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Overview of the Technology Acceptance Model: Origins, Developments and Future Directions

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User acceptance of technology has been an important field of study for over two decades now. Although many models have been proposed to explain and predict the use of a system, the Technology Acceptance Model has been the only one which has captured the most attention of the Information Systems community. Thus, it is essential for anyone willing to study user acceptance of technology to have an understanding of the Technology Acceptance Model. This paper provides a historical overview of the Technology Acceptance Model (TAM) by summarizing the evolution of TAM, its key applications, extensions, limitations, and criticisms from a selective list of published articles on the model. Current observations indicate that although TAM is a highly cited model, researchers share mixed opinions regarding its theoretical assumptions, and practical effectiveness. It is concluded that research in TAM lacks sufficient rigor and relevance that would make it a well established theory for the IS community.

Keywords: Technology Acceptance, Information System Deployment, TAM, Information System Theory.

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Overview of the Technology Acceptance Model: Origins, Developments and Future Directions

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Abstract
User acceptance of technology has been an important field of study for over two decades now. Although many models have been proposed to explain and predict the use of a system, the Technology Acceptance Model has been the only one which has captured the most attention of the Information Systems community. Thus, it is essential for anyone willing to study user acceptance of technology to have an understanding of the Technology Acceptance Model. This paper provides a historical overview of the Technology Acceptance Model (TAM) by summarizing the evolution of TAM, its key applications, extensions, limitations, and criticisms from a selective list of published articles on the model. Current observations indicate that although TAM is a highly cited model, researchers share mixed opinions regarding its theoretical assumptions, and practical effectiveness. It is concluded that research in TAM lacks sufficient rigor and relevance that would make it a well established theory for the IS community.

Introduction

With growing technology needs in the 1970's, and increasing failures of system adoption in organizations, predicting system use became an area of interest for many researchers. However, most of the studies carried out failed to produce reliable measures that could explain system acceptance or rejection (Davis, 1989). In 1985, Fred Davis proposed the Technology Acceptance Model (TAM) in his doctoral thesis at the MIT Sloan School of Management (Davis, 1985). He proposed that system use is a response that can be explained or predicted by user motivation, which, in turn, is directly influenced by an external stimulus consisting of the actual system's features and capabilities (Figure 1).

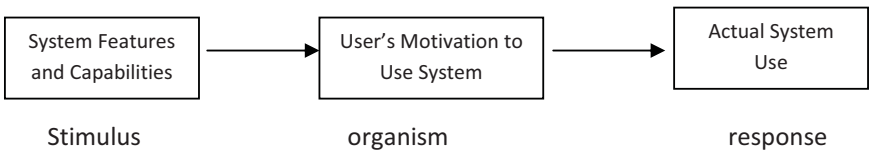

Figure 1: Conceptual model for technology acceptance (Davis, 1985, p. 10).

By relying on prior work by Fishbein and Ajzen (1975), who formulated the Theory of Reasoned Action, and other related research studies, Davis further refined his conceptual model to propose the Technology Acceptance Model as shown in Figure 2.

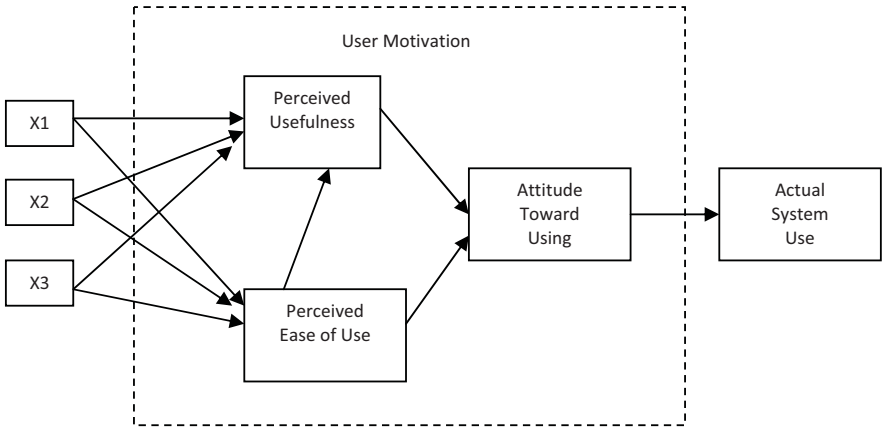

Figure 2: Original TAM proposed by Fred Davis (Davis, 1986, p. 24).

In this proposal, Davis (1985) suggested that users' motivation can be explained by three factors: *Perceived Ease of Use*, *Perceived Usefulness,* and *Attitude Toward Using* the system. He hypothesized that the attitude of a user toward a system was a major determinant of whether the user will actually use or reject the system. The attitude of the user, in turn, was considered to be influenced by two major beliefs: perceived usefulness and perceived ease of use, with perceived ease of use having a direct influence on perceived usefulness. Finally, both these beliefs were hypothesized to be directly influenced by the system design characteristics, represented by X_1, X_2 and, X_3 in Figure 2.

During later experimentation stages, Davis (1985) would refine his model to include other variables and modify the relationships that he initially formulated. Similarly, other researchers would apply, and propose several additions to the Technology Acceptance Model (TAM), such that over time, TAM evolved into a leading model in explaining and predicting system use. In fact, TAM has become so popular that it has been cited in most of the research that deals with user acceptance of technology (Lee, Kozar, & Larsen, 2003). However, some researchers claim that TAM may have attracted more easy and quick research, such that less attention has been given to the real problem of technology acceptance (Lee, Kozar, & Larsen, 2003). Today, research on technology acceptance is still ongoing, and thus an understanding of the assumptions, strengths, and limitations of the Technology Acceptance Model is essential for anyone willing to study user acceptance of technology.

This paper therefore, examines the historical evolution of TAM in the IS literature from 1985 to 2007, focusing on its historical origin, and some of its major applications, validations, extensions, and criticisms. Findings from a selective list of articles published on TAM are thus, summarized and organized as follows: the next section briefly describes the Theory of Reasoned Action proposed by Fishbein and Ajzen (1975), followed by a description of how the measures of perceived usefulness and perceived ease of use for TAM were developed and validated. Then, the method used to determine the causal relationships between the different constructs of TAM will be described. Subsequently, several applications of TAM will be presented followed by different

extensions proposed to the original TAM. Finally, the paper will conclude with a note on the foreseeable future for TAM after having elaborated on its limitations and criticisms.

The Theory of Reasoned Action

Figure 3 shows a model of the Theory of Reasoned Action, which was proposed by Fishbein and Ajzen (1975).

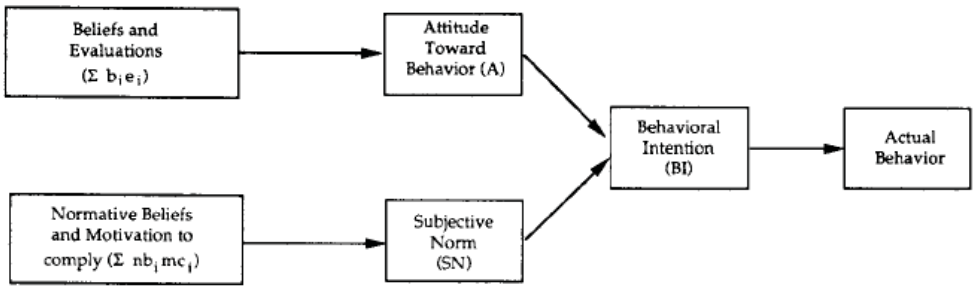

Figure 3: The Theory of Reasoned Action model (Davis, Bagozzi and Warshaw, 1989)

In their theoretical model, Fishbein and Ajzen suggested that a person's actual behavior could be determined by considering his or her prior intention along with the beliefs that the person would have for the given behavior (Davis, 1985). They referred to the intention that a person has prior to an actual behavior as the behavioral intention of that person, and defined it as a measure of one's intention to perform a behavior.

Fishbein and Ajzen also proposed that behavioral intention could be determined by considering both the attitude that a person has towards the actual behavior, and the subjective norm associated with the behavior in question. They defined the attitude towards a given behavior as a person's positive or negative feelings about performing the actual behavior, suggesting that the attitude of a person towards a behavior (A) can be measured by considering the sum of the product of all salient beliefs (b_i) about consequences of performing that behavior, and an evaluation (e_i) of those consequences, as shown by the following formula:

$$A = \sum b_i e_i.$$

They also defined the subjective norm associated with a behavior as the person's perception that most people who are important to him or her think he or she should or should not perform the behavior. Fishbein and Ajzen, then suggested that subjective norm (SN) could be determined by considering the sum of the product of a person's normative beliefs (nb_i), that is perceived expectations of other individuals or groups, and his or her motivation to comply (mc_i). The formula they proposed for measuring the subjective norm associated with an actual behavior is as follows.

$$SN = \sum nb_i mc_i.$$

Thus, the behavioral intention (BI) of a person to perform a behavior could be calculated using the formula shown below, with A as a measure of the attitude toward the behavior and SN as a measure of the subjective norm associated with the behavior considered.

$$BI = A + SN$$

The Theory of Reasoned Action thus, provided a useful model that could explain and predict the actual behavior of an individual. Ten years later, Davis (1985) took the same

model and adapted it to the context of user acceptance of an information system, in order to develop the Technology Acceptance Model. Davis considered that the actual use of a system is a behavior and thus, the Theory of Reason Action would be a suitable model to explain and predict that behavior. Davis however, made two main changes to the Theory of Reasoned Action (TRA) model. Firstly, he did not take subjective norm into account in predicting the actual behavior of a person. He suggested that Fishbein and Ajzen (1975) themselves acknowledged that subjective norm was the least understood aspect of TRA, and that it had uncertain theoretical status. Thus, Davis (1985) only considered the attitude of a person towards a given behavior in his TAM model. Secondly, instead of considering several individual salient beliefs to determine the attitude towards a given behavior, Davis (1985) relied on several other related studies to identify only two distinct beliefs, perceived usefulness and perceived ease of use, that were sufficient enough to predict the attitude of a user toward the use of a system.

Related studies on perceived usefulness and perceived ease of use

Prior to the work of Davis (1985), several studies had highlighted the importance of perceived ease of use and perceived usefulness in predicting a person's behavior. An extensive review of these studies can be found in Davis (1985). For now, only some of them are described.

Schultz and Slevin (1975), for instance, carried out an exploratory study, and found that perceived usefulness provided a reliable prediction for self-predicted use of a decision model. Robey (1979) later replicated the work of Schultz and Slevin (1975), and confirmed the high correlation that existed between perceived usefulness and system usage. On the other hand, support for the importance of perceived ease could be found in the meta-analysis of Tornatzky and Klein's (1982) on innovation adoption. Tornatzky and Klein studied the relationship between the characteristics of an innovation and its adoption, and found that the complexity of an innovation was one of the three factors that had the most consistent significant relationships among a wide range of innovation types.

Bandura (1982) further, showed the importance of considering both perceived ease of use and perceived usefulness in predicting behavior. He suggested that in any given instance, behavior would be best predicted by both, self-efficacy and, outcome judgments. Self-efficacy, which was similar to perceived ease of use, was defined as judgments of how well one can execute courses of action required to deal with prospective situations, whereas outcome judgment, which was similar to perceived usefulness, was defined as the extent to which a behavior once successfully executed is believed to be linked to valued outcomes.

Similarly, Swanson's research (1982) provided evidence that perceived ease of use and perceived usefulness were both important behavioral determinants. Swanson hypothesized that potential users will select and use information reports based on a tradeoff between perceived information quality and associated cost of access. In Swanson's work, information quality was similar to perceived usefulness, whereas associated cost of access was found to be similar to perceived ease of use.

In the end, Davis (1985) concluded that people tend to use or not to use a system to the extent that they believe it will help them perform their job better (perceived

usefulness), and also that the beliefs of the efforts required to use a system can directly affect system usage behavior (perceived ease of use). More formally, Davis (1985) defined perceived usefulness and perceived ease of use as follows:

> Perceived usefulness: *The degree to which an individual believes that using a particular system would enhance his or her job performance*.
>
> Perceived ease of use: *The degree to which an individual believes that using a particular system would be free of physical and mental effort.*

Davis then, proceeded to the problem of measuring both the perceived usefulness and perceived ease of use of a system

Developing measurement scales for perceived usefulness and perceived ease of use

To develop measurement scales for perceived ease of use and perceived usefulness, Davis referred to psychometric scales used in psychology (Davis, 1989). These scales typically prompt an individual to respond to various questions that pertain to a given context. Responses obtained from these prompts can then be analyzed, and used as an indication of a person's internal belief for the context considered. In the case of TAM, Davis developed his psychometric scales for both perceived ease of use and perceived usefulness in three stages: a pretesting phase, an empirical field study, and a laboratory experiment, and each time he modified and refined the scales.

In the pretesting phase, Davis (1989) interviewed 15 experienced computer users to evaluate 14 items that he thought would be suitable for measuring perceived ease of use, and perceived usefulness of a system. As shown in Tables 1 and 2, each belief, perceived ease of use and perceived usefulness, had 14 statements that were tailored towards the use of an electronic mail system.

Table 1
Initial scale items for perceived usefulness (Davis, 1989, p. 324)

Item No.	Candidate item for measuring for perceived usefulness
1	My job would be difficult to perform without electronic mail.
2	Using electronic mail gives me greater control over my work.
3	Using electronic mail improves my job performance.
4	The electronic mail system addresses my job-related needs.
5	Using electronic mail saves me time.
6	Electronic mail enables me to accomplish tasks more quickly.
7	Electronic mail supports critical aspects of my job.
8	Using electronic mail allows me to accomplish more work than would otherwise be possible.
9	Using electronic mail reduces the time I spend on unproductive activities.
10	Using electronic mail enhances my effectiveness on the job.
11	Using electronic mail improves the quality of the work I do.
12	Using electronic mail increases my productivity.
13	Using electronic mail makes it easier to do my job.
14	Overall, I find the electronic mail system useful in my job.

Table 2
Initial scale items for perceived ease of use (Davis, 1989, p. 324)

Item No.	Candidate item for measuring perceived ease of use
1	I often become confused when I use the electronic mail system.
2	I make errors frequently when using electronic mail.
3	Interacting with the electronic mail system is often frustrating.
4	I need to consult the user manual often when using electronic mail.
5	Interacting with the electronic mail system requires a lot of my mental effort.
6	I find it easy to recover from errors encountered while using electronic mail.
7	The electronic mail system is rigid and inflexible to interact with.
8	I find it easy to get the electronic mail system to do what I want it to do.
9	The electronic mail system often behaves in unexpected ways.
10	I find it cumbersome to use the electronic mail system.
11	My interaction with the electronic mail system is easy for me to understand.
12	It is easy for me to remember how to perform tasks using the electronic mail system.
13	The electronic mail system provides helpful guidance in performing tasks.
14	Overall, I find the electronic mail system easy to use.

The pretest phase assessed the semantic content of the items, and categorized them in clusters of similarities such that, items that were free from ambiguity, and accurate enough to measure either perceived ease of use or perceived usefulness were easily identified. Consequently, some items that did not cluster with other items were eliminated, and some of the existing remaining ones were rephrased to produce a ten item scale as shown in Tables 3 and 4.

Table 3
Revised 10 item scale for perceived usefulness (Davis, 1989, Table 3, p. 326)

Item No.	Candidate item for psychometric measures for perceived usefulness
1	Using electronic mail improves the quality of the work I do.
2	Using electronic mail gives me greater control over my work.
3	Electronic mail enables me to accomplish tasks more quickly.
4	Electronic mail supports critical aspects of my job.
5	Using electronic mail increases my productivity.
6	Using electronic mail improves my job performance.
7	Using electronic mail allows me to accomplish more work than would otherwise be possible.
8	Using electronic mail enhances my effectiveness on the job.
9	Using electronic mail makes it easier to do my job.
10	Overall, I find the electronic mail system useful in my job.

Table 4
Revised 10 item scale for perceived ease of use (Davis, 1989, Table 4, p. 326)

Item No.	Candidate item for psychometric measures for perceived ease of use
1	I find it cumbersome to use the electronic mail system.
2	Learning to operate the electronic mail system is easy for me.
3	Interacting with the electronic mail system is often frustrating.
4	I find it easy to get the electronic mail system to do what I want it to do.
5	The electronic mail system is rigid and inflexible to interact with.
6	It is easy for me to remember how to perform tasks using the electronic mail system.
7	Interacting with the electronic mail system requires a lot of my mental effort.
8	My interaction with the electronic mail system is clear and understandable.
9	I find it takes a lot of effort to become skillful at using electronic mail.
10	Overall, I find the electronic mail system easy to use.

To test the reliability and validity of the new 10 item scales, Davis (1989) conducted a field study with 112 employees working for IBM in Toronto, Canada. Davis requested the participants to use the scales shown in Tables 3 and 4 to rate the usefulness and ease of use of two systems that the employees were already using inside the organization. Participants could assign a rating of 1 to 7 on a likert scale for each of the psychometric measures shown in Tables 3 and 4, with a rating of 1 meaning that the participant strongly agreed with the psychometric measure statement, and a rating of 7 meaning that the participant strong disagreed with the statement. Rating scales in between these two extremes, 1 and 7, represented varying degrees of agreement. Responses were then subjected to further analysis, using principal component analysis, multitrait-method analysis, and factor analysis to determine the reliability and validity of the 10 scale items tested. All the tests showed a high reliability and validity for the 10 item scales.

Davis (1989) also asked the participants from IBM to report their attitude towards the two systems they were rating, using a scale developed by Ajzen and Fishbein (1980) for operationalizing attitude toward behavior. The scale measured five different types of attitude that a person may have toward a system on a seven point scale with mid-point labeled "neutral" as shown below.

All things considered, my using electronic mail in my job is:

	Neutral	
Good	: ___:___:___:___:___:___:___:	Bad
Wise	: ___:___:___:___:___:___:___:	Foolish
Favorable	: ___:___:___:___:___:___:___:	Unfavorable
Beneficial	: ___:___:___:___:___:___:___:	Harmful; and
Positive	: ___:___:___:___:___:___:___:	Negative.

Moreover, the participants had to report their actual usage of the two systems on a six position categorical scale with the following labels:

Don't use at all, Use less than once each week, Use about once each week, Use several times a week, Use about once each day and Use several times each day.

Results obtained showed that, self-reported usage was significantly correlated with both perceived ease of use and perceived usefulness for the two systems in use at IBM, thus confirming Davis (1985) original TAM model (Figure 2).

However, Davis (1989) went further and refined both 10 item scales to develop two shorter six item scales, because he thought that keeping the scales short would be more practical in real world situations. He used the Spearman-Brown prophecy formula to reduce the number of items to six so as to obtain a .97 reliability measure, and thus develop the six item scales shown in Tables 5 and 6.

Table 5

Revised 6 items scale for perceived usefulness worded towards CHART-MASTER

Item No.	Candidate item for psychometric measures for perceived usefulness
1	Using CHART-MASTER in my job would enable me to accomplish tasks more quickly.
2	Using CHART-MASTER would improve my job performance.
3	Using CHART-MASTER in my job would increase my productivity.
4	Using CHART-MASTER would enhance my effectiveness on the job.
5	Using CHART-MASTER would make it easier to do my job.
6	I would find CHART_MASTER useful in my job.

Table 6

Revised 6 items scale for perceived ease of use worded towards CHART-MASTER

Item No.	Candidate item for psychometric measures for perceived usefulness
1	Learning to operate CHART-MASTER would be easy for me.
2	I would find it easy to get CHART-MASTER to do what I want to do.
3	My interaction with CHART-MASTER would be clear and understandable.
4	I would find CHART-MASTER flexible to interact with.
5	It would be easy for me to become skillful at using CHART-MASTER.
6	I would find CHART-MASTER easy to use.

Davis (1989) used these six item scales to conduct a laboratory study with 40 participants to validate the TAM model shown earlier in Figure 2. The systems evaluated were two IBM PC-based graphics systems, Chart-Master and Pen-draw, which the participants had never used. In this case, Davis was interested in finding whether there was any correlation between the six item scale items he developed, and the predicted use of the two systems. So, he gave the participants a one hour hands-on experience with each system, and then asked them to rate their perceived usefulness and perceived ease of use for both systems.

Here too, he used the measurement scales developed by Fishbein and Ajzen (1975) to measure the attitude of the participants towards the two systems. Finally, the participants reported their self-predicted future use of both systems by answering the following question at the end of the experiment.

> Assuming CHART-MASTER would be available on my job, I predict that I will use it on a regular basis in the future.

Participants had to respond to the above question by rating their predicted use of the system on two seven-point scales, one with likely-unlikely end-point adjectives, the other, with improbable-probable endpoint adjectives.

By analyzing the results obtained in his experiment, Davis (1985) found a positive correlation between the scales and self-predicted future usage. Furthermore, Davis used regression analysis to determine the relationships that existed in his TAM model. Along with the confirmation of his initial hypothesis, Davis would also discover other relationships that he had expected to be insignificant as shown in Figure 4.

Davis (1993) thus, suggested that in contrast to what he initially predicted, perceived usefulness could also have a direct influence on actual system use. At the same time, he found that system characteristics could directly influence the attitude of a person toward using the system, without the need for the person to form an actual belief about the system as shown in Figure 4.

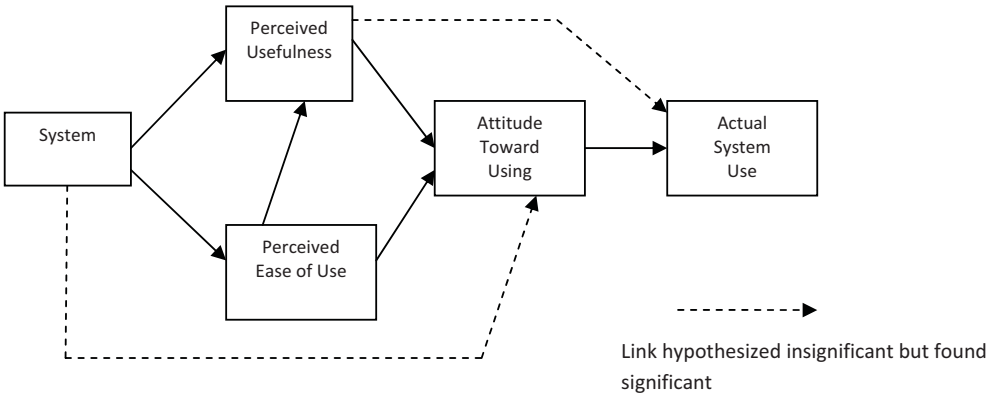

Figure 4: New relationship formulation in TAM (Davis, 1993, p. 481).

Consequently, several other studies followed in order to investigate in depth the relationships between the different variables in the TAM model.

TAM evolving

Later development of TAM would include behavioral intention as a new variable that would be directly influenced by the perceived usefulness of a system (Davis, Bagozzi and Warshaw, 1989). Davis et al. (1989) suggested that there would be cases when, given a system which was perceived useful, an individual might form a strong behavioral intention to use the system without forming any attitude, thus giving rise to a modified version of the TAM model as illustrated in Figure 5.

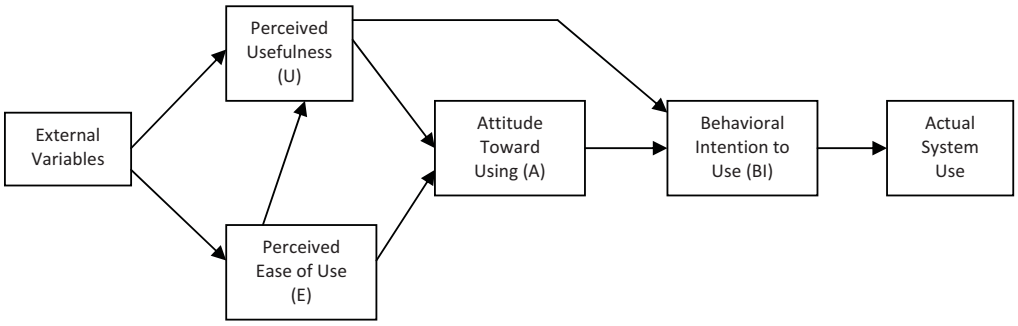

Figure 5: First modified version of TAM (Davis, Bagozzi and Warshaw, 1989, p. 985)

Davis, Bagozzi and Warshaw (1989) used the above model to conduct a longitudinal study with 107 users to measure their intention to use a system after a one hour introduction to the system, and again 14 weeks later. In both cases, their results indicated a strong correlation between reported intention and self-reported system usage with perceived usefulness responsible for the greatest influence on people's intention. However, perceived ease of use was found to have a small but significant effect on behavioral intention which later subsided over time. But the main finding was that both perceived usefulness and perceived ease of use were found to have a direct influence on behavioral intention, thus eliminating the need for the attitude construct from the model shown in Figure 5. The resultant model is shown in Figure 6.

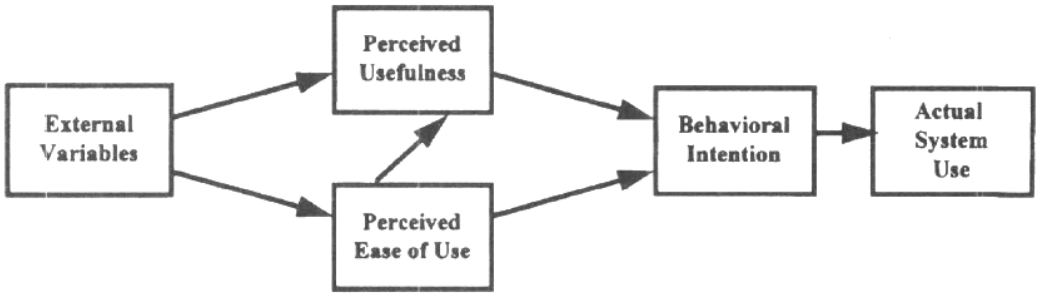

Figure 6: Final version of TAM (Venkatesh & Davis, 1996, p. 453)

Thus, by eliminating the attitude construct and introducing the behavioral intention construct, the results obtained for the direct influence of perceived usefulness on actual system use, as was shown in Figure 4, could be explained. At the same time, removing the attitude variable eliminated any unexplained direct influence observed from the system characteristics to the attitude variable. An additional change brought to the original TAM model, was the consideration of other factors, referred to as external variables that might influence the beliefs of a person towards a system. External variables typically included system characteristics, user training, user participation in design, and the nature of the implementation process (Venkatesh & Davis, 1996).

With this final version in place, further research led to 1) replicating TAM and testing its propositions and possible limitations; 2) comparing TAM with other models such as the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB); 3) adapting TAM for various settings such as mandatory scenarios, different applications,

and cultures; and 4) extending the model to include other variables such as subjective norm (SN), extrinsic motivations, playfulness, and so on.

Replicating TAM and testing its possible limitations

One of the earliest replications of TAM was carried out by Adams, Nelson and Todd (1992). They carried both field and laboratory studies in order to test TAM's variables, perceived ease of use and perceived usefulness, for their validity and reliability in explaining the use of five different applications: email, voice mail, word perfect, Lotus 123, and Harvard graphics. Participants were MBA students, and self-reported use data of the five applications were used as a measure for actual use. The results of their study indicated that the TAM model maintained its consistency in predicting and explaining system adoption.

Hendrickson, Massey and Cronan (1993) further tested the reliability of the scale items used to measure perceived ease of use and perceived usefulness in TAM. They carried out a field study with 123 undergraduate students who were introduced to a database, and a spreadsheet application, and used self-reported use data of the two systems to perform a test-retest analysis. Hendrickson, Massey, and Cronan found that for both perceived usefulness and perceived ease of use, the scale items exhibited significant test-retest reliability result. Subramanian (1994) also replicated TAM with voice mail and customer dialup systems in a field study with 179 knowledge workers, and found evidence for previous results reported in TAM studies.

Davis and Venkatesh (1996) on the other hand, confirmed the reliability and validity of the perceived usefulness and perceived ease of use variables in TAM by verifying whether grouping of the scale items introduced errors in predicting usage. They carried out a laboratory experiment with 195 students by exposing them to different permutations and combinations of the scale items. That is, instead of asking participants to rate a given system using two scales, which had statements grouped by either perceived ease of use or perceived usefulness, participants were given different variations of the two scales, with statements for both perceived ease of use and perceived usefulness mixed together. After the experiment, Davis et al. (1996) found that there was no significant difference between the reliability and validity of the scales when the grouping of their statements was changed. Hence, Davis and Venkatesh concluded that previously obtained reliability and validity measures were not due to items grouping. However, responses from verbal protocols carried out during the experiment revealed that respondents were more confused when measurement scale items for perceived usefulness and perceived ease of use were mixed together. Thus, Davis and Venkatesh recommended the use of the initial measurement scales for TAM, as was previously shown in Tables 5 and 6.

Comparing TAM with the Theory of Reasoned Action and the Theory of Planned Behavior

Davis, Bagozzi and Warshaw (1989) compared the performance of TAM with the Theory of Reasoned Action (TRA) for predicting the intention of 107 MBA students in using a word processing system after a one-hour exposure with the system, and again 14 weeks later. They found that the beliefs variables in both TRA and TAM provided significant results to predict the intention of the participants to use the word processor.

In the Theory of Reasoned Action model however, Davis, Bagozzi and Warshaw found that there was very little correlation between the subjective norm (SN) and the behavioral intention variables. They formulated two possible reasons for this observation a) the weakness of the SN measurement scale from a psychometric standpoint, and b) the fact that word processors are usually very individual and personal; thus, their use will be less influenced by perceptions from other groups.
Finally Davis, Bagozzi and Warshaw concluded that compared to the Theory of Reasoned Action, TAM provided a much simpler and less expensive method to implement because the beliefs variables were context-independent whereas, in the case of the Theory of Reasoned Action, it was necessary to develop a series of salient beliefs specific to word processors before formulating the scales for measuring the beliefs.

Mathieson (1991) on the other hand, compared TAM with the Theory of Planned Behavior (TPB) proposed by Ajzen (1985). The Theory of Planned Behavior model is very similar to the Theory of Reasoned Action model, except that it takes into account the additional construct: perceived behavioral control (PBC), which refers to the perception of control over performance of a given behavior. PBC is also influenced by the effects of two beliefs: control beliefs and perceived facilitation. Control beliefs include perceived availability of skills, resources, and opportunities, whereas perceived facilitation belief is the individual's assessment of available resources to the achievement of a given set of outcomes. Figure 7 depicts the model for the Theory of Planned Behavior.

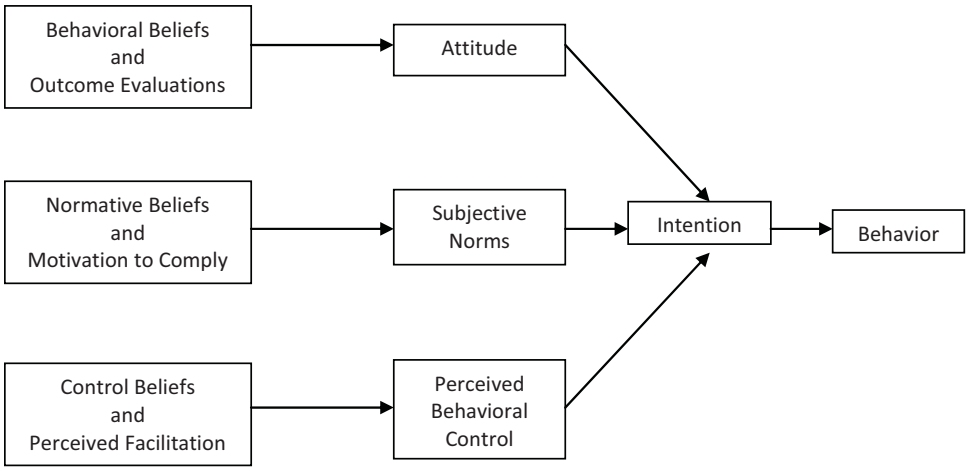

Figure 7: Theory of planned behavior (TPB) (Mathieson, 1991, p. 175)

Mathieson (1991) carried out an experiment applying both TAM and the Theory of Planned Behavior for predicting the intention of 262 participants in using a spreadsheet application. Since no predefined measurement scales existed for the Theory of Planned Behavior, an initial interview session was required to identify those salient beliefs that would be specific to the system under investigation. As discussed earlier, this was an inherent characteristic of the Theory of Reasoned Action model. Interestingly, results of the experiment showed that both TAM and the Theory of Planned Behavior were suitable to predict system usage.

However, compared to the TAM model, the Theory of Planned Behavior (TPB) model provided more details that explained the intention of the participants to use the spreadsheet application. This is because TPB being a more complex model had several independent variables that could capture various aspects of an individual's belief. For example, as shown in Figure 7, the perceived behavioral control construct could help identify specific barriers to system use such as limitations in user skills. Furthermore, the model also could identify groups whose opinions might be important to future users through the subjective norms construct. Moreover, since the Theory of Planned Behavior model considered only beliefs that were specific to the given system, more accurate information could be obtained. TAM instead, was a simpler model that could be generally applied to any system, and thus provided only broad information about perceived ease of use and perceived usefulness.
Yet, due to its simplicity and ease of implementation, TAM remained more attractive than either the Theory of Reasoned Action or the Theory of Planned Behavior. Further efforts later concentrated on either applying TAM in different settings or extending TAM to include more variables.

Adapting and extending TAM
With more than 700 citations to his original proposal for TAM, Davis' research (Davis, 1989) has been adapted and extended in many ways. To date, there have been several attempts to consolidate the results obtained from these studies. The most recent one is by Yousafzai, Foxall, and Pallister (2007) who did a meta-analysis of 145 articles published on TAM. Earlier meta-analysis studies can be found in Sharp (2006), King and He (2006), Ma and Liu (2004), Lee, Kozar and Larsen (2003) and, Legris, Ingham and Collerette (2003). Table 7 highlights some of the main applications, participants, countries, and settings for which TAM was used.

Table 7
Applications, participants, country and setting used for applying TAM (Yousafzai et al., 2007), Sharp, 2006, King et al., 2006, Ma et al., 2004, Lee et al., 2003, and, Legris et al., 2003)

Variation in TAM application	Examples
Applications	Email, voicemail, fax, dial-up system, e-commerce application, groupware, word processor, spreadsheet, presentation software, database program, case tools, hospital IS, Decision support system, Expert support system, and telemedicine technology.
Country	USA, UK, Taiwan, Hong Kong, Switzerland, Japan, Australia, Turkey, Canada, Kuweit, Nigeria, France, Singapore, China, and Finland.
Type of Study	Lab study, Field study and Web surveys
Participants	Students (undergraduate and graduates), knowledge workers, physicians, bank managers, programmer analysts, IT vendor specialists, computer programmers, internet users, brokers, and sales assistants.

Most of these studies found significant statistical result for the high influence of perceived usefulness on behavioral intention to use a specific system. They also found mixed results for the direct relationship between perceived ease of use and usage

behavior. In general, all these studies provided strong evidence to support TAM as a model for predicting system usage behavior. Unfortunately, TAM could not go beyond the general items that measured perceived usefulness and perceived ease of use. It was thus, difficult to identify the reasons behind the perceived ease of use or perceived usefulness variables used in the model. Furthermore, most research in TAM focused only on voluntary environments with little consideration for mandatory settings. To address these issues TAM was therefore extended.

One of the important extensions brought to TAM is by Venkatesh and Davis (2000) who proposed the TAM2 model shown in Figure 7. Venkatesh and Davis identified that TAM had some limitations in explaining the reasons for which a person would perceive a given system useful, and so they proposed that additional variables[1] could be added as antecedents to the perceived usefulness variable in TAM. They called this new model, the TAM 2 model. Venkatesh and Davis were also interested in evaluating the performance of TAM 2 in a mandatory setting. Hence, they conducted a field study with 156 knowledge workers, who used four different systems, two of which were for voluntary use, and the other two were mandatory. The study also collected user perceptions and self-reported use at three points in time: pre-implementation, one month post-implementation, and three months post-implementation.

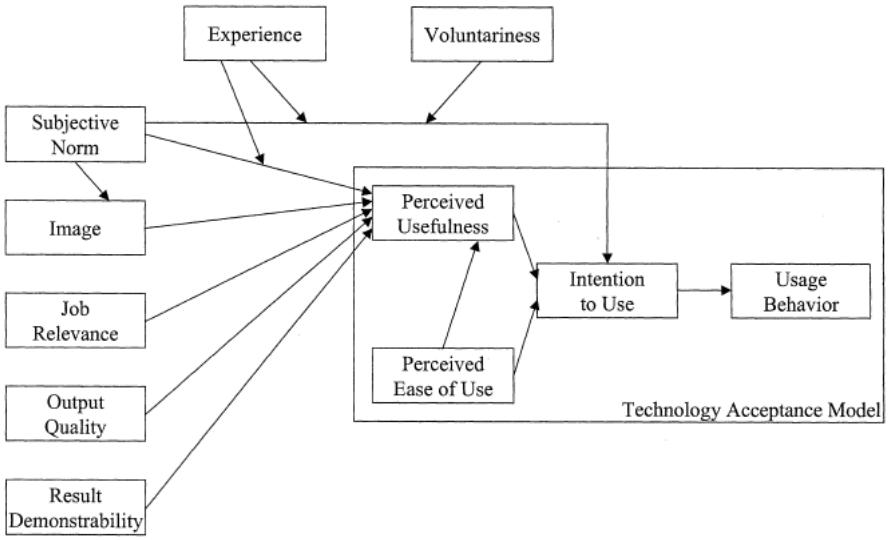

Figure 7: TAM 2 (Venkatesh and Davis, 2000)

Using the TAM 2 model Venkatesh and Davis were able to provide more detailed explanations for the reasons participants found a given system useful. Their results also indicated that TAM 2 performed well in both voluntary and mandatory environments with the exception that subjective norm had no effect in voluntary settings but did in mandatory settings.

A second important extension of the TAM model is by Venkatesh (2000), who was interested in identifying the antecedents to the perceived ease of use variable in the

[1] Descriptions for the new variables are given in Appendix A

TAM model. As shown in Figure 8, Venkatesh identified two main groups of antecedents for perceived ease of use: anchors and adjustments. Anchors were considered as general beliefs about computers and computer usage whereas adjustments were considered as beliefs that are shaped based on direct experience with the target system. In both groups, Venkatesh (2000) proposed several determinants[2] that are mostly derived from previous research on identifying the antecedants to perceived ease of use (Davis, Bagozzi and Warshaw, 1992, Venkatesh and Davis, 1996). Venkatesh (2000) tested his proposal in three different organizations with 246 participants, and three measurements taken over a three-month period. Results obtained indicated strong support for the variables in explaining perceived ease of use for a given system.

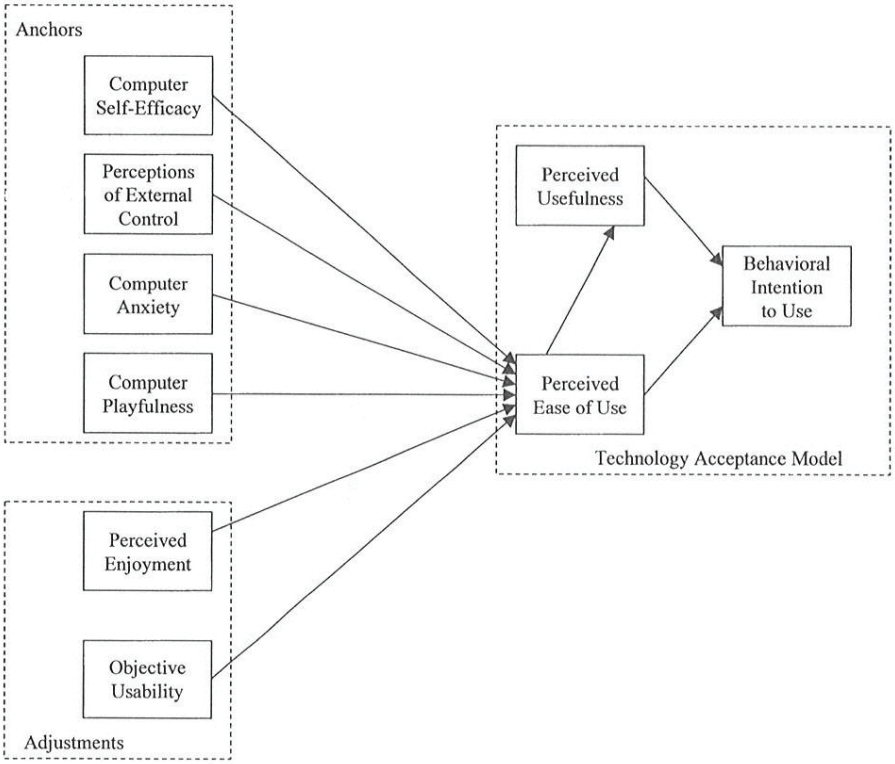

Figure 8: Extending TAM to include determinants for perceived ease of use (Venkatesh, 2000)

However, along with the fact that several studies have confirmed the robustness of the TAM model, several other researchers have also highlighted important limitations of the model. Typically, criticisms for the TAM model fall in three categories 1) the methodology used for testing the TAM model, 2) the variables and relationships that exist within the TAM model, and 3) the core theoretical foundation underlying the TAM model.

[2] Descriptions for the new variables are given in Appendix A

Limitations in the methodology used for testing the TAM model

One of the main criticisms for studies on the TAM model is that self-reported use data are used to measure system use instead of real actual use data. As some researchers pointed out, self-reported use data is a subjective measure, and is thus unreliable in measuring actual use of a system (Legris, Ingham and Collerette, 2003, Yousafzai, Foxall, and Pallister 2007). However, many studies on TAM employ self-reported use data. Moreover, several studies on TAM make use of students as participants in controlled environment, and therefore, results obtained from these studies cannot be generalized to the real world (Lee, Kozar, & Larsen, 2003). As many researchers argue, students may have different motivations such as obtaining grades, rewards, and so on (Legris et al. 2003, Yousafzai et al. 2007, and Lee et al., 2003). Finally, in contrast to the large number of studies carried on applying TAM to explain and predict the voluntary use of systems, very few studies considered systems that were for mandatory use (Yousafzai et al. 2007). However, in real life settings, most organizations usually require users to use the system available with little choice for alternatives (Lee at al. 2003).

Limitations in the variables and relationships present within the TAM model

Yang and Yoo (2003) suggested that attitude may have important effects on system use, and therefore need to be reconsidered in the TAM model. They replicated the TAM model but instead of eliminating the attitude variable as Davis, Bagozzi and Warshaw (1989) suggested, two additional attitude variables, affective and cognitive, were considered. Yang and Yoo carried out a survey asking respondents to rate their usage of a spreadsheet application, and data analysis of the survey questionnaires indicated that although the affective attitude variable did not show statistical significance to predict system use, the results obtained for the effect by cognitive attitude was very significant.

Similarly, Brown, Massey, Motoya-Weiss, and Burkman (2002) carried out a field study to replicate TAM in the banking industry. However, instead of considering voluntary use of a system, Brown, Massey, Motoya-Weiss and, Burkman applied TAM in a context where use of system was mandatory. They found that perceived ease of use may have a more important impact on system acceptance than perceived usefulness, in mandatory settings. Their result contrasts with earlier observations for the TAM model applied in voluntary setting, in which perceived usefulness was seen to have more influence than perceived ease of use on system acceptance (Davis, 1985).

Burton-Jones and Hubona (2006) also replicated TAM by administering a survey to 125 employees of a US Government agency. Information about the participants' beliefs and, usage behavior with respect to two applications were gathered and analyzed. Results obtained showed that perceived usefulness and perceived ease of use may not mediate all influences from external environmental factors on system usage. Instead, some external factors such as system experience, level of education, and age may have a direct influence on system usage.

Limitations in the theoretical foundation for the TAM model

Bagozzi (2007) highlighted the poor theoretical relationship that was formulated among the different constructs formulated in TAM. He questioned the theoretical strength of the intention-actual use link, and observed that behavior could not be considered as a terminal goal. Instead, he argued that behavior should be treated as a means to a more fundamental goal. Moreover, he explained that intention may not be representative enough of actual use, because the time period between intention and

adoption could be full of uncertainties and other factors, that might influence an individual's decision to adopt a technology. Bagozzi also questioned the possibility of determining behavior by adding up measures for perceived usefulness and perceived ease of use. He considered that there might be differential contributions of salient beliefs and also that human memory might not work in the same way that salient beliefs were processed in TAM.

Finally, Bagozzi remarked that TAM was a deterministic model, and therefore, an individual's act was assumed to be totally determined by his or her intention to act. But as Bagozzi argued, a person's intention could be subjected to evaluation and reflection, which might direct the person to reformulate his or her intention, and even to take a different course of action. Thus, he concluded that the TAM model could not be suitable for explaining and predicting system use.

Conclusions

The Technology Acceptance Model is indeed a very popular model for explaining and predicting system use. To date, there have been an impressive number of studies on TAM, but while several confirmatory results have been obtained, there are skepticisms shared among some researchers regarding the application and theoretical accuracy of the model. Consequently, it is tempting to conclude that research on TAM may have reached a saturation level, such that future research will focus in developing new models that would exploit the strengths of the TAM model while discarding its weaknesses.

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Appendix A: Antecedants to PU and PEOU as proposed in extending TAM

Voluntariness	The degree to which use of the innovation is perceived as being voluntary, or of free will.
Experience	Prior experience of an individual with a specific technology
Subjective norm	Person's perception that most people who are important to him think he should or should not perform the behavior in question
Image	The degree to which use of an innovation is perceived to enhance one's image or status in one's social system
Job relevance	The capabilities of a system to enhance and individual's job performance
Output quality	The perception how well the system performs tasks that match with job goals
Result demonstrability	The degree to which the results of adopting/using the IS innovation are observable and communicable to others
Computer self-efficacy	The belief that one has the capability to perform a particular behavior
Perceptions of external control	The control beliefs relating to resource factors such as time and money and IT compatibility issues that may constrain usage
Computer anxiety	An individual's apprehension, or even fear, when she/he is faced with the possibility of using computers
Computer playfulness	The degree of cognitive spontaneity in microcomputer interactions
Perceived enjoyment	The extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system usage
Objective usability	A construct that allows for a comparison of systems on the actual level of effect regarding efforts to complete specific tasks

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