

# Development, Extension, and Application: A Review of the Technology Acceptance Model

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## Abstract

With the continued implementation of a wide range of technologies both by individuals and within organizations, user acceptance remains a significant area of study. The question of why people decide to accept or reject a particular technology continues to be an important issue. Numerous models have been developed and applied to a broad scope of technologies. One of the most influential and often used models for examining user acceptance is the Technology Acceptance Model or TAM. Although seminal articles were written almost two decades ago, this model continues to be used extensively. This paper examines the development, extension, and application of TAM and identifies three specific areas for future research. It contributes to information systems educators by providing faculty with a foundation from which to guide students in the area of technology acceptance research as well as a starting point from which to evaluate emerging technologies for potential classroom use. In general, this paper provides a relatively brief, but informative, overview of TAM for those interested in user acceptance of technology.

**Keywords:** technology acceptance model, user acceptance, determinants, external variables, history

## 1. INTRODUCTION

With the ever-increasing implementation of information technology into personal and organizational settings, the question of why people decide to accept or reject a particular technology continues to be a major issue. Both the companies that develop information technologies and those that implement them make a significant investment of time and money. If people choose not to accept and use these technologies, many companies stand to suffer considerable loss. Thus, having a better understanding of why people accept or reject various information technologies is crucial.

The Technology Acceptance Model or TAM (Davis, 1989; Davis et al., 1989) has become a predominant model for examining the factors of user acceptance. Although the seminal articles in this area were written almost two decades ago, this topic is still a highly prominent research area. Several reasons can be identified for its predomi-

nance: (1) its specific focus on information technologies; (2) its proven validity and reliability; (3) its extensive application; and (4) its accumulated research tradition. Specifically, this review seeks to examine the development, extension, and application of TAM in an attempt to identify possible gaps in the research and propose potential areas for future research. Additionally it provides information system educators with a foundation for guiding students through the TAM literature and examining emerging technologies for classroom adoption. In general, it serves as a helpful reference guide for those interested in user acceptance of technology.

## 2. METHODOLOGY

The methodology for examining TAM-related literature consisted of a keyword search on three electronic databases which included ABI Inform, Academic Search Premier, and IEEE Express. Due to the extensive number of articles utilizing TAM the selection of articles was based on the following criteria:

(1) as an extension of Legris, Ingham, and Colletette (2003), who conducted an analysis of articles published between 1980 and the initial part of 2001, this review primarily examined articles published between 2001 and 2005, with minimal overlap; (2) for consistency in comparison only articles utilizing quantitative research methods (e.g., PLS, LISREL, path or regression analysis) were included; (3) however, unlike Legris et al., who limited their review to 6 information technology related journals, a broader range of journals was chosen. Similar articles were grouped based on logical categories chosen by the author rather than on any previously defined classification schemes (Strauss and Corbin, 1998).

### **3. DEVELOPMENT OF THE TECHNOLOGY ACCEPTANCE MODEL**

#### **Original TAM**

Adopting constructs from the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975), the original TAM (Davis, 1989) identified perceived usefulness and perceived ease of use as major determinants of intention to use a technology. A third construct, attitude, was included as a mediating factor between these two determinants and behavioral intent. It was further hypothesized that based on behavioral intent, a prediction of actual usage could be made. Davis defined perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance" (p. 320), whereas perceived ease of use was defined as "the degree to which a person believes that using a particular system would be free of effort" (p. 320). Two studies were conducted to test these hypotheses. The first was conducted among 120 users employed by IBM. The technologies included PROFS, an electronic mail system, and XEDIT, a general editor. The second was conducted among 40 MBA students using two different charting tools, ChartMaster and Pendraw.

Although both perceived usefulness and perceived ease of use were statistically proven to be significant determinants of behavioral intention, results of the two studies revealed that perceived usefulness was a significantly stronger determinant than perceived ease of use (Davis, 1989). This phenomena was explained by arguing that regardless of how

easy the technology was to use if it was not perceived as beneficial or did not help improve job performance, ease of use was considered irrelevant by the user. The study also found that perceived ease of use may actually serve more as an antecedent to perceived usefulness than a direct parallel determinant of system usage. So, in essence the first priority for users is usefulness followed by ease of use. Another finding indicated that attitude was only a partial mediator of perceived usefulness and perceived ease of use on behavioral intent.

#### **Parsimonious TAM**

Davis et al. (1989) applied TAM in a study conducted among 107 MBA students using a word processing application called WriteOne. The results of their study confirmed the findings of Davis (1989). Perceived usefulness continued to show a strong influence on intention, whereas perceived ease of use was less influential, but still significant. Davis et al. also found that attitude did not fully mediate perceived usefulness and perceived ease of use. Based on these complimentary findings, therefore, a more parsimonious TAM was suggested which removed the attitude construct from the model.

#### **TAM2**

Due to the consistent findings that perceived usefulness was a major determinant of intention to use (Davis, 1989; Davis et al., 1989) Venkatesh and Davis (2000) proposed an extended model named TAM2. This model sought to identify external variables influencing perceived usefulness. These variables included subjective norm, the influence of others on the user's decision to use or not use the technology; image, the desire of the user to maintain a favorable standing among others; job relevance, the degree to which the technology was applicable; output quality, the extent to which the technology adequately performed the required tasks; and result demonstrability, the production of tangible results. Experience and voluntariness were included as moderating factors of subjective norm.

Venkatesh and Davis (2000) conducted a longitudinal study including two voluntary environments and two involuntary environments. The two voluntary environments consisted of studies conducted among 38 floor supervisors using a proprietary system

and 39 personal financial services employees migrating to a Windows-based environment. The two mandatory environments included studies conducted among 43 accounting firm services employees working on a Windows-based account management system and 36 investment banking employees utilizing a stock portfolio analysis system.

The pooled results across studies and time periods revealed that subjective norm, image, job relevance, and result demonstrability were significant determinants of perceived usefulness. It was also shown that subjective norm, perceived usefulness and perceived ease of use were direct determinants of intention to use (Venkatesh & Davis, 2000). As was the case in the original and parsimonious TAM (Davis, 1989; Davis et al., 1989), perceived ease of use was a significant determinant of perceived usefulness. The only two-way relationship shown to be significant was between output quality and job relevance. The two-way relationship between subjective norm and experience and subjective norm and voluntariness were not significant (Venkatesh & Davis, 2000).

#### **Antecedents of Perceived Ease of Use**

With the development of TAM2, Venkatesh & Davis (2000) added multiple antecedents to perceived usefulness because it was shown to be such a strong determinant of intention to use. Prior to the development of TAM2, Venkatesh and Davis (1996) argued that it was also important to examine the antecedents of perceived ease of use. Venkatesh and Davis (1996), therefore, examined the affect of computer self-efficacy and objective usability on perceived ease of use. Computer self-efficacy addressed how users perceive their ability to use technology in general, while objective usability introduced an objective system measure into the model. In this study in particular the keystroke model method and comparison of novice and expert performance were utilized. It was argued that computer self-efficacy is a constant influence on perceived ease of use, while objective usability is itself influenced over time by direct experience. The results of the study revealed that computer self-efficacy served as a determinant of perceived ease of use prior to and after hands-on use, however, objective usability acted as a determinant only after direct experience.

Venkatesh (2000) revisited the antecedents of perceived ease of use. In addition to computer self-efficacy and objective usability, this model included several other antecedents. These antecedents included: perceptions of external control, such as availability of support staff; computer anxiety, fear of or apprehension toward information technology; computer playfulness, the desire to play and explore the technology; and perceived enjoyment, which examined enjoyment apart from performance consequences. Venkatesh conducted a study among three organizations in which three measurements were taken over a three month period. The pooled results indicated that in time one, perceived enjoyment and objective usability were not significant. In time two, all antecedents were significant. Finally, in time three, computer playfulness was not significant. Objective usability was not significant until the second measure, and its influence further increased in the third measure, supporting the findings of Venkatesh and Davis (1996) that objective usability is influenced by direct experience.

#### **4. EXTENSION OF THE TECHNOLOGY ACCEPTANCE MODEL**

##### **Determinants of Intention to Use and Attitude**

The original TAM (Davis, 1989) identified perceived usefulness and attitude as direct determinants of use, whereas, the parsimonious TAM (Davis et al., 1989) showed that perceived usefulness and perceived ease of use were direct determinants. Several additional determinants have been postulated as having a direct influence on the behavior of users as well.

Hu, Lin, and Chen (2005) and Chau and Hu (2002) examined the influence of subjective norm on behavioral intention. Hu et al. mimicked the results of Venkatesh and Davis (2000) by finding subjective norm to be significant. However, the results of Chau and Hu opposed these findings, indicating that subjective norm was not significant.

Hu et al. (2005) found that availability, the perception that the information technology would be available to use, was not a significant determinant of use. Huang (2005) and Moon and Kim (2001) examined the influence of perceived playfulness. Huang found

that perceived playfulness was not significant, whereas, Moon and Kim found that it was significant. Gong, Yu, and Xu (2005) applied computer self-efficacy to intention to use as opposed to perceived ease of use (Venkatesh & Davis, 1996, 2000) and found that it was also a significant determinant. Mathieson, Peacock, and Chinn (2004), added perceived resources, "the extent to which an individual believes that he or she has the personal and organizational resources needed to use an IS" (p. 89) to the model. Perceived resources was significant.

Perceived behavioral control (Chau & Hu, 2002), adopted from the Theory of Planned Behavior, application specific self-efficacy (Yi & Hwang, 2003), and perceived enjoyment (Van der Heijden, 2004) were all found to be significant determinants of intention to use. Table 1 summarizes the findings.

Table 1: Determinants of Intention to Use

Author	Determinant	Finding
Chau & Hu (2002)	Perceived Behavioral Control	Significant
Gong et al. (2003)	Computer Self-efficacy	Significant
Hu et al. (2005)	Availability	Significant
Huang (2005); Moon & Kim (2001)	Perceived Playfulness	Not significant; Significant
Mathieson et al. (2004)	Perceived Resources	Significant
Van der Heijden (2004)	Perceived Enjoyment	Significant

In addition to perceived usefulness and perceived ease of use (Davis, 1989), perceived playfulness (Moon & Kim, 2001), and relevance (Shih, 2004) have been shown to be significant determinants of attitude. Table 2 summarizes the findings.

Table 2: Determinants of Attitude

Author	Determinant	Finding
Huang (2005); Moon & Kim (2001)	Perceived Playfulness	Significant
Shih (2004)	Relevance	Significant

**External Variables of Usefulness and Ease of Use**

Davis et al. (1989) identified that one purpose of TAM is to serve as a starting point for examining the impact that external variables can have on behavioral intention. Consequently, numerous studies have extended the various versions of TAM to include a broad range of external influences.

In addition to perceived ease of use (Davis, 1989; Davis et al., 1989) and the antecedents included in TAM2 (Venkatesh & Davis, 2000), numerous external variables believed to influence perceived usefulness have been tested. The following external variables were all found to be significant determinants of perceived usefulness: efficiency gain, improvement of task performance efficiency (Hu et al., 2005); perceived risk, "the uncertainty that customers face when they cannot foresee the consequences of their purchase decisions" (Chan & Lu, 2004, p. 24); shared belief in benefits, organizational, and personal beliefs shared among superiors and peers (Amoako-Gyampah & Salam, 2004); computer attitude (Chau, 2001); relevance (Hong, Thong, Wong, & Tam, 2001-2002; Shih, 2004); and perceived enjoyment (Liaw & Huang, 2003; Yi & Hwang, 2003). Table 3 summarizes the findings.

Table 3: External Variables of Perceived Usefulness

Author	External Variable	Finding
Amoako-Gyampah et al. (2004)	Shared Beliefs	Significant
Chan & Lu (2004)	Perceived Risk	Significant
Chau (2001)	Computer Attitude	Significant
Hong et al. (2001-2002); Shih (2004)	Relevance	Significant
Hu et al. (2005)	Efficiency Gain	Significant
Liaw & Huang (2003); Yi & Hwang (2003)	Perceived Enjoyment	Significant

Venkatesh (1996) and Venkatesh and Davis (2000) tested multiple antecedents of perceived ease of use. Computer self-efficacy, in particular, has been evaluated in numerous other studies. Several studies have confirmed that computer self-efficacy is a significant determinant of perceived ease of use (Chan & Lu, 2004; Gong et al., 2004; Hong et al., 2001-2002). One study, however, indicated that it was not significant (Chau, 2001). Perceived enjoyment (Venkatesh, 2000) was employed in a study by Yi and Hwang (2003) and was also found to be significant.

Other external variables found to be significant determinants of perceived ease of use included: shared belief in benefits and training (Amoako-Gyampah & Salam, 2004); knowledge of search domain (Hong et al., 2001-2002); relevance (Hong et al., 2001-2002; Shih, 2004); and individual computer experience (Liaw & Huang, 2003). External variables found not to be significant determinants included computer attitude (Chau, 2001) and perceived resources (Mathieson et al., 2001). Table 4 summarizes the findings.

Table 4: External Variables of Ease of Use

Author	External Variable	Finding
Amoako-Gyampah et al. (2004)	Shared Beliefs, Training	Significant
Chau (2001)	Computer Attitude	Not significant
Hong et al. (2001-2002)	Knowledge of Search Domain	Significant
Hong et al. (2001-2002); Shih (2004)	Relevance	Significant
Liaw & Huang (2003)	Individual Computer Experience	Significant
Mathieson et al. (2001)	Perceived Resources	Not significant

**5. APPLICATION OF THE TECHNOLOGY ACCEPTANCE MODEL**

**Original TAM**

The popularity of the original TAM can be seen in the numerous studies that have used it to evaluate the user acceptance of various technologies. In the initial study conducted

by Davis (1989) the results indicated that both perceived usefulness and perceived ease of use were significant determinants of usage, but with perceived usefulness showing a significant stronger effect. Several recent studies appear to confirm these results. Hu et al. (2005) conducted a study among 283 law enforcement officers using an intelligence and security informatics technology called COPLINK. Huang (2005) evaluated 390 subjects using a women-centric Website. Amoako-Gyampah and Salam (2004) looked at the implementation of an enterprise wide resource planning system among 409 end-users. Mathieson et al. (2001) investigated user acceptance of a bulletin board system by 401 members of an organization for professional accountants. Finally, Chau and Hu (2002) conducted a study among 408 physicians on the use of telemedicine technology. In all of these studies, perceived usefulness was shown to be a stronger significant determinant than perceived ease of use. Table 5 summarizes the findings.

Table 5: Supporting Studies of the Original TAM

Author	Technology	Sample Size
Amoako-Gyampah & Salam (2004)	ERP system	409 end-users
Chau & Hu (2002)	Telemedicine	408 physicians
Hu et al. (2005)	COPLINK	283 police officers
Huang (2005)	Women-centric Website	390 subjects
Mathieson et al. (2004)	Bulletin board system	401 members

However, several studies show just the opposite. Gong et al. (2004) conducted a study among 152 full-time teachers enrolled in a part-time Bachelor of Education program. Moon and Kim (2001) examined World Wide Web acceptance by 152 graduate students. Shih (2004) looked at Internet utilization behavior of 203 Taiwanese office workers. Finally, Brown, Massey, Montoya-Weis, and Burkman (2002) evaluated 107 bank employees using a computer banking system. In each case, perceived ease of use was shown to be a stronger determinant

than perceived usefulness. Table 6 summarizes the findings. Table 7 summarizes the impact of attitude on intention to use in the original TAM (Davis, 1989).

Table 6: Opposing Studies of the Original TAM

Author	Technology	Sample Size
Brown et al. (2002)	Computer banking system	107 bank employees
Gong et al. (2004)	Web-based learning system	152 teachers
Moon & Kim (2001)	World Wide Web	152 graduate students
Shih (2004)	Internet utilization behavior	203 office workers

Table 7: Influence of Attitude on Intention to Use

Significant	Not Significant
Amoako-Gyampah & Salam (2004); Chau & Hu (2002); Huang (2005); Gong et al. (2004); Mathieson et al. (2004); Moon & Kim (2001); Shih (2004)	Brown et al. (2002); Hu et al. (2005)

**Parsimonious TAM**

The parsimonious TAM also continues to be used frequently in the literature. This model developed by Davis et al. (1989) argued that attitude did not fully mediate perceived usefulness and perceived ease of use and therefore should be excluded. In their study it was revealed that both perceived usefulness and perceived ease of use were significant determinants of behavioral intention with perceived usefulness showing the strongest effect. In recent studies these results have been confirmed. Hong et al. (2001-2002) conducted a study among 585 students using a digital library. Chau (2001) looked at acceptance of general IT usage among 360 undergraduate business students using a word processor, spreadsheet, presentation software, and a database. Liaw and Huang (2003) researched user acceptance among 114 medical students utilizing search engines. Lin and Wu (2004) examined end-user computing among 195 workers from service, manufacturing, and extractive sectors in Taiwan. Yi and Hwang (2004) utilized

a Web-based system among 109 introductory information systems students.

Each of these studies either showed perceived usefulness as a stronger determinant on behavioral intent than perceived ease of use or showed that perceived ease of use was not a significant determinant. Table 8 summarizes the findings.

Table 8: Supporting Studies of the Parsimonious TAM

Author	Technology	Sample Size
Chau (2001)	General IT usage	360 undergraduates
Hong et al. (2001-2002)	Digital library	585 students
Liaw & Huang (2003)	Search engine	114 medical students
Lin & Wu (2004)	End-user computing	194 workers
Yi & Hwang (2004)	Web-based information system	109 students

One study, Van Der Heijden (2004) showed just the opposite. Table 9 summarizes the findings. An examination of the environment in which the study was conducted was also evaluated as either volitional or mandatory as summarized in Table 10.

Table 9: Opposing Studies of the Parsimonious TAM

Author	Technology	Sample Size
Van der Heijden (2004)	Hedonic information system	1114 users

**TAM2**

One study examined used the TAM2 (Venkatesh & Davis, 2000). Chan & Lu (2004) conducted a study of Internet banking among 499 undergraduate and graduate students. Results indicated that perceived usefulness was a strong determinant of behavioral intention, however, perceived ease of use was not significant.

Table 10: Study Environment

Volitional	Mandatory Use
Amoako-Gyampah & Salam (2004); Chan & Lu (2004); Chau (2001); Chau & Hu (2002); Hong et al. (2001-2002); Hu et al. (2005); Huang (2005); Gong et al. (2004); Liaw & Huang (2003); Lin & Wu (2004); Mathieson et al. (2004); Moon & Kim (2001); Shih (2004); Van der Heijden (2004); Yi & Hwang (2004)	Brown et al. (2002); Davis & Venkatesh (2000)

## 6. RESEARCH POTENTIAL

Based on the review of the literature, three potential areas of future research were identified. The first area involves the mixed results between perceived usefulness and perceived ease of use on intention to use. The second area concerns the environment in which a user acceptance study is conducted. The final area examines the role of attitude in the acceptance model.

### Mixed Results between Usefulness and Ease of Use

A first area of potential research is to examine more closely the mixed results between perceived usefulness and perceived ease of use as the stronger determinant of intention to use. In the studies reviewed, ten studies indicated that perceived usefulness was the stronger determinant, whereas, six studies revealed that perceived ease of use was stronger. A possible explanation of these mixed results might be the type of technology employed. Future research might attempt to classify studies based on the technology.

### Volitional versus Mandatory Use Environments

It is interesting to note that the majority of these studies were conducted within a volitional environment. That is, the user had the choice of whether to accept or reject the technology. In fact, Venkatesh (2000) noted that a volitional environment is one of the boundary conditions of TAM. Venkatesh fur-

ther suggested, however, that "future research should examine mandatory usage contexts to test the boundary conditions of the proposed model" (p. 358).

This was the basic premise of Brown et al. (2002) who sought to analyze a setting where the user has very little or no input on the type of technology implemented. This setting was referred to as a mandatory use environment which was defined as "one in which users are required to use a specific technology or system in order to keep and perform their jobs" (p. 283). The basic argument was that applying technology acceptance models to a mandatory use environment will yield results contrary to those produced in volitional environments.

Brown et al. (2002) concluded that "the results show a different pattern of relationships in the mandated environment than we have seen in prior research on voluntary adoption contexts" (p. 289). As suggested by Brown et al., there may be additional determinants that exist to better explain acceptance of technology. This line of research investigating the use of technology acceptance models for mandatory use environments has promise for future research.

### The Role of Attitude in User Acceptance

Although studies have shown that attitude does not fully mediate perceived usefulness and perceived ease of use (Davis, 1989; Davis et al., 1989), Davis et al. (1989) suggested that "more research is needed to identify the conditions under which attitudes mediate the belief-intention link" (p. 999). This review shows that all but one of the studies utilizing the original TAM (Davis, 1989) indicated that attitude was a significant direct determinant of behavioral use.

Even if attitude is not shown to be a significant determinant of behavioral intent as was the case in Hu et al. (2005), Brown et al. (2002) acknowledged this fact, but stated that the truth of the matter is that employees "will intend to use the system (in order to keep their jobs) regardless of whether they have positive or negative attitudes toward it" (p. 285). Brown et al. further pointed out that the importance of attitude often related more to job satisfaction, loyalty to superiors and the organization, and as a deterrent to system sabotage. It is possible

that these factors might serve as significant determinants of intention to use.

## 7. IMPORTANCE TO INFORMATION SYSTEMS EDUCATORS

This paper is important to information systems education because it provides a foundation for assisting faculty to guide students about the types of technologies that have been evaluated using TAM. It also provides a quick summary of statistical significance of the various determinants and external variables that have been incorporated into the model. Faculty members may also find this paper a helpful starting point as they begin to evaluate various hardware, software, and emerging technologies for implementation into the classroom setting. Technologies evaluated in this review geared toward educational purposes included Web-based learning systems, digital libraries, and search engines. It is the author's hope that this brief, but informative, overview of recent studies conducted using TAM will reduce the amount of time that faculty need to spend researching the subject of user acceptance of technology and will serve as a ready reference for the topic.

## 8. CONCLUSION

From the sheer volume of research conducted using TAM since it was first published, the popularity of the model is quite evident. A strength of the model as evidenced by the literature is its flexibility and applicableness. This is shown by the numerous direct determinants and external variables that have been added to the model and the various technologies to which it has been applied. Because of the growing use of information technologies within personal and professional contexts, it appears that the issue of user acceptance should continue to be of great importance.

To reiterate the purpose of this review, the author sought to examine the development, extension, and application of TAM. In doing so, it was shown that TAM has progressed through a rigorous development process, has tremendous flexibility to be extended, and is applicable to many different information technologies. This review also identified three specific areas of potential research: (1) the mixed results of perceived usefulness and perceived ease of use as the stronger

determinant; (2) volitional versus mandatory use environments; and (3) the role of attitude in user acceptance. Finally, this review provides both a ready reference for information systems educators as well as a general overview of TAM for those interested in the area of technology acceptance.

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