation method. It uses likelihood functions to estimate missing data. However, ML is not adequate for small samples. This means that for our case ML might not be adequate. (Shafer and Graham, 2002, p. 159)

Multiple Imputation (MI)

MI is again a modern method and it is more flexible in its application than ML. According to Allison from UPenn (unpublished paper) MI is a very strong imputation method and can introduce the right amount of random error in the imputations resulting in unbiased and strong estimates. Allison claims that there is no other method that can do this. Also, it is very easy to use with any kind of data of any type which makes it an easily applied missing value analysis method.

Choice between SPSS MVA and Amelia

In our thesis we evaluated the SPSS MVA module for missing values analysis. Also we evaluated the R program which is publicly available and the Amelia interface to R which makes it very user friendly.

The SPSS MVA module uses Expectation Maximization (EM) for data imputation. However, it received criticism in the literature. This criticism is that "it is limited to point estimates (without standard errors) of means, variances, and covariances" (Von Hippel, 2004, p.160). Since this is the case we looked at multiple imputation and we found that Amelia and R can perform multiple imputation (MI) successfully and so this is what we used to impute our data.

FACTOR ANALYSIS

Principal Components Analysis vs Principal Axis Factoring

Principal Components is not a real factor analysis method. It is simply a data reduction method that was used decades ago instead of a factoring method because of its ease of use. Still however it is used on more than half of the cases where factoring is needed. One major drawback of PCA is that it does not distinguish between shared and unique variance in variables. There are several authors that suggest using other factoring methods instead of principal components. (Costello & Osborne, 2005, p. 2).

Principal Axis Factoring (PAF) is a true factoring method that isolates shared variance so that latent variables and the structure of factors can be revealed. Another very strong point of PAF is that it will provide consistent results even if the underlying data is not normally distributed. In our study we chose to use Principal Axis Factoring as a true factor method.

A Discussion on Sample Size

There are many rules of thumb and many suggestions from researchers about sample size for factor analysis. The most common rule is to have 10 to 15 participants per variable. Also:

- Nunnally (1978) suggested that there should be 10 times more participants as there are variables.
- Kass & Tinsley (1979) suggest having between 5 and 10 participants per variable with a maximum number of participants of 300 beyond which factor analysis tends to be sound regardless of the number of answers.
- Tabachnic and Fidell (2001) mention that 300 participants represent a good number for factor analysis.
- Comrey and Lee (1992) suggest that a sample of 100 is poor, a sample of 300 adequate, and a sample of 1000 as excellent.
- Arrindell and Van Der Ende (1985) conducted a study to test the rigidity of factor analysis with various numbers of participants. The conclusion was (in this Monte Carlo Study) that the ratio of participants to variables did not play any role.
- Guadagnoli & Velicer (1988) suggest that if a factor has four or more loadings greater than 0.6, then this factor is reliable regardless of sample size. Also, they suggest that a factor with ten or more loadings greater than 0.4 is reliable if sample size is greater than 150. Factors with few loadings should be disregarded unless sample size is above 300.
- An alternative from all the above is to use the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1970, 1974). A value of KMO of

.7 and above signifies that factor analysis would be adequate regardless of sample size. (Field, 2005 p. 638-640)

Choices in Factor Analysis

Descriptives:

- **Coefficients**: since we need to have a look at the R-matrix
- **Significance Levels**: will produce the significance level of each correlation in the R-matrix.
- **Determinant**: this is a test of multicollinearity and we are looking for a value greater than .00001.
- **KMO and Bartlett's test of sphericity**: The KMO test will tell us if the sample size is adequate for factor analysis. Remember we are looking for a value of .7 and above.
- **Bartlett's test of sphericity**: is the essence of factor analysis. Variables in factor analysis should be somewhat correlated for us to find clusters. We are looking for the Bartlett's test to be significant (<.05)
- **Reproduced**: This option produces a correlation matrix based on the model and it compares the differences of correlations between the sample original data and the model. We are looking for residuals to have values below .05
- **Anti-image**: As its name implies, this option produces an anti-image correlation matrix. It is a measure of sample adequacy and the diagonal

elements should all be more than .5. If any variables fail this criterion they should be eliminated. (Field 2005 pp. 641-642)

Extraction

- **Method**: We selected principal axis factoring.
- **Analyze**: We chose to analyze the correlation matrix. This is because the correlation matrix is adequate even when some of the variables have been measured using different scales. Using the correlation matrix, different scales will not affect our analysis.
- **Display**: Here we choose to have a look at the unrotated factor solution and loadings and also have a look at the scree plot.
- **Extract**: Here we used both the option of Eigen values greater than 1 and we also forced various numbers of factors (five and six) to examine alternative factor loadings.
- **Maximum Iterations**: Here we chose a number of 100 just to make sure our factor model runs. (Field 2005, pp. 643-644)

Rotation

A rotation method needs a lot of thinking. Most researchers will do an orthogonal rotation. Here we need to pay attention to the fact that if we think that factors are independent from each other, then we should choose varimax rotation which is an orthogonal rotation. However, if we think that factors might be correlated with each other, then we should select an oblique rotation like Direct Oblimin. We chose Direct Oblimin since correlation of factors is the essence of factor analysis.

Display: Here we only selected to have the rotated solution displayed. Selecting loading plots makes sense if we expect to have up to three factors. Since in our model we expect four to five factors selecting this option would be very difficult to visually inspect loading variables.

Maximum Iterations: We choose 100 iterations.
(Field 2005, pp. 644-645)

Scores

If we choose to run the options here we will get two matrices. The first one will give us the factor loadings for each participant in the survey and the second matrix will be a component score variance from which we can deduce if our factors are correlated. If we expect our factors not to be correlated then we should run the Anderson-Rubin test and all the diagonal coefficients at the component variance matrix should be 1. If we expect correlations among factors, then we should choose the regression choice.

(Field 2005, pp. 645-646)

Options

Missing Values: We choose the option "exclude cases listwise" which option will exclude participants for which there is missing data for any variable in the factor analysis. Since we did multiple imputation and we have no missing data in our data file, it means that this option is irrelevant.

Coefficient Display Format: Here we choose to sort by size and also exclude factor loadings less than .4 (Stevens, 1992).

KMO and Bartlett's test for Sampling Adequacy

Kaiser (1974) suggests that a value of .5 and above is required for the sample to be adequate for factor analysis. A value between .5 and .7 is mediocre, a value between .7 and .8 is good, a value between .8 and .9 is great and a value above .9 is superb.

Anti-Image

However, the overall KMO value for the data is not enough. We must have a look at the anti-image table and specifically the anti-image correlation matrix and check the values. If we find values that are below .5 we must eliminate these variables and run the analysis again. In all our factor analysis scenarios we ran, we excluded the variables D2, O1, and TT1. One has to pay attention when removing variables from the anti-image. Variables should be excluded one by one and then factor analysis should be run again since the removal of one variable will strengthen the anti-image correlation values for all the rest of the variables significantly.

Bartlett's test of sphericity

Also, we see that Bartlett's test of sphericity is significant ($<.05$). This is excellent. Bartlett's test of sphericity tests the null hypothesis that the correlation matrix is an identity matrix. In other words, it tests the independence of variables from each other. If they were perfectly independent, then it means that we could not do factor analysis since we are looking for clusters of variables. In this case the test is significant at the ($p<.001$ level) and so we expect to find meaningful factors. (Field 2005 p. 642, p. 652)

FACTOR ANALYSIS RESULTS

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.804
Bartlett's Test of Sphericity	Approx. Chi-Square	1001.908
	df	351
	Sig.	.000

Figure 20: KMO and Bartlett's Test Eigen Values over 1.

The KMO test will tell us if the sample size is adequate for factor analysis. Remember we are looking for a value of .7 and above and the value obtained from our data is .804

Please note that the value of the KMO test is .804 which is excellent and the Bartlett's test is significant; both excellent results. This means that our sample size is adequate for factor analysis.

Factor Matrix[a]

	Factor					
	1	2	3	4	5	6
T5	.861					
T7	.855					
T9	.850					
T4	.837					
T13	.834					
T3	.797					
T12	.796					
D4	.787					
TT6	.774					
TT7	.765	.451				
D3	.717					
TT3	.688					
E3	.679		.511			
E1	.621		.410	.426		
TT5	.615					
T2	.577					
O3	.569	-.541				
O2	.521		-.518			
D1	.514					
O5	.498	-.426				
TT2	.428					
DepPlanningToAdopt						
O4		.616				
O7	.498	.565				
DepPurposeOSDB		-.465				
E2			.557	.498		
O6	.433		-.517			

Extraction Method: Principal Axis Factoring.

a. 6 factors extracted. 25 iterations required.

Figure 21: Factor matrix of unrotated solution.

Since we used direct oblimin rotation we should look at the pattern matrix which follows.

Pattern Matrix[a]

	Factor					
	1	2	3	4	5	6
T13	.755					
T3	.732					
T12	.694					
T7	.686					
T2	.601					
O5	.592					
T4	.557					
T5	.512					
T9	.505					
DepPurposeOSDB		-.689				
DepPlanningToAdopt		.654				
O2			-.932			
O6			-.694			
O3			-.449			
E2				.913		
E1				.899		
E3				.512	-.436	
D4					-.684	
D3					-.677	
TT5					-.618	
TT6					-.494	
D1						
TT2						-.690
TT3						-.633
TT7					-.465	-.551
O7						-.517
O4		.499				-.502

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 32 iterations.

Figure 22: Factor loadings of rotated solution.

These are practically the results of the factor loadings of the rotated solution. The pattern matrix presents our final factor clusters and loadings.

Factor Correlation Matrix

Factor	1	2	3	4	5	6
1	1.000	-.235	-.259	.318	-.520	-.223
2	-.235	1.000	.240	-.201	.183	-.128
3	-.259	.240	1.000	-.202	.259	.203
4	.318	-.201	-.202	1.000	-.373	-.096
5	-.520	.183	.259	-.373	1.000	.337
6	-.223	-.128	.203	-.096	.337	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

Figure 23: Factor Correlation Matrix.

Reliability Analysis

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
DepPlanningToAdopt	128.42	750.113	-.377	.944
DepPurposeOSDB	127.78	721.040	.375	.941
O2	124.96	683.225	.522	.940
O3	125.76	682.734	.570	.939
O4	125.31	706.537	.329	.942
O5	125.93	697.109	.487	.940
O6	124.98	696.795	.424	.941
O7	124.47	698.845	.447	.940
T2	125.00	696.682	.542	.939
T3	124.76	679.734	.769	.937
T4	124.67	667.091	.811	.936
T5	124.67	664.273	.845	.936
T7	124.64	663.780	.821	.936
T9	124.27	664.518	.815	.936
T12	124.51	670.210	.756	.937
T13	124.69	671.037	.794	.936
E1	125.38	694.604	.600	.939
E2	125.24	710.325	.361	.941
E3	125.04	682.498	.651	.938
TT2	125.60	707.427	.394	.941
TT3	124.96	688.453	.653	.938
TT5	125.29	688.665	.604	.939
TT6	124.91	678.810	.750	.937
TT7	124.44	678.162	.710	.937
D1	125.20	697.573	.498	.940
D3	124.87	680.209	.709	.937
D4	124.80	678.300	.738	.937
O8	125.87	709.436	.307	.942

Figure 24: Factor Reliability Analysis

Reliability Analysis is a method that always follows factor analysis. Here we check to see what will happen to the cronbach's alpha if an indicator is deleted from a factor. A value of alpha above .9 is excellent.

SEM ANALYSIS

Before we go on to the discussion of structural equation modeling we should refer to some changes we made to the names of constructs and variables. We have renamed the task-technology construct to "adoption drivers" because we concluded that this name better captures the nature of the construct. In addition, we have renamed the dependent variable to "intended usage".

WHY STRUCTURAL EQUATION MODELING

In technology adoption in organizations, many authors choose to use logistic regression with a categorical dependent variable to assess the propensity of adoption. We claim that this method is not adequate for such analysis. Indeed, any method of multiple regression, discriminant analysis, logistic regression, analysis of variance, factor analysis, or cluster analysis assumes three pre-conditions for applicability:

1. First, they assume that the model is a simple serialized one with a dependent variable and various independent variables. That is, the above techniques, build models that do not reflect reality. Although we tend to leave out some reality factors when we build models, in the case of the presence of more complex mediating variables these techniques are inappropriate. (Haenlein and Kaplan, 2004, p. 284)

2. Second, such techniques assume that the independent variables can be directly observable. While this is true in some cases, it is not always the case. Indeed some authors like McDonald (1996) claim that a variable is observable "if and only if its value can be obtained by means of a real-world sampling experiment." Consequently, most variables in survey based research are not directly observable and techniques like the analysis of variance or any form of regression would not be adequate. (Haenlein and Kaplan, 2004, p. 284)
3. Finally, the above techniques make the assumption that there is no error in the measurement which is impossible in observations coming from a survey instrument and not a laboratory experiment. This error is made of two parts: a random error, which is attributable to the respondent and a systematic error which is attributable to the measurement scales we applied in the questionnaire. The most important thing to retain is that a score practically measures three items: the true score, the random error, and the systematic error. Regression or MANOVA, or Factor, assume that there is no random or systematic error which is an impossibility (Haenlein and Kaplan, 2004, p. 284)

Structural Equation Modeling came to address these shortcomings as a modern technique which is especially applicable when there are multiple dependent and independent variables and when dependent variables cannot be measured directly. We have two types of SEM: Covariance based SEM in which case we use EQS, AMOS, or LISREL and Variance based SEM in which case we use Partial Least Squares.

COVARIANCE BASED SEM VS VARINACE BASED SEM

As (Haenlein and Kaplan, 2004, p. 290) state "The covariance based approach 'attempts to minimize the difference between the sample covariances and those predicted by the theoretical model… Therefore, the parameter estimation process attempts to reproduce the covariance matrix of the observed measures' (Chin and Newsted, 1999, p.309)'".

Variance based SEM was first introduced by Wold (1975) with the name Nonlinear Iterative Partial Least Squares (NIPALS). Its basic characteristic is that it tries to maximize the variance of the dependent variables explained by the independent variables. PLS has several advantages:

1. It involves no assumptions about the population of the data set which makes it adequate even for small samples. (Haenlein and Kaplan, 2004, p. 291). However, in an editorial by Marcoulides and Saunders (2006) we should treat this PLS strength with caution. PLS is not a silver bullet to apply with sample sizes of any number. Also, we need to pay attention to have enough indicators per construct of what they call consistency at large. At this point there is no clear method to follow or a statistical test to perform to account for sample size. Things get easier when we base our research on previously proven theory and then we apply PLS to expand previous models. As a conclusion a researcher needs to pay attention to
    a. The psychometric properties of the variables.
    b. The strength of the relationship among the variables
    c. The complexity of the model
    d. The amount of missing data

e. The distributional characteristics of the variables considered (Marcoulides and Saunders, 2006, p. iv)

2. However, (Haenlein and Kaplan, 2004, p. 291) state that distribution assumptions of variables in PLS are not important.
3. Also, PLS analysis is not affected by the type of the variable in the sense of ordinal, nominal, or scale (Haenlein and Kaplan, 2004, p. 291)
4. PLS is also very good when the number of indicators per latent construct is excessively large. In this case covariance based techniques reach their limits. (Haenlein and Kaplan, 2004, p. 292)

FORMATIVE VS. REFLECTIVE MODELS

The literature is very specific on the distinctions between formative and reflective models: First, Jarvis, Mackenzie, and Podsakoff, (2003, p. 207) have confirmed that the vast majority of researchers assume that their constructs are reflective. They selected 178 articles over a period of 24 years from four top journals in marketing research (p. 206). In 71% of the cases the constructs were correctly identified as reflective while in 29% of the cases were incorrectly identified as reflective. That is, in 29% of the cases researchers should have identified their constructs as formative but instead they identified them as reflective. Andy Field (2005), an authority in statistics, claims that we first need to use our logic and then statistics. Following a beaten statistical path about reflective constructs has lead researchers to major model misspecifications.

Edwards and Bagozzi (2000, p. 155) explain that theory is divided in two parts: "one that specifies relationships between theoretical constructs and another that describes relationships between constructs and measures." The latter description of relationships among indicators and constructs is of absolute importance if we would like to convert abstract constructs into measurable entities.

Researchers should pay attention not only at the relationships among constructs but also to the nature of such relationships. In fact, researchers, by far assume that the models they build are based on reflective indicators. Software like AMOS, LISREL, and EQS make it easy to assume that structural equation modeling is all covariance based (Diamantopoulos and Wiklhofer (2001, p. 274). However, this is not always the case and we should at least examine the applicability of variance based SEM with formative indicators using Partial Least Squares (PLS).

Jarvis, Mackenzie, and Podsakoff (2003, p. 202) created a comprehensive list of criteria to help researchers distinguish between formative and reflective models. We will use this list to check our own model. Then, we can firmly deduce whether our model is based on formative or reflective indicators. There are four sets of questions that researchers should consider to decide the type of model they should use:

SET 1: DIRECTION OF CAUSALITY BETWEEN INDICATORS AND CONSTRUCTS

Direction of causality is from indicators to construct

That is, a formative model does not assume that indicators or measures are caused by a single, underlying construct (Jarvis, Mackenzie, and Podsakoff (2003, p. 201). Actually, indicators cause or build the construct. Bollen and Lennox (1991, p. 306) stress that causal indicators is just a way to name them.

Diamantopoulos (2001, p. 265) explains that most social scientists just assume their indicators to be effect indicators. This is not always the case. We call formative indicators causal or composite but it is important to understand that such indicators determine the latent variable. In our model all the indicators act as formative since the presence or the degree of an indicator will affect the nature of the corresponding construct. For example, the presence of financial resources will affect the extend to which an organization can tinker with open source technology. Similarly, the degree of competition intensity will characterize a market and the willingness of a corporation to use additional database technologies.

Indicators are defining characteristics of the construct

Churchill (1979, p. 65) explains that when we operationalize constructs we measure their attributes and not the constructs themselves. An automatic operationalization of an entity to a reflective construct cannot and should not be made. This is an easy argument to make for our model. For example, for the case of technology, the characteristics define the construct. That is, if we talk about a database server, then do we immediately deduce that it supports triggers? Actually, we believe the opposite is true, that is, if triggers and stored procedures exist in a database server, then this server is different than another which does not support these two features. Also, for the organizational variables whenever we talk about an organization does that automatically mean that it is formalized? No, its degree of formalization, decentralization and other characteristics define the organization.

Changes in the Indicators Should Cause Changes in the Construct

In this case we expect to see the construct affected by a change in its indicators. Please note that we do not talk about covariance here. We will discuss covariance later on. This is again an easy case to make and if we talk about formalization in a company then its degree of formalization will define the decision structure in the company and in its turn the nature of the organization. In the case of technology if we have a database server that supports transactions, then we can use it for transactional support in an organization's operations instead of just decision support.

Changes in the Construct do not cause changes in the indicators

We have discussed this item above but as Bollen and Lennox (1991) suggest a change in a construct will not cause a change in all indicators. For example, if we define happiness as having three formative indicators (health, friends, and work satisfaction) then a change in happiness will not affect all indicators. It might affect only one of them like work satisfaction.

HOW DIRECTION OF CAUSALITY IS APPLIED TO OUR MODEL

To understand formative indicators let us use as an example four technology indicators from our model: cost effectiveness, longevity, migration support, and compliance to standards. A change in the cost effectiveness will change the desirability and applicability of the technology but an overall change in the technology will not affect all four causal indicators at the same time. In reflective models a change in one construct will change all indicators of that construct.

The same is true with our organizational variables. A change in financial resources or related knowledge will lead to an easier adoption of open source databases. However, a change in the organization's design or financial structure will not cause all organizational characteristics to change.

For the task-technology characteristics this argument is even easier. Expected increases in market share or competitive advantage based on adoption of open source database servers will lead to the adoption of such technologies. However, setting business objectives in general will not lead to analogous changes in all the characteristics of this construct such as market share, technology fit, or competitive advantage.

For the environment construct, the degree of vertical coordination, competition intensity, or visibility are characteristics that define the environment in which the corporation operates. A general change in this external environment, such as the introduction of a new competitor, might affect the competition intensity indicator but not all environmental indicators at the same time.

For the decision maker construct we think that the argument is straightforward. That is, the degree of exposure to information of open source databases will lead to analogous degrees of adoption of open source databases. On the other hand, if the decision maker changes that does not mean that all the decision maker indicators will abruptly change. Also, in our model, the decision maker construct contains two additional indicators: constraints by commercial systems and license modes. These two indicators, coming from factor analysis, strengthen even more our argument for a formative decision maker construct since they will not change if the decision maker changes.

SET 2: INTERCHANGEABILITY OF INDICATORS

Indicators need not be interchangeable

As Diamantopoulos (2001, p. 269) explains, in formative models, indicators are used to develop an index or in other words the latent variable is an index of its own indicators. As such, when one or more of the indicators constituting this index is missing, the index will not reflect what is supposed to be measuring. Consequently, we cannot take out indicators at will in formative models as we can do in reflective models. In reflective models "effect" indicators covary with each other and with the latent variable with which they are associated (excluding standard and systematic errors). If this is the case, then we can take out an indicator without affecting the strength of the factor. In formative indicators if we take out an indicator then the whole meaning of the construct will change.

Researchers should not be hesitant building formative models. Edwards and Bagozzi (2000, p. 162) provide an excellent presentation of formative models in which they explain that for direct formative models we do have a disturbance term (ζ) which is that part of the construct not explained by its indicators. Having knowledge of this effect we can build a formative model and then try to understand this disturbance term if existent. The formative model that we present in this thesis is a direct one (one level of indicators to their respective constructs) and can be represented by the equation:

$$\eta = \sum_{i} \gamma\iota\chi\iota + \zeta$$

where x_s are the indicators and ζ the disturbance term. The most important goal of the above model is to "create an 'induced' latent variable that represents an aggregation of observed variables." (Edwards and Bagozzi (2000, p. 162) and it is not imperative to have a perfect theoretical model right from the beginning.

However, when we use partial least squares, principal components analysis, or canonical correlation we need to pay attention. These methods do not take into consideration the disturbance term and actually distribute weights analogously to the indicators we use. Such application of weights by these statistical methods, though useful, should be taken into consideration by the researcher. We cannot assume that there is no disturbance term in our model. Of course, it is very difficult to recognize it but this is the purpose of the researcher; to further and continuously investigate the theoretical model presented and identify the disturbance term (Edwards and Bagozzi 2000, p. 162).

Indicators need not have the same or similar content

We have a case in our model with a variable named O5 which we assumed it was an organizational variable. It has to do with the budget available to a corporation to try additional software. Though an organizational variable in our model (as a result of factor analysis) it finally became part of the technology construct. When we tried to remove it, the technology construct weakened considerably to the point of not being significant. In formative models indicators are not bound to have similar content.

Dropping an Indicator may alter the conceptual domain of the construct

Jarvis, Mackenzie, and Podsakoff (2003, p. 202) suggest that there might be serious consequences if we drop a formative indicator from its construct. Actually, formative indicators cannot be removed at will as is the case with a reflective model. The same opinion is shared by Bollen and Lennox (1991, p. 308) where they say that we can test the importance of an indicator if we drop it and then run the SEM model again.

Actually, we tried this for multiple indicators in multiple constructs in our PLS model and when an indicator was removed the path coefficients immediately weakened. However, researchers should not be hesitant using formative indicators since as Diamantopoulos and Winklhofer (2001, p. 272) suggest "the need at the indicator specification stage is to be sufficiently inclusive in order to capture fully the construct's domain of content."

HOW INTERCHANGEABILITY OF INDICATORS IS APPLIED TO OUR MODEL

In our formative model the indicators for each construct are not interchangeable. First, we went through a process of removing some indicators that we thought they do not belong to the construct. For example, we thought the variables O4 (Preference to invest in other areas) and O7 (Knowledge Diversity) belong to the organizational construct but they came up belonging to the task-technology construct. In fact, when we tried to remove them the construct weakened a lot. The same is true for the decision maker construct; we thought the variables TT6 (Constraints by commercial systems) and TT5 (License mode- project scope) belonged to the task-technology construct but they finally belong to the decision maker construct. Trying to remove those variables immediately weakened the decision maker construct. The same was true for all the rest of our constructs in this model. Trying to remove a variable from a construct immediately weakened its significance level. The above points prove two prepositions of formative models: first, indicators cannot be removed at will and second, indicators of constructs might not have similar content.

SET 3: COVARIATION AMONG INDICATORS

Not Necessary for Indicators to covary with each other

Jarvis, Mackenzie, and Podsakoff (2003, p. 203) indicate that formative indicators do not need to have a positive relationship among themselves. Also, Bollen and Lennox (1991, p. 307) state that "...causal indicators of the same concept can have positive, negative, or no correlation." Finally, Edwards and Bagozzi (2000, p. 156) explain that "covariances among measures can help differentiate formative from reflective measures, because these covariances follow a predictable pattern for reflective measures but are indeterminate for formative measures." The presence or not of patterns of covariation among indicators however should not lead to immediate conclusions about a model being reflective or formative. This is only one postulation we should check and include in our checklist.

A change in one indicator should not necessarily be associated with changes in other indicators

At this point we need to recall that in formative models constructs are practically indexes. More specifically, these constructs represent a linear relationship of their indicators and are not clusters of variables like in reflective models. In clusters we can easily take out a data point without affecting the nature of the cluster. Also, in clusters, if the underlying condition causing the cluster changes, then the whole cluster will change. This is not the case in formative models with linear relationships among indicators. Finally, as Fornell and Bookstein (1982, p. 444) explain: "components, which are exact linear combinations of their indicators, 'maximize variance' whereas factors 'explain covariance.'" Jarvis, Mackenzie, and Podsakoff (2003, p. 202)

In this chapter we have already presented five tables of bivariate correlations for each construct. Having a look at those tables we can see that there does not exist a pattern of correlations or covariance among variables in each construct. Actually, correlations can be as low as 0.1 or as high as 0.8. This is expected in formative models.

SET 4: CONSTRUCT VALIDITY

In reflective models we follow a specific set of procedures to assess construct validity in the sense of convergent and discriminant validity. In formative models such procedures are not relevant (Diamantopoulos 2001, p. 271) (Jarvis, Mckenzie, Podsakoff, 2003, p. 202).

Furthermore, as Bagozzi (1994, p. 333) explains: "reliability in the internal consistency sense and construct validity in terms of convergent and discriminant validity are not meaningful when indexes are formed as a linear sum of measurements" However, we do need a procedure to decide what indicators we should retain for each construct. Diamantopoulos (2001. p. 273) explains: use the t values from each indicator to decide which ones to keep and do this through an iterative process. This is exactly what we followed to decide what indicators to keep in our own model.

MODEL 1: FORMATIVE MODEL WITH SIZE

To control for size, we need to prove that size is an insignificant factor. As such we run factor analysis again and the results indicate that all the factors load nicely with the two size variables having high loadings at the .984 and .731 levels. The results of the factor analysis show below:

Factor Analysis

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.710
Bartlett's Test of Sphericity	Approx. Chi-Square	1105.853
	df	406
	Sig.	.000

Figure 25: KMO test for extraction of factors for the SEM model

KMO test for extraction of factors for our SEM model. For an explanation of the KMO test please see the preceding Factor Analysis section.

Pattern Matrix[a]

	Factor						
	1	2	3	4	5	6	7
T13	.764						
T3	.681						
T12	.673						
T7	.664						
T2	.568						
O5	.529						
T4	.500						.410
T5	.497						
T9	.489						
DepIntentedUsage		-.682					
O4		-.603				-.491	
DepPurposeOSDB		.534					
Revenue			.984				
Employees			.731				
E1				.929			
E2				.921			
E3				.544			.444
O2					.955		
O6					.735		
O3					.512		
TT3						-.675	
TT2						-.628	
TT7						-.601	.417
O7						-.511	
D3							.629
D4							.628
TT5							.551
D1							.419
TT6							.409

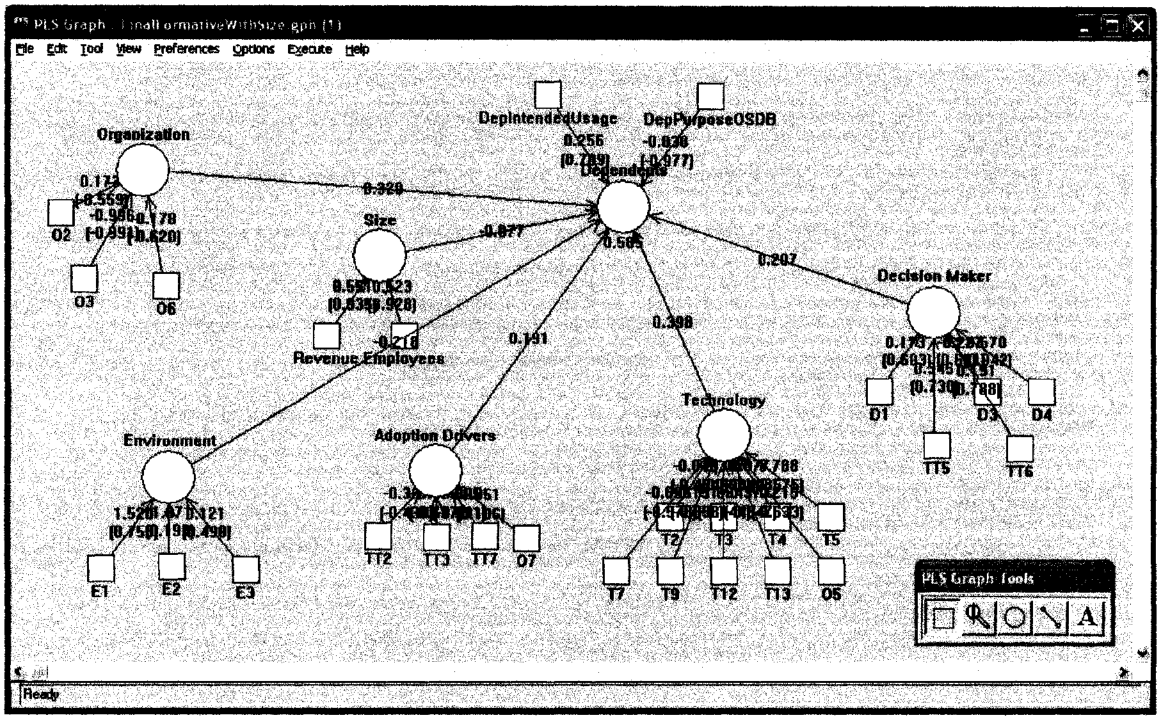
Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 41 iterations.

Figure 26: Pattern Matrix of Factor Analysis for the Formative Model.

Size is included as a control variable. For an explanation of the pattern matrix please see the preceding Factor Analysis section.

Formative Model with Size

We ran PLS analysis and the model shows below:



The outer loadings file and the path coefficients show below:

Path Coefficients Table (T-Statistic)

	Organiza	Size	Environm	Technolo	Decision	Adoption
Organiza	0.0000	.0000	0.0000	0.0000	.0000	0.0000
Size	.0000	.0000	0.0000	0.0000	0.0000	0.0000
Dependen	**1.9238**	**.3625**	**2.2214**	**2.3454**	**2.2790**	**1.9934**
Environm	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technolo	.0000	.0000	0.0000	0.0000	.0000	0.0000
Decision	0.0000	0.0000	0.0000	0.0000	.0000	0.0000
Adoption	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure 27: Formative Model with Size.

We can clearly see that size is insignificant with a t value of 0.365. We can also notice that size is the only insignificant construct. Consequently, since we controlled for size and it came out insignificant, we can take it out and run our model again. The new model appears below.

MODEL 2: FORMATIVE MODEL WITHOUT SIZE

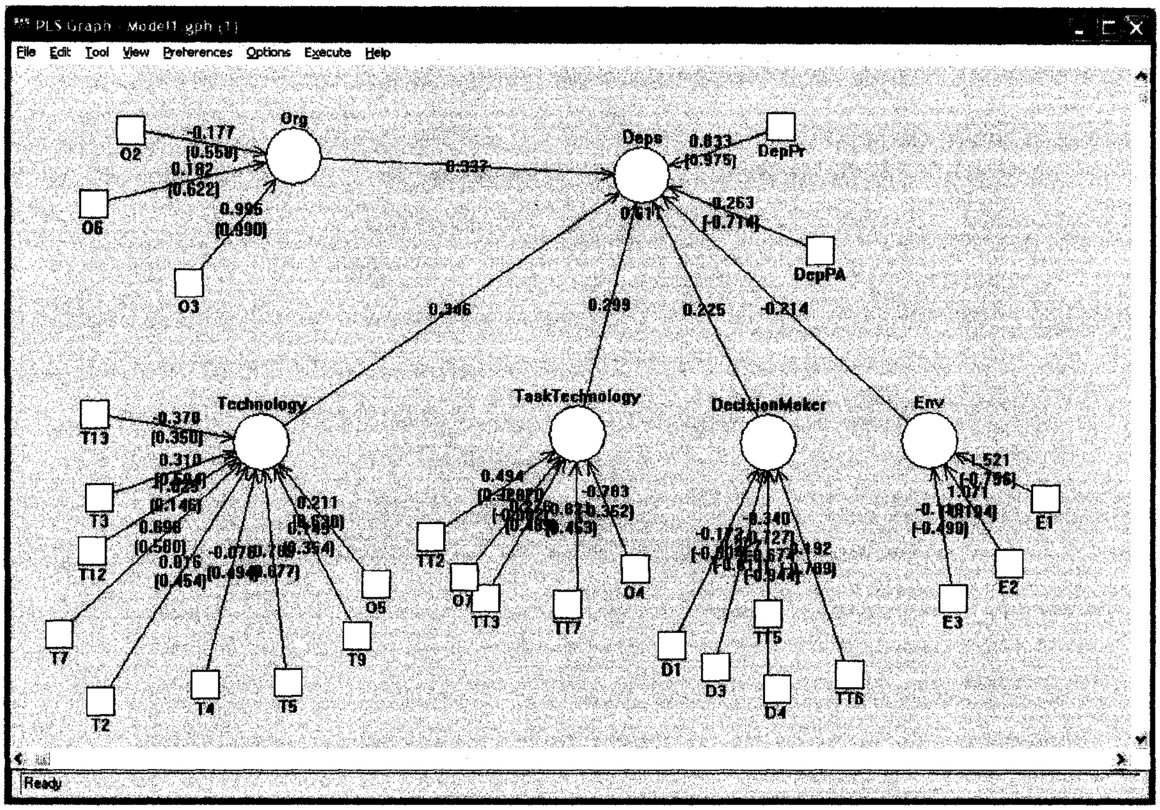


Figure 28: Formative Model without the size construct.

Path Coefficients Table (T-Statistic)

	Organiza	Dependen	Environm	Technolo	Decision	AdoptionDrivers
Organiza	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dependen	**1.8379**	**0.0000**	**1.9582**	**2.2690**	**2.4400**	**2.4493**
Environm	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Technolo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Decision	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adoption	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure 29: Path Coefficients of Formative Model without size.

Dependents

DepPr: Purpose of Open Source	This variable asks if the OSDB is intended for transactional support, decision support, or both.
DepIU:IntendedUsage	A categorical variable asking participants if they plan to adopt open source databases.

Organization

O2	Financial Resources
O6	Related Knowledge
O3	Expansion Strategy

Technology

T4	Compliance to Standards
T7	Cost Effectiveness
T5	Range of Open Source Database Characteristics
T12	Longevity
T2	Degree of Complexity
T13	Migration support
T9	Support
T3	Flexibility
O5	Budget

Environment

E1	Degree of Vertical Coordination
E2	Competition Intensity
E3	Visibility

Adoption drivers

TT3	Expected Increases in Market Share
TT2	Technology Fit with Current Processes
TT7	Competitive Advantage
O4	Preference to invest in other areas
O7	Knowledge Diversity

Decision Maker

D1	Exposure to personal information

D3	Preference for Information heterogeneity
D4	Positive attitude toward open source systems
TT6	Constraints by commercial systems
TT5	License mode- project scope

Convergent and Discriminant Validity

In formative models the issues of internal consistency, convergent and discriminant validity, do not apply.

- First, it would be absolutely ok for formative indicators to be correlated or completely uncorrelated (Jarvis, Mckenzie, Podsakoff, 2003, p. 202).
- Instead of looking at convergent and discriminant validity we should look at nomological validity and criterion-related validity. (Jarvis, Mckenzie, Podsakoff, 2003, p. 202)
- Diamantopoulos (2001, p. 271) claims that in formative models internal consistency is of minimal importance and procedures "used to assess the validity and reliability of scales composed of reflective indicators... are not appropriate for composite variables (i.e. indexes) with formative indicators."
- Bagozzi explains that "reliability in the internal consistency sense and construct validity in terms of convergent and discriminant validity are not meaningful when indexes are formed as a linear sum of measurements" (Bagozzi 1994, p. 333)

CHAPTER 5: CONTRIBUTIONS, LIMITATIONS, AND FUTURE RESEARCH

CONTRIBUTIONS

There are four specific contributions of this thesis to the research and business community.

First Contribution

First, we examined the adoption of open source software and in particular open source database servers by organizations. There is little and very narrow research on the subject and the breadth and depth of it is really negligent and casual. We have stressed the importance, availability, and usage of open source database servers by corporations today and it is really peculiar that no research is done on the topic.

Second Contribution

The second contribution is the extension of the TOE framework to the Extended TOE framework (E-TOE). In this case we added two newly theorized constructs in the traditional TOE framework and we examined their potential impact in the model. Our goal was to try to improve the explanatory power of the TOE framework without affecting its parsimony.

The results of our study indicated that the two new constructs are suitable to extend the traditional TOE model. We found strong evidence for the adoption drivers construct and for the decision maker construct. The adoption drivers construct is a step ahead for both academics and professionals. In the case of academia, adding the adoption drivers construct strengthens the TOE framework since adoption of a technological breakthrough is not dependent on the general framework of organizational, technological, or environmental issues.

Empirical evidence indicates that there has to be a close match of what the organization needs with the characteristics of the technology that is trying to adopt. This fact alone can have multiple implications for professionals as well. For example, although there are multiple database servers in the market, both commercial and open source, the case is that they have different characteristics suited to particular scenarios. For example, do we need the database server to support our mission critical applications? Do we intend to use it for transactional support in our operations? If so, we need to look at specific features that some open source databases do not support. For example, support for transactions, triggers, stored procedures, and other such items are always critical. For non critical applications and in particular for decision support we might need different features such as reporting capabilities, the presence of ETL tools, data mining support, OLAP and MDX support. If these features are not present, and the case is that they are not in most open source databases, then the adoption of an open source database server will have adverse effects. This argument can also be expanded the other way. That is, why do we need to adopt a complex database server with advanced analytic features if we do not need them? We can select a simpler open source database server and do our job effectively.

Finally, the decision maker construct is of significant consequences. The data indicates that business and logical reasoning for technological adoptions will follow the perceptions of the decision maker about open source systems. That is, adoption of such systems is not a rational decision. It might involve politics, personal perceptions, business relationships and other factors that will critically affect the opinion of the decision maker for adoption. This idea is not something new; Franz and Robey (1984) talked about the significance of politics in organizations and indicated their significance.

Third Contribution

Third, we have done an extensive literature review through which we identified, organized, and clarified issues of technology adoption at the individual and organizational levels. This review was necessary for increased awareness of the issues in this area, to help researchers apply the correct level of analysis depending on the type of model they theorize, and of course to identify the various model categories.

Fourth Contribution

The fourth contribution of this thesis is the confirmation of the TOE framework in open source database systems. Indeed, the basic TOE framework was strongly confirmed from the results of our research. This has been the first time that the TOE framework was tested in open source systems and its confirmation indicates the strength and applicability of the framework.

LIMITATIONS

Finally, although we managed to extend and prove the extended TOE, our research was limited in several ways.

First, half of our survey data came from clients of Hewlett Packard who were mainly from the finance industry. This is a limiting factor and any conclusions are primarily applicable to the finance industry. The second group of respondents consisted of EMBA students from two Universities. Although the industry representation was increased through this second group of working professionals, still we cannot claim that the ETOE framework is applicable in every industry in the economy and thus its universal applicability is questionable. More data and research is needed to establish the

ETOE framework. At the same time, we do expect that the ETOE framework will hold in research that includes multiple data points from various industries.

A second limiting factor is location. All the data collection effort for the survey and the pilot studies was done in the State of New York in the United States. The city of New York is a major international financial center and this factor might have skewed the results of our research. A better approach would have been to collect data from multiple regions of the country.

Third, our study was focused on open source databases and in particular open source database servers. We have not included any other open source systems in our study and this factor limits the universal applicability of the ETOE framework for open source systems. It would be a good idea for other researchers, in both academia and business, to test this framework with other open source systems that organizations might be willing to adopt. Such systems might include operating systems, portals, enterprise resource planning systems, customer relationship management systems and others. Such open source systems are readily available and actually used by for profit organizations.

Fourth, we have a questionable item in our research design. The literature suggests (Edwards and Bagozzi 2000, p. 162) that our model is called a direct formative model. Formative models have error (disturbance) terms as well. In a latent construct we have a set of indicators but we are never sure that we have all of them. One or more indicators might be missing. When we use PLS what is happening is minimization of the error term. That is, we assume that we do not miss any indicators from any latent construct. This is a theoretical assumption that rarely holds with empirical data. This does not mean that we cannot use variance based SEM with PLS because it has tremendous advantages as explained in chapter four and also because this is the best approach for our model. However, we need to be aware of its limitations and expand our research to minimize or eliminate the effects of error terms. In practical terms, PLS distributes weights analogously to the indicators that we have specified without producing a disturbance term for the missing two. In LISREL on the other hand, we have maximization of the error term so that indicators are really clean and strong. Again more research and data points are needed to capture all the indicators and eliminate the disturbance term in direct formative models using variance based SEM.

A fifth limitation is that we used the key informant method. That is, from each corporation we used a single respondent who answered the survey according to his or her own views. As Gallivan (2001) suggests, this method distorts results since there is a single biased view of the situation. In future research it will be a good idea to have several respondents from the same corporation so that we can balance personal biases.

The conclusion is that more work is needed with various data samples and multiple types of technologies to prove the ETOE framework.

FUTURE RESEARCH

There are a number of opportunities for additional research for both academia and business. For academia this is an unexplored area and there are two avenues to follow. For the first we need to conduct additional research to strengthen and verify the model we have presented and prove its universal applicability. The second is to expand the model and build a framework for organizational adoption which researchers can use for multiple technologies and innovations.

For business professionals this is a topic of high importance since it will affect several aspects of the corporate business processes. Open source systems in general and databases in particular are of primary importance since they constitute the repositories of data from which information is obtained for business decision making. Consequently, adoption decisions and the characteristics of such systems will affect businesses in two ways: First, they will affect the manner in which businesses keep their data in their transaction processing systems and in consequence the way they function in day to day operations. Second, and most importantly they will affect the way a corporation conducts its business intelligence efforts. For example, at the very basic level, the ability of an open source database server to import data from multiple heterogeneous data sources such as text files, spreadsheets, hierarchical (XML) files and other databases will greatly affect the way a business can put together its information retrieval processes.

Secondly, in future research we should absolutely use a bigger and diverse sample (in terms of industries and locations) so that we can attain a double goal: First, a bigger sample will strengthen our research methods and results, a process that will decrease our ambiguity about certain aspects of our research that we talked in our limitations section. Second, a diverse sample in terms of industries and locations will prove the universal applicability of the model.

Third, we need more research so that we can expand and strengthen our formative model to make sure that our indicators for each formative construct are adequate and complete to minimize any potential error terms in each factor. As we have explained in detail in chapter four, in formative models this is an imperative process. In one sentence, in future research we need to make sure that we do have all the latent constructs in place and most importantly for each latent construct the indicators are complete.

Fourth, as we have explained in chapter two there are various theories trying to explain organizational adoption of innovations. Such theories include the critical mass theory Shaker and Gerard (2002) (Truman et al. (2003), the absorptive capacity theory Cohen and Levinthal (1990), the organizational learning theory Attewell (1992), the political and process theory Franz and Robey (1984), and the bridging theory Yetton et al. (1997). From all these theories we have incorporated in our model only the organizational learning theory. It would be of outmost interest to expand the ETOE model to include all the above theories and produce a theoretical framework that includes these theories. Then, we can really talk about a sound framework of organizational adoption of innovations.

Fifth, it is obvious that the ETOE framework needs to be tested with additional technologies and open source systems. Thus, there are two avenues that need exploration: the first should be the testing of the framework with other open source systems except database servers. The second is that we need to test the ETOE framework with commercial systems as well.

Sixth, the vast majority of research in the literature focuses only on adoption of innovations and ignores resistance to change and the factors affecting rejection of innovations. We should conduct some research that addresses the factors affecting rejection of innovations and understand them.

Seventh, future research should examine adoption of open source database servers in small and medium sized organizations. As Premkumar (1999, p. 468) suggests most adoption research today relies on data from big businesses. It would be interesting to see how database adoption works in small businesses and what are the factors that will convince a small business owner to install an open source database server.

Eighth, most of the studies on open source software, including this thesis, are vertical in nature (Capiluppi et al. 2003) or in other words they concentrate on a single OS software package. It would be valuable to research how a model behaves when multiple OSS packages are involved in the same study.

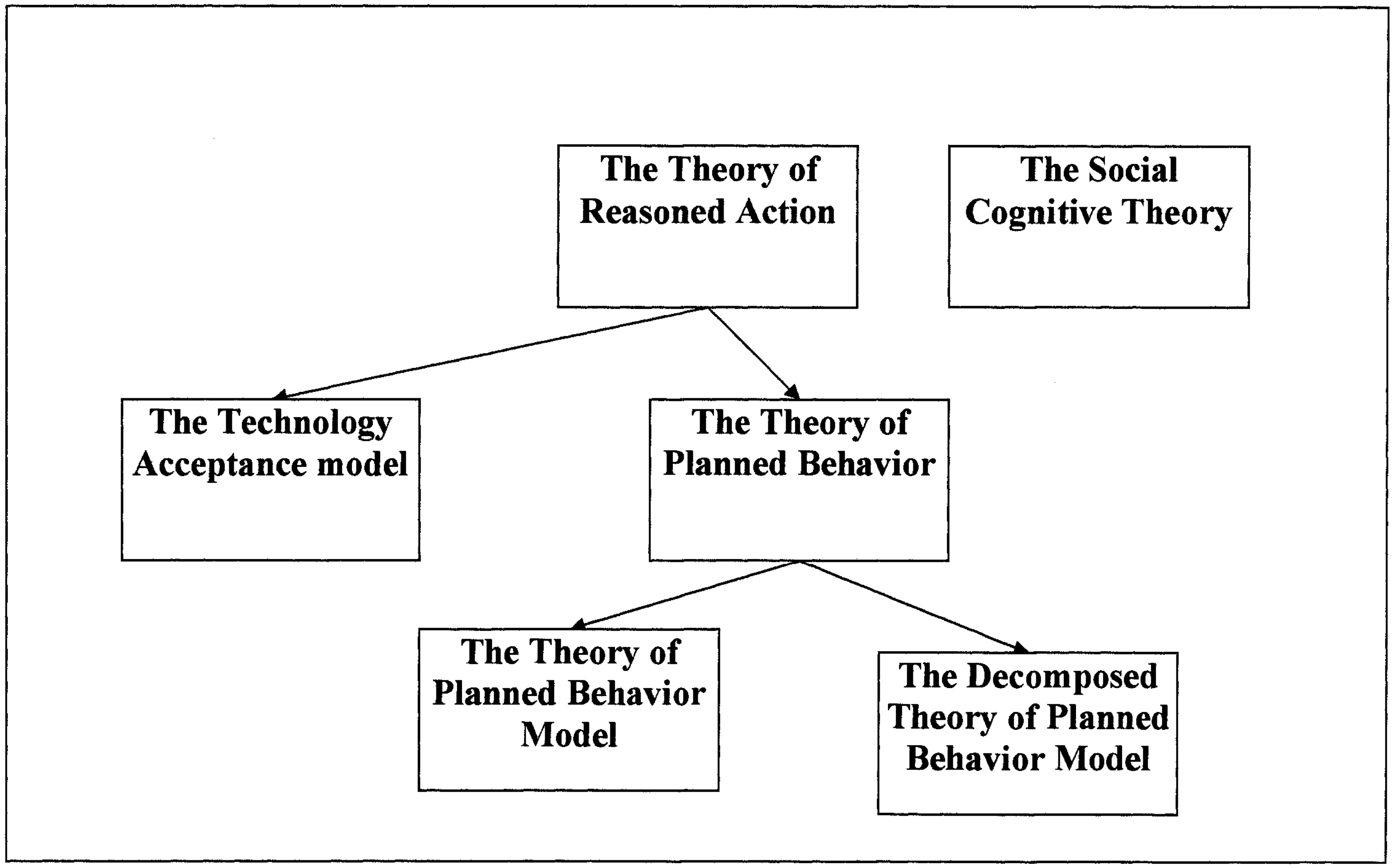
A ninth avenue for future research would be to investigate adoption of open source software in countries outside the US and Europe (Kshetri, 2004 p. 74). A study in countries like China, India, and others around the globe with a solid software basis would be highly desirable.

In conclusion, if we follow the avenues for additional research that we presented in this chapter we would have a sound argument that our model can constitute the basis for a framework that can be used as the blueprint for adoption of technological innovations to come.

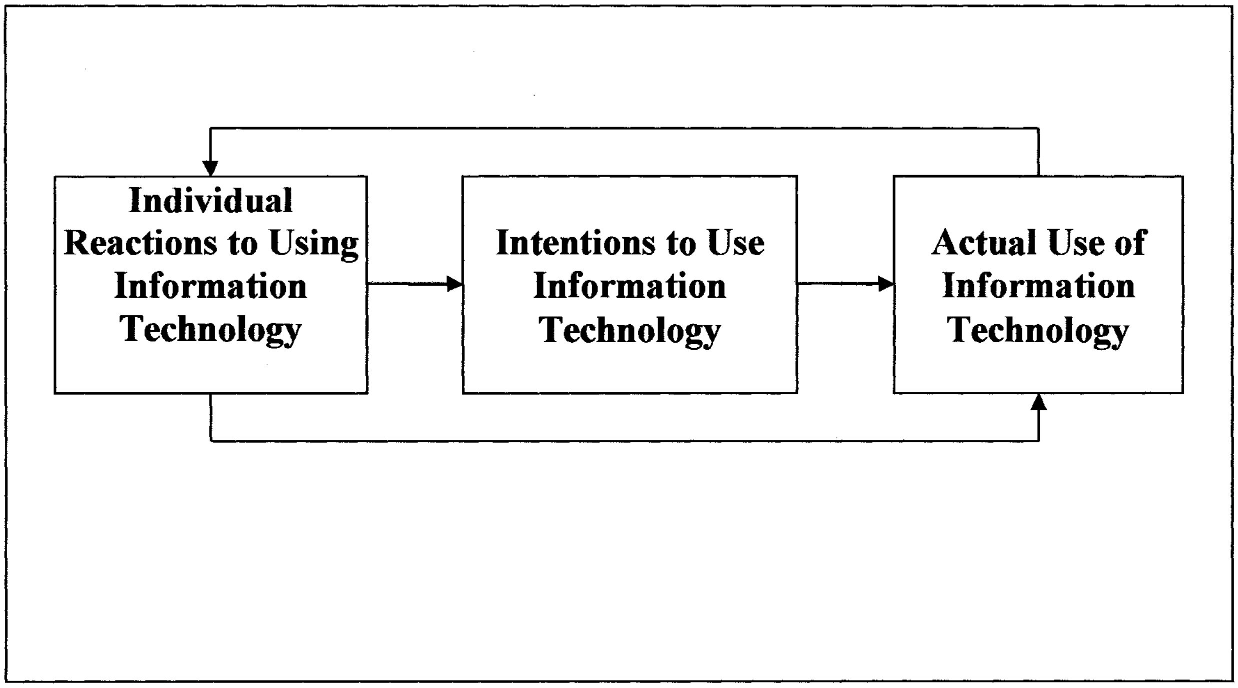
APPENDICES

Individual Technology Adoption Models

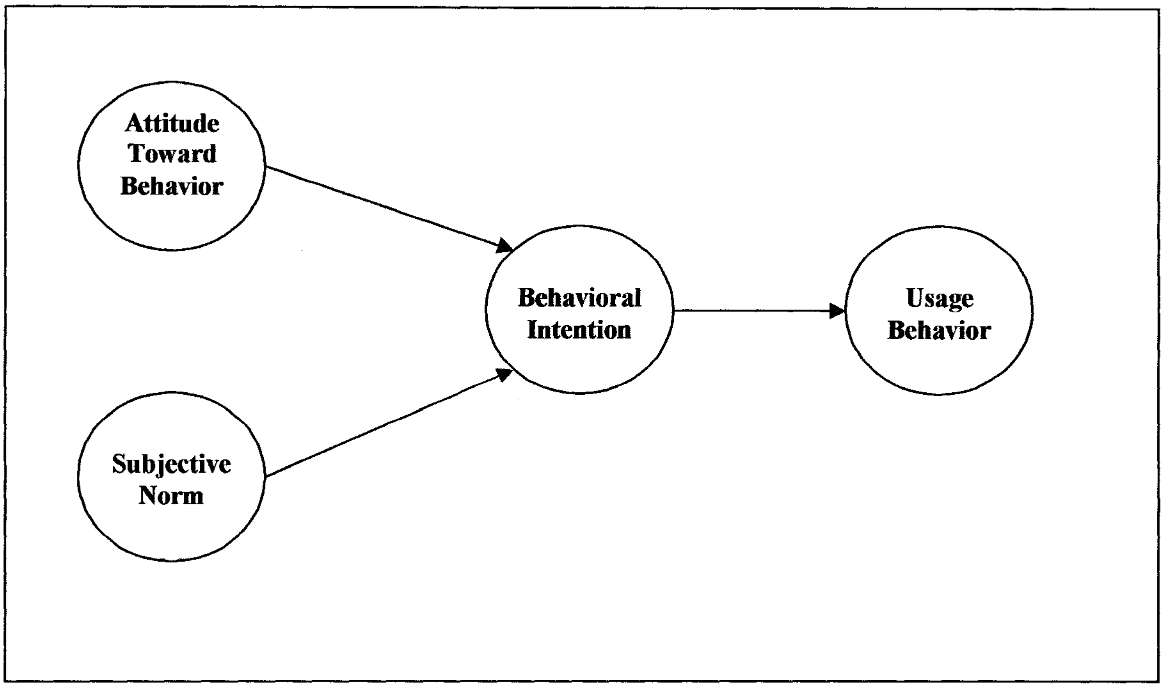
Theory Development in User Acceptance of Information Technology



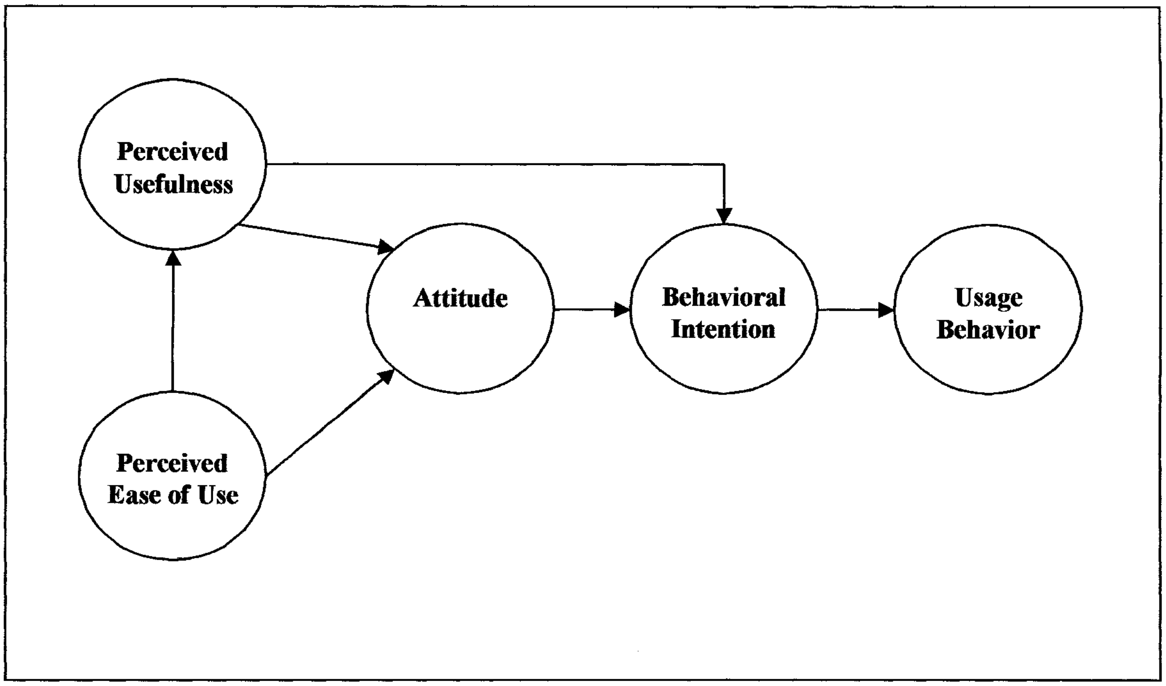
Basic Underlying Concept of User Acceptance Models



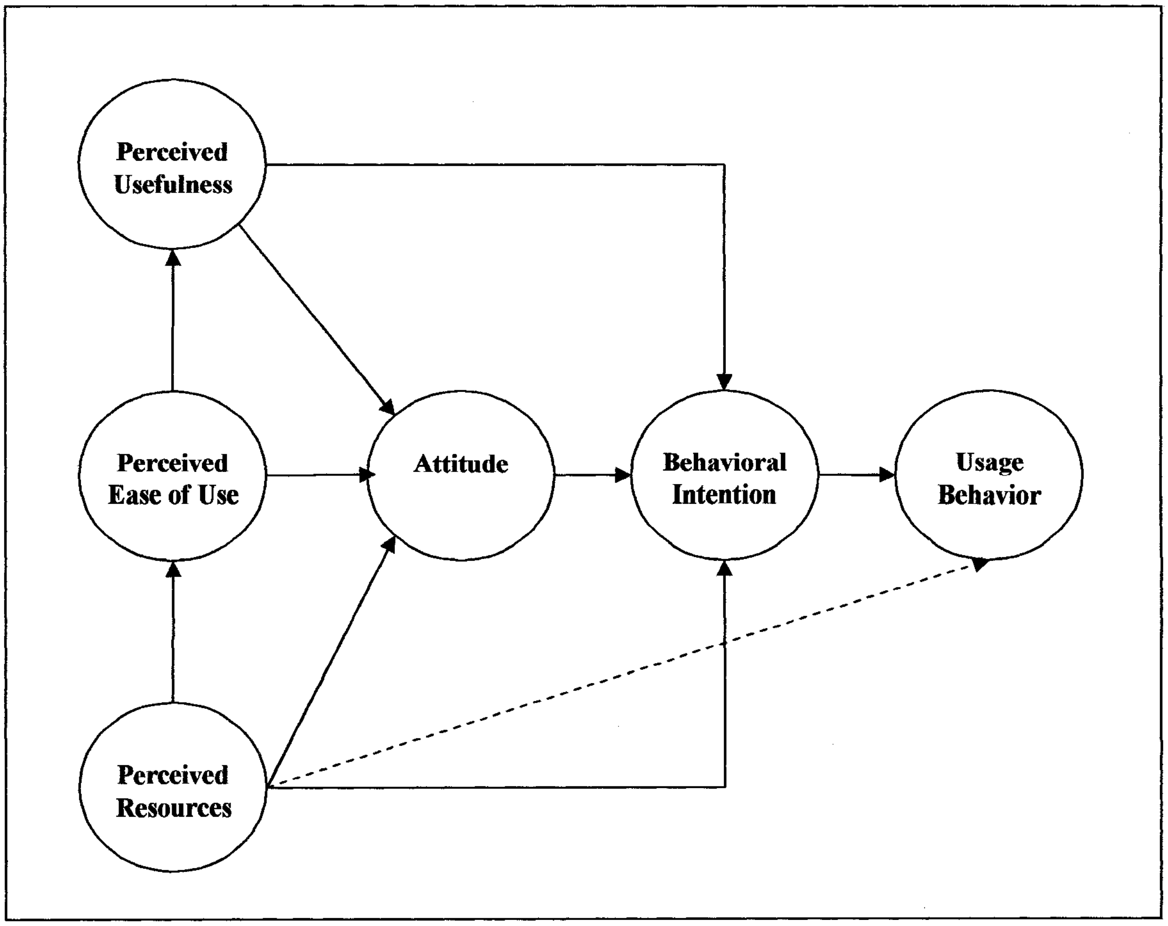
The Theory of Reasoned Action



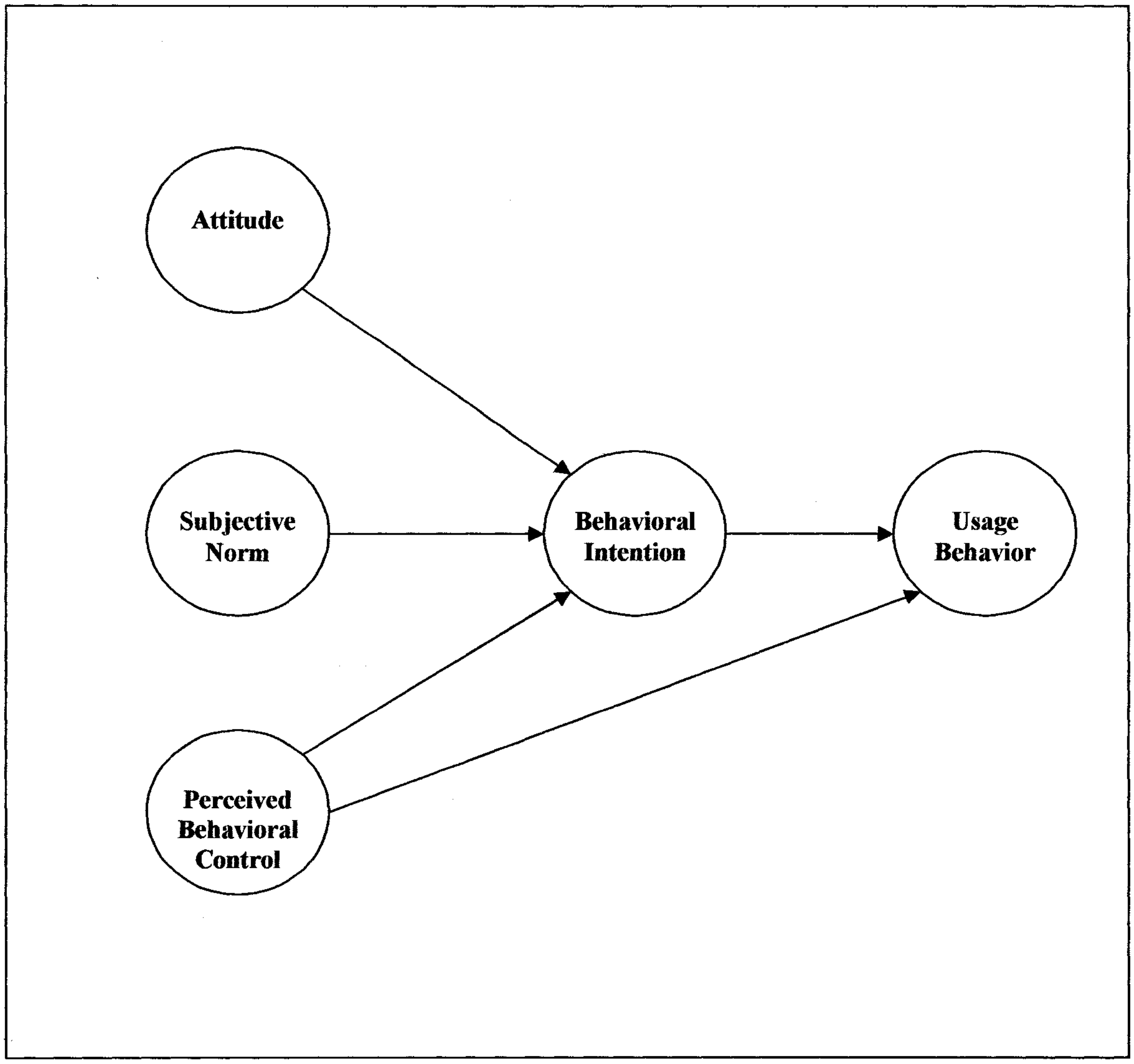
The Technology Acceptance Model



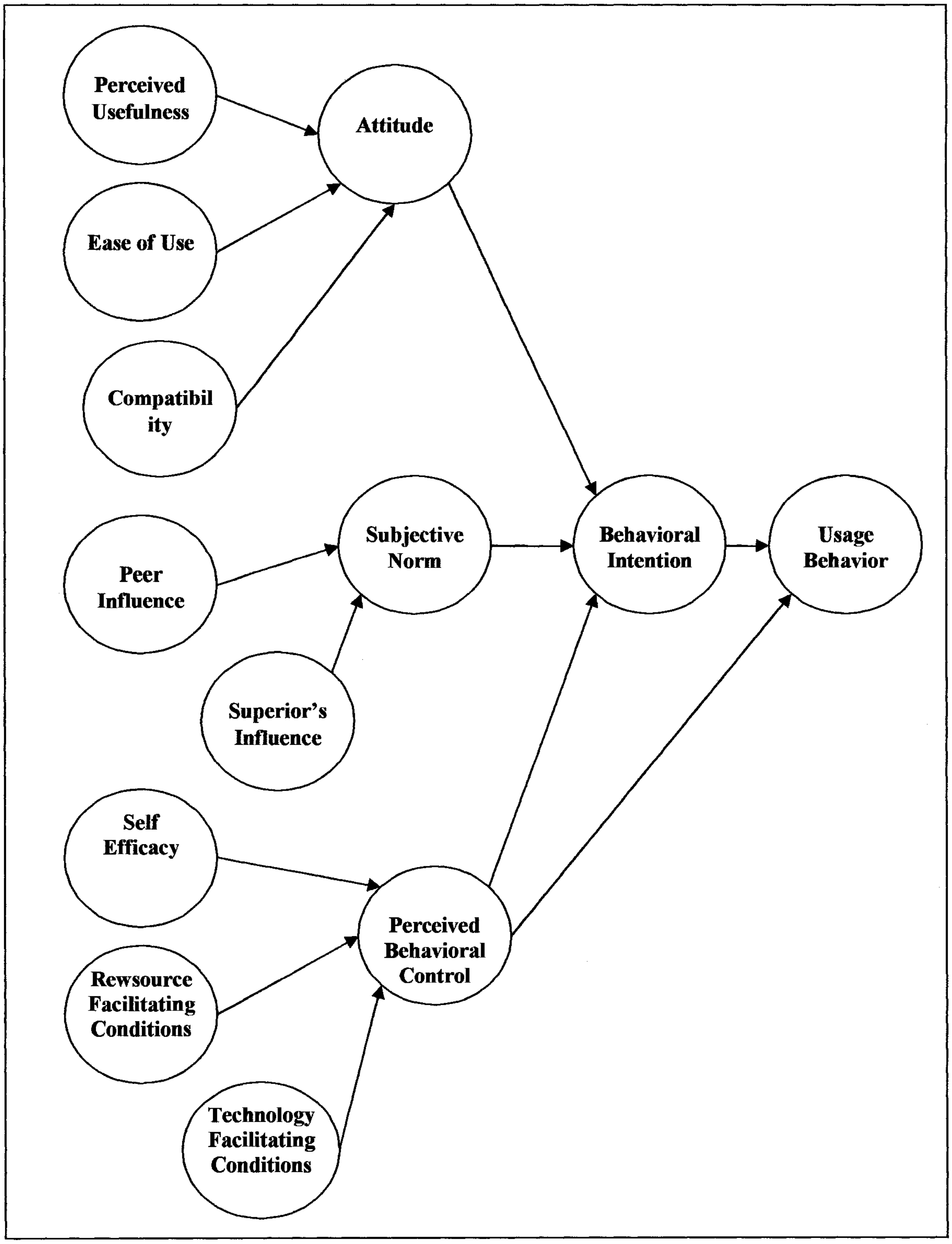
The Resource Extended Technology Acceptance Model



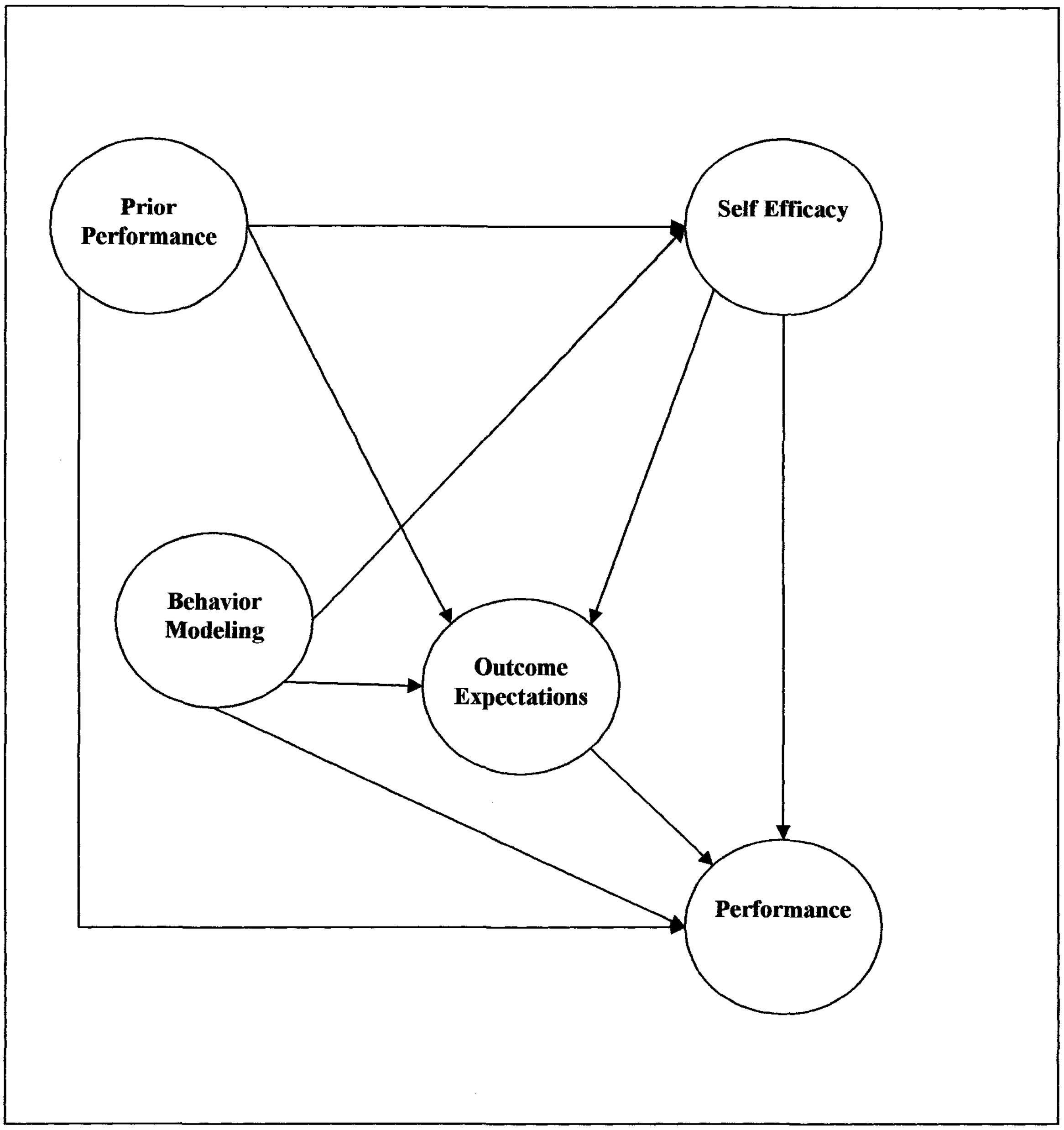
Theory of Planned Behavior Model



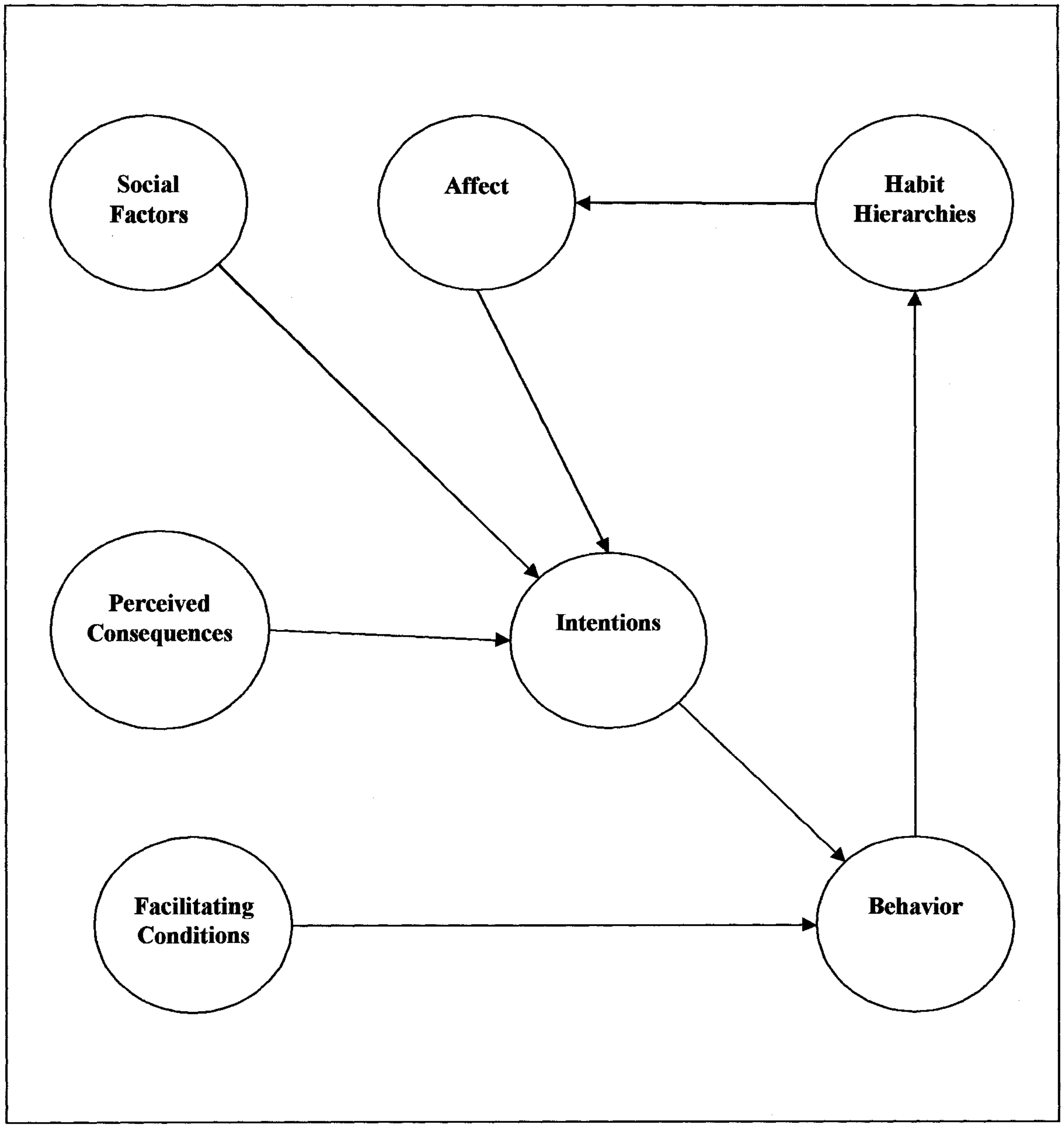
The Decomposed Theory of Planned Behavior



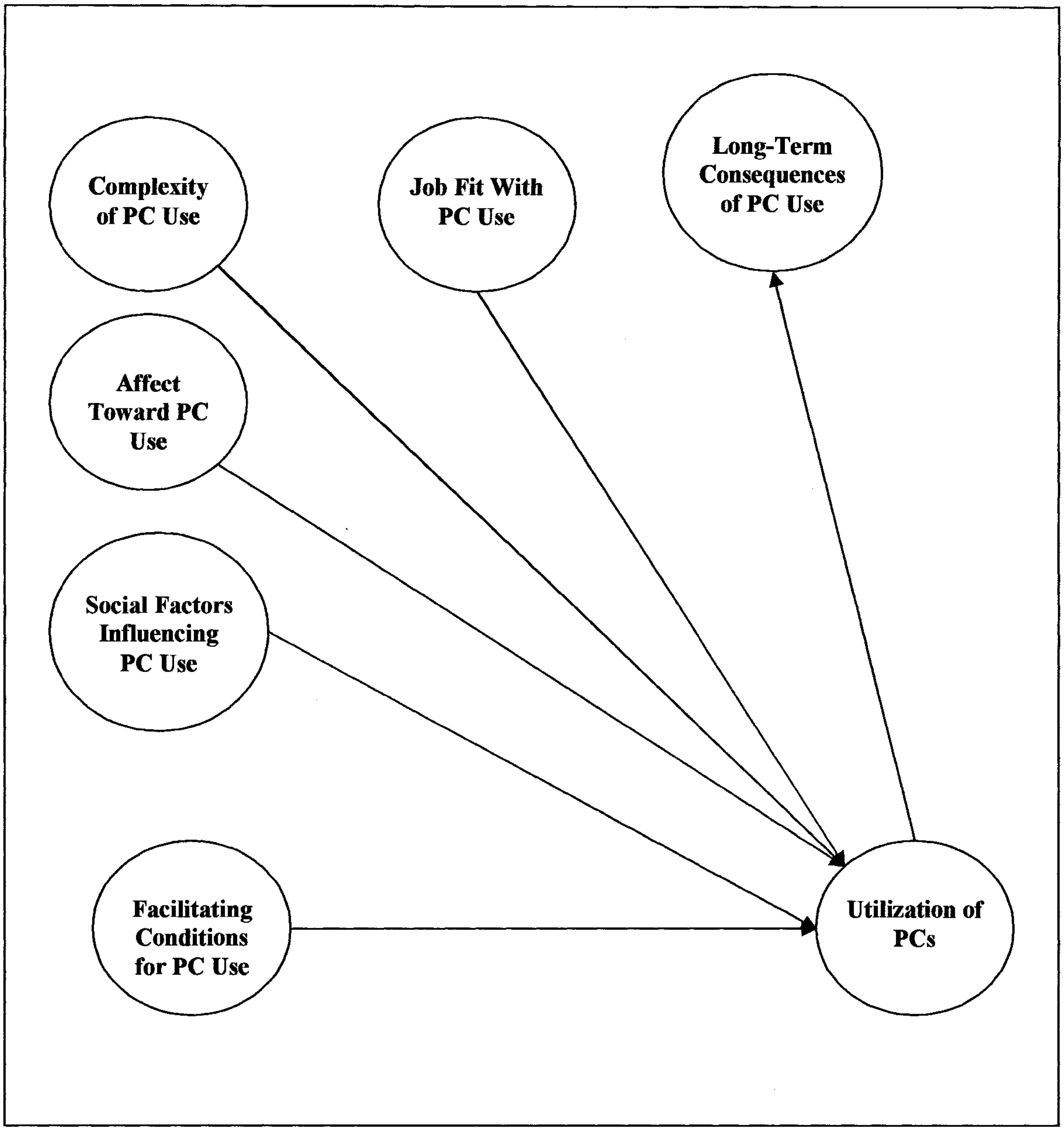
The Social Cognitive Theory Model



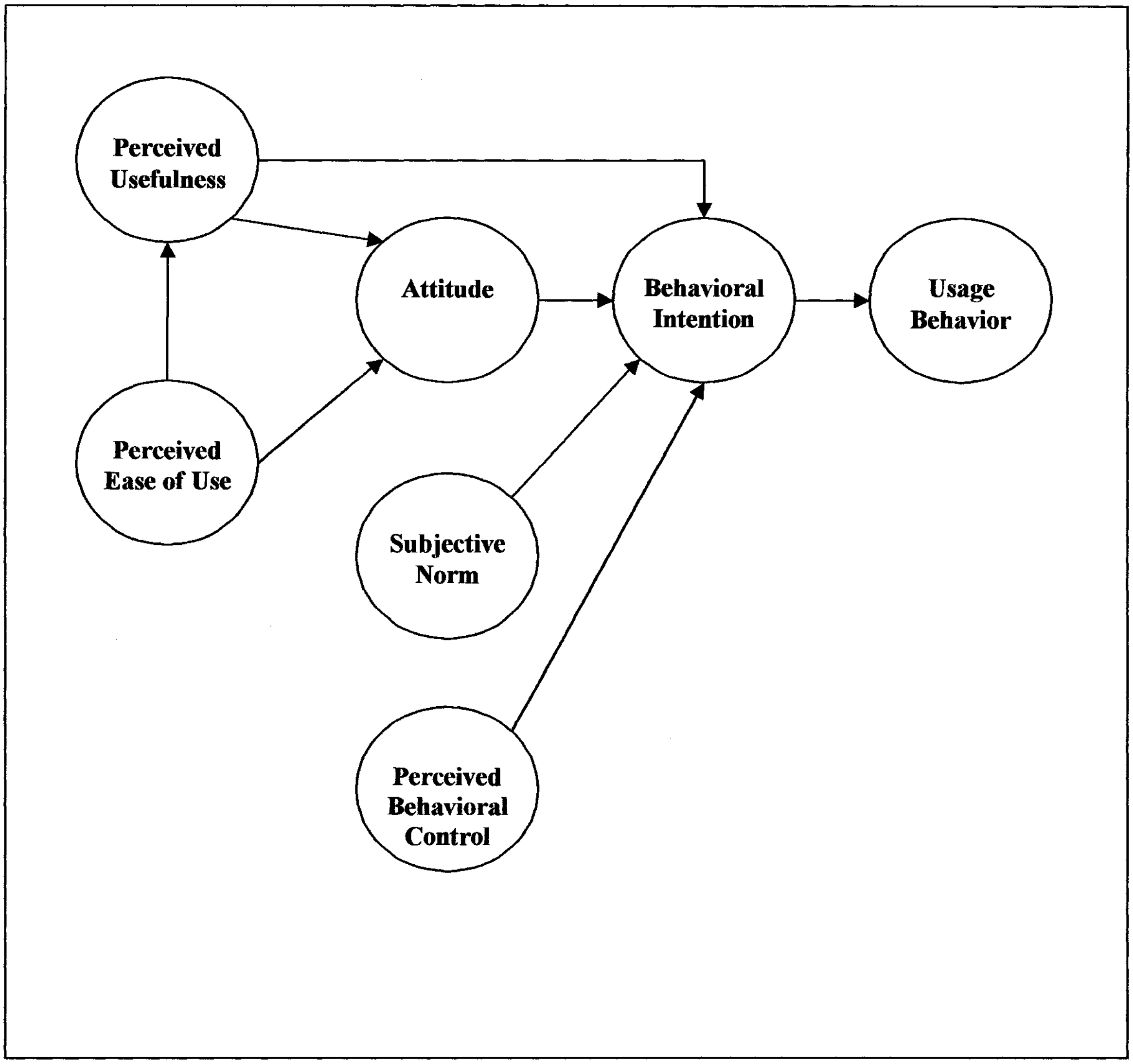
TRIANDIS MODEL OF FACTORS INFUENCING BEHAVIOR



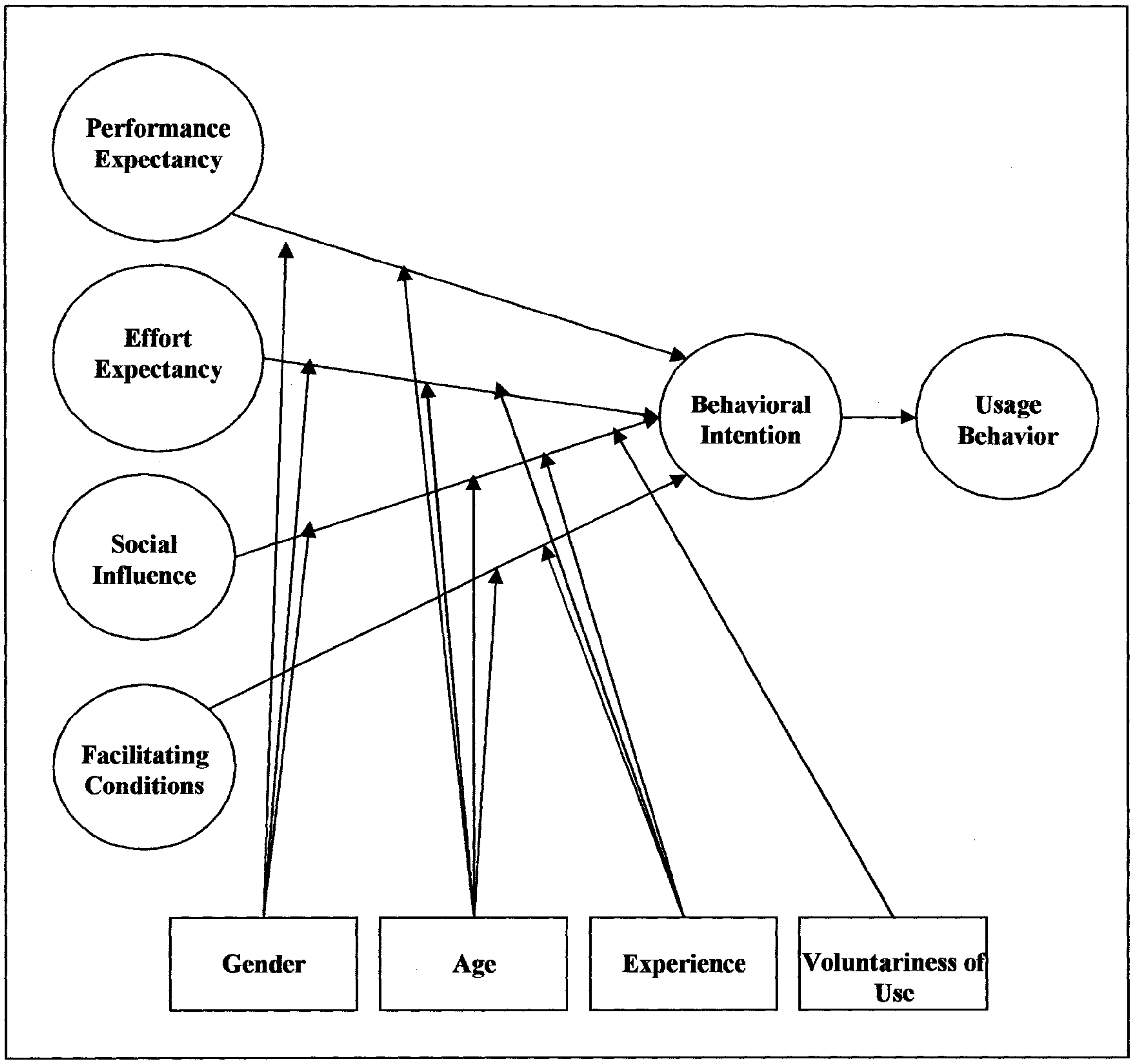
PC UTILIZATION MODEL



THE C-TAM-TPB MODEL

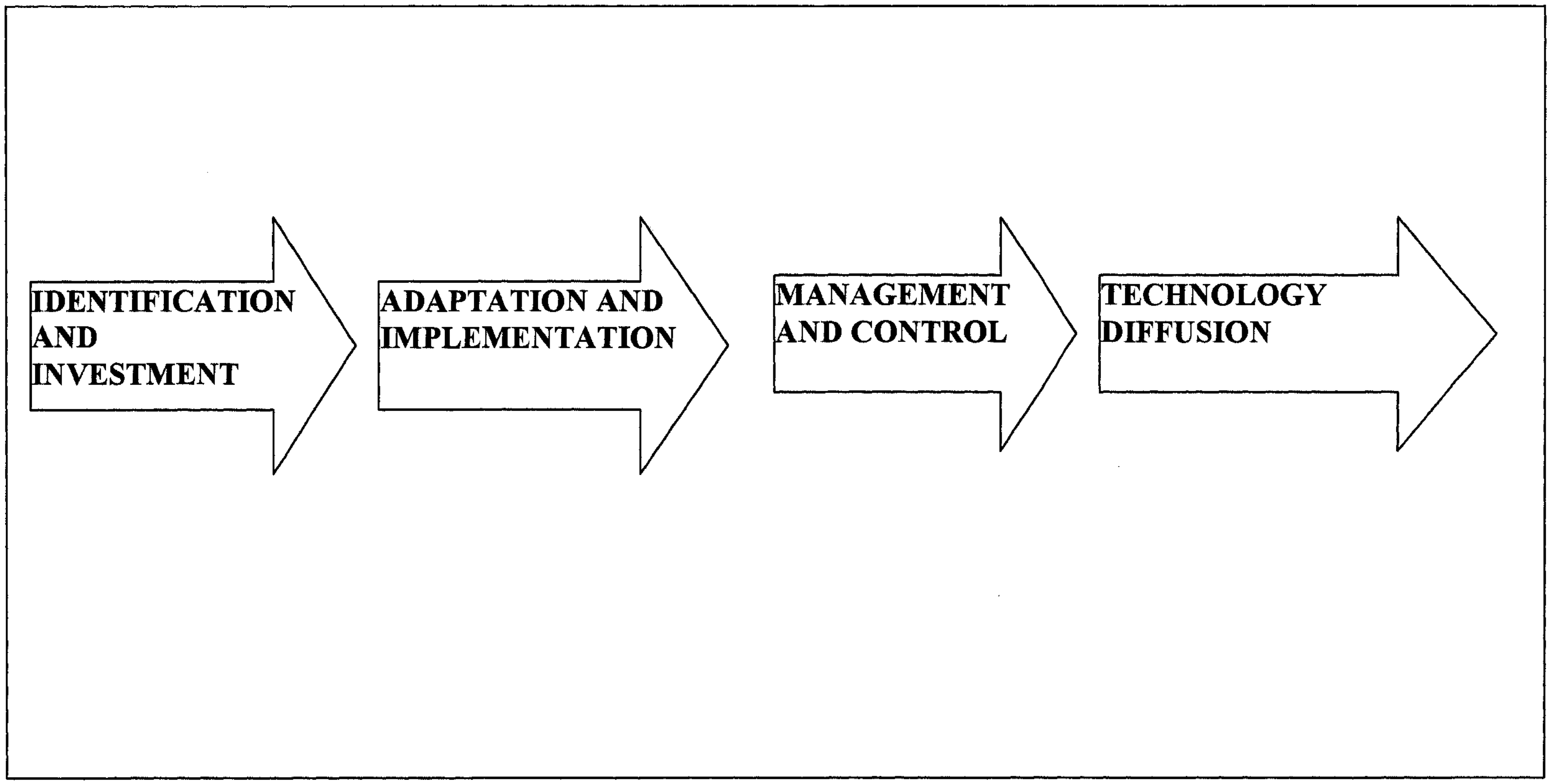


The UTAUT Model

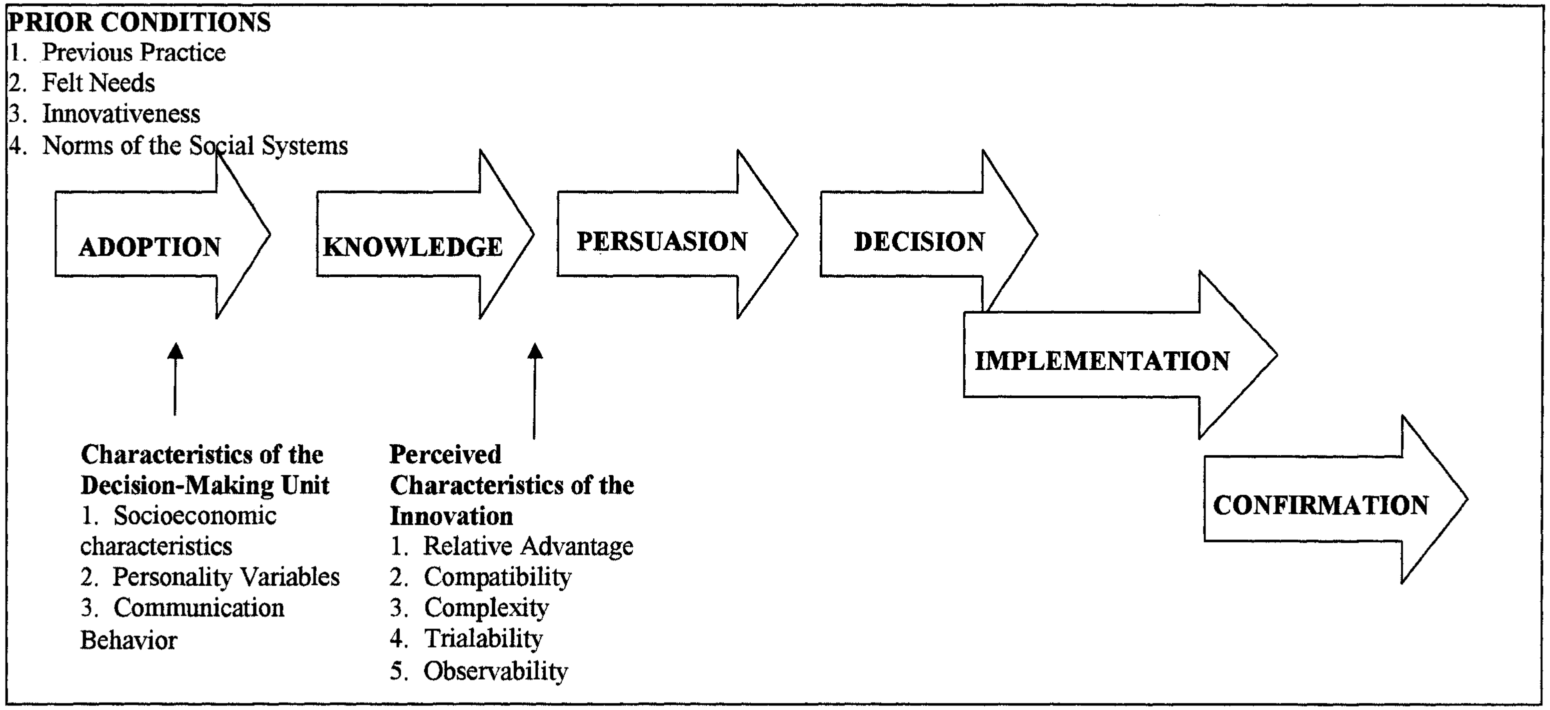


Organizational Adoption Technology Models

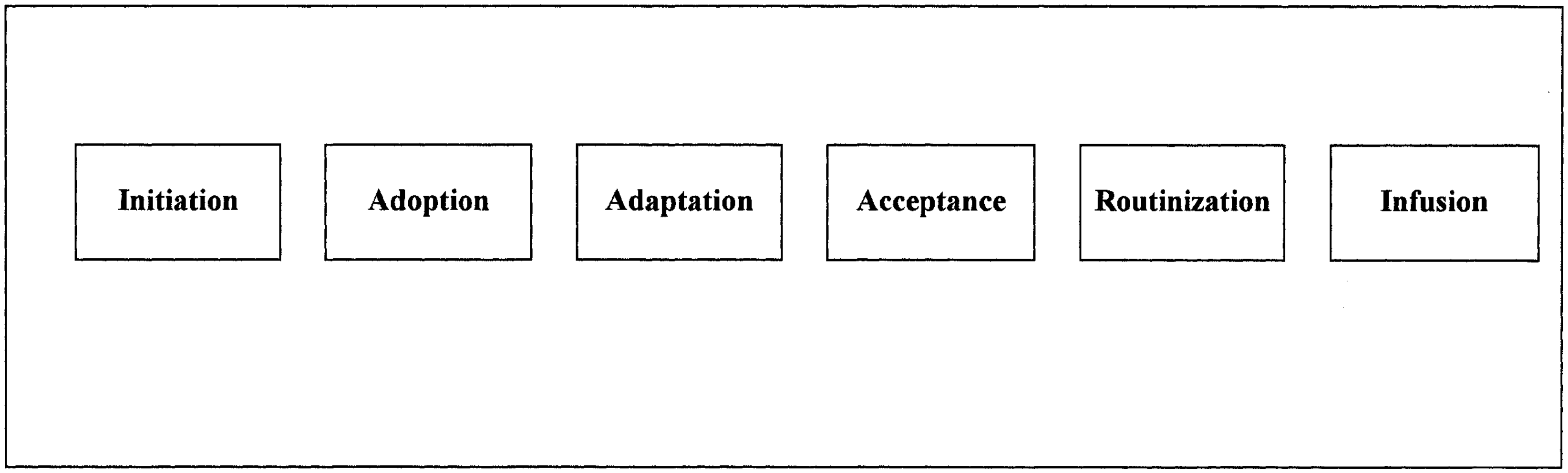
McKenney and McFarlan Four Stage Model (1982)



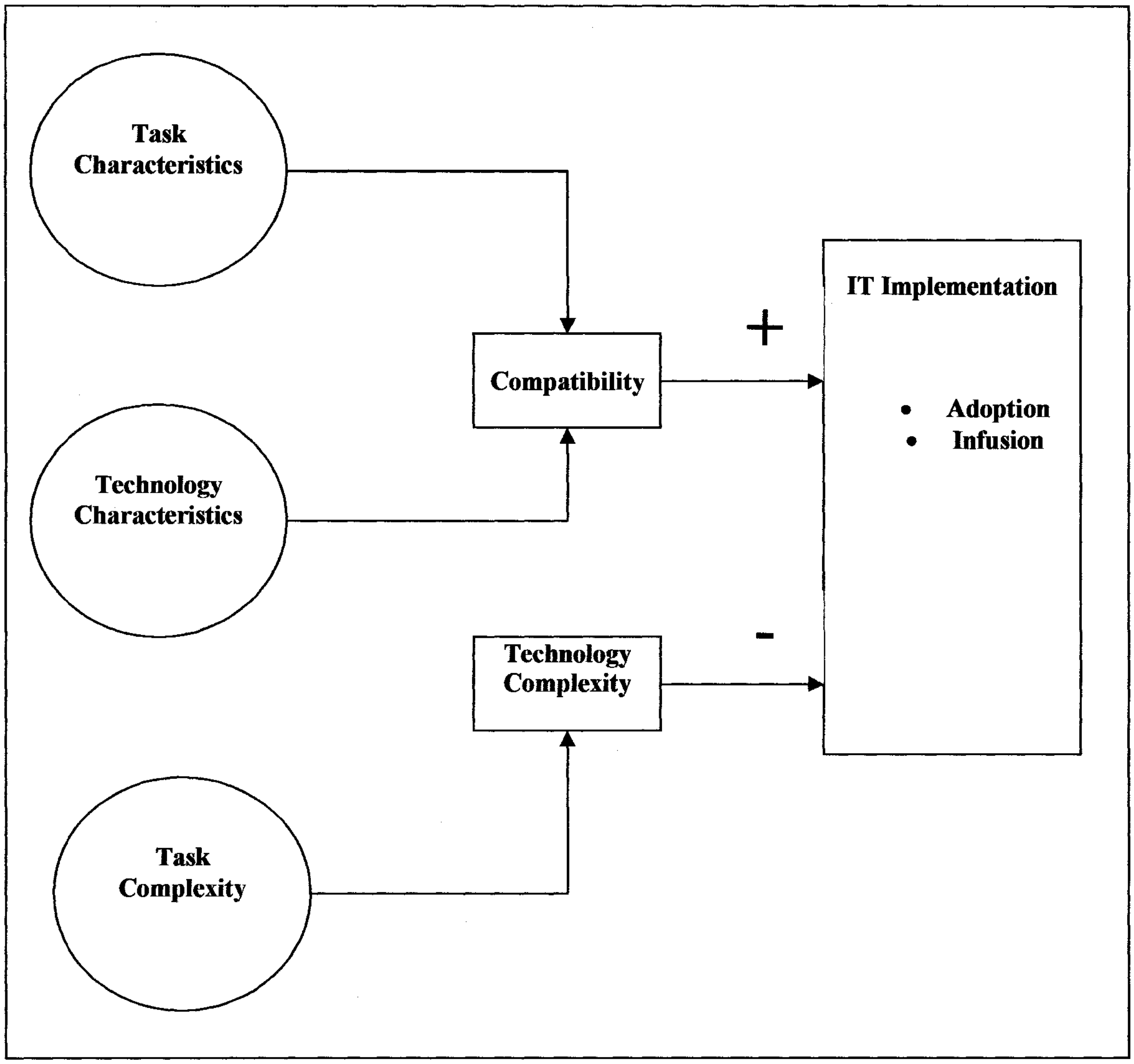
Roger's 1983 Five Stage Adoption Model



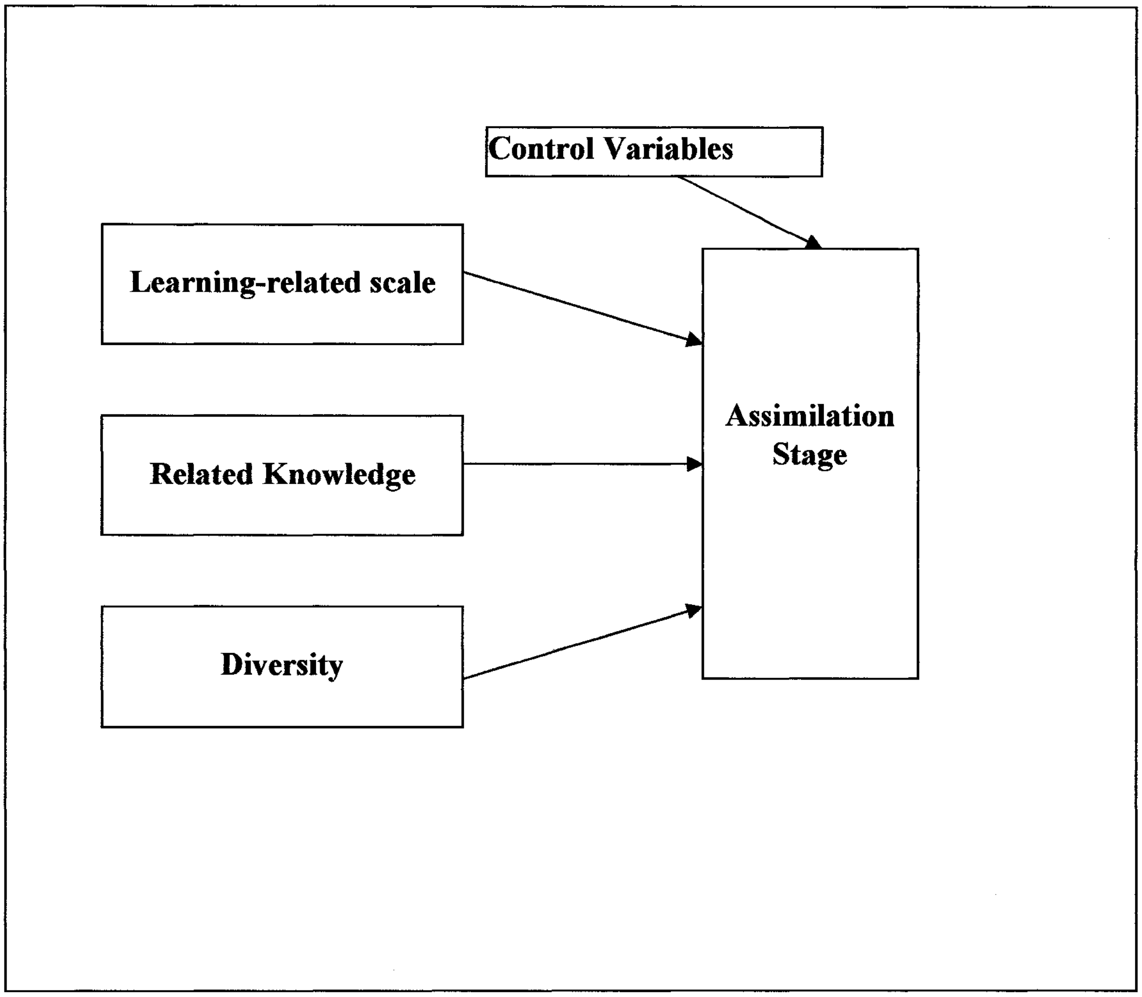
Six Stage Model by Zmud and Apple (Unpublished Work)



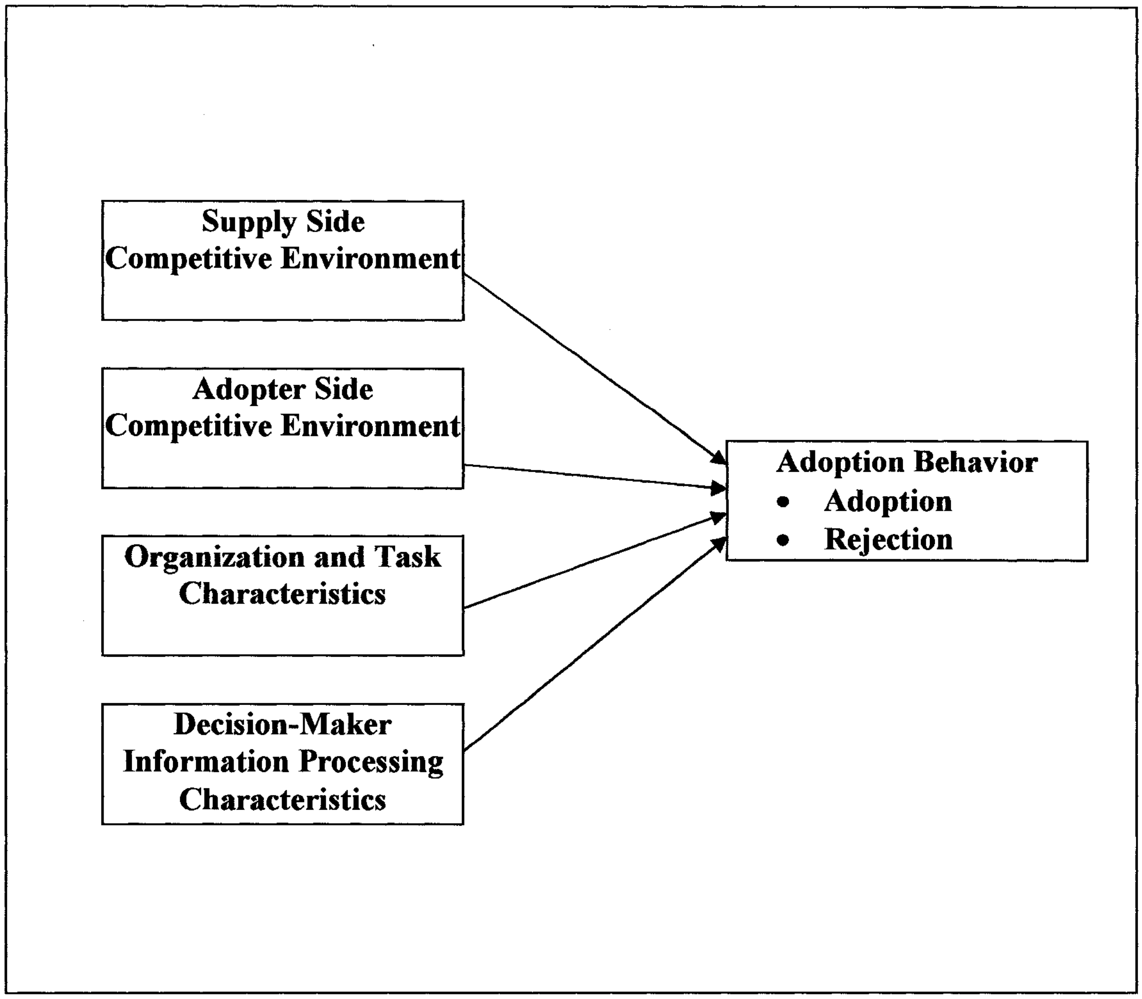
Cooper and Zmud (1990) Factor Model



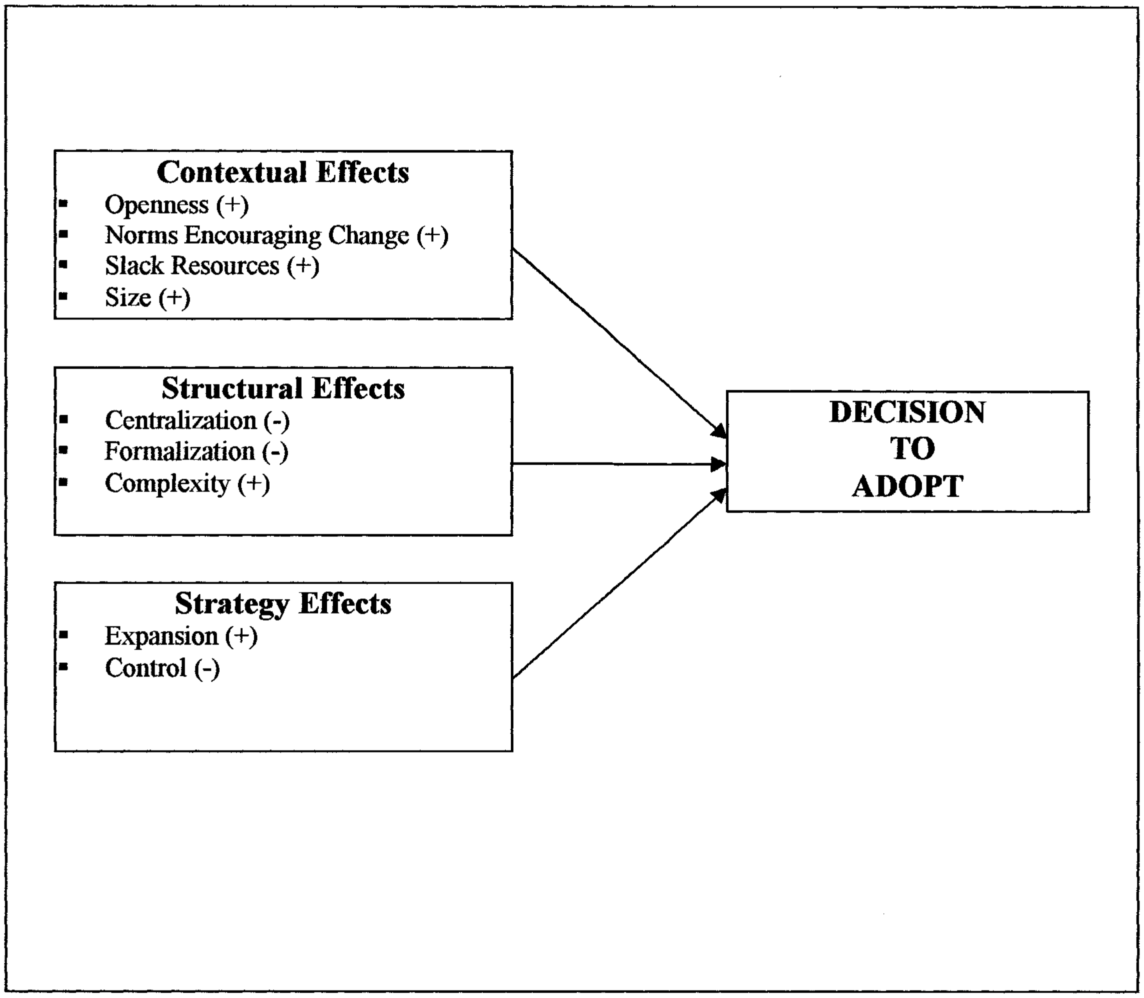
Fichman and Kemerer Model of Assimilation of Software Process Innovations



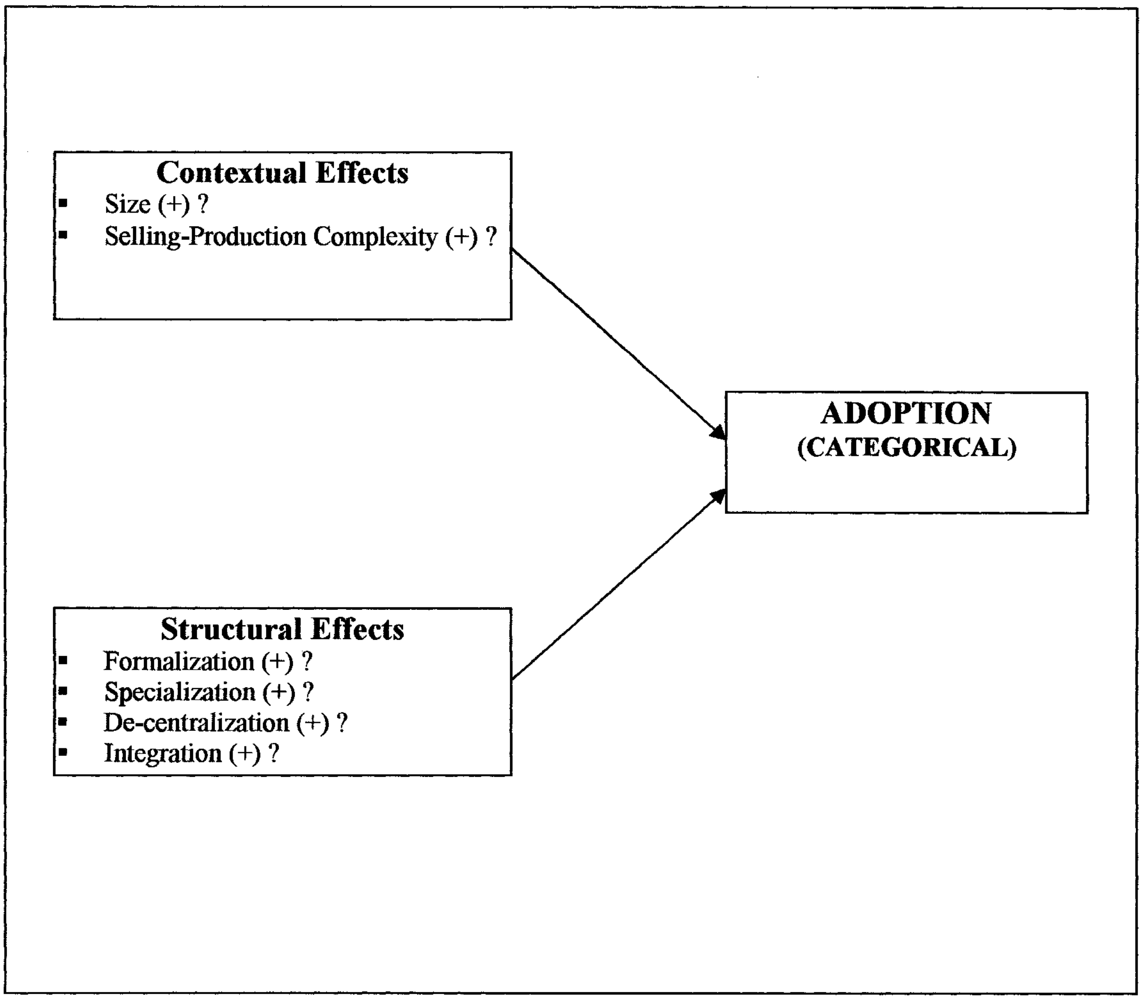
Gatignon and Robertson (1989) Factor Model



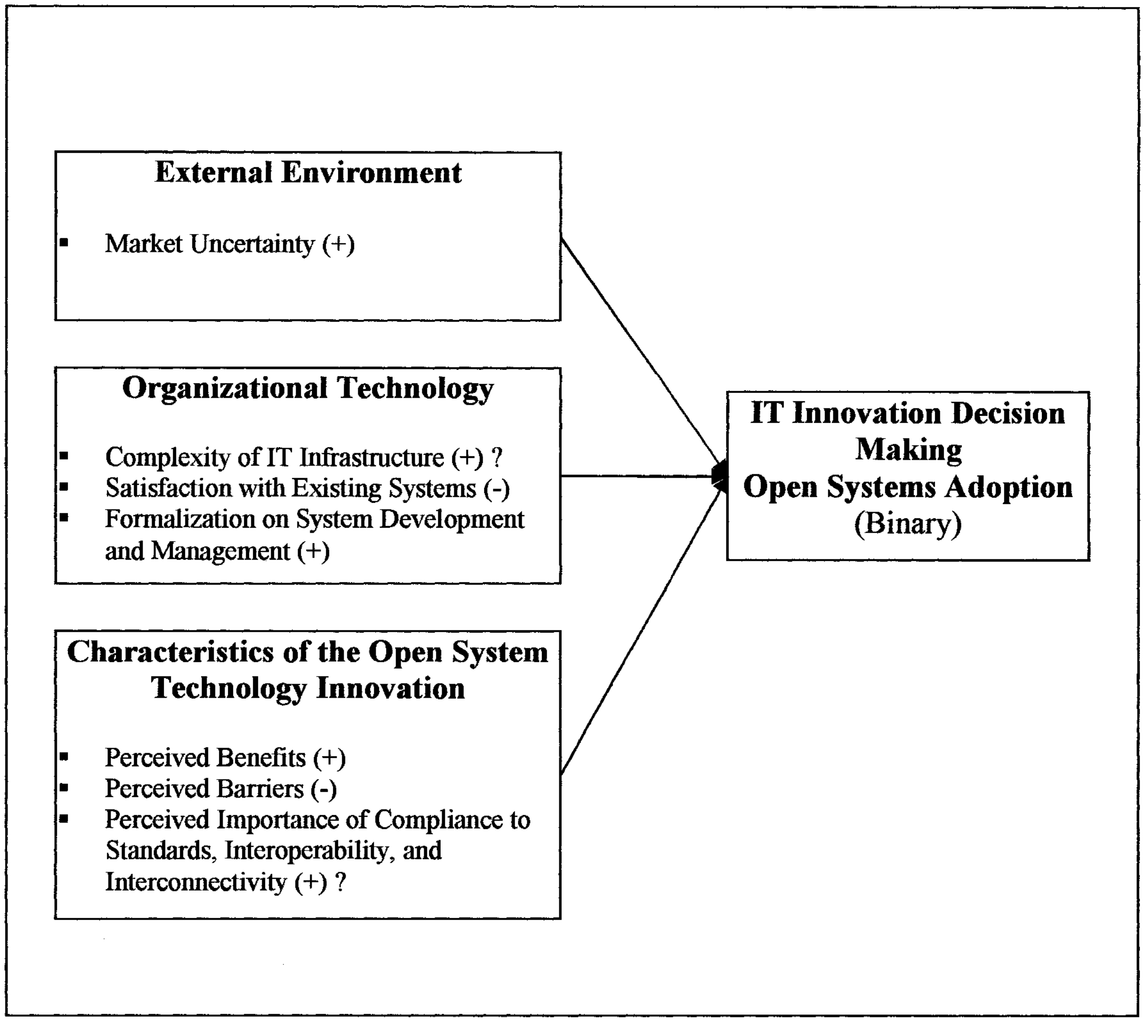
(1997)
Vincent S. Lai and Jan L. Guynes Factor Model



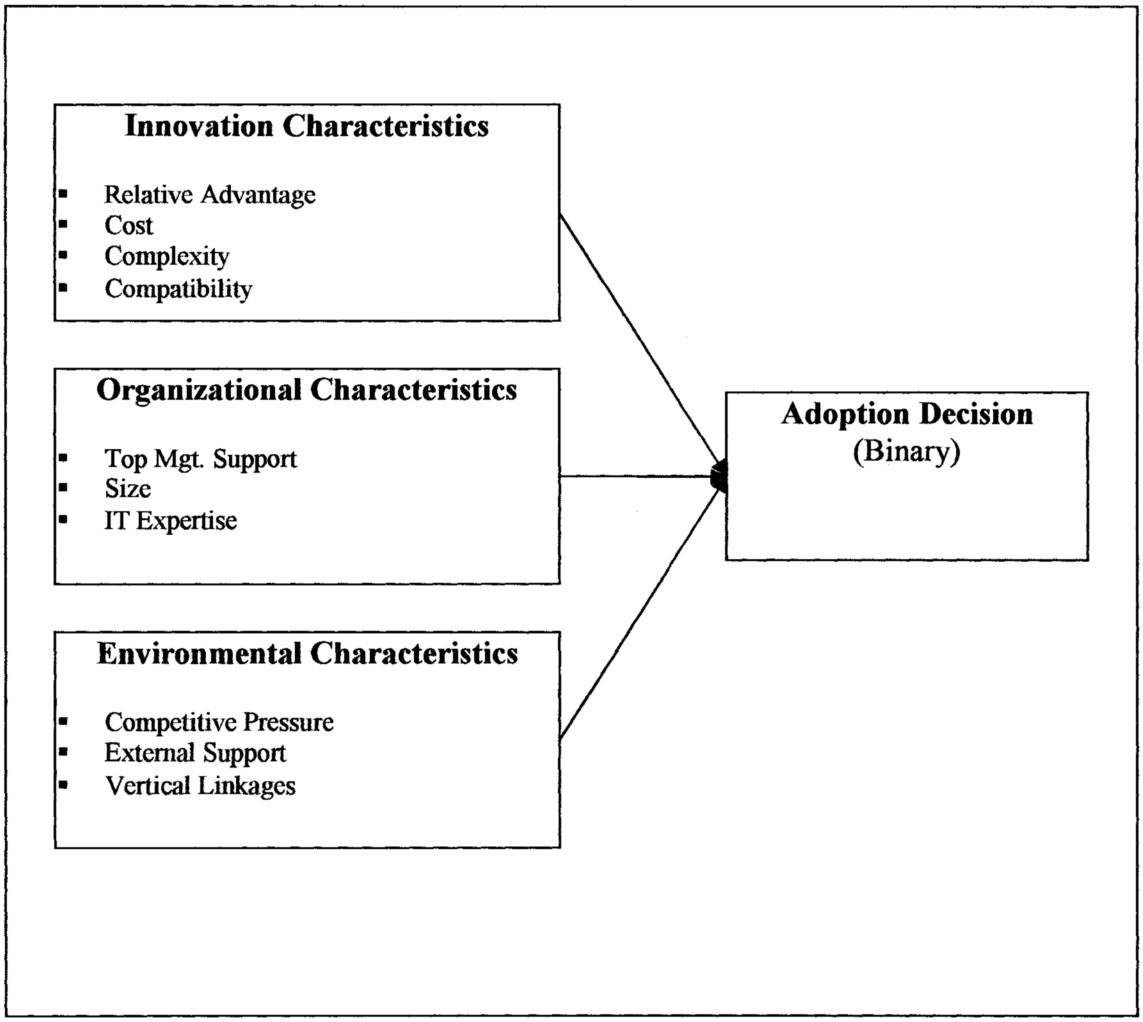
Daugherty, Germain, and Droge (1995)



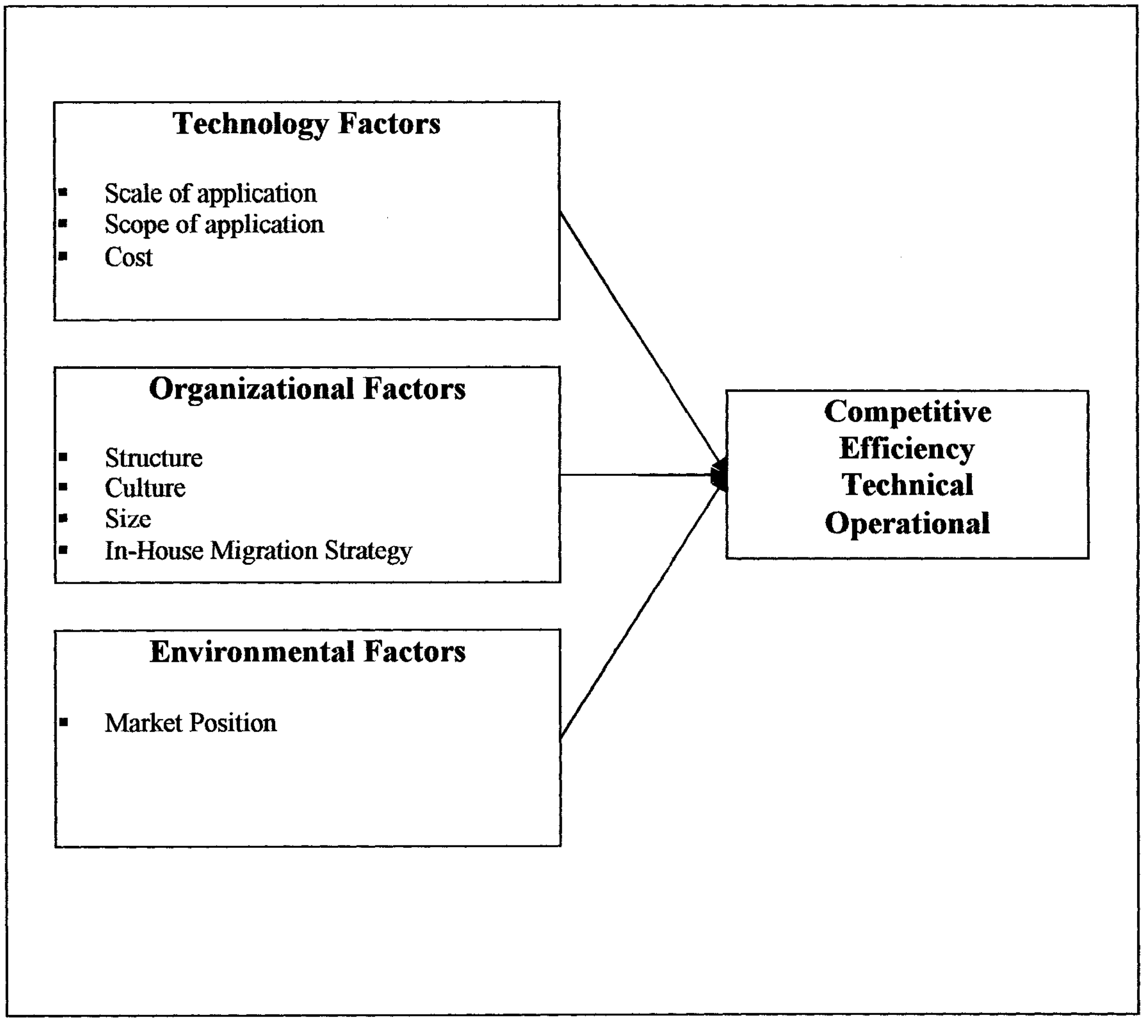
Chau and Tam (1997)



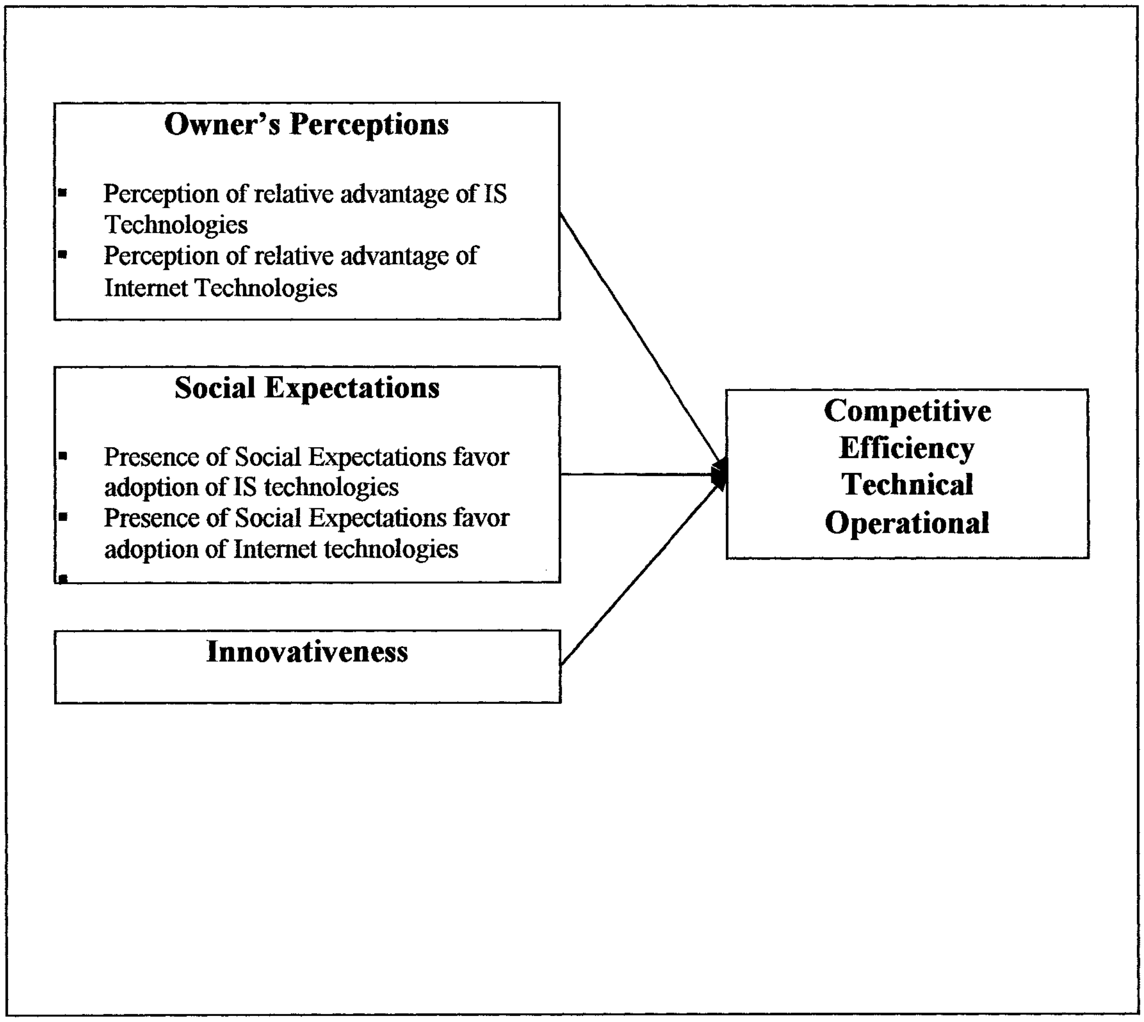
Premkumar Roberts (1999)



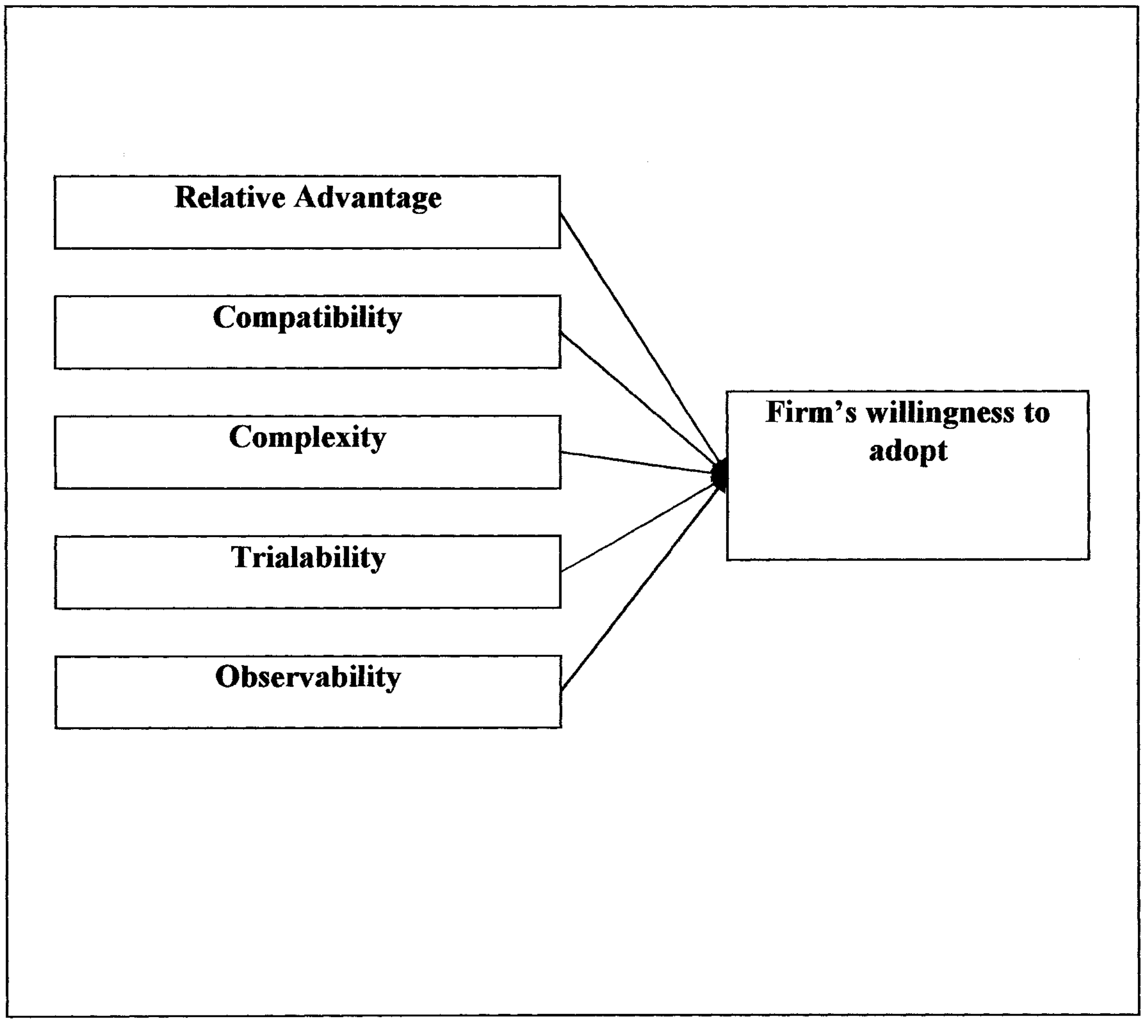
Chengalur-Smith Duchessi



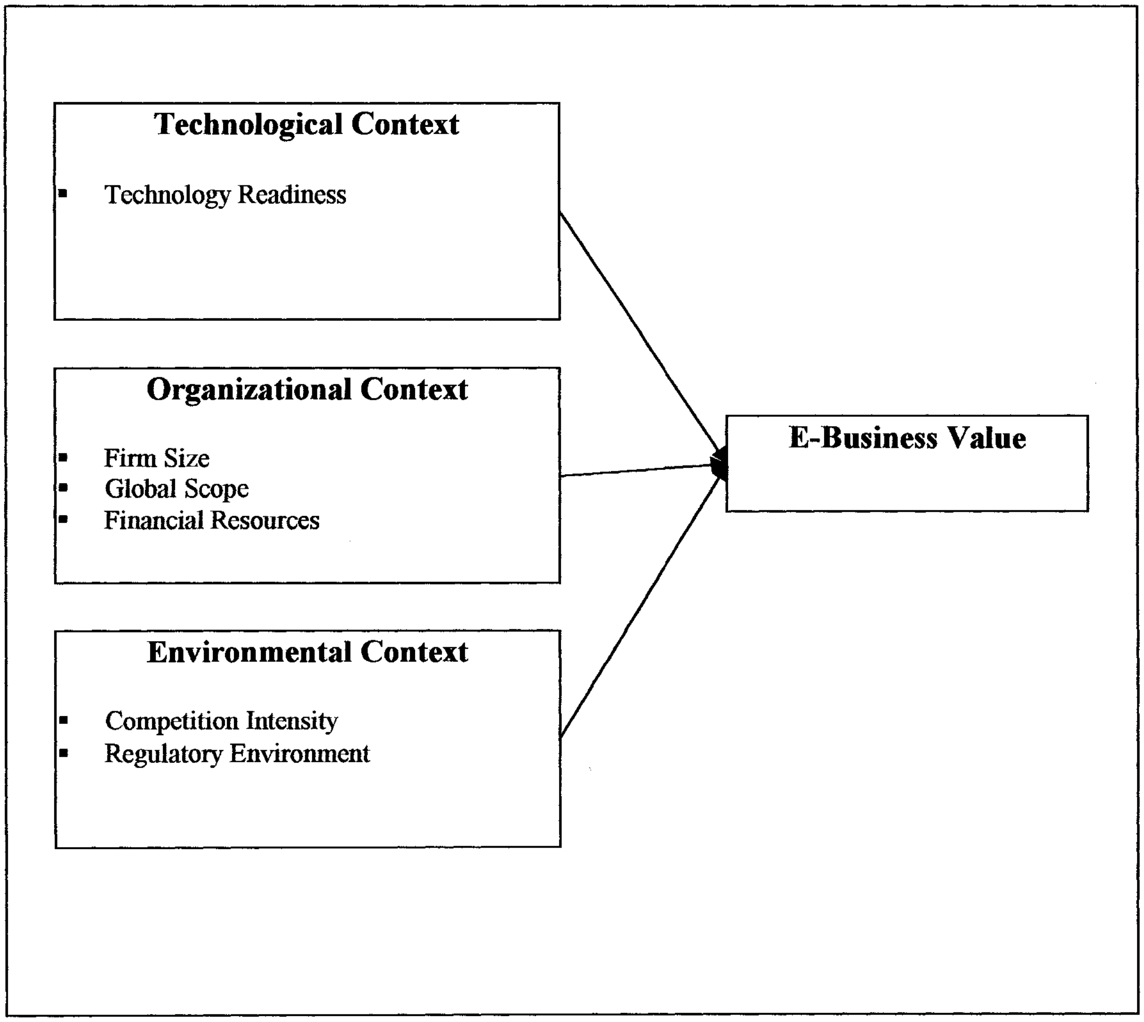
Lee and Runge (2001)



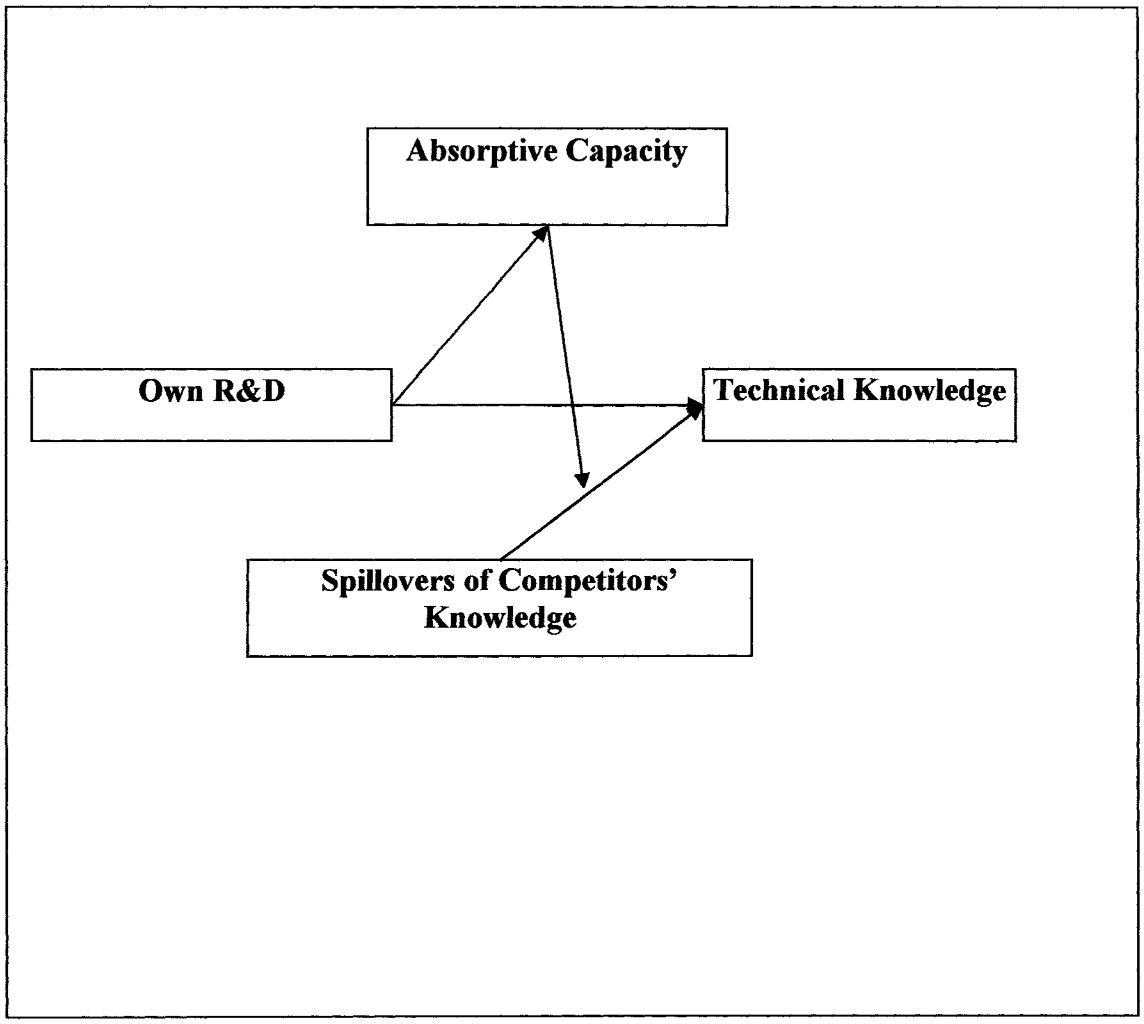
Kendall et al. (2001)



Zhu, Kraemer, Xu, and Dedrick (2004)



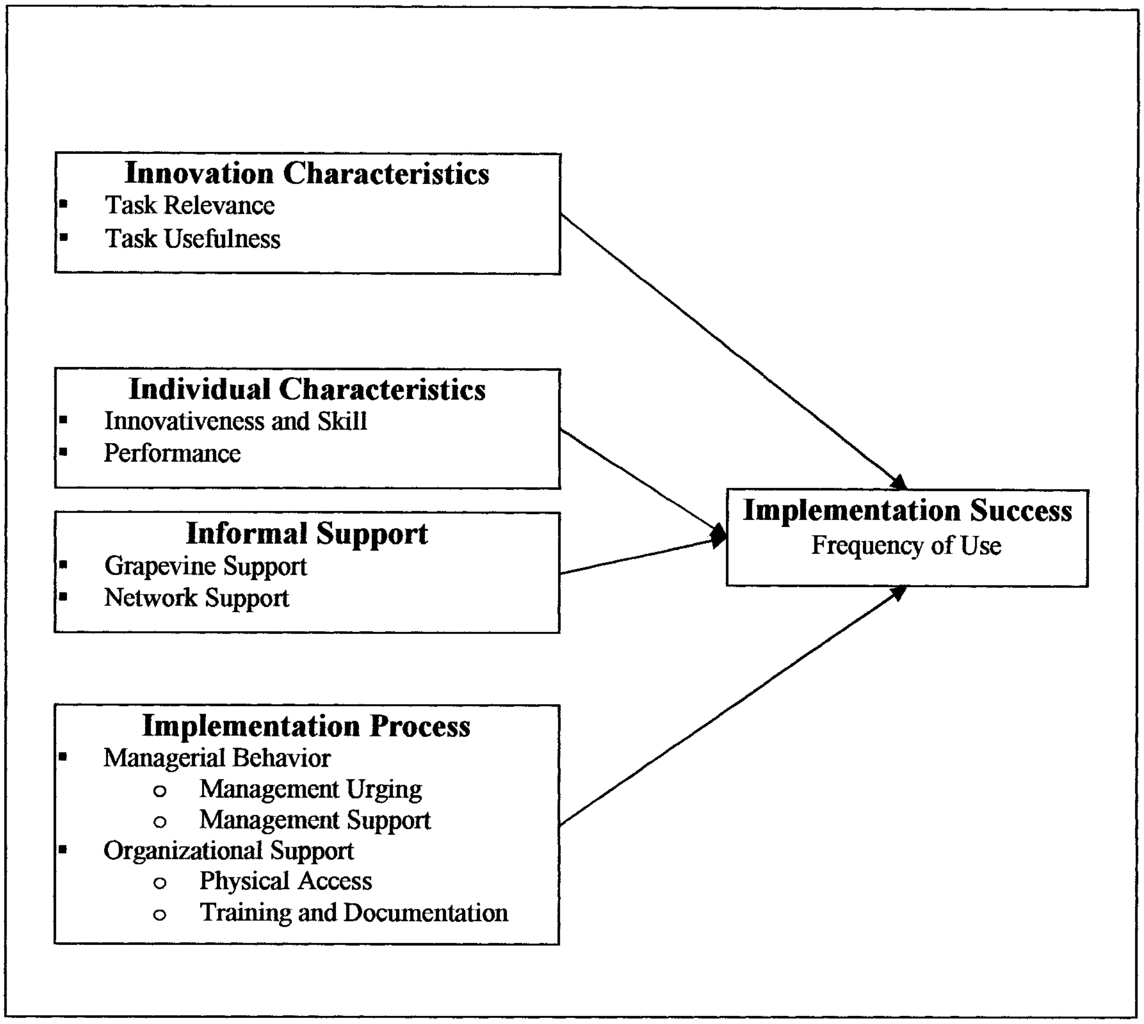
Cohen and Levinthal Model of Sources of Absorptive Capacity (1990)



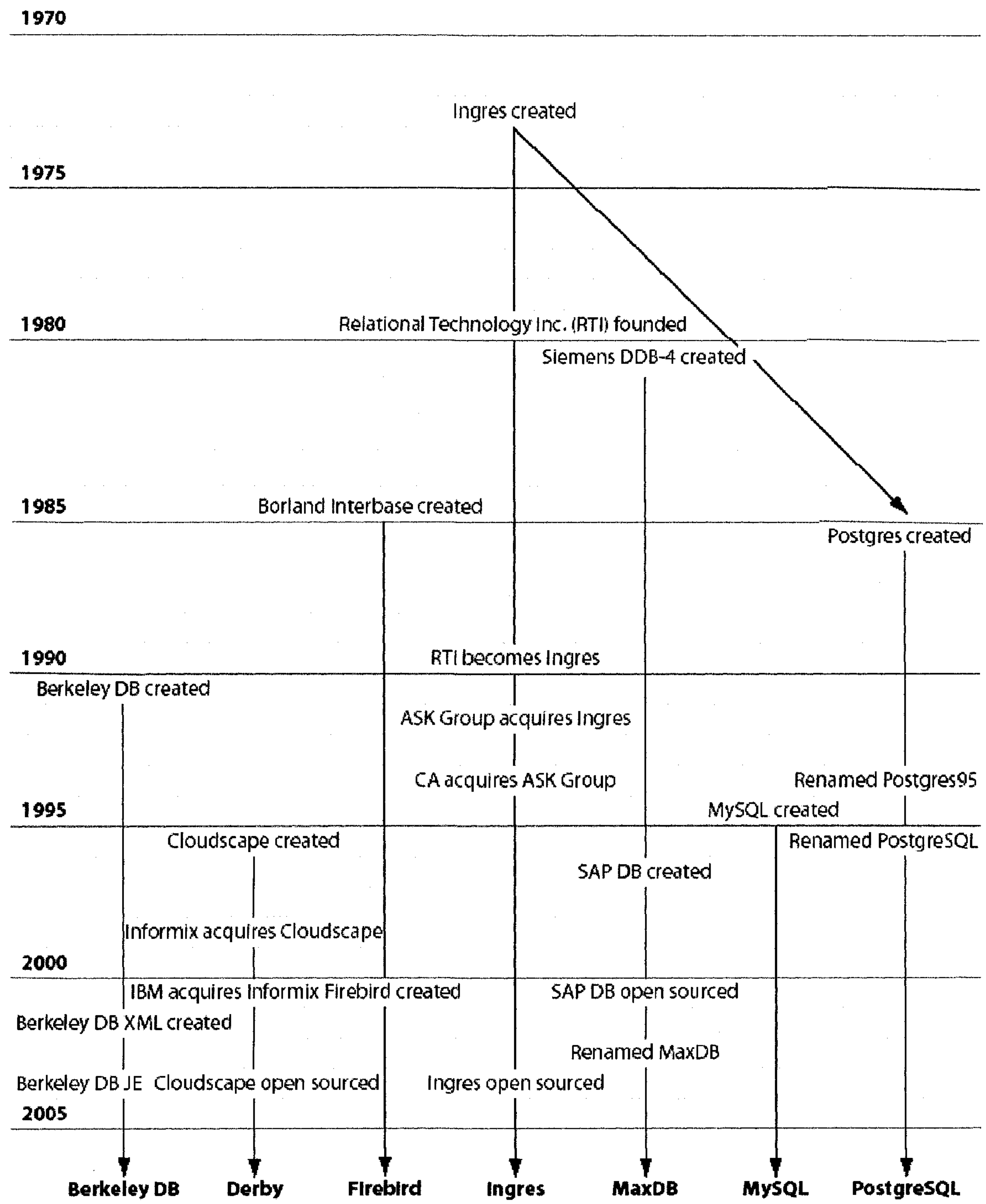
Attewell (1992) Knowledge-Barrier Institutional-Network Approach

1. **Organizational Learning is Partly a Consequence of Immobility of Technical Knowledge**
2. **The burden of developing technical know-how (organizational learning) becomes a Hurdle to adoption.**
3. **Given such Hurdles, the relationships between supply-side and user organizations in a network go beyond selling and buying equipment.**
4. **Mediating Institutions come into existence where technical knowledge is scarse and/or organizational learning around a technology is burdensome**
5. **Mediating institutions capture economies of scale in learning.**
6. **The S-curve reflects changing knowledge barriers over time.**
7. **Service is an alternative to adoption or non adoption.**
8. **Technology services are an alternative to knowledge transfer**
9. **A transition occurs from service to self-service**

Yetton, Sharma, Southon (1997) Bridging Theory



Open Source Databases Timeline



Source: Forrester Research, Inc.

Pilot Survey Questionnaire

This survey is anonymous and your participation is voluntary. All information collected will be kept confidential and will be used only in the context of this research study.

Introduction: Open source database servers provide corporations with the ability to deploy an enterprise database without any of the acquisition and licensing costs pertaining to commercial database servers.

Please choose one open source database server application like mySQL, PostgresSQL, with which you are most familiar and answer the following questions. Complete all sections even if the open source DB application is still being implemented. Base your answers on current status. If you are unsure about a particular question, leave it blank.

Section I – Background Information

Your Title is ☐**CIO/CTO,** ☐**VP,** ☐**DIR,** ☐**MGR,** ☐**Supv,** ☐**Other** ______________

Your industry is

☐**Manufacturing,** ☐**Service,** ☐**Retail,** ☐**Government,** ☐

Your company's annual revenues last year ☐**up to 50 million,** ☐**50-500 million,** ☐**500 million to 1 billion,** ☐**over 1 billion**

Number of employees in entire company ☐**0-500,** ☐**501 – 5000,** ☐**5001-10,000,** ☐**10,001-20,000,** ☐**over 20,000**

Your corporate IT Budget: ☐**up to 5 million,** ☐**5-10 million,** ☐**10-50 million,** ☐**50-100 million,** ☐**over 100 million**

Your primary operating systems are: (Please check all that apply) ☐**Windows,** ☐**Unix/Linux,** ☐**MacOS,** ☐**Solaris,** ☐ **OS/2,** ☐**VMS,** ☐**VSE,** **other** ______________

Installed Number of open source database server instances? _______ installed commercial instances? _______

Number of open source database server instances used for mission critical applications?_______ non-mission critical applications?

Are you planning to adopt open source databases or increase the installed instances? ☐Yes ☐No

What is the purpose of an intended open source database server? ☐**Transaction Processing Support** ☐**Decision Making Support?**

Planned number of open source database server instances within the next year? _____ next five years? _______

Please indicate your level of agreement or disagreement with each of the following statements. ***The following classifications are used:***

1 = strongly disagree; 2 = Slightly disagree; 3 = disagree; 4 = neither agree or disagree; 5 = Slightly Agree; 6 = agree; 7 = strongly agree.

Section II – Information	1	2	3	4	5	6	7

about the Organization							
In our company we have highly specialized personnel for database servers.							
In our company we have the hardware, software, and telecommunications infrastructure to experiment with open source database servers.							
In our company we have an IT expansion strategy in place to take advantage of advancements in database systems such as open source database servers.							
In our company we prefer to invest the time and resources of our IT function in other projects than to experiment with open source database servers.							
My company would adopt open source databases if the cost for development, technical support, and maintenance is still lower than the respective cost for commercial software.							
Our IT people have enough knowledge to handle open source database servers.							
Most IT knowledge in our corporation focuses around specific commercial operating systems and database servers.							
Top management is supportive of the idea of adopting open source database servers.							

Section III – Information about the Technology							
We would consider adopting open source database servers if:							
They were compatible with our existing IT infrastructure.							

They were not overly complicated.							
They were flexible enough to accommodate our future changing needs.							
They comply to industry standards							
They support replication, load balancing, sub-queries, Unicode data types.							
They had easy to use management tools.							
Their overall cost is less than commercial databases.							
Their maturity level was acceptable							
There was an adequate level of support.							
We were certain about their reliability.							
We could try and test them without high costs.							
We were certain the technology will exist in the long run							
They came with a good migration package (Extraction Transformation, and Loading tool).							
They have a proven security record for business operations.							

Section IV – Information about the Environment							
We would consider adopting open source database servers if:							
Some of our suppliers and or customers had adopted them.							
Some of our competitors had adopted them.							
We could see positive results from other businesses							

Section V – Information about the Decision Maker							
I base my decisions on my own experience with open source database servers.							
I base my decisions on other sources such magazines, advertisements, and brochures.							
I consider sources of information within my own industry as well as sources outside my own industry.							
I have a positive attitude toward open source database servers.							

Section VI – Information about the Task – Technology Match							
We would consider adopting open source database servers:							
For non-mission critical applications only.							
If our company processes could remain unchanged.							
It would increase our market share.							
It would increase our revenues.							
If the available license types allowed us to keep our changes private							
If we could overcome the constraints imposed by commercial databases.							
If doing so would provide us with significant competitive advantage.							

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