Understanding Technology Acceptance: Phase 1 – Literature Review and Qualitative Model Development

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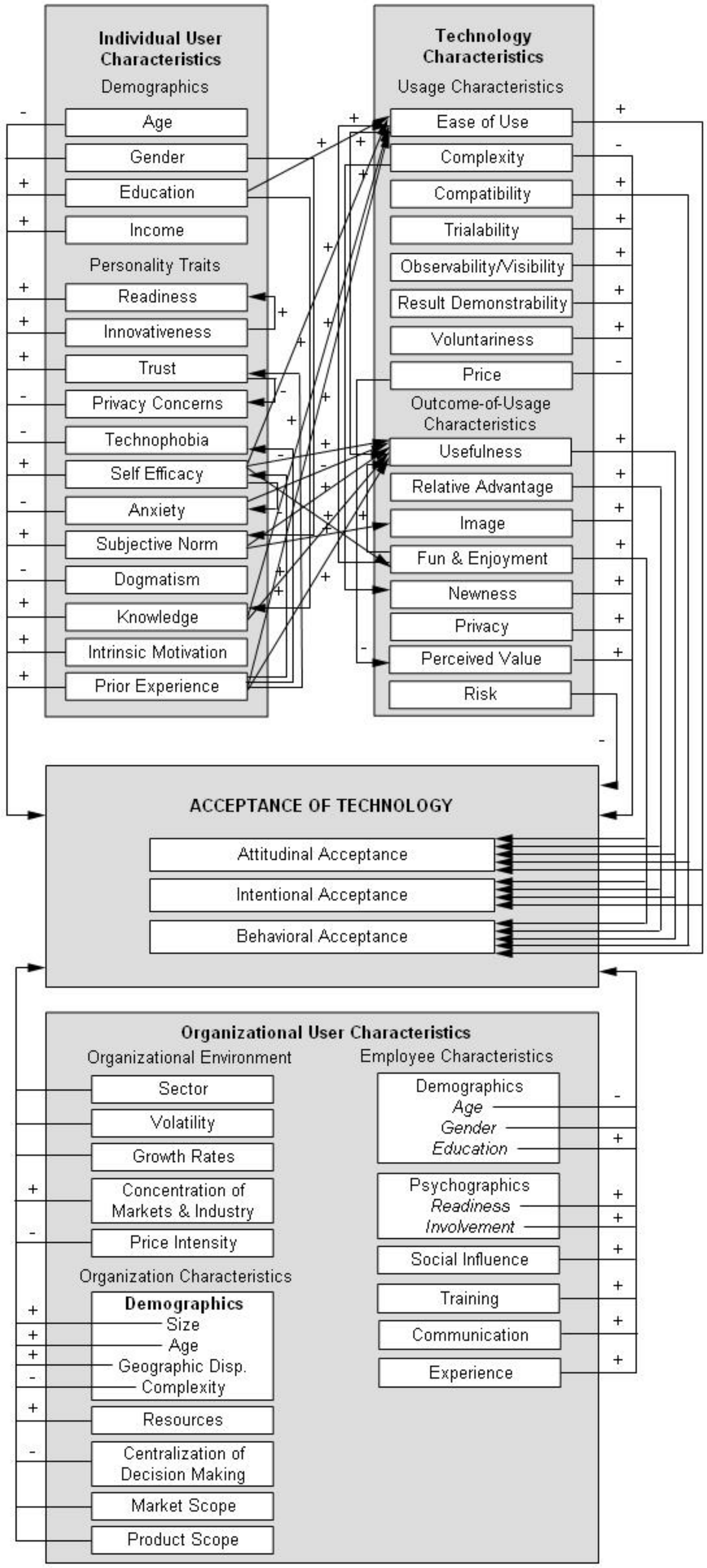
Executive Summary

Understanding technology acceptance is a seemingly simple idea on the surface, but it is a rather complex proposition. We conducted an extensive review of the different research literatures that report technology acceptance studies; namely, marketing, psychology, human factors, and communication. A plethora of variables have been identified as possibly relevant to technology acceptance; these variables relate to the technology itself, characteristics of the individual user, and features of the organization for technologies used in the work environment. We developed a comprehensive qualitative model to classify and organize the research studies in this domain. Individual user characteristics and technology characteristics interact to influence acceptance in terms of attitudes, intentions, and behaviors. These variables and their interrelationships are illustrated in the qualitative model on the following page. The model is described in detail in Chapter 6.

The qualitative model provides an integrative summary of the research literature on technology acceptance. One immediate benefit of developing a general qualitative model, as we have organized it, is to understand the different categories of relevant variables. For example, some user characteristics, such as age, gender, or dogmatism, may not be malleable but they are certainly measurable and can be used to make predictions about technology acceptance. Other variables, such as technophobia, knowledge, or prior experience, can be changed through exposure or through training and instruction. As such, companies have the opportunity to influence levels of acceptance. A similar logic applies to the organizational user characteristics.



A qualitative model of technology acceptance

With respect to the technology characteristics, understanding variables that relate to technology acceptance also provides the opportunity for influence. Some variables such as ease of use, complexity, and fun/enjoyment can be influenced through marketing activities. Other factors such as privacy, risk, and compatibility can be considered during the design process to maximize acceptance by at least some user groups. The finding that certain variables relate to usage and others to the outcome of usage also provides insight into the general technology acceptance process.

The qualitative model we have developed provides the state-of-the-science on technology acceptance. Our systematic review of this extensive literature revealed that, although the topic of technology acceptance has been much studied, there are limitations and gaps in the current understanding. First, much of the research and resultant models were developed in the context of information technology (e.g., personal computers, software), thus limiting understanding of technology acceptance more broadly. Second, there are too many purportedly "relevant" variables for a predictive model of technology acceptance. It is unclear which variables are more or less critical for understanding acceptance at the individual user level. And third, although concepts such as perceived ease of use and perceived usefulness have often been shown to be predictive of acceptance but not diagnostic. That is, few studies have investigated *why* a particular technology would be perceived as easy to use or useful by specific people. Lastly, the role of technology "costs" such as risk, privacy concerns, and security issues have been minimally investigated and hence are not well-understood.

The focus of Phases II and III (FY06 and FY07) will be on conducting the necessary research to fill these gaps of knowledge for the specific product domains of *Intelligent Mobile Equipment* and *Telematics*.

Chapter 1 – Understanding Technology Acceptance

Background and Overview

Given that the success rate of new product and technology development (from initial ideas to launch) is relatively low, it is important that those products and technologies that make it to launch are accepted in the market place. Research to increase the understanding of customer acceptance of new products and technologies is widespread and scattered. Researchers from psychology, sociology, information technology, organizational behavior, economics, and marketing have examined the determinants of new product and technology acceptance with mixed success. The problem is that there has been no integration of data and no theory developed to support a predictive model of acceptance of technology.

The overall objective of this research project is to develop a model that would enable understanding, at the individual user level, of the technology acceptance decision-making process. Such an understanding would enable the development of technologies that would be most likely to be accepted and provide guidance for the introduction and dissemination of information about such products. From the corporate perspective this knowledge should ultimately reduce uncertainty when considering new technologies for product development programs.

The objective of this first phase of the research project was to develop a qualitative model to understand the variables that are relevant to the technology acceptance process – variables related to technology characteristics, user characteristics, and the context in which the technology is used. Development of a qualitative model requires specification of the critical variables, their inter-relationships, and their relative importance based on empirical evidence rather than intuition, anecdote, or conjecture. This review and analysis of the literature and development of a general qualitative model is a necessary first step to the ultimate development of quantitative models of technology acceptance (which is the goal of Phases II and III of this research program).

Specific Goals and Objectives of Phase I

The primary goal of this phase of the project was to conduct an in-depth review and analysis of the empirical literature on the topic of technology acceptance (and non-acceptance), very broadly defined. The outcomes of our review are:

1. an in-depth report on the state of the science in the area of technology acceptance;
2. identification of the characteristics of technology that relate to acceptance;
3. identification of the characteristics of end users that relate to acceptance;
4. investigation of the *relative importance* of critical variables and *interactions* among variables;
5. insights into the decision-making process that people engage in when deciding to accept or reject a technology or product;
6. identification and understanding of the gaps in the research literature that would be most relevant to understanding acceptance of *Telematics* and *Intelligent Mobile Equipment*;
7. a general qualitative model of technology acceptance to specify the relevant variables and the relationships among the variables
8. testable research hypotheses (based on the qualitative model) most relevant to understanding acceptance of *Telematics* and *Intelligent Mobile Equipment*.

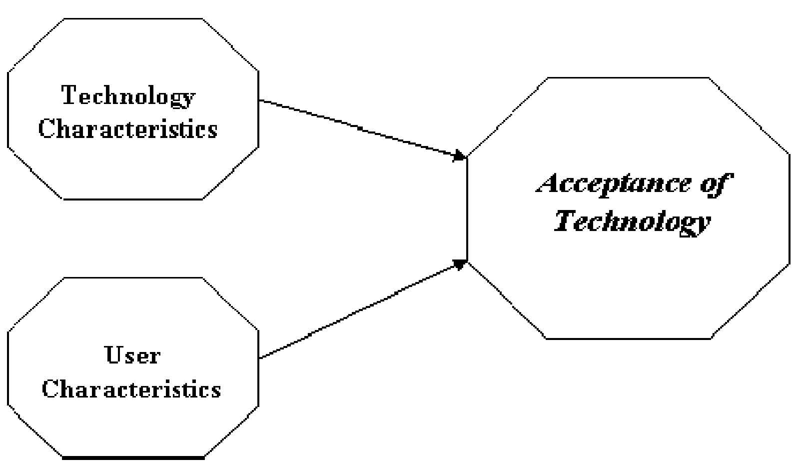
Note that our emphasis on *Telematics* and *Intelligent Mobile Equipment* stems from the relevance of these categories of technology to all divisions of Deere & Company and our understanding from our interactions with Deere representatives that these were logical areas of focus. (See Appendix A for an overview of the research team.)

Approach

Our approach to achieving these goals was to cast a very wide net to determine what research had been done in this domain and what conclusions could be drawn with certainty. Our research approach to the literature review is detailed in Chapter 2.

One of the first challenges of the review was to specify what is meant by "technology" and what is meant by "acceptance." In Chapter 3 we discuss the definitions and assessment tools that have been used across different literatures. It is important to note that we use the term acceptance as shorthand to refer to both acceptance and non-acceptance (i.e., rejection). However, our review revealed that most empirical research has focused on drivers of acceptance. While valid, it remains unclear if drivers of acceptance have an identical, opposite effect on the rejection of technologies – we address this more in our discussion later.

It was clear from our review of the literature that there were two main categories of variables that had been studied and shown to be relevant to understanding technology acceptance. The first category could be described as characteristics of the technology itself (e.g., perceived complexity, level of innovation). The second category is construed as specific characteristics of the user (e.g., experience, personal traits, motivation).



Our review of the literature is thus organized around this framework. In Chapter 4, we provide an overview of the types of products and technologies that have been studied in the literature along with a detailed analysis of the technology characteristics that have been shown to relate to acceptance of technology. Chapter 5 gives an overview of user characteristics as they have been studied in the literature, both for individuals and for organizations. The predictive validity of a model of technology acceptance should include an understanding of these dimensions as they relate to technology acceptance.

In Chapter 6, the main findings from the review are integrated into a qualitative research framework that will form the basis for future empirical research. Chapter 7 provides propositions which serve as the basis for testable hypotheses in later research studies. Chapter 8 presents our conclusions and plans for future directions.

Chapter 2 – Methods for Literature Review

Overview

The purpose of the literature review was to conduct a systematic analysis of previous research on technology acceptance. The process comprised 5 steps, as illustrated in Figure 2.1. The following sections describe each step in detail.

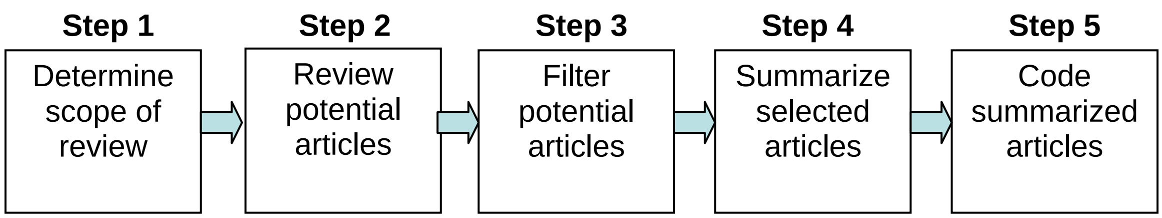


Figure 2.1. A summary of the literature review process.

Step 1 – Determine Scope of Review

The first step was to determine the scope of the review. Technology acceptance is a broad topic that has been investigated in a variety of domains. Thus our first goal was to determine the overall process for the literature review, to select the journals and databases that would be searched, to define the constraints of the search, and to identify the key search terms. This determination was made through a preliminary literature review wherein we identified the following most commonly-used terms and models used in formal technology acceptance research.

- Acceptance
- Adoption
- Bass Model
- Diffusion Model
- Innovation
- New product
- Technology
- Technology Acceptance Model (TAM)
- Rejection
- User Acceptance

We used these terms to complete a broad search of the online databases accessible from the Georgia Tech library system, as listed in Table 2.1. We reviewed abstracts of the articles returned from the database search and retrieved the full article if the abstract seemed relevant to the search goals. Upon reading the full article, we documented definitions describing technology acceptance. We also explored the databases using terms found from these articles to develop a comprehensive list of key words. In addition, we used references from the retrieved articles as sources for potential terms.

Table 2.1. *Online Library Databases Searched for Preliminary Review*

Database	**Years Covered**	**Description**
PsycARTICLES	1988-present	Basic, applied, clinical, and theoretical research in psychology; 34,000 full-text articles from 51 journals
Psychology & Behavioral Sciences Collection	1984-present	>500 peer-reviewed full-text journals; emotional, behavioral characteristics, observational, experimental
Social Sciences Citation Index	1907-present	Periodicals in anthropology, economics, geography, law, political science, social work, sociology, and international relations
PsycINFO	1887-present	Citations and summaries of journal articles, book chapters, books and technical reports, dissertations; more than 2,000 periodicals

Based on this initial search, we developed a final list of 21 search terms that were used in the comprehensive literature review. These terms were:

- Acceptance
- Acceptance of Technology
- Adoption
- Adoption of Technology
- Bass Model
- Consumer Acceptance
- Customer Acceptance
- Hazard of Technology
- Innovation
- Product Acceptance
- Rejection
- Rejection of Technology
- Risk of Technology
- Technology
- Technology Acceptance
- Technology Acceptance Model (TAM)
- Technology Adoption
- Technology Hazard
- Technology Rejection
- Technology Risk
- User Acceptance

Forty-two journals were identified as being the first-tier journals from fields relevant to the study of technology acceptance. These journals came from the fields of economics, psychology, human factors, human-computer interaction, and management (see Appendix B for the complete list).

We also agreed upon a *working definition of technology* to use in the literature review: *"An innovation or product that embodies new knowledge or information about a certain field. Technology can enhance an old product or be completely new. This can include intangible things such as information and technology."* This definition was developed with input of the Georgia Tech and the Deere & Company team members (see Appendix A). We selected the Endnote software package (Version 7.0) to manage the bibliographic information on selected sources, along with supplementary information researchers could use to describe each article (Thompson-ISI Research, 2003).

Step 2 – Finding Potentially Relevant Articles

The second step was to find all of the potentially relevant articles and select those that explored technology acceptance in some way. Each journal listed in Appendix B was searched using the 21 keywords listed above. The searches were conducted between April and June 2005. If a search resulted in more than 300 citations, the search was narrowed by using a combination of search terms. The combination search terms were:

- Acceptance of Innovation
- Acceptance of Product
- Acceptance of Technology
- Adoption of Innovation
- Adoption of Product
- Adoption of Technology
- Innovation Acceptance
- Innovation Adoption
- Innovation Rejection
- Product Acceptance
- Product Adoption
- Product Rejection
- Rejection of Innovation
- Rejection of Product
- Rejection of Technology
- Technology Acceptance
- Technology Adoption
- Technology Rejection
- RISK + word generating 300+ citations

This initial process yielded 11,100 citations. Based on the titles and abstracts we eliminated articles that did not fit project goals. Citations deemed relevant were downloaded to the EndNote library located on the central file server. This review step yielded 781 potentially-relevant citations.

Step 3 – Filter Specific Articles

The third step was a more in-depth filter that required retrieving each article and giving it a preliminary review to assure a complete fit with the project goals. Articles that were considered to be a good fit were labeled as "accepted." Citations that did not seem to be a good fit were labeled as "rejected", but the citations were kept in the EndNote database for reference if needed. At the end of this step, 290 articles had been retrieved, reviewed, and accepted as directly relevant to understanding technology acceptance.

Step 4 – Summarize Specific Articles

In the fourth step each accepted article was summarized by extracting all key variables into an EndNote database. Each summary contained the definition of acceptance given in the article, the type of technology discussed, whether the environment discussed in the article was business or consumer, the methods used, the outcome variables (dependent variables), other variables (independent variables), a summary of the key findings, and any other notable features about the article. During the summary process we also noted the article's value to the project (e.g., highly relevant, poor methodology) as well as insights, gaps, or questions raised by the article. A complete explanation of the type of information contained in the EndNote database by field is provided in Appendix C.

Step 5 – Code Summarized Articles

In step 5, articles were coded using a scheme that was developed specifically for the purposes of this study. A coding scheme is a method of organizing information into a set of useful and usable categories. The coding scheme for the articles was developed over the course of the project and was finalized after a number of iterations (see Appendix D for details). Articles were coded along five dimensions:

1. Type of article (e.g., review, empirical study, model)
2. Focus of research (e.g., acceptance, rejection, or both)
3. Characteristic of the innovation (e.g., incremental or radical)
4. Form (e.g., computer hardware or software, electronic or mechanical device, physical object, system)
5. Setting (e.g., personal or organizational use)

The coding of the articles allowed us to develop a general overview of the domains, technology types, and environments that have been most frequently studied in the context of technology acceptance research. The detailed summaries of each article provided the basis for organizing the literature and identifying the variables most relevant to technology acceptance as well as gaps in the literature.

Summary of Review

Step 1	Step 2	Step 3	Step 4	Step 5
Determine scope of review	Review potential articles	Filter potential articles	Summarize selected articles	Code summarized articles
• Select journals • Select key words	• Use library databases to find articles with key words • Retrieve citations • Review abstracts for fit with project goal	• Retrieve articles • Skim articles for fit with project goal	• Read article • Document key variables in EndNote • Note article value • Highlight ideas for insights, gaps, questions	• Review populated variables • Organize variables into common categories • Review categories for effectiveness • Repeat as needed
42 journals 21 key words	**11,100 citations met criteria 765 relevant citations**	**408 articles retrieved 289 articles accepted**	**289 articles summarized**	**289 articles coded**

Chapter 3 – Acceptance of Technology

Defining Technology

The term *technology* has multiple definitions and types of technology can be differentiated along various dimensions. In the broadest sense, technology can be defined as "the practical application of knowledge…or a manner of accomplishing a task" (Merriam-Webster, 2000). Some research on the broad topic of acceptance of technology had its roots in understanding technology broadly defined. For example E. M. Rogers' (2003) work on the *Diffusion of Innovations* started with acceptance of farming practices (see also Meinzen-Dick, Adata, Haddad, & Hazall, 2004). However, most of the recent research we reviewed focused on the acceptance of *high technology*: "scientific technology involving the production or use of advanced or sophisticated devices especially in the fields of electronics and computers" (Merriam-Webster). Given that Deere & Company technology initiatives include *Telematics* and *Intelligent Mobile Equipment*, this research is very relevant to the Deere mission of understanding technology acceptance of their customer base.

An additional distinction relevant to Deere & Company is between technology and products. Technology is viewed as an approach or capability that can be implemented in a variety of products (e.g., automated steering, wireless communication). However, our review of the literature revealed that most research studies assessed acceptance of the technology as it was instantiated within a particular product. Figure 3.1 shows the distribution of research foci in the literature.

Most frequently investigated, by far, was computer technology of some form. We categorized the research as focusing on software (e.g., word processor, spreadsheet) or hardware (e.g., desktop, laptop, mini-computer). Electronic devices were non-computer technologies such as a video cassette recorder or a cell phone. Infrequently studied were mechanical devices (e.g., machinery) or physical objects (e.g., videotapes).

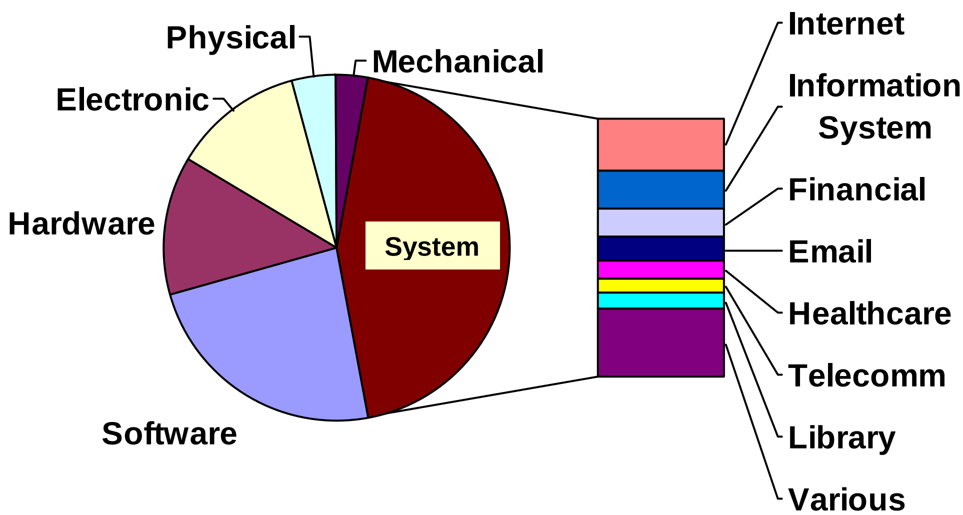


Figure 3.1. Distribution of products and systems assessed in the literature.

The category "System" is most comparable to the idea of technology that can be used in various products. The most common subcategories here were use of the Internet, electronic mail, as well as general information, financial, healthcare, telecommunications and library systems. However, there were also a variety of other systems investigated in a few studies such as assistive technologies or aware technologies.

It may very well be that technology acceptance is best understood as it is manifested by acceptance of a particular product that uses that technology. Henceforth, when we use the word technology it will generally refer to a *product* that employs technology as that is what is typically assessed.

An additional relevant dimension along which to consider technology acceptance is whether the product is incrementally new or radically new. Various terms have been used in the literature to convey this distinction between levels of "newness," as illustrated in Table 3.1.

Table 3.1. *Describing the Relative "newness" of a Technology*

Incremental	**Radical**
Evolutionary	Revolutionary
Extensions	New
Adapted	Original
Continuous	Discontinuous
Modifying	Pioneering
Sustaining	Disruptive

Sources: Christensen (1997); Christensen & Raynor (22003); Green, Gavin, &Aiman-Smith (1995)

We will use the terms radical and incremental as those were most frequently used in the literature. An example of radically new technology was the shift from DOS-based systems to windows-based systems. An incrementally new technology would be a new version of an established product (e.g., Microsoft Windows 2000 vs. Microsoft Windows^{xp}).

This is a potentially important dimension with respect to understanding technology acceptance – variables that are predictive of acceptance of incrementally new technology may not be the same variables that are predictive of the acceptance of radically new technology. However, as discussed in Chapter 4, there has been insufficient research to be able to fully understand these differences.

Defining Acceptance

What does it mean to accept technology? Is it to purchase a product? To use it on a regular basis or to use to the point where one is reliant on it to perform a particular activity? Is the degree to which a person tells others about the product a valid index of acceptance? Is rejection the opposite of acceptance? How should rejection be measured – active rejection or simply non-use? Clearly defining what acceptance of technology is and how it should be measured is an important step to understanding the factors that influence acceptance (and/or rejection).

The Princeton dictionary defines acceptance as "the act of accepting with approval," "favorable reception," "its adoption by society," "the act of taking something that is offered." The literature review revealed many different definitions of acceptance, and even more ways to operationalize the term (i.e., to measure it). There were 168 articles in which an empirical study of technology acceptance, in some form, was directly assessed. For each article reviewed, we classified the definition of acceptance that was used as well as the outcome measure or measures that were used to assess acceptance. Table 3.2 presents the most frequently used terms/phrases used to define acceptance of technology.

Table 3.2. *Definitions of Acceptance of Technology*

Definition of Acceptance of Technology	**Number of References***
Adoption	89
Use/Usage Behavior	44
Purchase	15
Not Defined	13
Acceptance	6
Other (transfer, social, comprehension)	5

** Classification was based on how authors explicitly defined acceptance or on our inference of their definition based on their overall discussion.*

As is clear from Table 3.2, acceptance of technology was most often defined in terms of adoption, use, and sometimes purchase. However, the means by which these terms were actually measured across studies varied tremendously. The dependent measures ranged from:

- Ability to use (facility with the system)
- Attitude
- Diffusion (within a company or within a community)

- Intentions (to adopt, to purchase, to use)
- Satisfaction
- Timing (early adoption versus late adoption)
- Usage (yes or no)
- Usage patterns (how used, variety of use)
- Usage rate (frequency of use)

In many studies, what was actually measured was not really acceptance or adoption, per se. Instead, the focus was on measuring precursors of acceptance such as perceived usefulness, perceived ease of use, or self-efficacy (belief in one's ability to use the technology). We discuss these variables in depth in Chapters 4 and 5.

Organizing the Literature

Another complexity related to the acceptance concept is that the overall consumer adoption process often is described as having multiple phases. For example, awareness, attention, information acquisition and evaluation, and intentions are sometimes differentiated (e.g., Boyd & Mason, 1999). Other descriptions of the process include awareness, investigation, evaluation, trial, repeated use, and commitment (e.g., Meuter, Bitner, Ostrum, & Brown, 2005).

One thing that became clear from the literature was the importance of differentiating between attitudes, intentions, and behaviors. Thus to begin to organize the literature in terms of acceptance, we categorized the research according to whether the focus was on *attitudinal acceptance*, *intentional acceptance,* or *behavioral acceptance*, as defined in Table 3.3. This distinction is based on the theory of reasoned action described by Fishbein & Azjen (1975). The idea is that attitudes influence intentions which in turn influence behaviors.

With respect to technology acceptance, a person may be accepting of the product in principle (attitudinal acceptance), may have accepted it to the level that they have formed an intention based on that acceptance, or their acceptance is relatively complete as indexed by their actual behavior. The majority of research has focused on intentional acceptance but where possible we describe the different predictors of these main acceptance categories.

Table 3.3. *Acceptance Types*

Acceptance Type	**Definition***	**Example**
Attitudinal Acceptance	Positive evaluation; beliefs about something.	"I like the technology."
Intentional Acceptance	Decisions to act in a certain way.	"I intend to buy the technology."
Behavioral Acceptance	Actions.	"I use the technology."

** Fishbein & Ajzen (1975)*

Another distinction we found was between pre-adoption attitudes and post-adoption attitudes (e.g., Karahanna & Straub, 1999). People form attitudes prior to having any direct experience with a technology (pre-adoption). They may amend or elaborate those attitudes after they have had at least one experience with the technology (post-adoption). The predictors may differ depending on which attitudes are being measured. Pre-adoption attitudes were most frequently assessed in the literature but we describe in Chapter 4 research wherein pre- and post-adoption attitudinal differences were reported.

Chapter 4 – Characteristics of Technology

Overview

Possible determinants influencing the acceptance of technologies are the characteristics of the technology itself. The literature on technology acceptance has long recognized that the properties of a technology can influence its acceptance (Rogers, 2003). Not all technologies are alike and understanding how technology-specific characteristics influence acceptance is a fundamental question in acceptance research. For instance, Henard and Szymanski (2001) found that the relationship between the product advantage and new product performance was more important in high-tech markets than low tech markets. Other research has shown that firms that focus on how a product might be perceived by consumers have a higher probability of the product being accepted (Carbonell-Foulquie, Munuera-Aleman, & Rodriguez-Escudero, 2004). In the following section, we discuss the technologies and products studied in the literature on technology acceptance.

Types of Technology Studied

To gain some perspective on the research context, Table 4.1 gives an overview of the different types of technology that have been studied. Hardware, software, information technology (IT), and Internet-related products and service are among the most studied technologies. However, as explained later, much of the research on technology acceptance has been built around this research that focused on IT technologies; this may perhaps limit our understanding of technology acceptance more broadly defined. That is, researchers have applied findings from research conducted in an IT environment to an unrelated environment (e.g., medical devices) without acknowledging that the original findings may be context-specific. This reduces the generalizability of many research findings. In particular, it has had a large impact on the types of variables studied, and more important, on the types of variables that have not or hardly been studied. For instance, in light of the research interests expressed by Deere & Company (Telematics, Intelligent Mobile Equipment), it is important to note that the amount of research on automation (e.g., robotics) and risk associated with giving up control of a technology is scarce.

Table 4.1. *Overview of Form of Technology Studied*

Form of Technology	% Studies	Example References
System	44%	Chau & Tam (1997); Chwelos, Benbasat & Dexter (2001); Grover, Fiedler, & Teng (1997); Kaasinen (2005); Koufaris (2002); Liaw & Huang (2003); Meuter, Bitner, Ostrom, & Brown (2005); Morris & Dillon (1997); Parthasarathy & Bhattacherjee (1998); Venkatesh & Morris (2000)
Computer software	24%	Agarwal, Sambamurthy, & Stair (2000); Bagozzi, Davis, & Warshaw (1992); Leonard-Barton & Deschamps (1988)
Computer hardware	13%	Shih & Venkatesh (2004); Sultan & Chan (2000); Weil & Rosen (1995)
Electronic device	12%	Boyd & Mason (1999); Im, Bayus, & Mason (2003); Mick & Fournier (1998)
Physical objects	4%	Donnelly Jr. (1970); Mittelstaedt, Grossbart, Curtis, & Devere (1976)
Mechanical device	3%	Ettlie & Vellenga (1979); Jacobson & Kossoff (1963); Kumar, Ganesh, & Echambadi (1998)

Note. See Figure 3.1 for exemplars of the system category.

Context of Use

We categorized the research according to whether it was assessing acceptance of technology by individuals on their own (41%) or individuals within an organizational context (59%). Within each group, we then determined the frequency of research within different sectors of use (see Figure 4.1). The most common category was general use because much of the research assessed, general use of information technology, either for people at work or during their leisure time. Consequently, it is difficult to draw conclusions about the degree to which technology acceptance variables differ as a function of the sector of use.

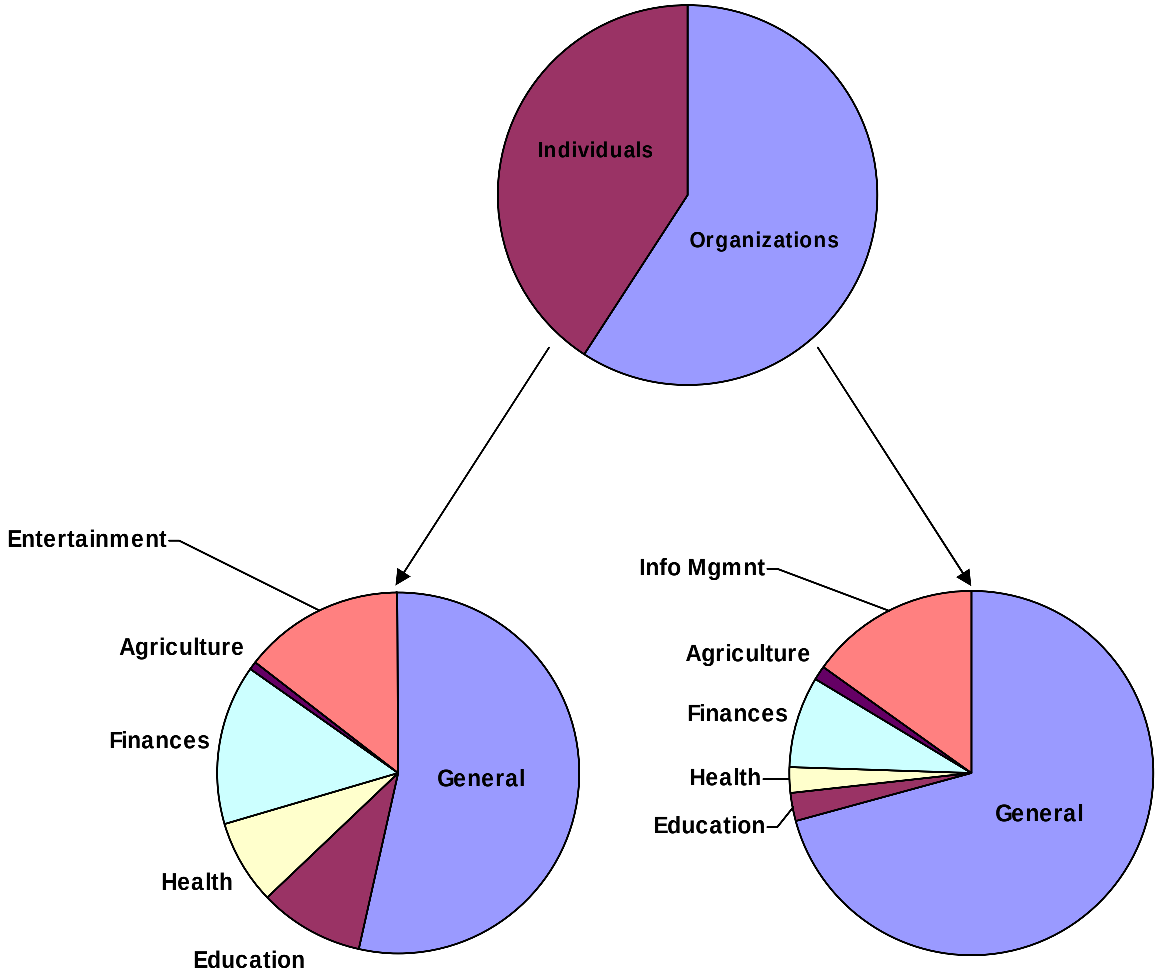


Figure 4.1. Categorization of research contexts.

Nature of the Innovations

As described in Chapter 3, it is important to specify the nature of the technology that people are choosing to accept or not accept. *Sustaining/continuous/incremental innovations* refer to technologies that approach markets the same way, such as the development of a faster or more fuel efficient car. This type of innovation is evolutionary innovation, a step forward along a technology trajectory, with a high chance of success and low uncertainty about outcomes. On the other hand, *disruptive/discontinuous/radical innovations* significantly change a market or product category, such as the invention of a cheap, safe personal flying machine that could replace cars. This type of innovation involves larger leaps in the advancement of a technology or process.

Much of the research was conducted on incremental innovations (64%). The frequency of research was much less on radical innovations (16%) or both incremental and radical innovations (3%). (Note that for 17% of the studies we could not classify the nature of the innovation being investigated.)

Research that explicitly differentiated between the acceptances of different types of technology was scarce. There are, however, indications that differentiating between different types of technology may be important. For instance, the acceptance of radical innovations may be lower than that of incremental innovations due to, for example, the perceived complexity of radical innovations being higher than that of incremental innovations. It has been suggested that the predictors of the acceptance of radical and incremental innovation adoptions vary (Dewar & Dutton, 1986). Furthermore, Hoeffler (2003) found that people were “more uncertain when predicting the utility [i.e., perceived usefulness] of a radical new product than an incremental new product” (p. 406). This suggests that it is also difficult to provide an accurate estimate of the benefits of the radical new product. This is significant because it can lead to consumers not being able to fully recognize the benefits of a radical new product. Moreau, Lehmann, and Markman (2001) found that, compared to novices, experts reported higher comprehension, more net benefits, and therefore higher preferences for *continuous* innovations. However, for *discontinuous* innovations, experts’ entrenched knowledge was related to lower comprehension, fewer perceived net benefits, and lower preferences compared with that of novices.

The importance of considering the type of product being evaluated was illustrated in a study by Blake, Perloff, and Heslin (1970). They reported a relationship between acceptance and dogmatism – the degree of rigidity a person displays toward the unfamiliar and toward information that is contrary to his or her own established beliefs. However, the relationship was mediated by the type of new product. Dogmatism was negatively related to *novel* products – those that have been on the market for some time but that performed unexpected functions; novel productw were less accepted by more dogmatic individuals, presumably due to the uncertainty of the products. However, dogmatism was not related to the acceptance of *recent* products, that is, those that were not novel, per se, but that had simply been introduced on the market recently. This study illustrates the complexity of assessing personality traits as they may relate to technology acceptance – the relationships are not simple.

Technology Characteristics and their Impact on Acceptance

Most of the technology characteristics studied in the literature originated from Davis (1986), Rogers (2003), and Moore and Benbasat (1991). These dominant characteristics are summarized in Table 4.2. Note that each characteristic is "perceived" because the critical factor is whether the person's perception is that the technology is complex or easy to use and so on. These are subjective opinions of the individual rather than objective measures of the technology itself.

Although these are the most commonly assessed characteristics there are other relevant ones that have been less studied but may be important predictors (e.g., newness, enjoyment, privacy). We discuss all these characteristics in the context of their effect on the acceptance of technology.

Table 4.2. *Technology Characteristics and Definitions*

Characteristic	Definition
Perceived compatibility	The degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters
Perceived complexity	The degree to which an innovation is perceived as difficult to understand and use
Perceived ease of use	The degree to which the potential adopter expects a technological innovation to be free of effort in use
Perceived image	The degree to which potential adopters believe the adoption of an innovation will bestow them with added prestige in their relevant community (i.e., relative advantage)
Perceived observability	The degree to which the results of an innovation are visible to others
Perceived relative advantage	The degree to which an innovation is perceived to be superior to current offerings
Perceived result demonstrability	The degree to which the benefits and utility of an innovation are readily apparent to the potential adopter
Perceived trialability	The degree to which an innovation may be experimented with on a limited basis
Perceived usefulness	The extent to which a technological innovation is expected to improve the potential adopter's performance
Perceived visibility	The degree to which an innovation is visible during its diffusion through a user community
Perceived voluntariness	The extent to which innovation adoption is perceived to be under the potential adopter's volitional control

Davis (1986); Moore and Benbasat (1991); Rogers (2003)

Based on our critical review of the literature, we classified the characteristics of technology that influence acceptance of that technology in two main categories: *Usage characteristics* and *Outcome-of-usage characteristics*. Usage characteristics relate to the actual usage of the technology and include perceived ease of use (Davis 1989) and perceived compatibility (Rogers, 2003). Outcome-of-usage characteristics relate to the benefits of using the technology such as relative advantage, fun and enjoyment, or image. Figure 4.1 summarizes these factors. The focus of our review was on the empirical evidence supporting their impact on the acceptance of technologies and their possible inter-relationships.

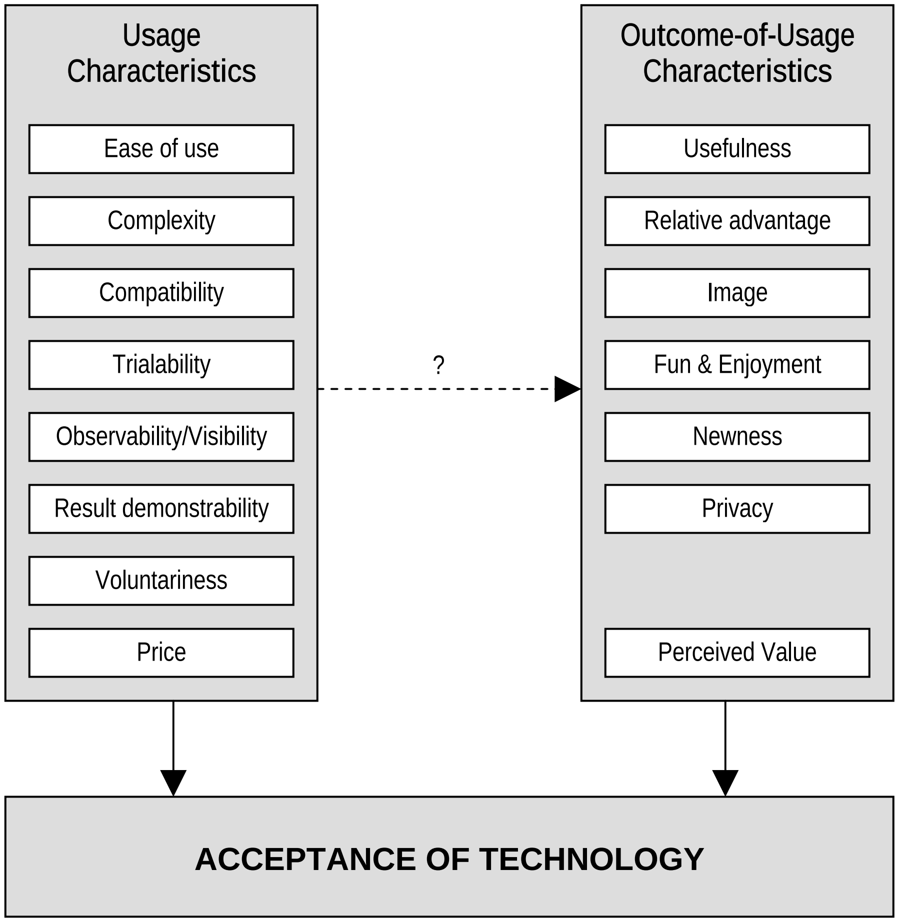


Figure 4.2. Usage and outcome-of-usage characteristics.

Usage Characteristics

Perceived ease of use. One of the most studied technology characteristics concerns a potential adopter's perception of the ease of use of the technology. The perceived ease of use is defined as the degree to which the potential adopter expects a technological innovation to be free of effort in use (Davis, 1996; Moore & Benbasat, 1991). The general accepted finding is that the *acceptance increases with an increase in the perceived ease of use* (Davis, 1989; Davis & Venkatesh, 1996; Gefen, Karahanna, & Straub, 2003; Kaasinen, 2005). This relationship is found for different levels of acceptance: *attitudinal acceptance* (Devaraj, Fan, & Kohli, 2002; Seyal & Pijpers, 2004), *intentional acceptance* (Bagozzi, Davis, & Warshaw, 1992; Davis, Bagozzi, & Warshaw, 1989; Hong, Thong, Wong, & Tam, 2001; Luarn & Lin 2005; Plouffe, Hulland, & Vandenbosch, 2001; Venkatesh & Davis, 1996); and *behavioral acceptance* (Davis, 1989; Henderson & Divett, 2003; Parthasarathy & Bhattacherjee, 1998; Thong, Hong, & Tam, 2002, Venkatesh & Davis, 2000).

In addition to direct effects of perceived ease of use, an indirect effect through perceived usefulness has been reported for technology acceptance (Davis, 1986, 1989; Devaraj, Fan, & Kohli 2002; Plouffe, Hulland, & Vandenbosch, 2001). Perceived usefulness, which will be discussed in more detail in the next section, is defined as the extent to which a technological innovation is expected to improve the potential adopter's performance. In fact some studies report only an indirect as opposed to a direct effect of perceived ease of use (Chau, 1996; Hardgrave & Johnson, 2003; Henderson & Divett, 2003; Keil, Beranek, & Konskynski, 1995; Plouffe, Vandenbosch, & Hulland, 2001; Van Schaik, Bettany-Saltikov, & Warren, 2002).

Perceived ease of use has sometimes been found to be more important than perceived usefulness (van der Heijden, 2004). However, the general consensus is that perceived usefulness is more important than ease of use (Davis, 1993).

Another comparison of the effects of ease of use and perceived usefulness is reported by Karahanna and Straub (1999). They found that ease of use was more important for pre-adoption attitudes, while perceived usefulness is more important for post-adoption attitudes. Thus one's initial decision to use a product of system may be most influenced by whether it seems easy to use and one's decision to continue to use it may be driven more by the belief that it is useful. However, this idea has not been extensively tested.

What are the factors that affect perceived ease of use? The flexibility of a technology in terms of whether it can be adjusted and incorporated in existing systems is one potentially important characteristic related to the perceived ease of use of a technology. The less flexible a technology is, the lower the perceived ease of use may be. However, not much research on the possible role of flexibility has been conducted (e.g., Coventry, 2001; Sultan & Chan, 2000).

Perceived complexity. Perceived complexity can be defined as the degree to which an innovation is perceived as difficult to understand and use (Rogers, 2003). Some innovations are readily understood by most members of a social system (e.g., cell phone), whereas others are more complicated (e.g., personal digital assistant). With few exceptions (e.g., Meuter, Bitner, Ostrom, & Brown, 2005), the general consensus is that *complexity decreases the acceptance of technology* (Aiman-Smith & Green, 2002; Ettlie & Vellenga, 1979; Hill, Smith, & Mann, 1987; Smither & Braun, 1994; Venkatesh, Morris, Davis, & Davis, 2003). Contrary to some of the other technology characteristics proposed by Rogers (2003), research on the effect of complexity on the acceptance of technology is relatively limited. One reason is that complexity often is not operationalized as such. More often than not, complexity is measured as an end-user characteristic referred to as self-efficacy. Self-efficacy is defined as a potential adopter's belief about his or her ability to use the technology (cf., Agarwal, Sambamurthy, & Stair, 2000). The more complex a technology is, the lower someone's belief about his or her ability to use the technology is, and the lower the degree of acceptance of that technology (e.g., Fang, 1998). A more comprehensive overview of research on the effect of self-efficacy can be found in Chapter 5 on user characteristics.

Perceived compatibility. Perceived compatibility is defined as the degree to which an innovation is perceived as being consistent with existing values, needs, and past experiences of potential adopters (Moore & Benbasat, 1991). The general consensus is that *compatibility increases the acceptance of technologies* (Chau & Hu, 2002; Meuter, Bitner, Ostrom, & Brown, 2005; Nambisan, 2002; Parthasarathy, & Bhattacherjee, 1998; Plouffe, Vandenbosch, & Hulland, 2001). The impact of perceived compatibility is found to be larger for behavioral acceptance than for attitudinal acceptance (Al-Gahtani & King, 1999).

An issue related to compatibility is the idea of intergeneration time, which is the time between an introduction of a technology and an upgrade of it. Intergeneration time negatively influences the adoption of the upgrade (Pae & Lehman, 2003). The longer time period may make the size of the upgrade larger, which may result in a lower perceived compatibility of these upgrades.

Perceived trialability. Perceived trialability is the degree to which an innovation may be experimented with on a limited basis (Moore & Benbasat, 1991). Personal experience with new technologies is the most effective learning tool and increases the acceptance of technology by reducing the uncertainty related to the new technology. *Trialability increases the acceptance of technologies* (Karahanna & Straub, 1999; Meuter, Bitner, Ostrom, & Brown, 2005; Moore & Benbasat, 1991; Plouffe, Hulland, & Vandenbosch, 2001; Shelley, 1998). Such trialability has been shown to be more important for pre-adoption attitude formation as opposed to post-adoption attitude formation among users of the technology (Karahanna & Straub, 1999).

Perceived observability and visibility. Perceived obervability is defined as the degree to which results of an innovation are visible to others (Rogers, 2003). The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Such observability stimulates peer discussion of a new idea, as friends and neighbors of an adopter often request innovation-evaluation information about it *(*Karahanna & Straub, 1999).

A related characteristic is visibility (Moore & Benbasat, 1991), which is defined as the degree to which an innovation is visible during its diffusion through a user community. The general consensus is that *increased observability and visibility increase the acceptance of technologies* (Liebeskind & Rumelt, 1989; Moore & Benbasat, 1991; Plouffe, Vandenbosch, & Hulland, 2001; Shelley, 1998).

With respect to pre- and post adoption attitude formation, visibility of the innovation appears to influence pre-adoption attitude formation more than post-adoption attitude formation (Karahanna & Straub, 1999).

Perceived result demonstrability. Perceived result demonstrability is defined as the degree to which the benefits and utility of an innovation are readily apparent to the potential adopter. With some exception (e.g., Plouffe, Hulland, & Vandenbosch, 2001), the general consensus is that *result demonstrability increases the acceptance of technologies* (Moore & Benbasat, 1991; Venkatesh & Davis (2000). Karahanna and Straub (1999) concluded that result demonstrability was more essential for pre-adoption attitude formation as opposed to post-adoption attitude formation.

Perceived voluntariness. Perceived voluntariness is defined as the degree to which use of an innovation is perceived as being voluntary or of free will (Moore & Benbasat, 1991). The factor is especially relevant in organizations, where enforced use of new technologies is more likely. The general consensus is that *voluntariness increases the acceptance of technologies* (Plouffe, Hulland, & Vandenbosch, 2001; Venkatesh, & Davis, 2000; Venkatesh, Morris, Davis, & Davis, 2003). Voluntariness has a more profound effect an adopter's intent to continue to use than it has on the initial intent to adopt (Karahanna & Straub, 1999).

Price. Price is an important consideration for many adopters. Generally speaking, *price decreases the acceptance of technologies* (Au & Kauffman, 2001; Baldwin & Lin, 2002; Karshenas & Stoneman, 1993; Krishnan, Bass, & Jain, 1999; Luarn & Lin, 2005; Wilton & Pessemier, 1981). Research also shows that anticipation of a new and better, but compatible, technology might cause potential adopters to wait, depending on how much costs they anticipate to incur upgrading their technology later (Au & Kauffman, 2001; Baldwin & Lin, 2002).

Although it is generally accepted that price, and more broadly the costs (e.g., price, training, maintenance) involved with obtaining a technology, is a critical determinant of technology acceptance, the number of studies that actually include price or any other financial consequences of accepting a technology is fairly limited.

Outcome-of-Usage Characteristics

Ease of use, compatibility, and complexity are all critical characteristics that can make or break the market performance of a new technology. However, the most critical component will be whether the new technology provides benefits that are appreciated by the potential adopter. The perceived benefits related to a technology *may* be able to offset the negative effects of perceptions of lack of compatibility, complexity, or for instance a high price (cf., Rogers, 1976).

Much research on the effect of the benefits of technologies and products has been conducted. Different terminologies have been used; for example, Davis (1989) grouped all benefits into one construct which he referred to as the perceived usefulness of a technology and Rogers (2003) referred to all of these benefits as the relative advantage.

Perceived usefulness. Perceived usefulness is defined as the extent to which a technology is expected to improve a potential adopter's performance (Davis, 1986; Davis & Venkatesh, 1996). As such it can be considered a summary measure of all benefits related to a technology. Many studies have examined the effect of perceived usefulness on the acceptance of technology, and the general consensus is that *perceived usefulness increases the acceptance of technologies* (Chau & Hu, 2002; Gefen, Karahanna, & Straub, 2003), for *attitudinal acceptance* (Devaraj, Fan, & Kohli, 2002; Hsu & Chiu, 2004), *intentional acceptance* (Chau, 1996; Davis, Bagozzi, & Warshaw, 1989, 1992; Davis & Venkatesh, 2004; Hardgrave & Johnson, 2003; Hong, Thong, Wong, & Tam, 2001; Liaw, 2002; Luarn & Lin, 2005; Morris, Venkatesh, & Ackerman, 2005; Plouffe, Hulland, & Vandenbosch, 2001; van der Heijden, 2004), and *behavioral acceptance* (Davis, 1986, 1989, 1993; Fang, 1998; Irani, 2000; Henderson & Divett 2003; Igbaria, Schiffman, & Wieckowski, 1994; Koufaris, 2002; Parthasarathy & Bhattacherjee, 1998; Sussman & Siegal, 2003; Thong, Hong, & Tam, 2002; Van Schaik, Bettany-Saltikov, & Warren, 2002). Some exceptions exist. For instance, Van Schaik (1999) reported no effect of perceived usefulness on attitudinal acceptance.

While sometimes it is found that ease of use is more important than perceived usefulness (van der Heijden, 2004), the general consensus is that perceived usefulness is more important than ease of use (Davis, 1989; Henderson & Divett, 2003; Igbaria, Schiffman, & Wieckowski, 1994), especially for post-adoption attitude formation (Karahanna & Straub, 1999).

Some determinants of perceived usefulness have been identified such as:

- the perceived benefits of a technology (Amoako-Gyampah and Salam, 2004);
- ease of use (Davis, 1989; Keil, Beranek, & Konskynski, 1995);
- relevant prior experience with the technology (Irani, 2000);
- relevance as in the case of a digital library (Hong, Thong, Wong, & Tam, 2001);
- higher levels of technology quality and credibility (Sussman & Siegal, 2003).

Higher levels of these variables were associated with higher estimates of increased usefulness. It is important to identify such precursors to perceived usefulness to be able to understand and influence attitudes.

Perceived relative advantage. The perceived relative advantage is defined as the degree to which an innovation is perceived to be superior to current offerings (Rogers, 2003). This conceptualization significantly differs from Davis' (1989) conceptualization as it acknowledges that "we are not alone in the market place." That is, a new technology is competing with existing technologies. Only in rare cases (i.e., radical innovations – first television, first computer etc.) will new technologies offer benefits that are not offered by any existing technologies. While the original operationalization by Rogers was relative, many studies use the terminology "advantage' and measure it in a more absolute sense (e.g., Davis, 1989).

The general consensus is that the *relative advantage increases the acceptance of technologies (*Henard & Szymanski, 2001; Manross & Rice, 1986; Meuter, Bitner, Ostrom, & Brown, 2005; Meyer & Goes, 1988; Plouffe, Vandenbosch, & Hulland, 2001), for *attitudinal acceptance* (Al-Gahtani & King, 1999; Boyd & Mason, 1999; Harrison, Mykytyn, & Riemenschneider, 1997), *intentional acceptance* (Chwelos, Benbasat, & Dexter, 2001; Plouffe, Hulland, & Vandenbosch, 2001; Loch & Huberman, 1999), and *behavioral acceptance* (Al-Gahtani & King, 1999; Au & Kauffman, 2001; Baldwin & Lin, 2002; Chau & Tam, 1997; Dickson, 1976; Dillon & Morris, 1999; Ettlie & Vellenga 1979; Featherman & Pavlou, 2003; Rogers, 2003; Van Schaik, 1999; Van Schaik, Flynn, Van Wersch, Douglass, & Cann, 2004; Venkatesh & Brown, 2001).

Perceived image. In the context of technology acceptance image is defined as the degree to which potential adopters believe the adoption of a technology will bestow them with added prestige in their community (Moore & Benbasat, 1991). This can also be interpreted as a social benefit of a technology. The general consensus is that *added prestige increases the acceptance of new technologies* (Plouffe, Hulland, & Vandenbosch, 2001; Venkatesh & Brown, 2001; Venkatesh & Davis, 2000). In fact, a negative image related to a new technology (disapproval by the relevant community) can be an important reason to reject a new technology (Ram & Sheth, 1989).

Perceived fun and enjoyment. The perceived fun of the use of a technology is defined as the extent to which using the technology results in enjoyment and perceived fun. Several studies have shown that with perceived fun, the acceptance of technologies increases. For instance, people's intentions to use computers in the workplace were positively influenced by the degree of enjoyment they experienced in using the computers (Davis, Bagozzi, & Warshaw, 1992). The general consensus is that *perceived fun and enjoyment increase the acceptance of technologies* (Chin, Marcolin, & Newsted, 2003; Smither & Braun, 1994; Yi & Hwang, 2003), for *attitudinal acceptance* (Al-Gahtani & King 1999; Hsu & Chiu, 2004), *intentional acceptance* (Koufaris, 2002; Liaw, 2002; van der Heijden, 2004), and *behavioral acceptance* (Brosnan, 1999; Igbaria, Schiffman, & Wieckowski, 1994; Venkatesh & Brown, 2001; Yi & Hwang, 2003).

Some studies have indicated that the perceived usefulness is more important than the perceived fun (Igbaria, Schiffman, & Wieckowski, 1994; Liaw, 2002) whereas others suggest that perceived fun and ease of use are more important than perceived usefulness (van der Heijden, 2004). Other research suggests that perceived fun only has an indirect effect on acceptance, through perceived usefulness and ease of use (Al-Gahtani & King, 1999; Huang, 2003).

One study reported that music and color affect the level of enjoyment and intention to use a service (Mundorf, Westin, & Dholakia, 1993). It is furthermore shown that quality perception influence perceived enjoyment (Hsiu-Mei, 2003). These studies are examples of research to identify the precursors to the variables fun and enjoyment. However, very few studies have taken that approach.

Perceived newness. Perceived newness refers to the potential adopter's perception of the newness of a technology. Research on the effect of newness is limited. It could be reasoned that newness is closely related to perceived compatibility. Something less compatible may be perceived as more new. It is generally accepted that people like newness (i.e., epistemic value), but that differences between individuals exist (see also Chapter 5 on user characteristics). While most people like some newness, too much newness is generally less preferred. The relationship between newness and acceptance is non-linear (inverse U-shape). Most research reported in the literature takes a more linear approach. With some exception (Gruen, 1960) most research shows that *newness increases the acceptance of technologies* (Venkatesh & Brown, 2001; Ziamou & Ratneshwar, 2002).

Although research on the effect of newness remains limited, Michaut (2004) offered some insights that provide an interesting basis for future research. First, she described newness, or innovativeness, as a multidimensional construct consisting of two dimensions: mere perception of newness and perceived complexity. Michaut reported that product liking linearly increased with both perceived complexity and mere newness. An inverted U-shaped relationship was reported between mere newness and market success *after one year*. She concluded that perceived complexity is a disadvantage to new product success in the short run, but this can be and is often overcome in time. As her research is conducted in the food domain, additional research in the technology domain is desirable.

Perceived privacy and trust. Research on privacy issues often examines people's attitudes towards being monitored in a work place (e.g., Zweig & Webster, 2002). However, other research focuses specifically on the aspects of the technology that affect acceptance. Grant and Higgins (1989), for instance, focused on how monitor design affects workplace monitoring. They demonstrated that tasks measured, frequency of measurement, object of measurement, and recipient of data affected the acceptability of a monitor design.

Luarn and Lin (2005) added a trust-based construct ("perceived credibility") to the TAM model and showed that it significantly increased intentional acceptance of a banking service. Trust plays a central role in helping consumers overcome perceptions of risk and insecurity (McKnight, Choudhury, & Kacmar, 2002). For example trust in a Web vendor makes consumers comfortable sharing personal information, making purchases, and acting on the vendor advice – behaviors essential to widespread adoption of e-commerce. Therefore, trust is critical to both researchers and practitioners. However, considering the limited amount of research on this matter, additional research will be necessary to fully understand how characteristics of technology influence perceptions about privacy and trust.

Network effects. For some technologies, acceptance strongly depends on what is referred to as network effects. The network effect causes a good or service to have a value to a potential customer dependent on the number of customers already owning that good or using that service. For instance, free mobile-to-mobile calling is only a benefit if more than one person has a cell phone. The more people who have a cell phone, the larger the benefit of free mobile-to-mobile calling becomes, attracting more people to the technology. Metcalfe's law (Gilder, 1993) states that the total value of a good or service that possesses a network effect is roughly proportional to the square of the number of customers already owning that good or using that service (Gowrisankaran & Stavins, 2004). This type of network effect was exhibited in a study of new communication technologies by older adults – they were less likely to use electronic mail if their friends and family did not use it also (Melenhorst, Rogers, & Bouwhuis, in press).

Network effects may inhibit innovation (Farrell & Saloner, 1986). After all, if an installed base exists and transition to a new standard must be gradual, early adopters bear a disproportionate share of transient incompatibility costs. This can produce "excess inertia." The installed base, however, is "stranded" if the new standard is adopted, possibly creating "excess momentum." These dynamic effects have strategic implications. The characteristics of the network in which technologies are introduced significantly influences the speed of acceptance (Abrahamson & Rosenkopf, 1997; Barua & Lee, 1997; Fang, 1998). For example, billers were more likely to adopt the *existing* technology early due to network externalities, even though the next technology might be superior to the current one (Au & Kauffman, 2001). Adoption decisions tend to be based on past usage decisions and expectations of the future network benefit from usage (Gowrisankaran & Stavins, 2004). When introducing a new technology that possesses a network effect, this effect needs to be taken into consideration.

Perceived value. As discussed, potential adopters may become adopters of a technology if the perceived benefits to outweigh the costs of obtaining that technology (Kim, Han, & Srivastava, 2002). It is therefore critical to "consider the balance of perceived advantages, or benefits, and disadvantages, or costs, of a new system in technology acceptance modeling" (Van Schaik, Flynn, Van Wersch, Douglass, & Cann, 2004, p. 321). The differentiation between perception of sacrifice and benefits add up to "perception of value" (Mazumdar, 1993).

There are different possible benefits related to technologies (e.g., perceived usefulness, image fun) as well as different types of costs. First, there are the financial costs. When a new technology is replacing an existing technology, which may still have some economic value left, money may be left on the table. Or, the new technology may require additional training (Greis, 1995). Besides the financial costs, mental attachment may affect acceptance. A reportedly negative relationship exists between satisfaction level with current systems and the acceptance of a new system (Chau & Tam, 1997). Measures of negative utility have been found to be significantly related to the acceptance of new technologies (Featherman & Pavlou, 2003).

Many studies have shown that a technology having great benefits alone is no guarantee for acceptance (Karshenas & Stoneman, 1993). Perceived value, or more importantly lack there of, is an important reason for potential adopters to reject (Ram & Sheth, 1989). *Perceived value increases the acceptance of technologies.* The gain in expected value or expected reward through adoption forms an important driver of technology acceptance (Dickson, 1976). In fact, Kauffman and Li's (2005) research suggested that a technology adopter should postpone investment until one technology's probability to win out in the marketplace and achieve critical mass reaches a critical threshold (cf., Loch & Huberman, 1999).

Risk. Closely related to the notion of value is the concept of risk. Potential adopters will try to judge the value of the new technology, but uncertainty surrounding the actual benefits and possibly the costs make the decision to accept a risky one (Chatterjee & Eliasberg, 1990; Donnelly, 1970). Different types of risk may play a role: performance risk, financial risk, time risk, psychological risk, social risk, and privacy risk (Featherman & Pavlou, 2003). Research on the role of risk and uncertainty in the acceptance of technologies is scarce; however, the consensus of the existing research is that *risk decreases the acceptance of technologies* (Featherman & Pavlou, 2003; Hsu & Chiu, 2004; McKnight, Choudhury, & Kacmar, 2002). Lecraw (1979) suggested risk as one of the factors that allows companies to choose a less efficient technology if they feel that the risk involved in adopting the technology is less than the risk in the more efficient one. Ram and Sheth (1989) posed that risk is an important reason for potential adopters to reject. Other research shows the organizational risk-taking climate influences the acceptance of technologies (Ettlie & Vellenga, 1979). Comparable results are found when differentiating individual adopters from non-adopters. The former were more risk raking than the latter (Sultan & Chan, 2000). Overall, these findings suggest that risk is an important variable in the acceptance decision-making process. But the amount of research on this topic is minimal, especially from the perspective of individual users.

Summary of Critical Characteristics of Technology

Figure 4.3 summarizes the key findings for the effects of characteristics of technologies on the acceptance of technologies. We classified the literature into two general categories of technology characteristics: those related to usage and those related to outcome of usage. Within each category, a number of outcome variables have been shown to be related to technology acceptance at the level of attitudes, intentions, and behaviors. Price and perceived value are separated because price is a more objective measure than the other usage characteristics and perceived value is a direct outcome measure of price and the outcome-of-usage characteristics (i.e., benefits) [value is the ratio between benefits and costs].

The plusses and minuses in Figure 4.2 indicate how the different characteristics influence the acceptance of technology. For instance, *ease of use positively* (+) influences the acceptance of technology whereas *complexity* has a *negative* influence on acceptance. There was evidence of interrelationships of these variables as well. *Ease of use,* for instance, *positively* (+) influences the *perceived usefulness* of a technology, which in turn *positively* (+) influences the acceptance of technologies.

To summarize, there are many variables that relate to characteristics of the technology itself that influence technology acceptance. However, understanding is limited with respect to the precursor variables that influence these factors, the relative role of cost factors (e.g., risk, privacy concerns), and whether the patterns of relationship generalize to a broader range of technology types.

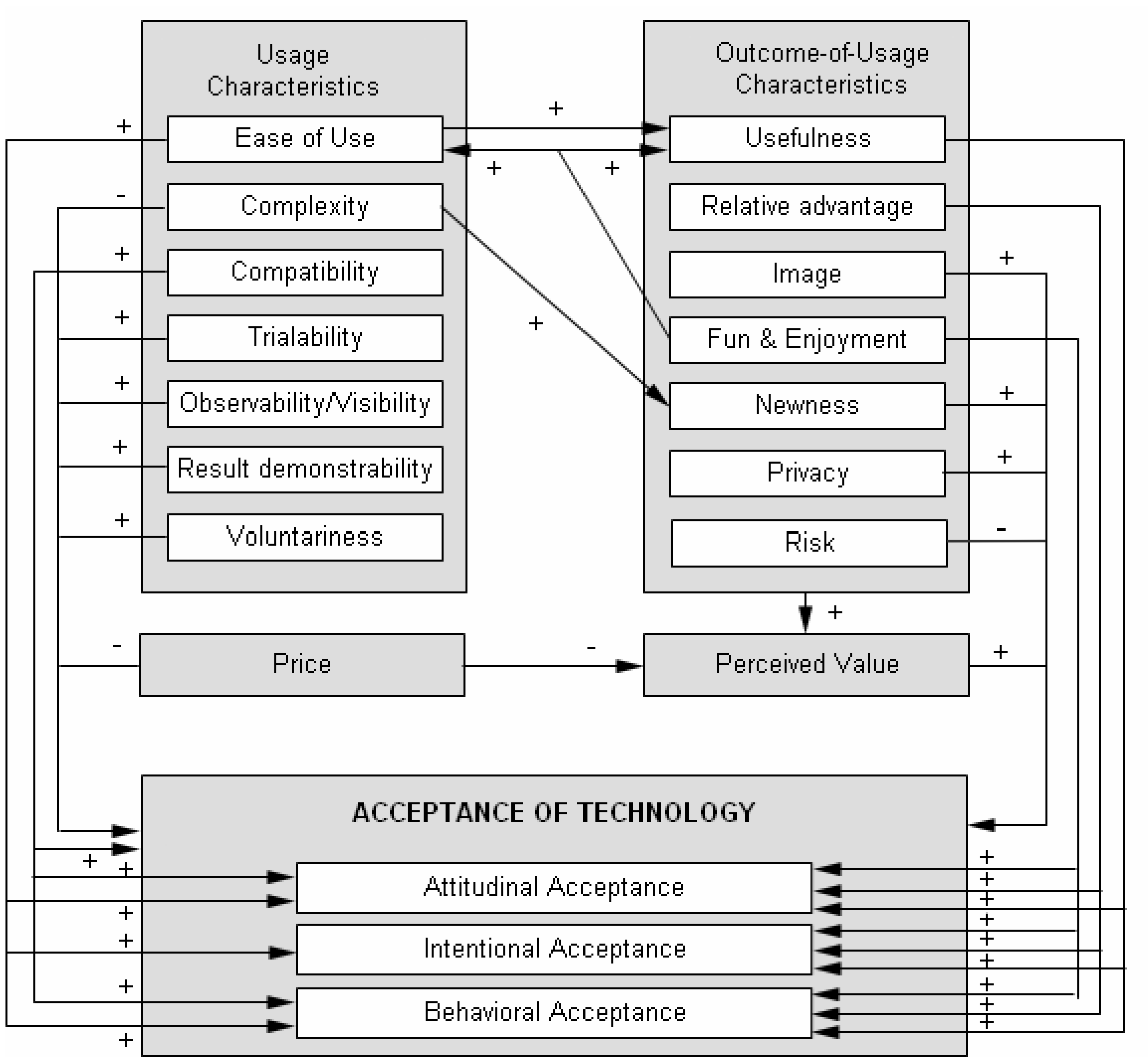


Figure 4.3. A summary of the relevant usage characteristics and outcome-of-usage characteristics and their inter-relationships.

Chapter 5 – Characteristics of Users

Types of Users Studied

To identify characteristics of users and their impact on acceptance, our literature review revealed that users need to be classified into two groups with respect to their purpose of using technology: individual users and organizational users. Individual users are those who use the technology for personal purposes other than work-related purposes. Organizational users use the technology for work-related tasks. Organizational-user characteristics were further classified into two subgroups: employee characteristics and organizational characteristics.

Characteristics of Individual Users and Their Impact on Acceptance

When discussing the characteristics of individual users, we differentiate between demographics and psychographics. Demographic variables are characteristics of individuals such as age, gender, education, and income. Demographics are generally easy to measure and people can be easily identified based on demographic characteristics. However, the predictive validity of demographic variables remains limited and they often do not provide an insight into *why* individuals do or do not accept a technology.

Psychographic variables are personality or psychological traits such as innovativeness or technology readiness. Psychographics are more difficult to measure, requiring more in-depth tests than demographic variables. However, psychographics generally provide better insights into why people do or do not accept technologies.

Demographic Characteristics

Demographic characteristics of the user has been shown to influence the acceptance of technologies in a number of studies (Agarwal & Prasad, 1999; Breakwell & Fife-Schaw, 1988; Brosnan, 1999; Dickerson & Gentry, 1983; Eilers, 1989; Eriksson-Zetterquist, Knights, 2004; Gefen & Straub, 1997; Gilly & Zeithaml, 1985; Gitlin, 1995; Hitt & Frei, 2002; Im, Bayus & Mason, 2003; Karaca-Mandic, 2004; Morris, Venkatesh, & Ackerman, 2005; Mundorf, Westin, & Dholakia, 1993). Age, gender, education, and income are the most widely studied demographics.

Age. Age is a frequently studied demographic characteristic that affects technology acceptance. Although there are findings in which age does not predict use (Gitlin, 1995), it has been found that age negatively affected new product acceptance (Breakwell & Fife-Schaw, 1988; Im, Bayus, & Mason, 2003; Gilly & Zeithaml, 1985; Morris, Venkatesh, & Ackerman, 2005). The general finding is that *increased age decreases the acceptance of technologies*. In a study that investigated the adoption of several key consumer-related technologies by older adults, it was found that the adoption of the older group was low in percentage for most of the innovations, except electronic funds transfer (Gilly & Zeithaml, 1985).

Age affects acceptance not only directly, but also through mediators. For instance, with increasing age individuals are less likely to try new technologies, particularly because of feelings of inability which has a negative effect on acceptance (Breakwell & Fife-Schaw, 1988). It has also been found that age, together with gender, moderates the relationship between user perceptions and acceptance (Venkatesh, Morris, Davis, & Davis, 2003). For example, Morris, Venkatesh, and Ackerman (2005) studied the moderator effects of age and gender on the relationship between various user perceptions and acceptance, based on Theory of Planned Behavior. Their results revealed that gender differences in technology perceptions were more pronounced among older relative to younger individuals. Perceived behavioral control (which relates to ease of use) positively influenced acceptance, more so for women than men, and more so for older adults. Finally with increasing age, there was a stronger relationship between attitude toward use and acceptance, more so for men than women.

Gender. Gender differences have been shown to affect acceptance (Brosnan, 1999; Gefen & Straub, 1997; Morris, Venkatesh & Ackerman, 2005; Mundorf, Westin, & Dholakia, 1993). *Gender is related to differences in perceptions of new technology* (Gefen & Straub, 1997). For instance, gender relates to acceptance through perceived usefulness (Brosnan, 1999). According to Gefen and Straub (1997), women valued perceived usefulness more than men did, whereas men have relative tendency to feel more at ease with computers. This suggests that researchers should include gender in diffusion models along with other cultural effects (Gefen & Straub, 1997).

Attitude toward using technology is a stronger predictor of technology acceptance for men than women (Morris, Venkatesh & Ackerman, 2005). However, subjective norm (belief about what others think one should do, social pressure) influenced acceptance, more so for women than men. The reason may be related to women's higher affiliation needs and their larger concern with pleasing others. Consequently, women tend to value opinions of their social group more than men do, making subjective norm more important for women (Morris et al., 2005).

Gender differences also become salient when hedonic product features, such as color, are taken into consideration. Interestingly, in a study on the effect of these hedonic features on acceptance of information services, it was found that although women show greater acceptance of the service, color strongly influenced men's acceptance positively (Mundorf, Westin, & Dholakia, 1993).

As described in the previous section on age, gender-related differences tend to interact with age-related differences (Morris, Venkatesh & Ackerman, 2005). Gender effects of perceived behavioral control and attitudes toward technology use were larger for older adults.

Education. Generally, individuals' skills, knowledge and technologic ability increase with education. Based on this simple logic, it is expected that *level of education increases the acceptance of technologies*. Consistent with this expectation, Dickerson and Gentry (1983) found that adopters of computers had higher levels of education. In addition, level of education influenced perceptions of ease of use, such that people with higher levels of education perceived new technologies as easier to use (Agarwal & Prasad, 1999).

Income. New technologies are usually proposed with higher prices at the introduction stage. When the product moves through its life cycle, usually its price decreases. Consequently, at the introduction stage of a new technology product, income level is expected to be a more important predictor of acceptance. In addition, although a new technology may be perceived to be potentially useful, consumers may not perceive it as a "need." As they have survived without using this new technology, they may not perceive it necessary to have this product. As a result, although consumers perceive the new technology useful, its order in their lists of products and services to be purchased will be lower than the order of others that they perceive as a need. When the income level of consumer is low, there may not be enough funds to purchase the new technology after other products and services presumed more necessary are purchased. Therefore, *income level increases the acceptance of new technologies*. For example, income has been shown to be a strong predictor of new-product ownership in the consumer electronics category with a positive effect on acceptance (Im, Bayus, & Mason, 2003). Similarly, Hitt and Frei (2002) found that customers who used computer banking were wealthier and households with higher income had a higher probability to adopt DVD technology (Karaca-Mandic, 2004).

We already know that price has a negative effect on acceptance (Au & Kauffman, 2001; Baldwin & Lin, 2002; Karshenas & Stoneman, 1993; Krishnan, Bass, & Jain, 1999; Luarn & Lin, 2005; Wilton & Pessemier, 1981). If we suppose that a decrease in price increases the actual income level, the positive effect of decreased price on acceptance can be explained also with the increase in the actual income. Now, if we suppose that price is stable, an increase in income will cause an increase in the actual income, which will result in a positive effect on acceptance. The literature on the effects of income on acceptance supports these predictions. For example, Dickerson and Gentry (1983) found that adopters of home computers had higher levels of income than non-adopters.

Psychographic Characteristics

Technology readiness. Technology-readiness is "people's propensity to embrace and use new technologies for accomplishing goals in home life and at work" (Parasuraman, 2000, p. 308). Technology readiness has four categories (Parasuraman, 2000): (1) optimism – a positive view of technology and a belief that it offers people increased control, flexibility, and efficiency in their lives; (2) innovativeness – a tendency to be a technology pioneer and thought leader; (3) discomfort – a perceived lack of control over technology and a feeling of being overwhelmed by it; and (4) insecurity – distrust of technology and skepticism about its ability to work properly. According to this classification, optimism and innovativeness were drivers of technology readiness, whereas discomfort and insecurity are inhibitors (Parasuraman, 2000).

A comparable construct – consumer readiness – was introduced by Meuter, Bitner, Ostrom, and Brown (2005). They defined variables for consumer readiness as role clarity, motivation (extrinsic-intrinsic), and ability. They found that consumer readiness variables, especially role clarity and extrinsic motivation were strong predictors of trial of self-service technologies. Moreover, they showed that the consumer readiness variables of role clarity, motivation, and ability were key mediators between established adoption constructs (innovation characteristics and individual differences) and the likelihood of trial. Ability mediated several antecedent predictors, but when all the factors were modeled together to predict trial, the stronger effects of role clarity and extrinsic motivation on trial overwhelmed its direct influence. In addition, when all consumer readiness variables were tested, intrinsic motivation was only marginally significant in the prediction of trial. Finally, they find that role clarity, motivation, and ability were stronger predictors of trial than were innovation characteristics (compatibility, complexity, observability, trialability, perceived risk, and relative advantage) and other individual differences (inertia, technology anxiety, need for interaction, previous experience, and demographics). Therefore, we conclude that *technology-readiness variables positively influence acceptance*.

Personal innovativeness. Personal innovativeness is defined as the predisposition to buy new and different products and brands rather than remain with previous choices and consumption patterns (Steenkamp, Hofstede, & Wedel, 1999). Another definition of innovativeness is the "willingness of an individual to try out any new (information) technology" (Agarwal & Prasad, 1998, p. 206). *Personal innovativeness influences new-product acceptance positively* (Im, Bayus, & Mason, 2003). Innovativeness is related to personal values (openness to change vs. conservatism, self-enhancement vs. self-transcendence), consumer-context-specific dispositions (consumer ethnocentrism, attitude toward the past), national cultural dimensions (individualism, uncertainty avoidance, masculinity), and sociodemographic factors (age, level of education, and income). National cultural dimensions also influence the effect of personal values and consumer-context-specific dispositions on consumer innovativeness (Steenkamp, Hofstede, & Wedel, 1999). Innovativeness not only directly influences acceptance, but also influences it through its positive effect on readiness, which in turn affects acceptance positively (Parasuraman, 2000).

Trust and privacy concerns. Trust in the technology provider is a predictor of consumer's intention to try the new technology. Customers who have never used a new technology before may have suspicions about its usefulness. But, their trust in the technology provider may help ease their anxiety and suspicions. Consequently, *potential customer purchase intentions will be influenced by their trust in the technology provider* (Gefen, Karahanna, & Straub, 2003). In addition, this effect of trust in a technology provider is stronger for potential, rather than repeat customers. For new customers, the effect of trust is the primary predictor of usage, whereas for repeat customers trust in combination with perceived usefulness predicts usage (Gefen, Karahanna, & Straub, 2003).

Trust in a technology provider is also expected to impact the privacy concerns of consumers, which in turn may impact the acceptance of a technology. Some common privacy concerns among consumers relate to the types of information that is collected about them and their ability to control where that information might be distributed (Phelps, Nowak & Ferrell, 2000). However, customers may be willing to give up personal information to a company that they trust to treat that information fairly (Culnan & Armstrong, 1999). For example, a study on adopters and non-adopters of home computers showed that adopters had lower concern for privacy than did non-adopters (Dickerson & Gentry, 1983) suggesting that the person variable, privacy concerns, is related to eventual acceptance of a specific technology.

Privacy concerns are expected to be highly related to consumers' trust in the technology provider, as well as their acceptance of technology. However, the current literature leaves these concepts muddled. Kaasinen (2005) pointed out that although users may be willing to accept giving up some privacy (specifically location information) in exchange for usefulness, "giving away user control should…not be the 'price of usefulness'" (p. 43). Kaasinen also argued that usefulness and privacy do not have to be traded off. For instance, by providing indirect location information (e.g., "home" or "office") instead of coordinate location information (e.g., GPS data), some privacy can be preserved while retaining the system's usefulness. However, how these variables are related to acceptance remains unspecified.

Technophobia. Technophobia is defined as the fear of or dislike for new technology. *Technophobia negatively influences acceptance of technology*. Technophobia can be assessed by measures of anxiety, cognitions, and attitudes toward technology (Weil

& Rosen, 1995). Technophobia is reduced by experience with a technology (Weil & Rosen, 1995).

Self-efficacy. Self-efficacy is "judgment of one's ability to use a technology to accomplish a particular job or task" (Venkatesh, Morris, Davis, & Davis, 2003, p. 432). A similar definition of (computer) self-efficacy is individuals' beliefs about their ability and motivation to perform specific tasks (Agarwal, Sambamurthy, & Stair, 2000). The general finding is that *self-efficacy positively influences acceptance* (Agarwal, Sambamurthy, & Stair, 2000; Hill, Smith, & Mann, 1987; Hong, Thong, Wong, & Tam, 2001; Liaw, 2002; Luarn & Lin, 2005; Venkatesh, & Davis, 1996; Yi & Hwang, 2003;).

Self-efficacy influences acceptance directly as well as indirectly through other variables (see Figure 5.1). Self-efficacy is positively related to perceived ease of use (Agarwal, Sambamurthy, & Stair, 2000; Hong, Thong, Wong & Tam, 2001; Luarn, & Lin, 2005; Venkatesh, & Davis, 1996) and previous experience, which affect acceptance of technology positively (Hill, Smith, & Mann, 1987). In addition, self-efficacy predicts computer anxiety, which predicts current usage (Brosnan, 1999). Another finding is that the higher people's self-efficacy towards technology, the more motivated they are to use it (Liaw, 2002). Also, self-efficacy influences enjoyment and usefulness positively, which in turn positively influence acceptance (Liaw, 2002). Finally, Internet self-efficacy positively influenced continuance intention both directly, and through its positive effect on satisfaction (Hsu & Chiu, 2004). Figure 5.1 summarizes all the findings concerning the effect of self efficacy on acceptance. In sum, self-efficacy plays an important role in technology acceptance.

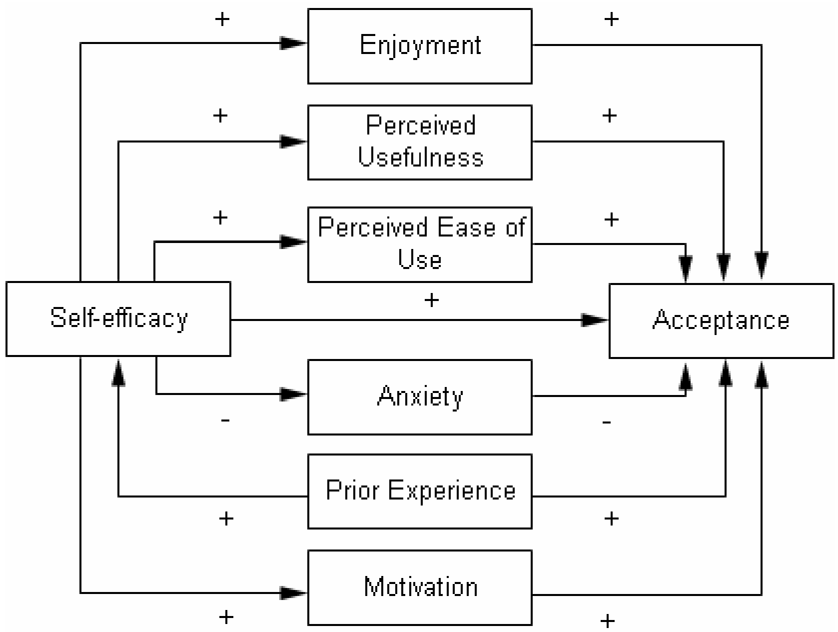


Figure 5.1. Direct and indirect effects of self-efficacy on acceptance.

***Anxiety*.** Anxiety is defined as "evoking anxious or emotional reactions when it comes to performing a behavior" (Venkatesh, Morris, Davis, & Davis, 2003, p. 432). *Anxiety influences acceptance negatively*, with high levels of anxiety leading to avoidance of technologies. Anxiety negatively influences perceived usefulness, which in turn influences acceptance (Brosnan, 1999). Anxiety is predicted by self-efficacy, such that increasing levels of self-efficacy reduce levels of anxiety (Brosnan, 1999).

***Subjective norm*.** Subjective norm is "the person's perception that most people who are important to him think he should or should not perform the behavior in question" (Fishbein & Ajzen 1975, p. 302). Subjective norm is influenced by others' normative beliefs and the individual's motivation to comply with belief (Van Schaik, 1999). *Subjective norm directly and positively affects acceptance* (Venkatesh & Davis, 2000). This positive effect is moderated by both experience and voluntariness, such that when the use of the system is perceived to be mandatory, subjective norm has a stronger effect on acceptance. But this effect decreases with increased experience (Venkatesh & Davis). On the other hand, when the system use was perceived to be voluntary, subjective norm had no significant direct effect on acceptance (Venkatesh & Davis). In addition, subjective norm positively influenced image, such that if others in the social group believed that one should perform a behavior, performing that behavior positively influenced one's image in that group (Venkatesh & Davis).

Subjective norm influences acceptance not only directly, but also via its direct positive effect on perceived usefulness. This positive effect is moderated by experience, such that increased experience attenuates it (Venkatesh & Davis, 2000). Figure 5.2 summarizes the findings concerning the effect of subjective norms on acceptance.

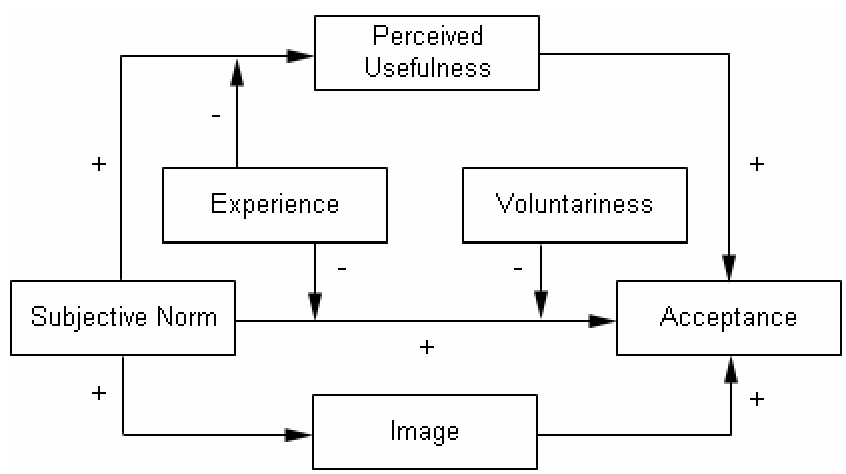


Figure 5.2. Direct and indirect effects of subjective norm on acceptance.

Hsu and Chiu (2004) decomposed subjective norm into two lower-order components: external influence and interpersonal influence. External influence refers to mass media reports, expert opinions, and other non-personal information. Interpersonal influence refers to influence by friends, family members, colleagues, superiors, and experienced individuals known to the potential adopter. They found that interpersonal influence had a strong effect on e-service continuance intention. Moreover, another study found that adopters of an innovation who did not continue to use the product relied less on external influence and more on interpersonal influence than those who continued to use the product (Parthasarathy & Bhattacherjee, 1998).

Dogmatism. Dogmatism is the extent to which a person can react to relevant information on its own merits, unencumbered by irrelevant factors in the situation (Blake, Perloff, & Heslin, 1970). The findings about the influence of dogmatism on acceptance are not consistent. For example, low dogmatic people reportedly chose new innovations more than high dogmatic people; while low dogmatic people depended on their own independent opinion of the information provided about a product, high dogmatic people relied on an authority's opinion (Jacoby, 1971). On the contrary, Blake, Perloff, and Heslin (1970) reported that dogmatism was significantly related to the acceptance of recent, but not novel, products. They found that highly dogmatic persons were more attracted to new products than the less dogmatic persons, but the two groups do not differ in acceptance of old products. *Dogmatism is expected to negatively influence acceptance*, especially for radical innovations (Blake, Perloff, & Heslin, 1970).

Knowledge and involvement. One would expect knowledge to be positively related to acceptance. However, recent research findings report a *complicated relationship between knowledge levels and technology acceptance*. Consumers' existing knowledge constrained their ability to understand and represent an innovation (Moreau, Lehmann, &

Markman, 2001). Compared with novices, experts reported higher comprehension, more net benefits, and therefore higher preferences for incremental (continuous) innovations. However, for radical (discontinuous) innovations, experts' entrenched knowledge was related to lower comprehension, fewer perceived net benefits, and lower preferences compared with that of novices. Only when this entrenched knowledge was accompanied by relevant information from a supplementary knowledge base were experts able to understand and appreciate radical (discontinuous) innovations. In short, more knowledge constrained the consumers' ability to understand the innovation and accept it when the innovation was radical, whereas it influenced acceptance positively when the innovation was incremental (Moreau, Lehmann, & Markman, 2001).

In a similar vein, Ziamou and Ratneshwar (2002) suggested that more information is not always better in reducing performance uncertainty. They reported that the effects of more (vs. less) information on the performance uncertainty of a new interface and consumer adoption intentions of the new product were moderated by the degree of newness of the particular functionality (i.e., set of potential benefits) that was delivered by the new product. When the new product had a preexisting functionality that the consumer was familiar with, then more knowledge decreased consumer uncertainty about the performance of the product. On the other hand, more knowledge increased consumer uncertainty about the performance of the product if the product had a new functionality (Ziamou & Ratneshwar, 2002).

Knowledge also influences other variables that affect acceptance. For instance, Agarwal and Prasad (1999) reported that participation in training influenced perceived usefulness and in another study knowledge had a positive relationship with perceived ease of use (Hong, Thong, Wong, & Tam, 2001).

Intrinsic motivation. Intrinsic motivation is the perception that users will want to perform an activity "for no apparent reinforcement other than the process of performing the activity per se" (Davis, Bagozzi, & Warshaw, 1992, p. 1112). Research suggests that *intrinsic motivation increases the acceptance of technologies* (Sultan & Chan, 2000; Venkatesh, 2000). Moreover, it is suggested that intrinsic motivation influences perceived ease of use positively (Venkatesh, 2000).

Prior experience. Research suggests that *experience influences acceptance positively* (Irani, 2000; Karaca-Mandic, 2004; Kraut & Mukhopadhyay, 1999; Liaw & Huang, 2003). Experience and perceived usefulness were found to be the strongest predictors of acceptance of Internet communication tools (Irani). Experience positively influenced trust, perceived usefulness, and perceived ease of use, as well as acceptance (Gefen, Karahanna, & Straub, 2003). Other studies also showed that prior, similar experience influenced perceived ease of use positively (Agarwal & Prasad, 1999; Venkatesh & Davis, 1996). Prior experience also positively influences perceived usefulness (Irani, 2000). Moreover, experience is the biggest predictor of self-efficacy (Liaw, 2002). Figure 5.3 summarizes all the findings concerning the effect of prior experience on acceptance.

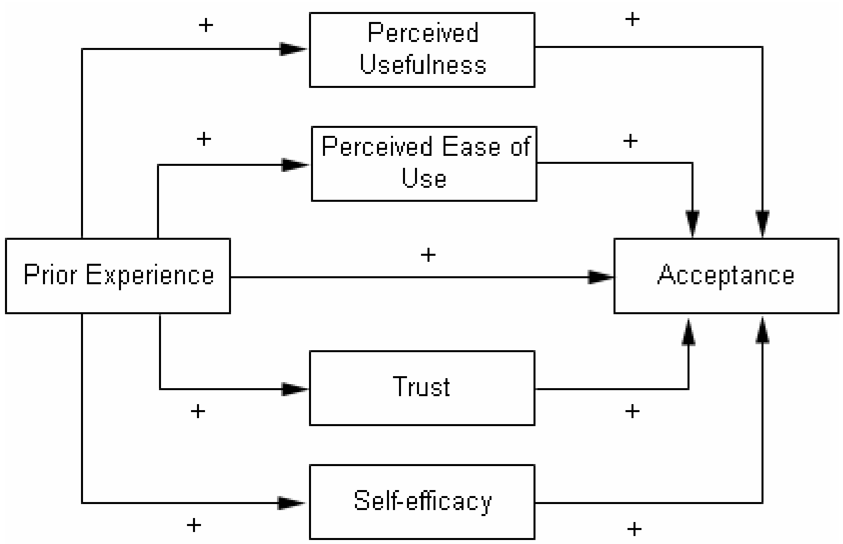


Figure 5.3. Direct and indirect effects of prior experience on acceptance.

Summary of Characteristics of Individual Users

The literature has shown that a number of individual characteristics relate to technology acceptance. Figure 5.4 summarizes the overall relationships of the characteristics of individual users and technology acceptance. However, this representation oversimplifies that relationships between the variables. As illustrated in Figures 5.1, 5.2, and 5.3 the variables of self-efficacy, subjective norm, and prior experience have complex relationships with other variables and show both direct and indirect effects on acceptance.

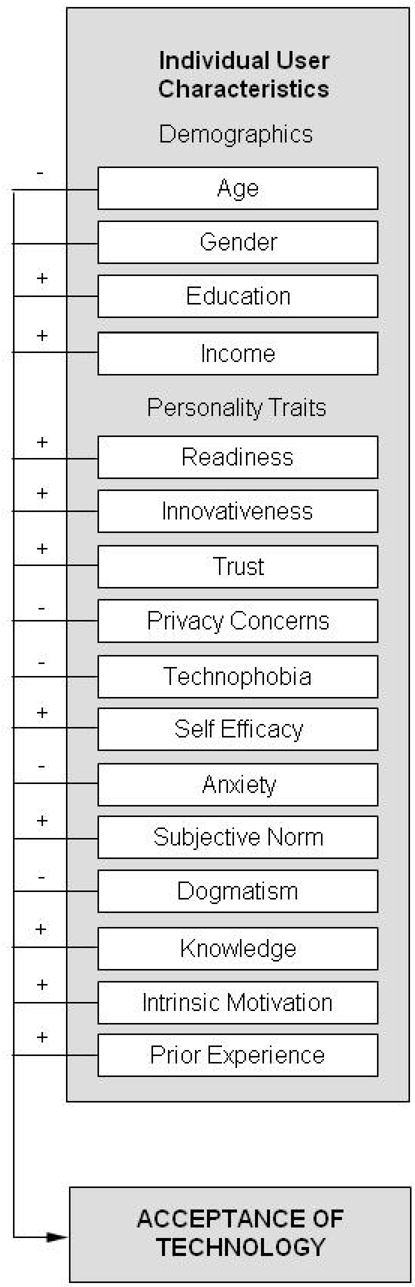


Figure 5.4. A summary of the individual user characteristics related to the acceptance of technology.

Characteristics of Organizational Users and Their Impact on Acceptance

In addition to characteristics of individual users, there are characteristics of the organization that may influence acceptance of technologies. These include employee demographics and psychographics; social influences within the organization; and issues of training, communication, and experience. Additionally relevant may be the organizational demographics, other characteristics of the organization itself, and the organizational environment. We review all of these factors next.

Employee Demographics – Age, Gender, Education

In this section, we discuss the demographics of individual employees within organizations that have been shown to influence the organizational acceptance of technologies. Some of these demographics have the same effect for individual employees as described above for individual consumer users.

For instance, the *age* of employees has been shown to have *a negative impact on the acceptance of new technologies in the workplace* (Mikkelsen, Ogaard, Lindoe, & Olsen, 2002; Morris & Venkatesh, 2000; Morris, Venkatesh, & Ackerman, 2005; Seyal & Pijpers, 2004). Sometimes, the effects of demographics, such as age, remain limited in the organization context (Baldridge & Burnham, 1975). This is most likely due to the many other factors that play a more critical role in organizations.

Gender also plays a role in the organizational environment (Mikkelsen, Ogaard, Lindoe, & Olsen, 2002; Morris, Venkatesh, & Ackerman, 2005; Seyal & Pijpers, 2004). Gefen & Straub (1997) reported that men and women differ in their perceptions of the technology they studied which was email. Venkatesh and Morris (2000) demonstrated that compared to women, men's technology usage decisions were more strongly influenced by their perceptions of usefulness. In contrast, women were more strongly influenced by perceptions of ease of use. Gattiker, Gutek, and Berger (1988) reported that males and females differed in how they use computers. Morris, Venkatesh, and Ackerman (2005) reported that gender differences in technology perceptions became more pronounced among older workers, but a unisex pattern of results emerged among younger workers. The results from this study suggest that old stereotypes that portray "technology" as a male-oriented domain may be disappearing, particularly among younger workers.

Employee *education* is shown to have *a positive influence on the acceptance of technologies* (Agarwal & Prasad 1999; Chao & Kozlowski, 1986; Mikkelsen, Ogaard, Lindoe, & Olsen, 2002). However, while among consumer users the effect of education seems to be driven by the effect of differences in cognitive abilities on acceptance, in the workplace, the effect of education also may be driven by job security concerns (Chao & Kozlowski, 1986).

Another organization-related demographic of employees that may influence the acceptance of technologies concerns *tenure in the work force*. However, Agarwal and Prasad (1999) reported no significant impact of tenure in the work force. What does influence acceptance of technologies are the employees' *positions within an organization*. For instance, Gruenfeld and Foltman (1967) showed that supervisors who were more integrated with the management group and had a high job satisfaction, were more likely to accept new technologies in their organization. Manross and Rice (1986) and for instance Baldridge and Burnham (1975) reported that the acceptance and usage of technologies also differed by *organizational role*—management, technical staff, and administrative personnel.

Employee Psychographics

Employee psychographics also influence the acceptance of technology in the work place. For instance, Chwelos, Benbasat, and Dexter (2001) reported that *readiness* is a significant determinant of acceptance, and even more important than perceived benefits. Comparable effects were reported by Venkatesh and Davis (2000). *User involvement and intrinsic motivation* increased the acceptance of technologies (Mikkelsen, Ogaard, Lindoe, and Olsen, 2002; Sultan and Chan, 2000; Venkatesh, 2000). Different studies have examined the effect of *self-efficacy* and reported that the effect of this characteristic on acceptance is moderated by the perceived usefulness and ease of use (Deng, Doll, & Truong, 2004; Seyal & Pijpers, 2004; Venkatesh, 2000). Venkatesh (2000) further reported that *emotion*, conceptualized as *computer anxiety*, influenced acceptance through ease of use. Igbaria, Schiffman, and Wieckowski (1994) reported that computer anxiety had both direct and indirect effects on user acceptance of technology, through perceived usefulness and perceived fun.

Morrison, Roberts, and Midgley (2004) introduced the concept of *lead user*, which they defined as an individual being at the leading edge of markets, and as having a high incentive to innovate. They reported that lead users helped accelerate early product adoption. Burkhardt and Brass (1990) demonstrated that early adopters decreased uncertainty as whole for *others* and in doing so helped facilitate the acceptance of technologies. Sultan and Chan (2000) reported that adopters were more willing to take *risk*. Zweig and Webster (2003) studied the effect of different personality characteristics and found that people who scored lower in *extraversion* and *emotional stability* were less likely to accept being monitored in the work place. This latter example illustrates the potentially complex relationship between a person characteristics and the *type* of technology being accepted (or not).

Social Influence

Social influences play a critical role in the consumer market (see previous sections), they may play an even more critical role in organizations. *Social influences* are also referred to as a social pressure, normative pressures, or subjective norms. Findings vary. Some studies reported no effect of these external pressures (Chau & Hu, 2002; Davis, Bagozzi, & Warshaw, 1989; Fang, 1998; Sultan & Chan, 2000). Others reported that these pressures have a large effect, and sometimes were the sole drivers of people's acceptance decisions (Harrison, Mykytyn, & Riemenschneider, 1997; Karahanna, & Straub, 1999; Venkatesh & Davis, 2000). The effects of social influences have been shown to depend on age and gender. Morris and Venkatesh (2000) reported that at two points of measurement, older workers were more strongly influenced by subjective norm and perceived behavioral control, although the effect of subjective norm diminished over time. Venkatesh, Morris, Davis, and Davis (2003) showed that social influences were more important for older workers, particularly for women, and in early stages of adoption. In a more recent article, Morris, Venkatesh, and Ackerman (2005) demonstrated that with age, more women were affected by subjective norm but this effect was not found for men. With increasing age, perceived behavioral control was also more important for women than men.

Besides the impact of social influences, other external influences have been shown to affect the acceptance of technologies (Forman, 2005). Especially within organizations, understanding the impact of the use of *hierarchical powers* to implement new technologies may be critical. Leonard-Barton and Deschamps (1988) reported that the perceived management encouragement of accepting a new technology depends on a variety of factors. First, they found that users of the expert system who were low in personal innovativeness toward this class of innovations perceived that management had encouraged them to adopt the technology, whereas this was much less the case for those high on personal innovativeness. Comparable conclusions were drawn for users for whom the subjective importance of the task being computerized was low, whose task-related skills were low, or who were low performers in their sales job. In contrast, users who rated high on any of these measures did not perceive any management influence in the adoption decision.

Training, Communication, and Experience

New technology introductions should be accompanied by training and active practical experience (Mikkelsen, Ogaard, Lindoe, & Olsen, 2002). The impact of *training* and active *experience* on acceptance can easily be explained by considering some of the technology-specific characteristics discussed in Chapter 4 (cf., Aiman-Smith, & Green, 2002; Karshenas, & Stoneman, 1993; Pennings, & Harianto, 1992). For example, training and experience will help establish the ease of use as well as the perceived usefulness of a product or system (Agarwal & Prasad 1999; Attewell, 1992; Shelley, 1998). Training and experience can clarify the benefits of the technology and as such increases acceptance (Amoako-Gyampah & Salam, 2004; Deng, Doll, & Truong, 2004) as well as help reduce the perceived risk of new technologies.

Communication within the organization affects technology acceptance (Al-Gahtani & King, 1999; Hiltz & Johnson, 1990; Sultan & Chan, 2000). Communication influences shared beliefs about the benefits in an organization, which in turn positively influence acceptance (Amoako-Gyampah & Salam, 2004; Czepiel, 1975; Deng, Doll, & Truong, 2004; Edmondson, Bohmer, & Pisano, 2001; Nilakanta & Scamell, 1990). Knowledge barriers are presumed to be important reasons for lack of technology acceptance (Chau & Tam, 1997).

Organization Demographics

The number of organizational demographic characteristics that have been studied in the literature remains fairly limited. The most widely studied characteristics concern the size of organizations. The general consensus is that organization size is the most consistent predictor of the acceptance of technologies – *larger organizations are more likely to adopt technologies than smaller organizations* (Astebro, 2002; Baldridge & Burnham, 1975; Damanpour, 1987; Dewar & Dutton, 1986; Faria, Fenn, & Bruce, 2003; Forman, 2005; Grover, Fiedler, & Teng, 1997; Harrison, Mykytyn, & Riemenschneider, 1997; Karshenas, & Stoneman, 1993; Kimberly & Evanisko, 1981; Liberatore, & Breem, 1997; Swamidass, 2003; Swanson, 1991). These effects can be explained from a resource point of view. Not only do larger organizations tend to have more resources (Forman, 2005), they also are better able to spread the costs of new technologies than smaller organizations (Astebro, 2002; Klein, Conn, & Sorra, 2001; Mathieson, Peacock, & Chin, 2001).

Other organizational characteristics have been shown to be relevant to technology acceptance. For example, the *age* of a company is important in that younger firms do not tend to enter the field with most recent technology (Faria, Fenn, & Bruce, 2003). Perhaps lack of experience with technology types – either old or new technologies – leads to their unwillingness to take risks. On the other hand, older firms, which have experience with the old existing technologies, tend to replace their mass production systems with flexible production.

The *complexity* of organizations tends to reduce acceptance of technologies (Baldridge & Burnham, 1975). However, geographic dispersion of employees was found to be complementary with Internet adoption, suggesting that Internet technology lowered internal coordination costs (Forman, 2005).

Research is lacking an understanding of how these variables may interact. Large complex organization may adopt new technologies. This is the problem with assessing the influence of variables in isolation. The key is going to be to understand the overall perceived value (the benefits/cost balance) to the organization.

Other Organizational Characteristics

Besides these demographic characteristics, the impact of a variety of other internal organizational characteristics on technology acceptance has been studied. Baldwin and Lin (2002), for instance, studied the effect of five impediments: *cost-related, institution-related, labor-related, organization-related, and information-related*. Interestingly, they reported that impediments were cited more often by users than by non-users of technologies. They explained their findings by arguing that innovation involves a learning process – technology users face problems that they have to solve and the more technologically innovative firms have greater problems. They concluded that the information on impediments in technology surveys should not be interpreted as impenetrable barriers that prevent technology adoption.

The *number of technical specialists* positively influenced the acceptance of technology (Dewar & Dutton, 1986). This is probably due to an increased knowledge base within the organization. Somewhat surprisingly, Dewar and Dutton found no association between the adoption of an innovation and decentralized decision making and managerial attitudes. On the contrary, Grover and Goslar (1993) found that *decentralization* of decision making positively influenced the acceptance of technologies. Furthermore, organizations that decentralized their decision making tended to evaluate and adopt more telecommunications technologies.

The *geographic scope* of an organization had a stronger association with magnitude than the speed of adoption, whereas *product scope* was more strongly linked to the speed of adoption (Gopalakrishnan, 2000). Furthermore, geographic and product scope influenced the propensity to adopt product and process innovations differently. Ettlie and Vellenga (1979) suggested that a key leverage point at the firm level for influencing the adoption time period is the risk-taking climate of an organization.

Organizational Environment

Different factors *external* to an organization have been shown to affect the acceptance of technologies by organizations (cf. Chau & Tam, 1997). First, it has been reported that *sector* affects adoption of new technology. For instance, organizations in the public sector are significantly underinvested in computer technology as compared to organizations in the private sector (Bretschneider & Wittmer, 1993).

The likelihood of acceptance increases when the manufacturing *environment is continuous*, and when the manufacturing *complexity* is low, for example with a low average number of parts (Cooper & Zmud, 1990). *Environmental uncertainty* positively influences the acceptance of technologies (Grover & Goslar, 1993). Furthermore, organizations that face greater uncertainty in the environment evaluated and adopted more telecommunications technologies. *Demand uncertainty* usually was related positively to the acceptance of innovations (Robertson & Gatignon, 1986).

Industry growth rates influence the acceptance of technologies (Karshenas, & Stoneman, 1993). Organizations that are most receptive to innovation were in *concentrated industries* with limited *price intensity* and that *supplier incentives and vertical* links to buyers were important in achieving adoption (Gatignon & Robertson, 1989). The lack of price pressure frees resources for potential adoption. Banks in more concentrated markets were more likely to adopt ATMs relative to other markets (Hannan, & McDowell, 1984).

Summary of Organizational Characteristics

Figure 5.6 provides a summary of the organizational variables that have been shown to be relevant to technology acceptance within an organization. Several conclusions can be drawn from the overview provided. First, the amount of research that systematically examines the impact of internal and external organizational characteristics on technology acceptance is scarce. More research is scattered and ill structured. A more structured approach seems desirable.

We highlight two exceptions that may provide a good starting point to structure research on the effect of organizational characteristics on the acceptance of technologies. First, Au and Kauffman (2003) provided an interesting set of conclusions with respect to how decision-makers within organizations decide to accept new technologies. First, they concluded that decision-makers will invest a reasonable amount of time to gather all relevant information from all possible sources and process the information optimally.

Such decision makers do not simply follow what others have done. Second, they found that decision-makers tended to form two kinds of expectations, which subsequently affect their acceptance decisions: “static expectations” which assume that next year will be like this year; and “rational expectations” which means that decision-makers make efficient use of all available information and their understanding of the model governing the market to formulate expectations. Third, decision-makers must pay attention to some value variances such as the time it takes to materialize the expected benefits from the technology, the availability of resources of each firm, and initial costs.

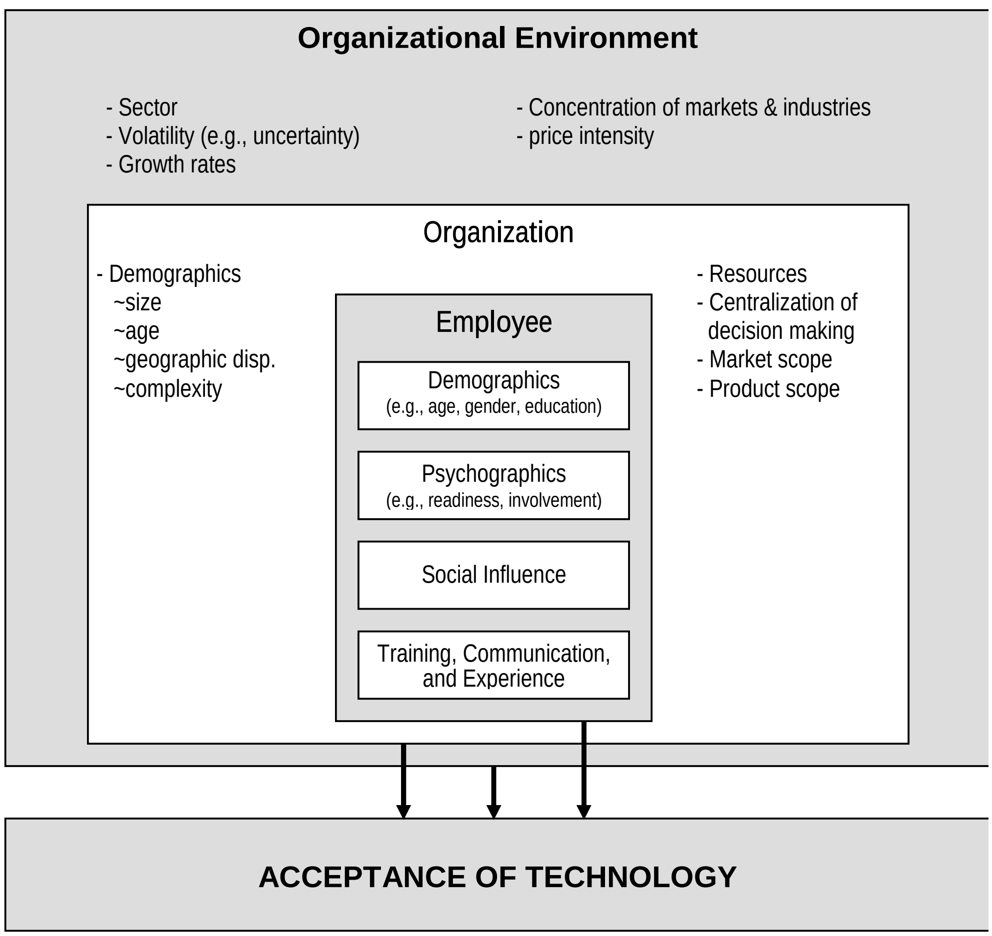


Figure 5.6. Characteristics of organizational users.

Another noteworthy study was by Waarts, van Everdingen, and van Hillegersberg (2002) who reported that the factors affecting late technology acceptance differ significantly from the factors explaining early adoption. At early stages of the diffusion process, adoption tends to be especially driven by a combination of internal strategic drives and attitudes of the firm together with external forces like industry competition and supplier activities. Later the mix of adoption stimulating factors seems to be focusing more on implementation issues such as the scalability of the system, the number of seats, and the yearly available budget. The study leads to both new methodological insights and substantive conclusions that also have practical implications.

Chapter 6 – A Qualitative Model of Technology Acceptance

Existing Models

Much research on the acceptance of technology is driven by a limited number of well-known research models. The most famous one is probably the Technology Acceptance Model (TAM; Davis, 1989). This model and its subsequent iterations are described and illustrated in Appendix E.

Although the TAM was developed to understand the acceptance of software and general information technology (IT), many applications can be found in the literature outside of the software-arena. Results suggest that TAM is a successful and cost effective tool for predicting end-user acceptance of systems (Morris & Dillon, 1997; Straub, Keil, & Brenner, 1997; Sussman & Siegal, 2003; Szajna, 1996; Van Schaik, 1999; Van Schaik, Flynn, Van Wersch, Douglass, & Cann, 2004; Venkatesh, Morris, Davis, & Davis, 2003; Yi & Hwang, 2003).

However, the widespread application of the TAM also forms an important basis for some of the weaknesses of existing research on the influence of technology characteristics on the acceptance of technology. First, TAM framed a lot of research (Horton, Buck, Waterson, & Clegg, 2001). That is, findings from the research conducted in an IT context have been applied in unrelated contexts without acknowledging possible context-specific factors. Second, while the TAM is easy to apply, it only supplies very general information on users' opinions about a system (Mathieson, 1991; Plouffe, Hulland, & Vandenbosch, 2001; Taylor & Todd, 1995). For instance, the perceived usefulness of a technology can be based on a wide range of different technology-related aspects. Consider automation of components of a combine or a commercial mower – it may be perceived useful based on the amount of time that is saved, the amount of money that is saved, or perhaps an increase in productivity. By merely measuring the perceived usefulness, however, a lot of information is lost – in particular, the reasons *wh*y the technology is perceived to be useful (or not).

The same criticism largely holds for Rogers' work (e.g., 2003) and other research models in the literature. Most models do not *refine* the benefits under consideration. For example, the perceived usefulness of technology may be based on a sum of multiple benefits. A more refined approach to measuring potential adopter's perceptions of the benefits of new technologies will result in a higher predictive validity and a more enriched understanding of people's underlying decision-making process.

A Summary Qualitative Model

A qualitative model (also called a conceptual model) provides a non-mathematical description of variables and their interactions to motivate further understanding of a phenomenon (in this case – technology acceptance). We have based our model on our extensive and systematic review of the literature. We were able to identify the critical variables in the research arena of technology acceptance and to specify the relationships between the variables. Individual characteristics interact with each other as well as with the technology characteristics to form a complex relationship network.

Figure 6.1 provides a summary of *all* the variables investigated in the technology acceptance literature and shown to have an influence. Figure 6.1 also shows the directional relationships between the individual user characteristics, technology characteristics and technology acceptance. Note that some relationships are specific to components of acceptance (attitudinal, intentional, behavioral) whereas others are more general. Also illustrated are the organizational user characteristics that relate to technology acceptance.

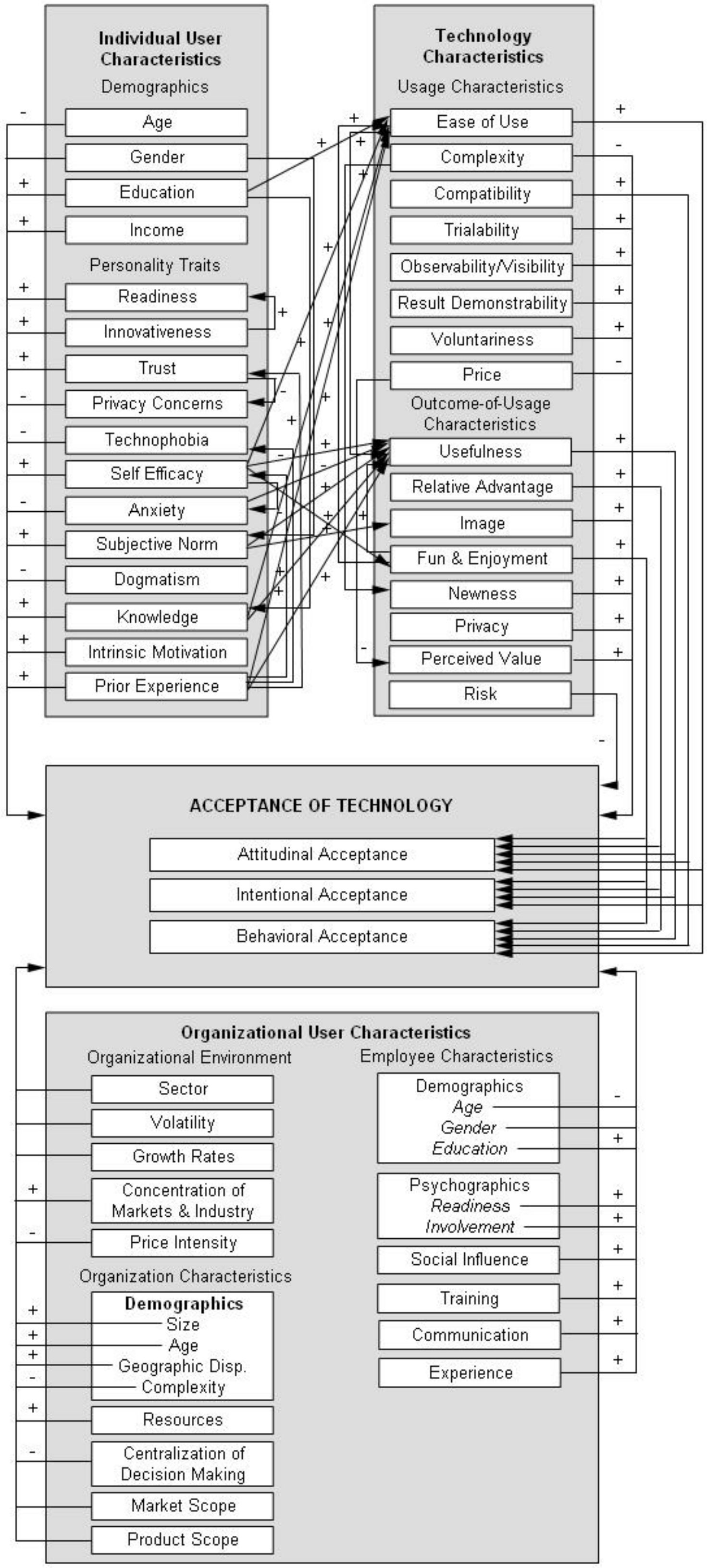


Figure 6.1.
A qualitative model of technology acceptance.

This comprehensive model illustrates the complexity of the technology acceptance construct. Many factors influence acceptance and many of them are themselves interrelated. Even this elaborate representation of the qualitative relationships between variables is simplified. For example, Figures 5.1, 5.2, and 5.3 illustrated how components of the model have been elaborated to understand the role of a specific variable.

One immediate benefit of developing a general qualitative model, as we have organized it, is to understand the different categories of relevant variables. For example, some user characteristics, such as age, gender, or dogmatism, may not be malleable but they are certainly measurable and can be used to make predictions about technology acceptance. Other variables such as technophobia, knowledge, or prior experience, can be changed through exposure or through training and instruction. As such, companies have the opportunity to influence levels of acceptance. A similar logic applies to the organizational user characteristics.

With respect to the technology characteristics, understanding variables that relate to technology acceptance also provides the opportunity for influence. Some variables such as ease of use, complexity, and fun/enjoyment can be influenced through marketing materials. Other factors such as privacy, risk, and compatibility can be considered during the design process to maximize acceptance by at least some user groups. The finding that certain variables relate to usage and others to the outcome of usage also provides insight into the general technology acceptance process.

Research Gaps

The qualitative model we have developed provides the state-of-the-science on technology acceptance. It indicates the relevant variables that have been studied in the research literature and provides guidance for the development of testable research propositions, some of which are detailed in Chapter 7. The literature review and resultant model also illuminates gaps in the research literature and we discuss these next.

Benefit Specificity

There is a lack of understanding in the literature of the product-specificity of benefits. Knowing that perceived usefulness or perceived value is predictive of acceptance is valuable, but limited. For example, a particular product such as a ride-on mower may have economic benefits, safety benefits, or aesthetic benefits (either compared to other ride-on mowers or compared to a push mower). However, current metrics of assessment would not differentiate which category was influencing behavior most and thus it would be difficult for a company to influence the process.

Changing Perceptions

What can be done to change a person's perceptions of ease of use or usefulness? This question relates to the previous issue of understanding benefit specificity. It is also more general and involves understanding the precursor variables that relate, generally, to factors such as perceived ease of use and perceived usefulness.

A related issue is how and whether the predictors of technology acceptance change as a function of extended use; that is, how do perceptions change over time. In addition, there is very little research on people who started to use a technology but then discontinued use. Understanding the lack of acceptance for this segment of the population will be invaluable for improving technology design.

Technology "Costs"

The role of technology "costs" such as risk, privacy concerns, and security issues have been minimally investigated and hence are not well-understood. For example, the role of perceptions of risk as they related to technology acceptance is a relatively recent concept (see Figure E6 for an illustration from Featherman & Pavlou, 2003). As such there is limited research on the topic. However, there is evidence to indicate that risk perceptions play an important role in technology acceptance, including a pilot study we conducted (Van Ittersum & Capar, 2005) that is described briefly in Chapter 7.

Similarly, the construct of privacy is not well-understood and research suggests that factors such as characteristics of the individual, characteristics of the technology, and the context of use will all (interactively) affect perceptions of privacy.

Relative Importance of Predictors

As Figure 6.1 clearly shows, the qualitative model that resulted from our research contains too many variables to be practically useful in predicting technology acceptance. Additional research is required to determine which variables are more or less important (for different technologies and different user groups).

Technology Type

The research illustrated that the predictiveness of certain variables was moderated by the type of technology that was being investigated. Different characteristics account for acceptance of different technologies. For instance, while privacy concerns have a strong predictive power when acceptance of Internet shopping is examined, this characteristic does not have much predictive power when the acceptance of a computer hardware product is examined. However, the research on this topic was very limited.

Moreover, the majority of research on technology acceptance (and the resultant models) has been conducted in the context of information technology. The degree to which the findings generalize to other technologies is not yet known.

Chapter 7 – Conclusions and Propositions

Propositions

The qualitative model provides the crucial foundations for the formulation of testable hypotheses and the development of quantitative models. In this chapter we present propositions that serve as the basis for testable hypotheses in later research studies.

Technology Characteristics

We propose to customize the measurement of the benefits of new technologies by establishing people's perception of each individual benefit of each individual technology, rather than using overall measures of perceptions, and applying these irrespective of the technology.

P1 *The predictive validity of potential-adopters' perceptions of a technology is larger when identifying and measuring their perception of each individual benefit of each individual technology than when identifying and measuring their overall perceptions, ignoring technology-specific benefits.*

A related problem is that the overall measures do not provide any insight into how potential adopters' perceptions with respect to these characteristics may be changed. When people's perceptions of each individual benefit of each technology are measured, insights into the drivers of these benefits may be obtained as well. This information may allow a company to change the technology such that people's perceptions of the technology change, increasing the likelihood of acceptance.

P2 *Measuring potential-adopters' perception of each individual benefit of each individual technology increases the understanding of how these perceptions* *may be changed, and as such this helps to increase the acceptance of technology.*

One downside of this technology-specific approach is that it is more cumbersome. For each individual technology, people's perceptions need to be identified, measured, and related to acceptance. The advantage of a more overall approach is that no new perceptual information has to be collected for each new technology. With this in mind, there is still one additional issue with the many technology characteristics studied that needs to be addressed. While several studies have compared the predictive validity of the different models and their characteristics, it remains unclear if *all* these characteristics have discriminant validity: do they really measure different aspects of a technology or are some of these characteristics virtually measuring the same thing? A recent study by Venkatesh, Morris, Davis, and Davis (2003) suggests that there is overlap of the different measures.

P3 The measurement efficiency of existing technology-characteristic scales can be improved by investigating the discriminant validity of these scales.

Research shows that the drivers of the acceptance of different types of technology may vary and the type of technology itself may result in different acceptance patterns. The greater the radicality of innovation: (1) the higher the extent and faster the speed of diffusion (probably due to more support by company) and (2) the greater the scope (i.e., target market) of the innovation (Donnelly, 1970; Lee, Smith, & Grimm, 2003).

P4 The effect of technology characteristics on the acceptance of technologies depends in part on the type of technology under consideration (radical versus incremental technologies).

Individual Users of Technology

Besides the technology characteristics, the characteristics of those who are supposed to accept the technology may influence the acceptance of technology. However, the predictive power of the user characteristics is likely to interact with the type of technology being accepted. We propose that instead of using overall measures of perceptions, and applying these irrespective of the technology, to customize the measurement of the benefits of new technologies by establishing people's perception of each individual benefit of each individual technology.

P5 *Predictive power of the user characteristics on acceptance of technology will depend on the kind of technology studied.*

Although many studies examined demographics as factors affecting acceptance, they have not been studied as much as psychographics. This is probably because the predictive effects of psychographics are stronger than the predictive effects of demographics. Plus, more insights into the reasons of acceptance or rejections may be obtained by studying psychographics. Consequently, we expect the predictive power of psychographics on acceptance to be stronger than the predictive power of demographics. For instance, we expect that a new technology will be accepted by an older individual with high self-efficacy compared to a younger person with low self-efficacy.

P6 *Psychographics are expected to have a more significant role on the prediction of technology acceptance than demographics.*

Each variable we examined reflects a single psychological trait of individuals. While this helps us to be more sensitive in our study, we cannot ignore the relationships among some of these variables. For instance, the close relationship between trust and privacy concerns or between readiness and innovativeness makes it difficult to distinguish the effect of each individual variable. Moreover, variables that have similar sources and that affect acceptance in the same direction are expected to have a clearer and stronger predictive power on acceptance.

P7 *Predictive power of the user characteristics on the acceptance of technology will be higher when they are grouped based on similarities of their sources.*

Organizational Users of Technology

Studying acceptance of technology by the individual user in the organization introduces characteristics other than demographics and psychographics. These involve characteristics such as involvement and technology readiness. If these characteristics do not support acceptance of technology, the other characteristics of the employee will have less effect on acceptance. For instance, technology readiness positively influences acceptance. If the employee is "ready" for the technology, he/she will accept it no matter how much communication and social influence there are in the organization, or how old he/she is. As a result, we believe that psychographics will have the most powerful effect on acceptance.

P8 *Psychographics are expected to influence acceptance of technology more than other employee characteristics.*

Besides all these factors that influence the acceptance of technology by employees, we believe that acceptance by the organization will have an effect on acceptance by the employee. This effect can be seen either through social influence and training, or directly on acceptance. Consequently, acceptance of the technology by the organization is predicted to influence acceptance by the employee.

P9 *Acceptance of technology by the organization will influence acceptance of the technology by the employee, but the magnitude of this effect is not expected to be greater than the effect of employee characteristics.*

Organizational environment particularly influences acceptance of technology by the decision-makers. Based on our proposition on the effect of organizational acceptance of technology on employee acceptance, we expect the direct effect of organizational environment on acceptance by organization to show itself on acceptance by individual employee. On the other hand, no direct effect of organizational environment on acceptance by employee is expected. To illustrate, industry growth rates, as an organizational environment character, affect acceptance of technology by the organization; on the contrary, employees' acceptance decision is not affected by low or high industry growth rates, but by the organization's acceptance.

P10 *Organizational environment will influence employees' acceptance of technology through its direct effect on acceptance by the organization, while it will have no direct effect on employees' acceptance.*

As mentioned before, uncertainty surrounding the actual benefits and possibly the costs make the decision to accept technologies a risky one (Chatterjee & Eliasberg, 1990; Donnelly, 1970). The general consensus is that *risk decreases the acceptance of technologies* (Featherman & Pavlou, 2003; Hsu & Chiu, 2004; McKnight, Choudhury, & Kacmar, 2002). We concluded that risk is an important variable in the acceptance decision-making process. Risk has been studied primarily from a technology-characteristic point of view. However, research has shown that different people and organizations may respond differently to uncertainty surrounding specific product benefits (e.g., Pennings & Smidts, 2003). Whereas some people and organizations do not mind, or actually like uncertainty (e.g., risk-seeking individuals/organizations), others do not like uncertainty and try to avoid it at all costs (e.g., risk-averse individuals/organizations).

Despite the potential importance of understanding the effect of this user characteristic on acceptance, research is scarce. We conducted a pilot study on the effect of people's attitudes towards the performance risk on the acceptance of technologies in the context of automation in the airline industry (Van Ittersum & Capar (2005). We found that individual differences in people's attitude toward technology-related risk significantly influence the acceptance of technologies. Furthermore, people's risk attitudes influenced the timing of the acceptance of technologies. As Figure 7.1 shows, risk-seeking individuals were more likely to accept a technology early after introduction, whereas risk-avoiding individuals were more likely to wait to accept the technology.

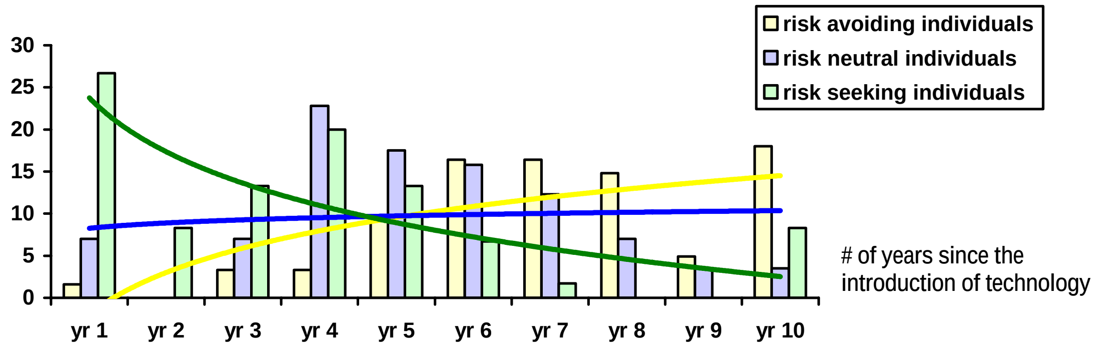


Figure 7.1. The influence of risk attitude on the timing of the acceptance of technologies.

Building on the literature and these study findings, we hypothesize that

P 11 *An individual's or organization's attitude towards risk significantly influences the acceptance of technologies.*

Summary of Propositions

The propositions provided in this chapter provide exemplars of the types of testable hypotheses that can be generated on the basis of the review we conducted and the qualitative model we developed. Research conducted in Phases II and III of this project will test these and other propositions that are developed during the research process.

Chapter 8 – Future Directions

This report details the results of the Phase I project, wherein the objective was to develop a qualitative model that identified the key variables most relevant to technology acceptance and rejection. In addition we were able to identify critical gaps in the research literature that are most relevant to technology acceptance issues applicable to the Deere enterprise.

The primary purpose of Phases II and III (FY06 and FY07) will be to conduct quantitative assessments to test the validity and completeness of the qualitative model, to develop a predictive model of technology acceptance, and to assess, comparatively, communication methods for deploying new technologies.

Phase II – Developing a Set of Metrics and Preliminary Testing of a Quantitative Model

In Phase II we will develop an operational definition (i.e., a measurable determination) for the critical variables identified in the qualitative model. We will identify available metrics that have been validated in the research literature. For each metric we will determine if it is appropriate for our model development and if it is relevant to Deere products. This process will require revision of the metrics to suit the specific requirements of Deere products. The outcome of this aspect of Phase II will be a set of metrics available to Deere for testing critical variables relevant to their products.

The second major aspect of Phase II will be a pretest of a quantitative model. We will use the metrics we have refined to assess whether the model is comprehensive. Our plan is to develop a questionnaire tool that will be tested first with subject matter experts and then administered to 400 customers. We will assess technology acceptance retrospectively – that is, we will query both adopters and non-adopters about their decisions related to products that have already been deployed. This preliminary questionnaire will enable us to test the reliability and the validity of the metrics we have developed as well as to identify gaps in the quantitative model.

Our plan is to assess the validity of our initial quantitative model for four products from two technology categories: *Telematics* and *Intelligent Mobile Equipment*. Within each category we would select one product that has been very successful (i.e., widely adopted) and another that has been less successful in terms of its rate of adoption. We will work closely with the Deere & Company members of the team to identify the most suitable products and to develop a sampling frame of customers to whom we will send the questionnaire.

The research objectives of Phase II are to (1) develop a set of reliable and valid metrics to assess technology acceptance, (2) test these metrics in the context of Deere & Company products; (3) use these preliminary data to test components of the qualitative model; and (4) assess an initial quantitative model for products from different categories that have been more or less successfully deployed in the marketplace.

Phase III (FY 07) – Refining and Testing a Quantitative Model

In Phase III (FY07) we propose to refine and test the quantitative model in a predictive way. This will be a larger scale assessment (~2000 people) of a product that is being newly introduced. In addition, we will empirically test methods of communicating the key features of new technology to increase the likelihood of acceptance. For example, if we learn that risk perception is a critical variable influencing technology acceptance, we will design and test the effects of different means of communicating true product risk. The details of the Phase III research approach will be refined on that basis of the findings from Phase II.

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Appendix A – Research Team

To accomplish our research goals and objectives, we assembled a team of individuals at Georgia Tech with complementary scientific backgrounds. We also worked closely with individuals from Deere & Company from different sectors of the organization to ensure that the results of our review and subsequent research would have broad relevance.

School of Psychology – Georgia Tech

The psychology group has expertise in the field of human factors (designing for human use). They have experience in evaluation of beliefs and attitudes towards technology by individuals of all ages (e.g., Melenhorst, Rogers, & Caylor, 2001; Mynatt, Melenhorst, Fisk, & Rogers, 2004; Rogers, Meyer, Walker, & Fisk, 1998). They have also conducted extensive research on age-related differences in needs, capabilities, and preferences that influence product use, trust in technology, and acceptance (e.g., Fisk, Rogers, Charness, Czaja, & Sharit, 2004; Hancock, Fisk, & Rogers, 2001; Sanchez, Fisk, & Rogers, 2004).

Name	Highest Degree	Research Focus
Kelly Caine	B.A. in Experimental Psychology, University of South Carolina	Understanding the capabilities and limitations of older adults with an emphasis on understanding how technology can be used to enhance a person's ability to function in later life.
Arthur (Dan) Fisk	Ph.D. in Experimental Psychology, University of Illinois	Skilled performance and training; similarities and differences across age groups in the attention, learning, and development of skilled performance; translating research to motivate technology design for older adults; application of human automatic information processing and mental workload analysis to training high performance skills.
Marita O'Brien	M.S., Telecommunications Engineering, University of Colorado	Psychological factors that facilitate or impair effective use of technologies; bridging the gap between the practical guidance designers need and the psychological literature on attention, motor control, visual search and other factors.
Wendy A. Rogers	Ph.D. in Experimental Psychology, Georgia Institute of Technology	Broad issues in skill acquisition, human factors, training, and cognitive aging; technology design and acceptance; the psychology of human-computer interaction

College of Management – Georgia Tech

The team members from the College of Management bring a background in marketing (Koert van Ittersum, Muge Capar) and marketing science (Len Parsons). Dr. Van Ittersum's research focuses on consumer decision-making and choice, and the role of risk attitude and risk perception on consumer risk behavior (e.g., Pennings & Van Ittersum, 2004). Furthermore, as part of a larger project on new product development, Van Ittersum works on improving the identification process of those product attributes consumers deem important (e.g., Van Ittersum, Pennings, Wansink, & Van Trijp, 2004a; 2004b). Dr. Van Ittersum also has an extensive practical background in agriculture and is aware of factors that influence the decision-making process of farmers. Muge Capar is a first year PhD student with an interest in drivers of the acceptance of new products and technologies. Dr. Parsons is an expert on market response models (e.g., Hanssens, Parsons, & Schultz, 2001). His current interests are in marketing productivity and benchmarking (e.g., Parsons 2002).

Name	Highest Degree	Research Focus
Muge Capar	B.S. in Management Science and Engineering, Istanbul Technical University	Technology acceptance
Leonard Parsons	Ph.D. in Industrial Administration, Purdue University	Market mix models; marketing productivity
Koert van Ittersum	Ph.D. in Marketing and Consumer Behavior, Wageningen University, The Netherlands	Consumer decision-making and choice; the role of risk attitude and risk perception on consumer risk behavior; improving the identification process of those product attributes consumers deem important

Other Students – Georgia Tech

Given the magnitude of this project, assistance was needed from many persons. We acknowledge the contributions of Jayme Gergen, Esther Millard, Sung Park, Daniel Rice, Emily Seifert, and Amy (Na) Wen.

Deere & Company

Deere & Company expertise was brought in through the active involvement of members of different divisions. These individuals provided expertise in marketing, technology management, and other appropriate disciplines within the Deere enterprise. The breadth of this team enabled us to develop a qualitative model of technology acceptance that represents the multi-faceted nature of this domain.

Name	Division/Unit	Position
John Arthur	Commercial & Consumer Equipment Div.	Manager, Compact Utility Tractor, Product & Technology Marketing
Mark Baumgarten	Deere & Company, Ag Marketing	Manager, Market Research
Greg Doherty	Commercial & Consumer Equipment Div.	Group Director, WW Product & Technology Marketing
Jerry Duncan	Deere & Company, Technology Center-Moline	Manager, Collaborative Science
James Jeng	Commercial & Consumer Equipment Div.	Manager, Consumer & Market Research
Carl Loweth	Deere & Company, Engineering	Coordinator, Advanced Technology Marketing Group
Stephen Meinzen	Agricultural Equipment Div., Production Services Marketing	Manager, Service Concept Delivery
Jim Morley	Construction & Forestry Div., WW Construction Marketing	Manager, Value Selling
Bruce Newendorp	Agricultural Equipment Div., Product Engineering Center	Sr. Staff Engineer, Operator Station Core Technology
Ritu Raj	Commercial & Consumer Equipment Div.	Manager, Dealer Development, Canada Sales Branch
Bryan Zent	Commercial & Consumer Equipment Div.	Manager, Consumer & Market Research

Appendix B – Journals Searched

Economics
- *American Economic Review*
- *Journal of Technology Transfer*
- *R&D Management*
- *RAND Journal of Economics*
- *Research Policy*
- *Quarterly Journal of Economics*

General Psychology
- *Journal of Experimental Psychology: Applied*
- *Journal of Experimental Psychology: General*
- *Journal of Experimental Social Psychology*
- *International Journal of Technology and Aging*
- *Journal of Consumer Psychology*
- *Journals of Gerontology*
- *Journal of Applied Psychology*
- *Psychological Reports*
- *Psychology & Aging*
- *Social Science Computer Review*

Human Factors/Ergonomics/HCI
- *Human Factors*
- *Human-Computer Interaction*
- *Behaviour & Information Technology*
- *Computers in Human Behavior*
- *Gerontology Journal*
- *IEEE Transactions on Engineering Management*
- *International Journal of Human-Computer Interaction*
- *International Journal of Human-Computer Studies*

Management
- *Administrative Science Quarterly*
- *Academy of Management Journal*
- *Journal of Management*
- *Management Science*
- *Organization Science*
- *Strategic Management Journal*
- *Journal of Applied Psychology*
- *Personnel Psychology*
- *Journal of Management*

Marketing
- *Journal of the Academy of Marketing Science*
- *Journal of Marketing*
- *Journal of Marketing Research*
- *Journal of Product Innovation Management*
- *Marketing Science*
- *Journal of Consumer Research*
- *Journal of Consumer Psychology*

Information Technology
- *Information Systems Research*
- *MIS Quarterly*
- *Journal of Management Information Systems*

INFORMS Journal on Computing

Appendix C – Overview of Fields & Codes

This appendix describes the labeling and coding scheme used for populating the EndNote fields for each article included in the database.

As shown below in Table C1, nine fields from EndNote were selected to customize each article entry according to the needs of the Technology Acceptance project. The EndNote field name lists the default name for the field, and the Tech Acceptance field name shows the recoded labeling selected to more effectively describe the contents of each field.

Table C1: Overview of Fields

Endnote field name	Tech Acceptance field name
Custom 1	Acceptance Definition
Custom 2	Outcome Measures
Custom 3	Other Variables
Custom 4	Environment (Business or Consumer)
Custom 5	Type of Technology or Product
Custom 6	Method Notes
Section	Team Notes
Tertiary Title	Other Notes to Ourselves
Reviewed Item	Use this field to note if reviewed and whether accepted

As we read each article, we were particularly attuned to the description needed to populate each field. For each field, we have documented the rules that were used by each coder to determine how to fill in the required information. Descriptions for each field also include field-specific instructions to clarify questions which arose during the coding process.

Custom 1 Acceptance Definition

Definitions of new technology or acceptance/adoption, with a goal of capturing the explicit definitions used in the article

- If definition is explicit, put in quotes with page number
- If not defined – say so explicitly rather than just leaving blank
- If not available, paraphrase using the most common terms found**
- Include alternate terms for technology acceptance
- Do not leave this field blank.

Try to use one of the answers below if it fits with the article, but do not force one of these answers either. If technology acceptance is not well defined, see if it fits with one of the "inferred" answers before putting something new in the field. We don't want to lose any information but we want to be able to group the definitions if possible.

**Possible answers for this field include:

- Adoption (this would infer that the author(s) used the term "adoption" in the article)
- Adoption [inferred]
- Use (this would infer that the author(s) used the term "use" in the article)
- Use [inferred]

- Purchase (this would infer that the author(s) used the term “purchase” in the article)
- Purchase [inferred]
- None given

Custom 2 Outcome Measures

- Put the terms that the authors use for each variable and then label it with our own in parentheses
- Examples for this field would include: attitude, preference, intention & frequency of use

Custom 3 Other Variables

- Put the terms that the authors use for each variable
- Include independent variables, quasi-independent variables, moderators, or drivers related to acceptance of technology

Custom 4 Environment (Business or Consumer)

- Determine whether the environment is consumer or business
  - Consumer environment – personal or private use (no salary involved)
  - Business environment – participants who use it for salary
  - Other – send descriptions to the list-serve and we will come to a consensus about how to code

Valid answers for this field include:

- Business
- Consumer
- Business and Consumer

Custom 5 Type of Technology or Product

- Describe the technology or product used for research and analysis in the article. Make sure to describe all products used for the original research (as opposed to descriptions of other studies used in the introduction, for instance).
- For example, computer, internet, TV, orange juice

Custom 6 Method Notes

Describe the method for each research study, designating multiple studies with the label Study 1, Study 2, etc.

- Label each article as review or empirical
- Describe participants - number, age, gender (descriptive characteristics) and their general characteristics – students, workers, end user, managers, CEO
- Describe method used, lab experiment, field experiment, questionnaire
- Describe statistical analysis used
- Note instruments used (custom scale, common scale, and if common scale note which common scale was used)

Tertiary Title Team Notes

- List all key findings
- Note reference to most common technology acceptance model(s), e.g., Bass model,

Theory of Planned Behavior, Technology Acceptance Model, Rogers' Diffusion model.

- This field is also used to note the reason for rejection for all rejected articles.

Section **Other Notes to Ourselves**

- Provide other notes to ourselves, i.e., perceptions about the article
- List your comments, e.g., was it worth reading, was there a good description of a new scale, a description of a product close to Deere & Company's product set, etc.
- Note if the article is potentially relevant to Len or any other team member's research.

Reviewed Item **Whether Item has been Reviewed By Us**

Use this field to note whether or not item has been reviewed by us, and whether or not we've accepted it or rejected it (with reason for rejection in team notes)

Valid answers in this field would be:

- [Blank] – abstract not yet reviewed
- Rejected based on abstract – [give reason in team notes field]
- Accepted based on abstract – [this indicates that we already have a PDF]
- Accepted based on abstract – No PDF
  - After PDF is retrieved, change status to Retrieved.
- Retrieved – [this indicates article has been retrieved but not yet reviewed]
  - Abstract may have been reviewed but not article.
- Retrieved, reviewed, rejected [give reason in team notes field]
- Retrieved, reviewed, accepted [fill in all relevant fields]
- Reviewed, accepted – No PDF
  - This will change to retrieved, reviewed, accepted after electronic copy is obtained. This will be used for items where we have a hard copy only, for instance books or a large thesis.
- NOTE WHY ARTICLE WAS REJECTED IF REJECTED IN THE TEAM NOTES FIELD.

Appendix D – Coding Scheme

Type of Article (mutually exclusive; sums to total number of articles)

- review
- p/s specific - product or system specific articles
- model
    - model-like studies that verify a hypothesis about acceptance of technology in general but not about a specific product are coded as "model" as well.

Note: Articles that stated explicitly as a "review" or "model" study were classified as such. Articles that studied a specific product or system were classified as "p/s specific". Some studies that verified a hypothesis about acceptance of technology in general but did not look at a specific product were coded as "model" as well.

Focus of Research (sums to total number of product or system-specific articles (198))

- acceptance
- rejection
- both
    - Generally the end result of a study determines acceptance or rejection.
    - For example, a questionnaire study that concludes a positive attitude toward computers will be classified as "acceptance."
    - If a paper did not specify a unidirectional (either acceptance or rejection) research question or a conclusion, it will be classified as "both."

Note: Coding was based on the focus of the study. For example, if an article examined factors that influence the discontinuance of a product then it was classified as "rejection." A questionnaire study that concluded a positive attitude toward computers was classified as "acceptance." However, most articles did not explicitly state whether they focused on one side (either acceptance or rejection) of adoption. If a paper did not specify a unidirectional (either acceptance or rejection) research question or a conclusion, which was almost the case, it was classified as "both."

Characteristic of Innovation (sums to at least total number of product or system-specific articles)

- incremental (e.g., upgraded software)
- radical (e.g., car, computer)
- multiple
- requires domain expertise
- insufficient information

Note: The focus was whether the technology was incremental or radical technology at the time of the research (Green, Gavin, & Aiman-Smith, 1995). The gap between the time of the research and the time when the technology is exposed to the users/customers are considered. For example, the first commercial computer was introduced in 1960 in the market. Hence, studies about acceptance of computers in

1990s no longer examine radical technology.

Form (sums to at least total number of product or system-specific articles)

- computer hardware (e.g., desktop, laptop, mini computer)
- computer software (e.g., word processor, spreadsheet, programming tool)
- electronic device (non-computer) (e.g., TV, VCR, cell phone)
- mechanical device (e.g., car, machinery)
- physical object (e.g., shoes, videotapes)
- system (e.g., Internet, email, banking system)
    - the idea of technology that can be implemented in a product
    - a group of elements that constitutes a unified technology

Note: The focus here was on the form of the technology. Some articles examined the implementation of the technology (i.e., computer hardware, computer software, electronic device, mechanical device, physical object) when others looked at the idea of the technology or a group of elements that constitutes a unified technology (i.e., system). For example, Internet is an idea of communication but at the same time can be implemented via web browser, Internet servers, and network lines. Hence, such is classified as "system."

Setting/Context of Use (sums to at least total number of product or system-specific articles)

- personal use
    - general*
    - education
    - health
    - finances
    - agricultural
    - entertainment
- organizational use
    - general*
    - education
    - health
    - finances
    - agricultural
    - entertainment
    - information management

** general – technology used in general setting and have little to do with a specific sector or setting*

Note: This category examined the context of use in terms of whether the technology was for personal use or organizational use. Sub classification is made on a specific sector or setting of the use. For example, technologies such as "home entertainment systems" are for personal use and entertainment purpose.

Appendix E - Models of Technology Acceptance

The technology acceptance model (TAM) proposes two main constructs as being most predictive of technology acceptance: perceived usefulness and perceived ease of use (Davis, 1989). In short, if a person believes that a technology has some utility and that it will be easy to use, that technology is likely to be accepted. These constructs of usefulness and ease of use have been shown to be predictive of a person's intention to use a technology which in turn is predictive of actual usage. This relationship is illustrated in Figure E1.

The TAM has been extended to investigate the relationships between perceived usefulness and perceived ease of use as illustrated in Figure E2. This extended model also includes the construct of perceived resources and the degree to which perceptions predict attitudes or intentions, per se. Nevertheless, key constructs of the extended TAM are perceived usefulness and perceived ease of use, although additional variables such as perceived credibility have been proposed as well (see Figure E3).

Understanding the precursors of perceived usefulness and perceived ease of use has been the focus of much research. The goal of these studies has been to identify demographic variables (e.g., age, gender) or other factors such as technology or task experience or organizational characteristics that are most predictive of perceived usefulness and perceived ease of use. Figure E5 illustrates the roles of experience, technology characteristics, and enjoyment as they relate to perceived usefulness and perceived ease of use.

Another avenue of extending the TAM was to incorporate the role of different aspects of perceived risk as illustrated in Figure E6. In this model usefulness remains the most predictive factor but it is itself predicted by a range of factors.

These iterations of the TAM have primarily been applied in the context of the acceptance of information technology. While the models are useful, there are limitations as described in Chapter 6 that preclude them from fully explaining technology acceptance in a range of secotrs, for various technologies, and for individual persons. They also do not provide guidance about *why* people find a given technology to be usefulness or easy to use.

Figure E1. Technology Acceptance Model (TAM; Davis, 1989).

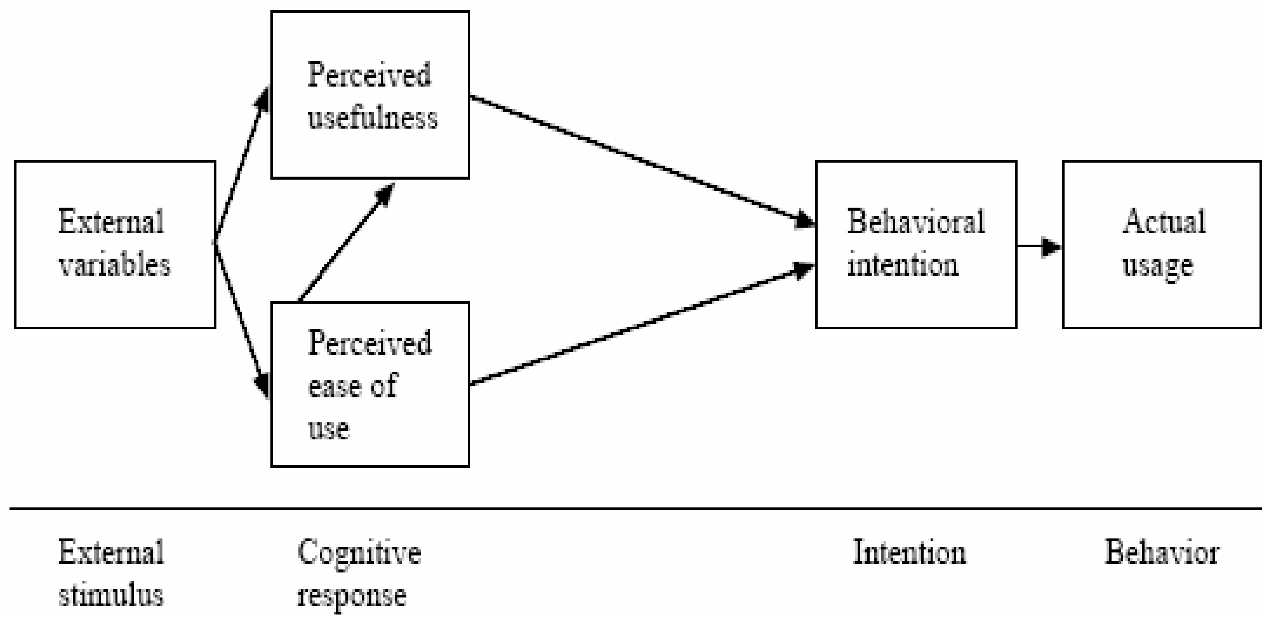

Figure E2. Extended Technology Acceptance Model (Mathieson, Peacook, & Chin, 2001).

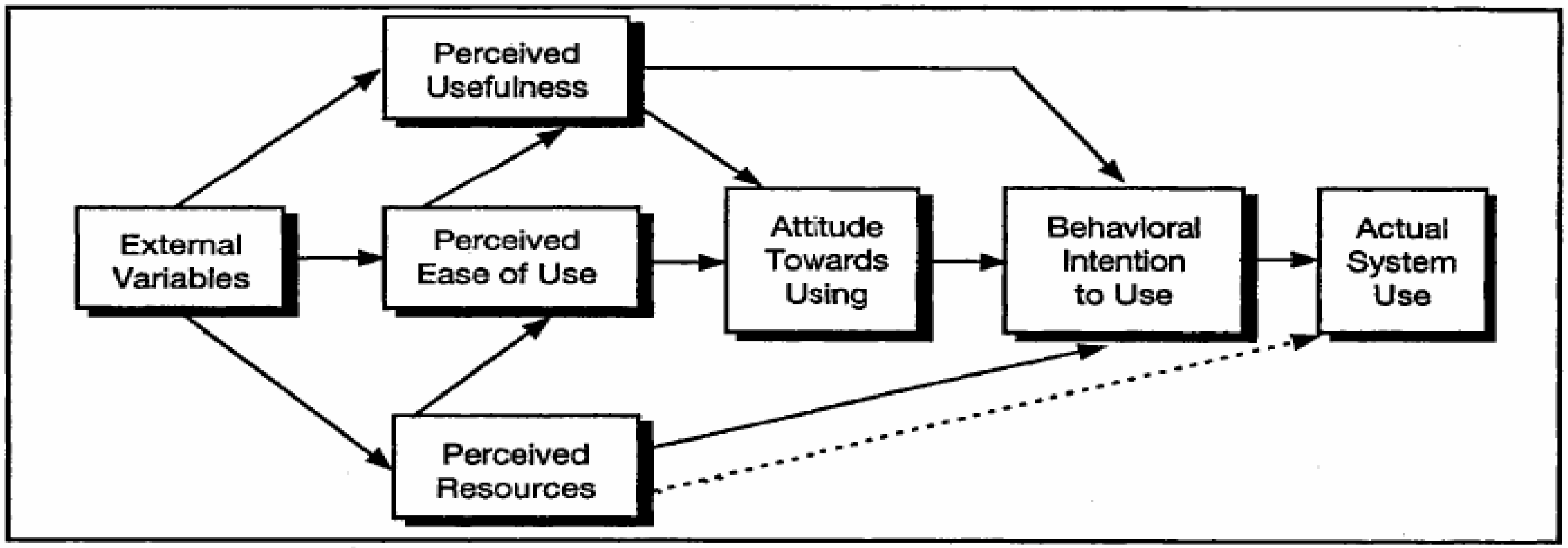

Figure 3. The Extended Technology Acceptance Model

Figure E3. Technology Acceptance Model with adiditonal variables (Luarn & Lin, 2005).

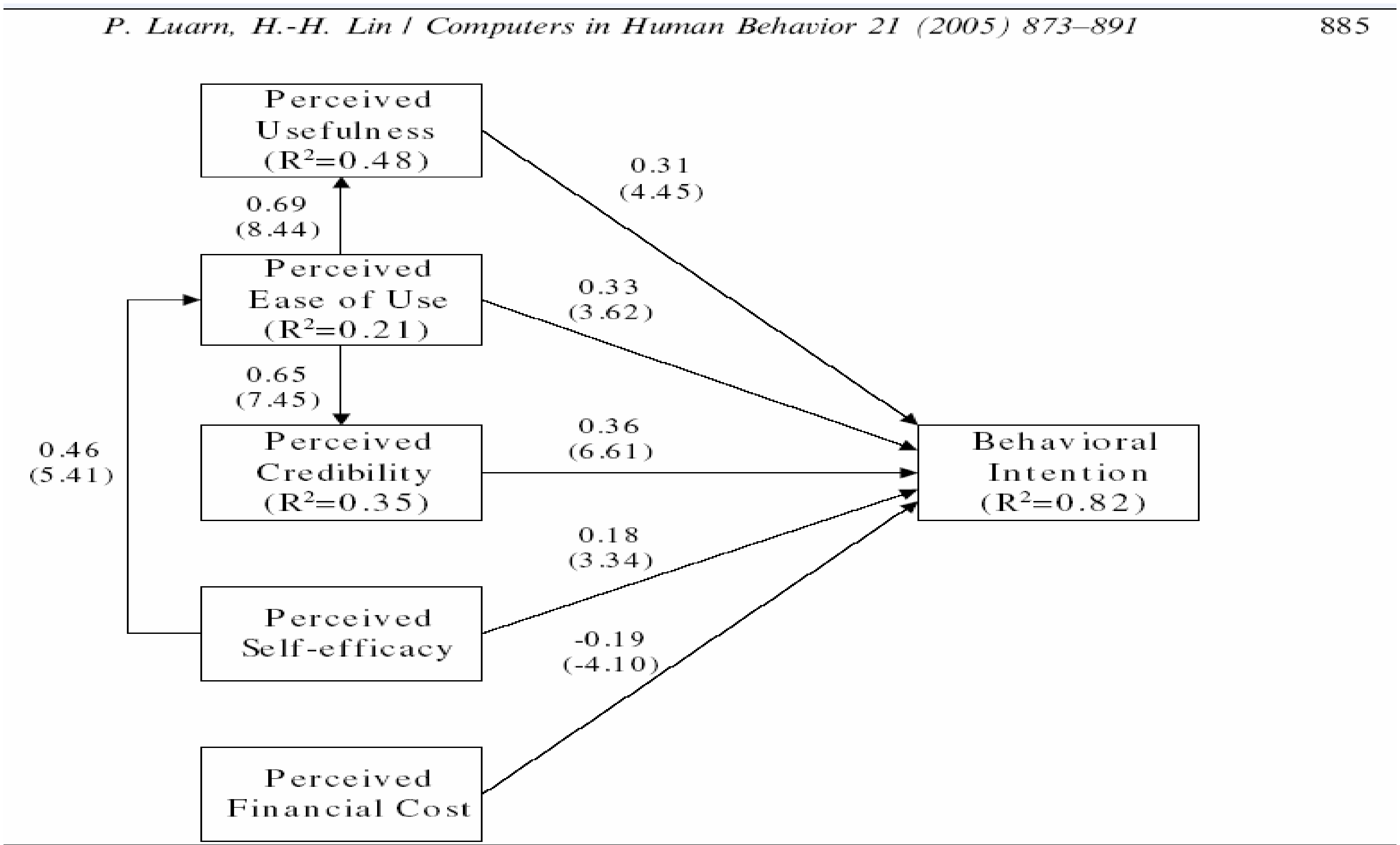

Figure E4. Theoretical Research Model – Extension of TAM (Seyal & Pijpers, 2004).

Senior government executives' use of the internet 201

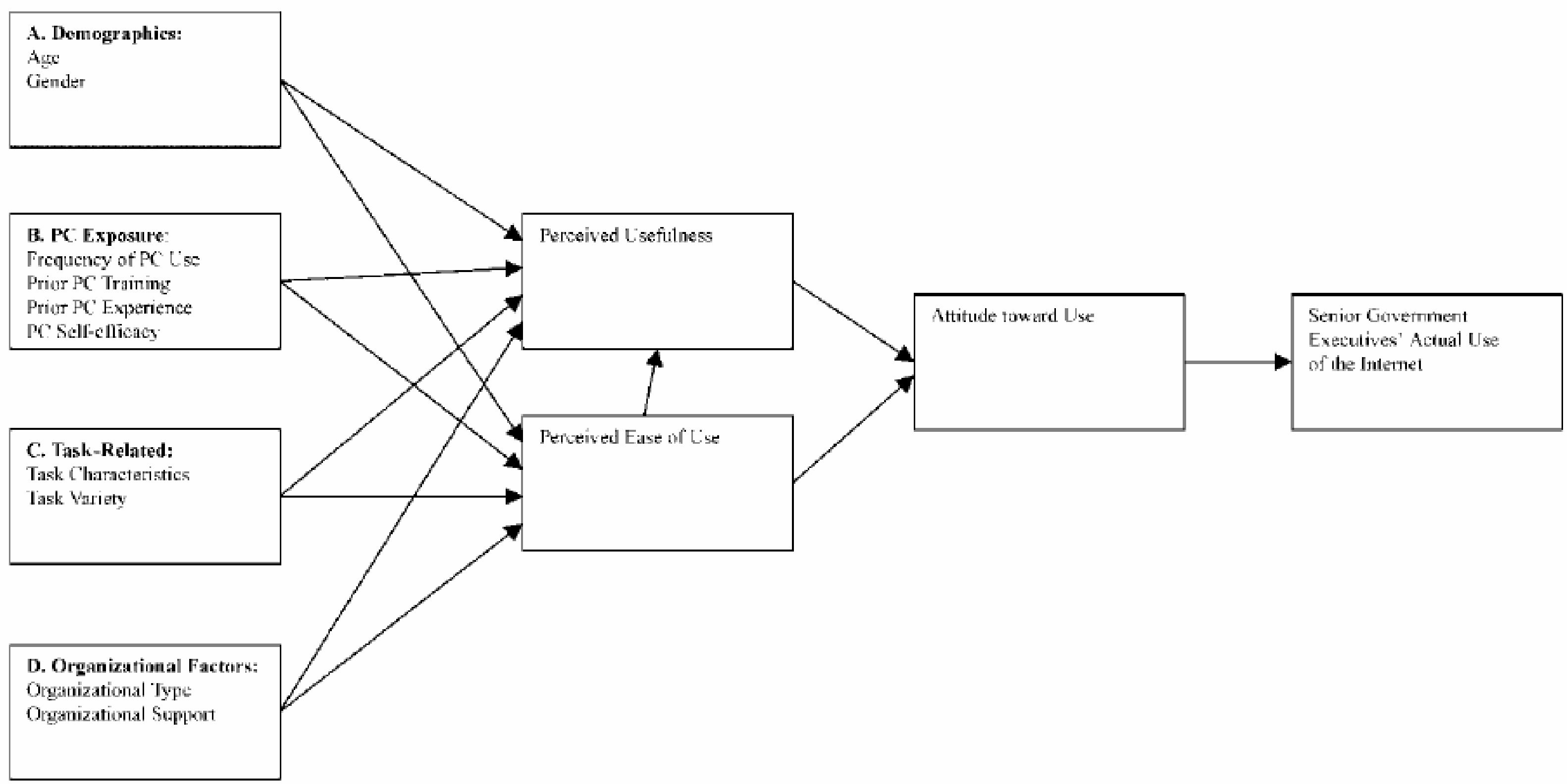

Figure 1. Theoretical Research Model (Extension of TAM).

Figure E5. Testing the TAM (Liaw & Huang, 2003).

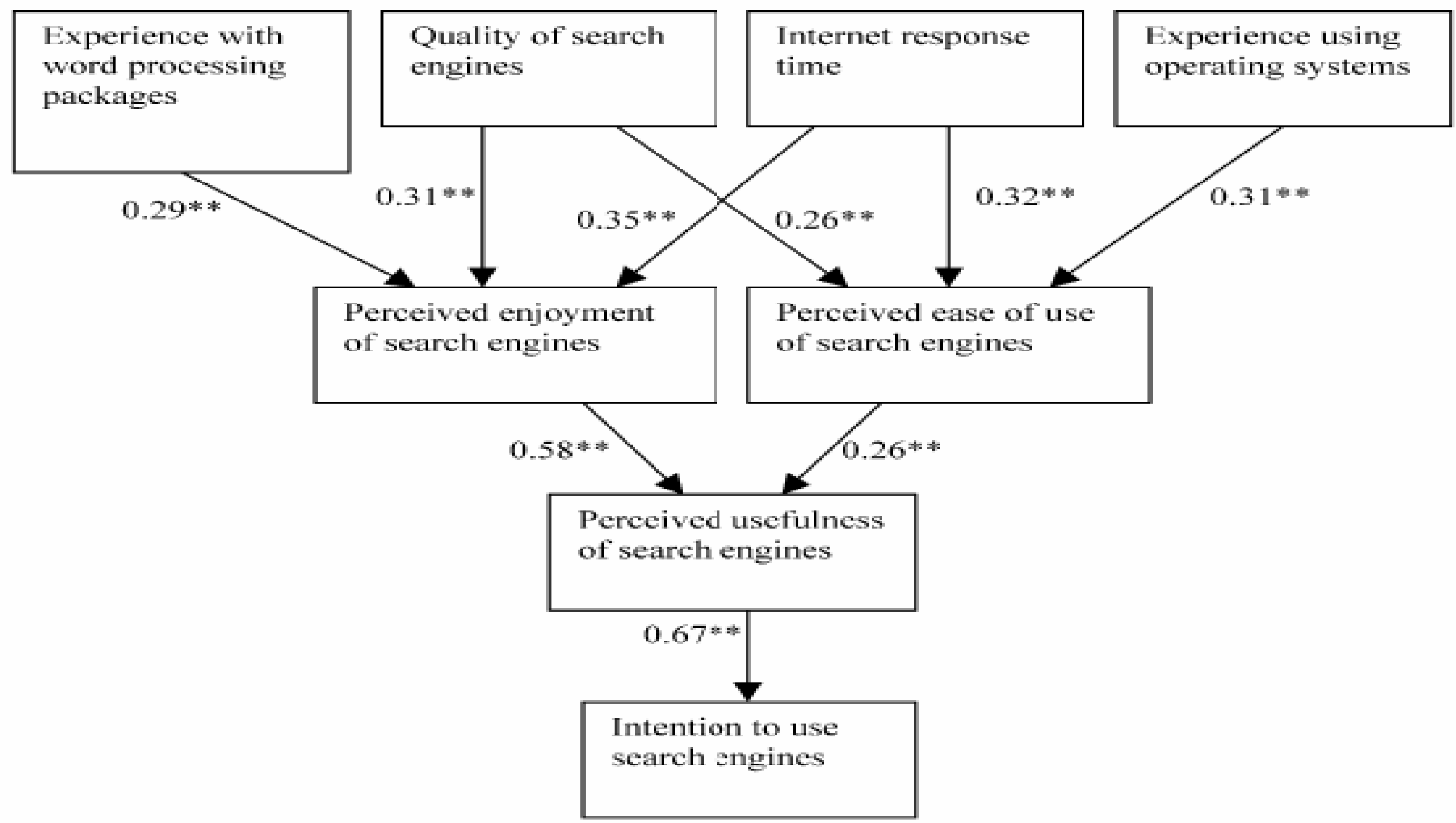

Fig. 2. The results of regression analyses. $^{**}P < 0.01$.

Figure E6. Incorporating risk factors into the TAM (Featherman & Pavlou, 2003).

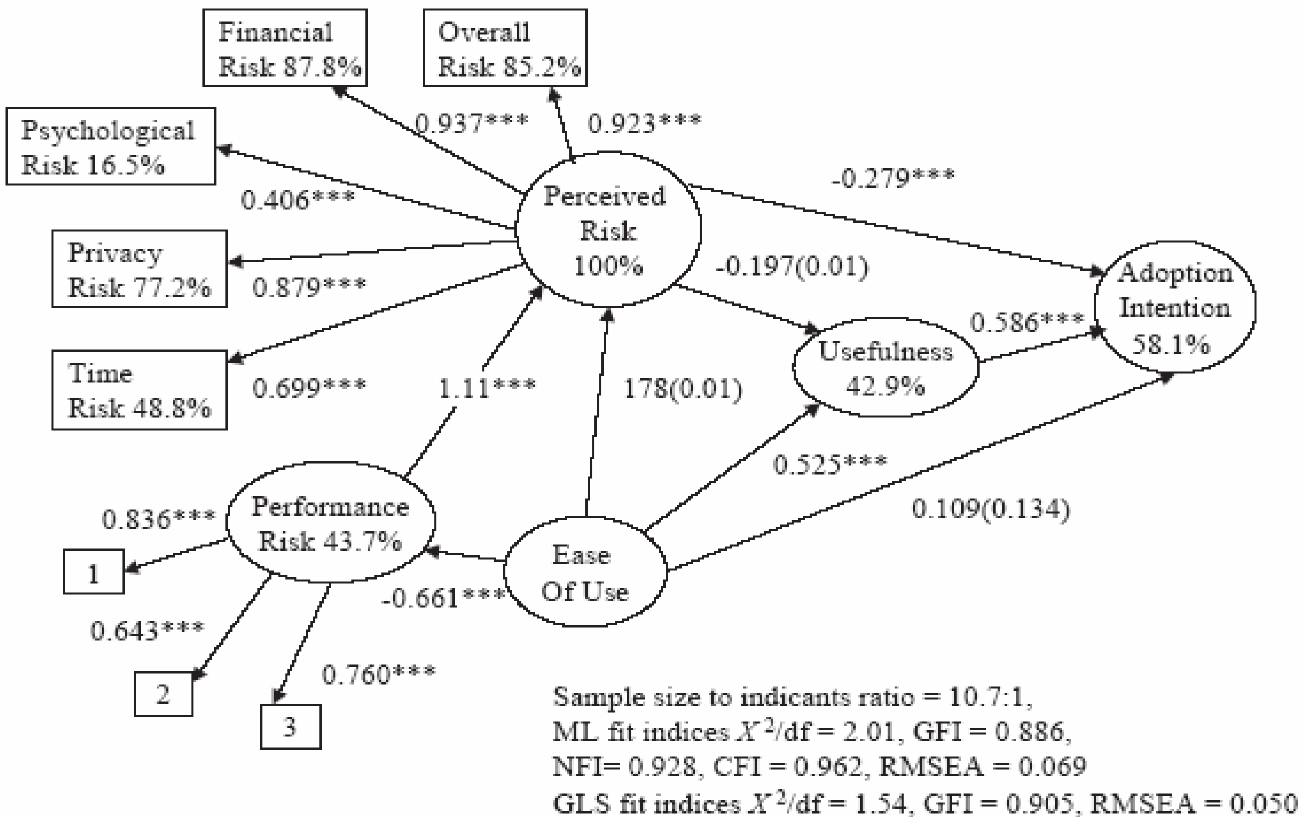

Fig. 4. Final structural equation model.