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Technology acceptance: a meta-analysis of the TAM: Part 1

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Abstract

Purpose – This paper is the first of two concerned with a meta-analysis of the technology acceptance model (TAM). This part aims to present a narrative literature review of 145 papers published on the TAM.

Design/methodology/approach – The approach takes the form of a literature review of 145 papers on the TAM.

Findings – The review identifies TAM as a basis for identifying gaps and providing guidelines for implementation of management and the conduct of future research.

Originality/value – The paper presents a comprehensive literature review and a rigorous meta-analysis to progress towards a unified view of the TAM.

Keywords Technology led strategy, Research, User studies

Paper type Literature review

> Bin-Adhem picked up a stone from beside the road. It had written on it, "Turn me over and read". So he picked it up and looked at the other side. And there was written. "Why do you seek more knowledge when you pay no heed to what you know already?" (Shah, 1968, p. 110).

The technology acceptance model (TAM) originally formulated by Davis (1986) is one of the most widely tested models of technology acceptance. The TAM adapted Ajzen and Fishbein's (1980) theory of reasoned action (TRA) to explain the causal relationship between users' internal beliefs (usefulness and ease of use), attitude, intentions, and computer usage behaviour (Davis *et al.*, 1989). Although, in the last 20 years the TAM has become well established as a robust, parsimonious, and powerful model for predicting users' acceptance of technology (Venkatesh, 2000), few studies have attempted to validate the full TAM model with all of its original constructs. Furthermore, the many TAM studies are characterized by different methodological and measurement factors, resulting in conflicting and somewhat confusing findings which vary considerably in terms of statistical significance, direction and magnitude. Reviews of the TAM (Lee *et al.*, 2003a, b; Ma and Liu, 2004) reveal that these mixed findings not only undermine the precision of TAM, but also complicate efforts for IT practitioners and academicians to better understand users' technology acceptance behaviour. However, the cause of such inconsistencies and the extent to which the existing body of research reflects significant and cumulative development is not completely clear. Ma and Liu's (2004) meta-analysis of the TAM does not provide a complete answer because these authors do not conduct a moderator analysis for the effect of different study characteristics. Moreover, their meta-analysis is based on a small sample of 26 studies (17 published articles and seven working papers and

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conference proceedings). Lee *et al.* (2003a, b) focus on the incremental development of TAM over the last 17 years, and calculate the total number of significant results for the relationships proposed by the TAM. Thus, a need exists for a comprehensive review and synthesis in order to progress towards a unified view of the TAM.

The first objective of this meta-analysis is to conduct a rigorous narrative and quantitative review of the TAM literature as a basis for providing guidelines for implementation management and the conduct of future research. Linked to this is our second objective: to investigate the potential impact of the methodological characteristics of the studies on the findings. To achieve these objectives the paper is divided into two parts. Part 1 identifies the major contributions and developments to the TAM model and discusses potential moderators. Part 2 delineates the meta-analytic approach and discusses the findings and their implications for future research.

This study provides an opportunity to pause and reflect on what has been achieved, to identify gaps which need to be addressed, and to set directions for future research. Such a meta-analysis at this time is able to take note of many studies in this domain published since the article by Davis *et al.* (1989). Instead of being confined to a specific topic or theme or a specific type of research setting, we adopt a comprehensive perspective and incorporate research pertaining to any of the methodological, technological, or process aspects of the TAM.

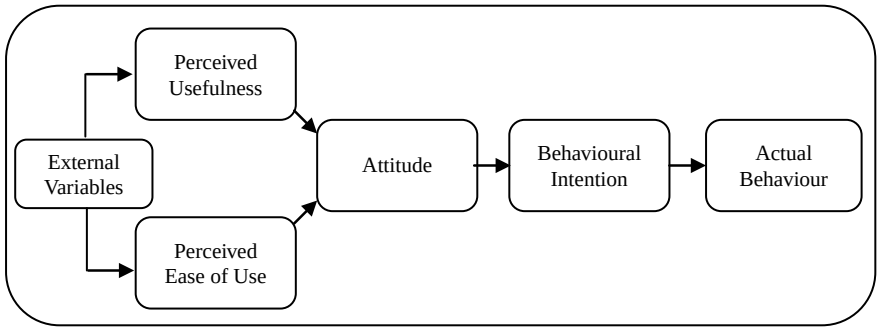
The technology acceptance model

A variety of theoretical perspectives has been applied to provide an understanding of the determinants of technology usage. Information systems (IS) investigators have suggested intention models from social psychology as a potential theoretical foundation for research on the determinants of user behaviour (e.g. the TRA (Ajzen and Fishbein, 1980) and the theory of planned behaviour (Ajzen, 1991)). From this stream of research, the TAM (Davis *et al.*, 1989), an adaptation of the TRA, has emerged as a powerful and parsimonious model that "belongs" to the IS field and represents the antecedents of technology usage through beliefs about two factors: the perceived usefulness (PU) and perceived ease of use (PEOU) of a technology. Hence, the TAM:

> . . . is specifically meant to explain computer usage behaviour . . . (Davis *et al.*, 1989, p. 983).

> The goal of TAM is to [be] . . . capable of explaining user behaviour across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified (p. 985).

The original TAM is shown in Figure 1. A person's acceptance of a technology is hypothesized to be determined by his or her voluntary intentions towards using the technology. The intention, in turn, is determined by the person's attitude towards the use of the technology and his or her perception of its usefulness. Attitudes are formed from the beliefs a person holds about the use of the technology. The first belief, PU, is the user's "subjective probability that using a specific application system will increase his or her job performance within an organizational context" (Davis *et al.*, 1989, p. 985). Initially defined in the context of one's job performance, PU was later used for any common task in non-organizational settings, e.g. internet shopping. PEOU, the second belief, is "the degree to which the user expects the target system to be free of efforts" (p. 985). PU is influenced by PEOU. The strength of such belief-attitude-intention-behaviour relationships in predicting actual behaviour



Source: Davis *et al*. (1989)

Figure 1.
The technological acceptance model

largely depends on the degree of measurement specificity attained in a research project (Ajzen and Fishbein, 1980). In order to apply these notions to the technology acceptance context, it is necessary to measure attitudes and beliefs regarding the use of technology rather than attitude and beliefs directed towards the technology itself, since individuals might hold a positive view about a technology without being favourably disposed towards its use.

Davis *et al.* (1989) test the original TAM in a longitudinal study and report that the data partially support the model. In a *post hoc* data analysis in voluntary settings (Davis *et al.*, 1989), they suggest a revision of the original TAM which they claim is a more "powerful [model] for predicting and explaining user behaviour, based on only three theoretical constructs: intention, PU, and PEOU" (p. 997). The attitudinal construct was removed because of the partial mediation of the impact of beliefs on intentions by attitude, a weak direct link between PU and attitude, and a strong direct link between PU and intentions. PEOU had a small effect on intentions that subsided over time. From this point onwards, the implications for future research as pointed by Davis *et al.* (1989) was to test the generality of a PU – PEOU trade-off, and to assess the impact of external variables on these internal behavioural determinants.

Originally developed to test the acceptance of word processor technology (Davis *et al.*, 1989), the TAM has since been extended to the acceptance e-mail, voice mail, graphics (Adams *et al.*, 1992), DBMS (Szajna, 1994), GSS (Chin and Gopal, 1995), personal computer (Igbaria *et al.*, 1995b), WWW (Gefen and Straub, 2000), and tele-medicine technology (Chau and Hu, 2001), among other applications of IT. Table I lists the 145 papers on the TAM reviewed here, indicating the sample size, sample type, study type, technology tested, dependent variable, and results of the hypothesis testing the original TAM relationships. The table also summarizes results about four new relationships not proposed in the original model, namely PU – usage, PEOU – intentions, PEOU – usage, and attitude – usage.

No single study tests all the relationships, but they are all measured in at least one study. While about 47 per cent of the studies measured self-reported usage, less than 9 per cent measured the actual usage. The behavioural intention to use the technology was measured as the dependent variable in 43 per cent of the studies. The majority (59 per cent) of the studies have been conducted with non-students and 41 per cent with

Table I.
Review of studies on technology acceptance model (TAM)

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
1	*Davis *et al.* (1989)																
	Time-1	107	Lab study	USA	MBA students	Word processor	Intention to use	X	X	X	X	Yes	Yes	Yes	Yes	NS	Yes
	Time-2	107	Lab study	USA	MBA students	Word processor	Self-reported use	Yes	X	X	X	NS	Yes	NS	Yes	Yes	Yes
2	*Davis (1989)	109	Field study	USA	Knowledge workers	Electronic mail	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
		75	Field study	USA	Knowledge workers	XEDIT file editor	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	X
		40	Lab study	USA	MBA students	Chart master	Self-predicted use	X	X	Yes	NS	X	X	X	X	X	NS
		40	Lab study	USA	MBA students	Pendraw	Self-predicted use	X	X	Yes	Yes	X	X	X	X	X	Yes
3	Mathieson (1991)	149	Lab study	USA	Under graduate students	Spread sheet	Intention to use	X	X	X	X	Yes	Yes	X	Yes	Yes	Yes
4	*Adams *et al.* (1992)	116	Field study	USA	Knowledge workers	Electronic mail	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
		68	Field study	USA	Knowledge workers	Voice mail	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
		64	Lab study	USA	MBA students	Word perfect	Self-reported use	X	X	NS	NS	X	X	X	X	X	Yes
		67	Lab study	USA	MBA students	Lotus 123	Self-reported use	X	X	Yes	NS	X	X	X	X	X	Yes
		54	Lab study	USA	MBA students	Harvard graphics	Self-reported use	X	X	NS	Yes	X	X	X	X	X	NS
5	*Davis *et al.* (1992)																
	Study-1	200	Field study	USA	Mba students	Word processor	Self-reported use	Yes	X	Yes	X	X	Yes	NS	X	X	Yes
	Study-2	80	Lab study	USA	MBA students	Graphic software	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
6	*Davis (1993)	185	Field study	USA	Knowledge workers	Email and text editor	Self-reported use	X	Yes	Yes	X	X	X	X	Yes	Yes	Yes
7	Hendrickson *et al.* (1993)	123	Field study	USA	Under graduate students	Database and spreadsheet	Self-reported perceptions	X	X	X	X	X	X	X	X	X	Yes
8	*Igbaria (1993)	519	Field study	USA	Knowledge workers	Microcomputer tech.	Self-reported use	Yes	Yes	X	X	Yes	Yes	X	Yes	X	X
9	Segars and Grover (1993)	191	NA	USA	Adams *et al.* data	E-mail/v-mail, s/w package	Self-reported use	X	X	Yes	NS	X	X	X	X	X	Yes
10	*Igbaria (1994)	471	Field study	USA	Knowledge workers	Micro computer	Self-reported use	X	Yes	Yes	X	X	X	X	X	X	X

(*continued*)

Table I.

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
11	*Lu and Gustafson (1994)																
	Time-1	35	Lab study	USA	Users of the system	Interactive supp. system	Measured use	X	X	NS	Yes	X	X	X	X	X	Yes
	Time-2	34	Lab study				Measured use	X	X	Yes	Yes	X	X	X	X	X	Yes
12	*Phillips *et al.* (1994)	303	Field study	China	Knowledge workers	Tech. equipment	Intention to use	X	X	X	X	Yes	X	X	Yes	Yes	NS
13	Straub (1994)	920	Field study	USA (711), Japan (209)	Knowledge workers	E-mail and fax	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
14	*Subra manian (1994)	179	Field study	USA	Knowledge workers	V-mail and customer dialup	Self-reported use	X	X	Yes	NS	X	X	X	X	X	NS
15	Szajna (1994)	231	Lab study	USA	MBA students	Bibliographic database	Self-reported perceptions	X	X	X	X	X	X	X	X	X	Yes
16	Chin and Gopal (1995)	64	Field study	Canada	Under graduate students	Group support systems	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
17	*Igbaria and Iivari (1995)	450	Field study	Finland	Knowledge workers	Personal computer	Self-reported use	X	X	Yes	NS	X	X	X	X	X	Yes
18	*Igbaria *et al.* (1995a)	214	Field study	USA	MBA students	Micro computer	Self-reported use	X	X	Yes	NS	X	X	X	X	X	Yes
19	*Igbaria *et al.* (1995b)	450	Field study	Finland	Knowledge workers	Micro computer	Self-reported use	X	X	Yes	NS	X	X	X	X	X	Yes
20	*Keil *et al.* (1995)	306	Field study	USA	Knowledge workers	Expert support systems	Self-reported use	X	X	Yes	NS	X	X	X	X	X	Yes
21	Straub *et al.* (1995)	458	Field study	USA	Knowledge workers	Voice mail	Self-reported/ measured use	X	X	Yes	NS	X	X	X	X	X	Yes
22	*Taylor and Todd (1995)	786	Lab study	Canada	Under graduate and MBA	Comp. resource centre	Measured use	Yes	NS	Yes	Yes	NS	Yes	Yes	Yes	Yes	Yes
23	*Agarwal *et al.* (1996)	230	Field study	USA	Knowledge workers	Operating system	Intention to use	X	X	X	X	Yes	X	X	Yes	Yes	Yes
24	*Chau (1996a)																
	Sudy-1	192	Field study	Hong Kong	Adminis trative staff	Word processor	Intention to use	X	X	X	X	X	Yes	NS	X	X	Yes
	Sudy-2	176				Spread sheet		X	X	X	X	X	Yes	NS	X	X	Yes
25.	*Chau (1996b)	97	Field study	Hong Kong	System developers	CASE tools	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes

(*continued*)

Table I.

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
26.	*Davis and Venkatesh (1996)	708	Lab study	USA	MBA students	Word proc. and spread sheet	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
27.	*Hendrickson and Collins (1996)	75	Field study	USA	Under graduate students	Lotus and word perfect	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
28.	*Igbaria *et al.* (1996)	471	Field study	USA	Knowledge workers	Micro computer	Self-reported use	X	X	Yes	X	X	X	X	X	X	X
29.	Montazemi *et al.* (1996)	125	Lab study	Canada	Knowledge workers	Software package	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
30	*Szajna (1996)																
	Time-1	61	Lab study	USA	Graduate students	E-mail	Measured use	NS	X	X	X	X	Yes	NS	X	X	Yes
	Time-1						Self-reported use	Yes	X	X	X	X	X	X	X	X	X
	Time-2	61	Lab study				Measured use	Yes	X	X	X	X	Yes	NS	X	X	X
	Time-2						Self-reported use	Yes	X	Yes	X	X	X	X	X	X	X
31.	*Venkatesh and Davis (1996)	108	Lab study	USA	Under graduate and MBA	Software packages	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
32.	*Agarwal and Prasad (1997)	73	Field study	USA	MBA students	World wide web	Self-reported use	Yes	X	Yes	Yes	X	Yes	Yes	X	X	Yes
33.	Gefen and Straub (1997)	392	Field study	Japan, Switzer land, USA	Knowledge workers	E-mail	Self- reported use	X	X	Yes	NS	X	X	X	X	X	X
34.	Ghorab (1997)	47	Field study	USE	Bank managers	Computerised bank sys.	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
35.	*Igbaria *et al.* (1997)	358	Field study	New Zealand	Knowledge workers	Personal computer	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
36.	*Jackson *et al.* (1997)	111	Field study	USA	Knowledge workers	Information system	Intention to use	X	X	X	X	NS	NS	Yes	NS	Yes	NS
37.	*Morris and Dillon (1997)	76	Field study	USA	Under graduate students	Netscape browser	Self-reported use	Yes	X	X	X	Yes	Yes	X	Yes	Yes	NS
38	Straub *et al.* (1997)																
	Group-1	142	Field study	Japan	Knowledge workers	E-mail	Self-reported use	X	X	NS	NS	X	X	X	X	X	X
	Group-2	152		Switzer land				X	X	Yes	NS	X	X	X	X	X	X
	Group-3	99		USA				X	X	Yes	NS	X	X	X	X	X	X

(*continued*)

Table I.

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
39.	*Wiedenbeck and Davis (1997)	173	Lab study	USA	Under graduate students	Word processor	Perceptions	X	X	X	X	X	X	X	X	X	Yes
40.	*Agarwal and Prasad (1998a)	76	Field study	USA	Knowledge workers	Software packages	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
41.	Agarwal and Prasad (1998b)	175	Field study	USA	MBA students	World wide web	Intention to use	X	X	X	X	X	Yes	NS	X	X	Yes
42.	*Bajaj and Nidumolu (1998)	25	Lab study	USA	Under graduate students	Software packages	Self-reported use	X	Yes	Neg	Neg	X	X	X	Neg	Yes	NS
43.	Doll *et al.* (1998)	902	Lab study	USA	Under graduate students	Spreadsheet, database	Perceptions	X	X	X	X	X	X	X	X	X	Yes
44.	*Dias (1998)	79	Field study	Brazil	Managers	Microcomputers	Perceptions	X	X	X	X	X	X	X	X	X	Yes
45.	Dillon *et al.* (1998)	78	Field study	USA	Accounting students	Tax preparation s/w	Intention to use	X	X	X	X	Yes	Yes	X	Yes	Yes	Yes
46.	*Gefen and Keil (1998)	196	Field study	USA	Knowledge workers	Expert system	Self-reported use	X	X	Yes	Neg	X	X	X	X	X	Yes
47.	*Green (1998)	31	Field study	USA	Computer programmers	Software packages	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
48.	*Loh and Ong (1998)	84	Web survey	Singa pore	Under graduate students	Online trading system	Self-reported use	X	NS	Yes	NS	X	X	X	Yes	Yes	Yes
49.	*Lu and Yeh (1998)	90	Field study	Taiwan	Knowledge workers	Buss. process re-engg.	Intention to use	X	X	X	X	Yes	Yes	Yes	Yes	Yes	Yes
50.	*Rose and Straub (1998)	274	Field study	Egypt, Jordan, Saudi Arabia, Sudan, Lebanon	Knowledge workers	Personal computers	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
51.	*Al-Gahtani and King (1999)	329	Field study	UK	Under graduate students	Spread sheets	Self-reported use	X	Yes	NS	NS	X	X	X	Yes	Yes	X
52.	Agarwal and Prasad (1999)	230	Field study	USA	IT vendor personnel	Personal computers	Intention to use	X	X	X	X	Yes	Yes	X	Yes	Yes	Yes
53.	*Brosnan (1999)	147	Lab study	UK	Under graduate students	Word processor	Self-reported use	Yes	X	Yes	X	X	Yes	X	X	X	Neg
54.	Dishaw and Strong (1999)	60	Field study	USA	Programmer analysts	S/w maintenance tool	Self-reported use	Yes	X	Yes	X	Yes	Yes	X	Yes	NS	Yes

(*continued*)

Table I.

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
55.	Hu *et al.* (1999)	408	Field study	Hong Kong	Physicians	Telemedicine technology	Intention to use	X	X	X	X	Yes	Yes	X	Yes	NS	NS
56.	Karahanna and Straub (1999)	100	Field study	USA	Knowledge workers	E-mail	Self-reported use	X	X	Yes	NS	X	X	X	X	X	Yes
57.	Karahanna *et al.* (1999)	268	Field study	USA	Knowledge workers	Operating system	Intention to use	X	X	X	X	Yes	Yes	NS	X	X	X
58.	*Lucas and Spitler (1999)	131	Field study	USA	Brokers, sales assistant	Work stations	Self-reported use	X	X	NS	NS	X	NS	NS	X	X	Yes
59.	*Phelps and Mok (1999)	54	Field study	Singa pore	Knowledge workers	Intranet	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
60.	*Schaik (1999)	19	Field study	Nether lands	Students	Smart card	Intention to use	X	X	X	X	Yes	Yes	Yes	Yes	Yes	NS
61.	*Teo *et al.* (1999)	1370	Web survey	Singa pore	Internet users	Internet	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
62.	Venkatesh (1999)	215	Lab study	USA	Business professionals	Virtual workplace sys.	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
63.	*Agarwal and Prasad (2000)	71	Field study	USA	Programmers	C programming	Intention to use	X	X	X	X	Yes	NS	Yes	Yes	NS	Yes
64.	*Agarwal and Karahanna (2000)	288	Field study	USA	Under graduate students	WWW	Intention to use	X	X	X	X	X	Yes	Yes	X	X	NS
65.	*Anandarajan *et al.* (2000b)	80	Field study	USA	MBA students	Internet	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
66.	*Anandarajan *et al.* (2000a)	88	Field study	Nigeria	Bank employees	Personal computer	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
67.	Gefen (2000)	135	Field study	USA	Knowledge workers	MRP-II systems	Self-reported use	X	X	Yes	NS	X	X	X	X	X	Yes
68.	*Gefen and Straub (2000)	217	Lab study	USA	MBA students	Online book shop	Intention to use	X	X	X	X	X	Yes	NS	X	X	Yes
69.	*Jiang *et al.* (2000)	335	Field study	France (110), Hong Kong (105), USA (120)	Under graduate students	Internet	Self-reported use	X	X	Yes	X	X	X	X	X	X	X
70.	Karahanna and Limayem (2000)	211	Field study	USA	Knowledge workers	E-mail	Self-reported use	X	X	NS	Yes	X	X	X	X	X	Yes
		173	Field study	USA	Knowledge workers	Voice mail	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes

(*continued*)

Table I.

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
71.	Kucuk and Arslan (2000)	148	Field study	Turkey (52), UK (51), Denmark (45)	Internet users	Web marketing tools	Intention to use	X	X	X	X	Yes	Yes	Yes	Yes	Yes	Yes
72.	Lederer *et al.* (2000)	163	Web survey	USA	Knowledge workers	World wide web	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
73.	*Lin and Lu (2000)	139	Lab study	Taiwan	Under graduate students	World wide web	Intention to use	X	X	X	X	Yes	Yes	Yes	Yes	Yes	Yes
74.	*Lou *et al.* (2000)	385	Field study	USA	Business students	Lotus groupware	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
75.	*Lucas and Spitler (2000)	41	Field study	USA	Knowledge workers	Broker work stations	Self-reported use	Neg	X	Yes	Yes	X	Yes	NS	X	X	Yes
76.	*Roberts and Henderson (2000)	108	Field study	Australia	Knowledge workers	Information technology	Self-reported use	X	Yes	Yes	X	X	X	X	Yes	X	X
77.	Ridings and Gefen (2000)	148	Field study	USA	Knowledge workers	Software package	Intention to use	X	X	X	X	X	Neg/Yes	NS	X	X	Yes
78.	*Venkatesh (2000)	282	Field study	USA	Knowledge workers	Software packages	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
79.	*Venkatesh and Davis (2000)	156	Field study	USA	Knowledge workers	Software packages	Self-reported use	Yes	X	X	X	X	Yes	Yes	X	X	Yes
80.	*Venkatesh and Morris (2000)	342	Field study	USA	Knowledge workers	Software package	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
81.	*Wober and Gretzel (2000)	77	Field study	Austria	Tourism managers	Decision support sys.	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
82.	*Al-Gahtani (2001)	324	Field study	UK	Under graduate students	Spreadsheet	Self-reported use	X	Yes	Yes	X	X	X	X	Yes	Yes	Yes
83.	Bhattacherjee (2001)	172	Web survey	USA	Website users	Online brokerage service	Intention to use	X	X	X	X	X	Yes	X	X	X	X
84.	Chau (2001)	360	Field study	Hong Kong	Under graduate students	MS word, Excel, Access	Intention to use	X	X	X	X	X	Yes	X	X	X	Yes
85.	Chau and Hu (2001)	421	Field study	Hong Kong	Knowledge workers	Telemedicine tech.	Intention to use	X	X	X	X	Yes	Yes	X	Yes	NS	NS
86.	Childers *et al.* (2001)	540		USA	Students/ Customers	World wide web	Attitude towards use	X	X	X	X	X	X	X	Yes	Yes	X

(*continued*)

Table I.

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
87.	Handy *et al.* (2001)	102	Field study	New Zealand	Doctors and midwives	Healthcare database	Self-reported use	X	Yes	Yes	Yes	X	X	X	Yes	Yes	X
88.	*Horton *et al.* (2001)																
	Study-1	386	Field study	UK	Bank employees	Intranet	Self-reported use	Yes	X	Yes	Yes	X	Yes	Yes	X	X	Yes
	Study-2	65	Field study	UK	Eng. co. employee	Intranet	Measured use	NS	X	NS	Yes	X	Yes	Yes	X	X	Yes
89.	*Lu *et al.* (2001)	108	Lab study	Taiwan	Under graduate students	Decision support sys.	Intention to use	X	X	X	X	Yes	Yes	Yes	Yes	Yes	Yes
90.	Mathieson *et al.* (2001)	401	Field study	USA	Graduate students	Bulletin board system	Self-reported use	Yes	X	X	X	Yes	Yes	X	Yes	Yes	Yes
91.	*Moon and Kim (2001)	152	Field study	South Korea	Under graduate students	World wide web	Self-reported use	Yes	X	X	X	Yes	Yes	Yes	Yes	Yes	Yes
92.	Pijpers *et al.* (2001)	87	Field study	Nether lands	Senior executives	Software packages	Self-reported use	X	X	X	X	Yes	X	X	Yes	Yes	NS
93.	*Plouffe *et al.* (2001)	172	Field study	Canada	Merchants	Smart card	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
94.	Riemens chneider and Hardgrave (2003)	85	Field study	USA	Application developers	CASE tools	Self-reported use	X	X	NS	Yes	X	X	X	X	X	Yes
95.	*Townsend *et al.* (2001)	64	Lab study	USA	Under graduate students	Desktop video conf.	Measured use	X	Neg	X	X	X	X	X	Yes	Yes	NS
96.	*Aladwani (2002)	387	Lab study	Kuwait	Business students	Online book store	Intention to purchase	X	X	X	X	X	Yes	Yes	X	X	Yes
97.	*Anandarajan *et al.* (2002)	143	Field study	Nigeria	Knowledge workers	Microcomputers	Self-reported use	X	X	NS	Yes	X	X	X	X	X	Yes
98.	Benamati and Rajkumar (2002)	10	Interview	USA	Outsourcing managers	Outsourcing	Intention to use	X	X	X	X	Yes	Yes	Yes	Yes	Yes	Yes
99.	Brown *et al.* (2002)																
	Model-1	107	Field study	USA	Bank employees	Comp. banking system	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
	Model-2							X	X	X	X	NS	NS	X	Yes	NS	Yes
100.	Chau and Hu (2002a)	408	Field study	Hong Kong	Physicians	Telemedicine tech.	Intention to use	X	X	X	X	Yes	Yes	X	Yes	NS	NS
101.	*Chau and Hu (2002b)	408	Field study	Hong Kong	Physicians	Telemedicine tech.	Intention to use	X	X	X	X	Yes	Yes	X	Yes	NS	NS
102.	Chen *et al.* (2002)	253	Web survey	USA	Website users	Virtual store	Self-reported use	Yes	X	X	X	Yes	NS	X	Yes	Yes	Yes

(*continued*)

Table I.

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
103.	*Dabholkar and Bagozzi (2002)	392	Lab study	USA	Under graduate students	Self-service technology	Intention to use	X	X	X	X	Yes	X	X	Yes	Yes	X
104.	*Dasgupta *et al.* (2002)	60	Lab study	USA	Under graduate students	Group support system	Measured use	X	X	Neg	Neg	X	X	X	X	X	Yes
105.	*Devraj *et al.* (2002)	134	Web survey	USA	Business students	Online shopping	Intention to use	X	X	X	X	Yes	X	X	Yes	Yes	Yes
106.	Gentry and Calantone (2002)	200	Field study	USA	Under graduate students	Virtual store	Intention to use	X	X	X	X	Yes	Yes	X	Yes	Neg	NS
107.	*Hong *et al.* (2002)	585	Field study	Hong Kong	Students	Digital library	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
108.	*Koufaris (2002)	280	Web survey	USA	Website users	Online book store	Intention to use	X	X	X	X	X	Yes	NS	X	X	Yes
109.	*Liaw (2002)	260	Field study	USA	Under graduate students	World wide web	Intention to use	X	X	X	X	X	Yes	X	X	X	X
110.	*Lowry (2002)	185	Field study	UK	Professional engineers	Building mgmt. system	Self-reported use	X	X	NS	NS	X	NS	Yes	X	X	Yes
111.	*Riemens chneider *et al.* (2002)	128	Field study	USA	Application developers	App. develop. method	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
112.	*Schaik *et al.* (2002)	49	Lab study	UK	Physio therapists	Clinical support system	Intention to use	X	X	X	X	X	Yes	NS	X	X	Yes
113.	*Seyal *et al.* (2002)	166	Field study	Brunei	Academic staff	Internet	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	X
114.	*Stafford and Stern (2003)	329	Field study	USA	Students	Online auction website	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
115.	*Suh and Han (2002)	845	Web survey	South Korea	E-banking users	Internet banking	Self-reported use	Yes	Yes	X	X	Yes	Yes	X	Yes	Yes	Yes
116.	*Thong *et al.* (2002)	397	Field study	Hong Kong	Students	Digital library	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
117.	*van Dolen and de Ruyter (2002)	198	Lab study	Nether lands	Business students	Moderated group chat	Attitude (satisfaction)	X	X	X	X	X	X	X	Yes	Yes	Yes
118.	*Venkatesh *et al.* (2002)	215	Lab study	USA	Knowledge workers	Software package	Measured use	Yes	X	X	X	X	Yes	NS	X	X	Yes
119.	*Choi *et al.* (2003)	2291	Web survey	South Korea	Website users	Interactive TV	Intention to use	X	X	X	X	Yes	Yes	Yes	Yes	Yes	Yes
120.	*Featherman and Pavlou (2003)	395	Lab study	USA	Business students	Electronic billing service	Intention to adopt	X	X	X	X	X	Yes	Neg	X	X	Neg

(*continued*)

Table I.

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
121.	Gefen (2003)	179	Web survey	USA	Business students	Online shopping mall	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
122.	*Gefen *et al.* (2003a)	213	Field study	USA	Business students	Website	Intention to use	X	X	X	X	X	Yes	Yes	X	X	Yes
123.	*Gefen *et al.* (2003b)	317	Lab study	USA	Business students	Online book store	Intention to use	X	X	X	X	X	Yes	X	X	X	NS
124.	Hackbarth *et al.* (2003)	116	Field study	USA	Graduate students	MS Excel	Perceptions	X	X	X	X	X	X	X	X	X	X
125.	*Hardgrave and Johnson (2003)	150	Field study	USA	Software developers	OOP develop. software	Intention to use	X	X	X	X	X	Yes	X	X	X	X
126.	*Hardgrave *et al.* (2003)	128	Field study	USA	Software developers	S/w develop. method	Intention to use	X	X	X	X	X	Yes	X	X	X	X
127.	*Heijden (2003)	825	Web survey	Nether lands	Website users	Web portal	Self-reported use	Yes	X	X	X	Yes	Yes	X	Yes	Yes	Yes
128.	Henderson and Divett (2003)	247	Web survey	Australia	Online customers	Web store	Measured use	X	X	Yes	NS	X	X	X	X	X	Yes
129.	Hu *et al.* (2003)	138	Lab study	Hong Kong	Public school teachers	Power point	Intention to use	X	X	X	X	X	Yes	NS	X	X	Yes
130.	Lee and Lee (2003)	130	Web survey	South Korea	Website users	Online store	Intention to use	X	X	X	X	Yes	Yes	NS	Yes	Yes	X
131.	Lee *et al.* (2003a)	31	Field study	n/a	Students	Black board systems	Self-reported use	X	Yes	Yes	X	X	X	X	Yes	X	Yes
132.	*Liaw and Huang (2003)	114	Field study	Taiwan	Medical students	World wide web	Intention to use	X	X	X	X	X	Yes	X	X	X	Yes
133.	Lim (2003)	n/a	Field study	Singa pore	Knowledge workers	Negotiation sup. syss	Intention to use	X	X	X	X	Yes	Yes	X	Yes	Yes	Yes
134.	Lu *et al.* (2003)	n/a	Field study	USA	MBA students	Wireless internet	Intention to accept	X	X	X	X	Yes	Yes	X	Yes	Yes	Yes
135.	O'Cass and Fenech (2003)	392	Web survey	Australia	Website users	World wide web	Intention to use	X	X	X	X	Yes	X	X	Yes	Yes	X
136.	Olson and Boyer (2003)	416	Field study	USA	Online customers	Online retailer	Self-reported use	X	Yes	Yes	Yes	X	X	X	Yes	Yes	Yes
137	Pavlou (2003)																
	* Study-1	102	Lab study	USA	Under graduate students	Online retailers	Intention to use	X	X	X	X	X	Yes	NS	X	X	Yes
	Study-2	155	Web survey	USA	Online users	Online retailers	Self-reported use	Yes	X	Yes	Yes	X	Yes	Yes	X	X	Yes
138.	*Riemens chneider *et al.* (2003)	156	Field study	USA	Knowledge workers	IT adoption	Intention to use	X	X	X	X	Yes	NS	X	Yes	Yes	NS

(*continued*)

	Study	Sample size	Study type	Country	Subject type	System type	Dependent variable	I→U	A→U	PU→U	PEU→U	A→I	PU→I	PEU→I	PU→A	PEU→A	PEU→PU
139.	*Selim (2003)	403	Field study	UAE	Under graduate students	Course related websites	Self-reported use	X	X	Yes	Yes	X	X	X	X	X	Yes
140.	Suh and Han (2003)	502	Web survey	South Korea	E-banking users	Internet banking	Self-reported use	Yes	X	X	X	Yes	X	X	X	X	X
141.	*Sussman and Siegal (2003)	63	Field study	USA	Consultants	Comp. mediated advice	Self-reported use	X	X	Yes	X	X	X	X	X	X	X
142.	*Teo *et al.* (2003)	69	Lab study	n/a	Under graduate students	Virtual communities	Intention to use	X	X	X	X	Yes	Yes	NS	Yes	Yes	NS
143.	*Venkatesh *et al.* (2003) n	348	Field study	USA	Knowledge workers	Workplace technologies	Measured use	Yes	X	X	X	Yes	Yes	Yes	Yes	Yes	Yes
144.	*Yi and Hwang (2003)	109	Web survey	USA	Under graduate students	Black board systems	Measured use	Yes	X	X	X	X	Yes	Yes	X	X	NS
145.	Shih (2004)	212	Field study	Taiwan	Knowledge workers	World wide web	Intention to use	X	X	X	X	Yes	NS	NS	Yes	Yes	Yes

Note: U – usage; I – behavioural intentions; PU – perceived usefulness; A – attitude; PEU – perceived ease of use; Yes – relationship validated; NS – relationship non-significant or rejected; Neg. – reverse findings; x – relationship not tested; NA – not available; * = studies marked with an asterisk (*) are included in the meta-analysis (due to availability of required data); ● = Studies marked with "●" are longitudinal studies

Table I.

the students. In a few cases, longitudinal studies have been conducted, although the duration of the studies was not always reported.

The widespread popularity of the TAM is broadly attributable to three factors:

(1) it is parsimonious, IT-specific, and is designed to provide an adequate explanation and prediction of a diverse user population's acceptance of a wide range of systems and technologies within varying organizational and cultural contexts and expertise levels;

(2) it has a strong theoretical base and a well researched and validated inventory of psychometric measurement scales, making its use operationally appealing; and

(3) it has accumulated strong empirical support for its overall explanatory power and has emerged as a pre-eminent model of users acceptance of technology (Chau, 1996a; Hu *et al.*, 1999; Mathieson, 1991; Szajna, 1996).

Replication of the original TAM study suggests that it holds across persons, setting, cultures, countries, and times, the last being a requirement for robust theories (Cook and Campbell, 1979). The first study outside North America was by Phillips *et al.* (1994) whose work validated the TAM in China and whose results suggest that cultural affinity had a significant and positive influence on the TAM through PEOU. The results of Straub *et al.* (1997) indicate that the TAM holds for the USA and Switzerland but not for Japan, suggesting that culture can exert an effect on the predictive capacity of the TAM. Table II presents summative statistics for TAM studies classified by country.

Role of attitude in the TAM

Attitude is described in the literature as an "individual's positive or negative feelings (evaluative effect) about performing the target behaviour" (Fishbein and Ajzen, 1975, p. 216). Ajzen and Fishbein (1980) argue that attitudes towards an object influence intentions which, in turn, influence behaviour with respect to the object, that is, its use. Considering user satisfaction as an attitude (DeLone and McLean, 1992), the IS research to date has mostly assessed the attitude towards the output of a system, rather than that of using the system. Brown *et al.* (2002) suggest that a neglected stimulus in IS research is the attitude towards using the system.

Austria	1 (77)	Hong Kong	12 (3695)	Singapore	4 (1508)
Australia	3 (747)	Japan	3 (493)	South Korea	5 (3920)
Brazil	1 (79)	Jordan	1 (121)	Sudan	1 (45)
Brunei	1 (166)	Kuwait	1 (387)	Switzerland	2 (304)
Canada	4 (1147)	Lebanon	1 (35)	Taiwan	5 (663)
China	1 (303)	Netherlands	4 (1129)	Turkey	1 (52)
Denmark	1 (45)	Nigeria	2 (231)	UAE	2 (450)
Egypt	1 (45)	New Zealand	2 (460)	UK	8 (1536)
Finland	2 (900)	Saudi Arabia	1 (28)	USA	98 (17787)
France	1 (110)				

Total sample size for TAM studies = 36463

Note: No of studies (cumulative sample size for the country)

Table II.
Technology acceptance model (TAM) studies by country classification

Attitude is included in the original formulation of TAM, however, a subsequent study by Davis *et al.* (1989, pp. 995-6) conducted in a volitional environment demonstrated that the explanatory power of the TAM is equally good and it is more parsimonious without the mediating attitude construct. After that, it became the norm to exclude the attitude construct from the TAM (Table I). Later research on the TAM indicates that attitude may play a central mediating role for determining mandatory usage; however, its direct relationship to behavioural intentions was not supported (Jackson *et al.*, 1997; Adams *et al.*, 1992). "Attitude, like many behavioural variables, may be a necessary but not sufficient condition for success" (Jackson *et al.*, 1997, p. 383). This would appear to support the contention of Davis *et al.* (1989) that attitude may not be a strong determinant of intentions in workplace settings when other factors such as usefulness are independently taken into account. The explanation for such findings is based on the fact that, in work-related settings, performance is key, and intentions will be formed based on performance considerations rather than simply on personal likes or dislikes with respect to performing a behaviour (Taylor and Todd, 1995).

Although the revised TAM dispenses with attitudinal mediation between beliefs and intentions, research indicates that in mandatory environments, attitude has been shown to correlate strongly with usage behaviour. In the mandatory environment, "a user's only freedom of choice, assuming that he or she does not want to leave the organization, is how wholeheartedly to accept the innovation" (Leonard-Barton, 1998, p. 604). Employees who do not wholeheartedly accept the innovation can delay or obstruct the implementation, and resent, under-utilize or sabotage the new system (Markus, 1983). Brown *et al.* (2002) suggest that these reactions are a result of the positive or negative attitude that employees form towards the technology. In mandatory environments, attitude is likely to take on heightened importance and thus warrant consideration.

Measurement of the dependent variable

Previous research on the TAM has found little similarity between self-reported (subjective) and computer recorded (objective) measures of IT usage (Chin, 1996; Straub *et al.*, 1995; Szajna, 1996). To be an effective surrogate, self-reported usage must be a valid measure of use correlating strongly with other methods of measuring usage, that is, it must exhibit convergent validity (Nunnally, 1978). In addition, it should correlate more strongly with another method of measuring the same construct (e.g. actual usage) than with another construct using the same measuring method (e.g. intentions), that is, show discriminant validity (Campbell and Fiske, 1959). However, both Straub *et al.* (1995) and Szajna (1996) found a weak correlation between self-reported and actual usage. Szajna also found that the correlation of self-reported usage with intention was higher than its correlation with actual usage, providing little support for discriminant validity. The weak support for discriminant validity was due to the fact that all constructs of the TAM (PU, PEOU, intention, attitude) are self-reported and when correlated with self-reported usage, common method variance becomes an important factor (Podsakoff and Organ, 1986). In addition, the demand characteristics of the research environment and the halo effect can influence associations among self-reported constructs (Szajna, 1996). Straub *et al.* (1995, p. 1336) suggest that:

> ... research that has relied on subjective measures for both independent variable ... and dependent variables, such as system use ... may not be uncovering true, significant effects, but mere artifacts.

They further suggest that IT usage should be reformulated as two separate constructs: perceived usage and actual usage, and that the TAM may require a substantial reformulation. Questioning this interpretation, Chin (1996) brought in the notion of observer-relative features to explain why the usage measures developed in Straub *et al.* (1995) fail to be related within the TAM construct. He suggests that the extent of usage may not be as appropriate as an adoption/acceptance function usage when embedded in the TAM context. Chin (1996) also highlighted internal consistency and temporal problems in measured use and suggest that the meaning attributed to usage must be assessed more deeply than the mode of measurement.

Relative importance of PU and PEOU in the TAM

The TAM emphasizes the importance of PU (over PEOU) as the key determinant of acceptance. Most of the studies, beginning with that of Davis *et al.* (1989), have not found a direct linkage between PEOU and usage, leading to PEOU's being treated as something of a "step-child" (Venkatesh, 1999, p. 254). Similarly, Davis (1989) found the direct effect of PEOU on intentions to be stronger in the early stages of learning and behaviour. With time and experience, the effect was found to become indirect, operating through PU (p. 332), a thesis that has also been posited by later research (Adams *et al.*, 1992 Study-1; Chau, 1996a; Gefen and Straub, 2000; Igbaria *et al.*, 1996). Moreover, Keil *et al.* (1995, p. 89) report that "no amount of ease of use will compensate for low usefulness".

The role of PEOU in TAM remains debatable, however, in that some studies show that PEOU has a direct and equal (Adams *et al.*, 1992 Study-2; Agarwal and Prasad, 1997), or a stronger effect than PU (Chau, 1996b; Igbaria *et al.*, 1997; Karahanna and Limayen, 2000) on technology adoption. In contrast to Davis (1989) and Lu and Gustafson (1994) found a spurious relationship between PU and initial usage and suggested that PEOU is an intervening variable between usage and PU. In fact, some studies suggests a negative effect of PU on usage (Bajaj and Nidumolu, 1998; Dasgupta *et al.*, 2002).

Gefen and Straub (2000) argue that, since in many cases the new technology is adopted because of its extrinsic aspect (captured through PU) and not its intrinsic aspect, PEOU will affect use when the intrinsic character of the technology contributes to the actual outcome of its application. Similarly, the results from Venkatesh (1999) indicate that PEOU can be a strong catalyst fostering acceptance in a positive and enjoyable training environment. His results suggest that users who underwent a game-based training experienced a higher overall effect of PEOU on their intentions as compared to PU. This implies that the appropriate priming of users and tasks increases the importance of PEOU.

The results of Igbaria and Iivari (1995) on the one hand strengthened the external validity of the TAM in Finland, and on the other shed light on inconsistent earlier results. They suggest that "beliefs about outcome (PU) may not be sufficient to affect behaviors if individuals doubt their capabilities to successfully use the computer technology" (p. 600). Contrary to the original TAM, which assumed the influence of external variables to be channelled through PU and PEOU, their results indicated a

strong direct effect of experience on usage; it was the second highest influence after PU. Szajna (1996) also recommended adding an experience component as an extension of the TAM.

PU was later expanded to include two closely related but different concepts: near-term PU and long-term PU, with near-term PU having the most significant affect on intentions, followed by long-term PU, whereas no significant relationship was found between PEOU and intentions (Chau, 1996b). Jiang *et al.* (2000) validated these results for self-reported use. Research suggests sex (Gefen and Straub, 1997; Venkatesh and Morris, 2000) and task type (Gefen and Straub, 2000; Moon and Kim, 2001) affect the relative importance of PU and PEOU.

These considerations and Table I suggest that for different type of technology user populations, and in different time periods the relative importance of PU and PEOU is variable, reflecting a potential "non-applicability" of the TAM in some contexts. However, the TAM literature has not effectively dealt with these inconsistencies.

Reliability and validity of PU and PEOU measurement scales

Davis (1986, 1989, 1993) and Davis *et al.* (1989) developed and validated the original instrument for measuring PU and PEOU, which was later replicated by Adams *et al.* (1992), Mathieson (1991), and Hendrickson *et al.* (1993). Segars and Grover (1993) used confirmatory factor analysis with LISREL and identified potential weaknesses in the measures, suggesting that PU be split into two dimensions "PU" and "effectiveness". They note that:

> ... determining the structure of psychological constructs such as "ease of use" and "usefulness" is a complex activity ... of critical importance in accurately explaining levels of usage ... [and that] no absolute measure for these constructs exists across varying technological and organizational contexts (p. 525).

However, Chin and Todd (1995) question this interpretation; they re-examine data from Adams *et al.* (1992) together with data from a new study and show that the original single dimension of PU was more accurate. In another study of two applications in two organizations, Subramanian (1994) found that PU and PEOU constructs were robust and concluded that IS researchers can use these instruments in varying technological and organizational contexts.

The Cronbach α reliability of the TAM scales generally exceeds 0.9 across numerous studies. The scales exhibit a high degree of convergent, discriminant, and nomological validity (Doll *et al.*, 1998). Over the last 17 years, the cumulative number of items for measuring PU has increased from the original six to currently about 50, and that for PEOU has increased from six to 38 (Ma and Liu, 2004).

Davis and Venkatesh (1996) in their experiments on 708 subjects, found that item grouping vs item intermixing had no significant effect (positive or negative) either on the high levels of reliability and validity of the TAM scales, or on the path coefficients linking them together. They suggest that the TAM measures should be employed using the original (grouped) format in order to best predict and explain user acceptance of technology.

External variables and internal beliefs

A key limitation of the TAM is that while it provides a valuable insight into users' acceptance and use of technology, it focus only on the determinants of use (PU and PEOU) and does not reveal how such perceptions are formed or how they can be manipulated to foster users' acceptance and increased usage (Mathieson, 1991). According to Davis *et al.* (1989), one of the key purposes of the TAM was to provide a basis for tracing the impact of external factors on internal beliefs, i.e. PU and PEOU, and to link that to actual use. Chin and Gopal (1995, p. 46) suggest, "greater understanding may be garnered in explicating the casual relationship among beliefs and their antecedent factors". The implication is that without a better understanding of the antecedents of PU and PEOU practitioners are unable to know which levers to pull in order to affect these beliefs and, through them, the use of technology. The first external variable added to the TAM was output quality (Davis *et al.*, 1992), and since then researchers have proposed more than 70 external variables for PU and PEOU. Table III divides these external variables into four categories of organizational, system, users' personal characteristics, and other variables.

Potential moderators

Although TAM has been proved as a robust model with high-predictive validity, results from a variety of studies suggests that in some circumstances the model does not provide a complete understanding of the phenomenon studied. More specifically, in some cases the predictive efficacy of an independent variable and/or the form of relationship may vary systematically as a function of some other variable(s). Understanding of these variables, although not part of the model, can provide greater insight into the phenomenon examined. One alternative to the classic validation model, proposed by Saunders (1956) in psychological literature and used increasingly in marketing, is the concept of moderating variables. A moderator variable has been defined as one which systematically modifies either the form/or strength of the relationship between a predictor and a criterion variable (Sharma *et al.*, 1981). There are three different points of views about what specifically a moderator variable is and how it operates to influence the classic validation model:

(1) Some researchers suggest that a variable is a moderator if it interacts with a predictor variable irrespective of whether the hypothesized moderator variable is a significant predictor as well (Fry, 1971; Horton, 1979; Peters and Champoux, 1979).

(2) A second concept is that a moderator cannot be a significant predictor variable (Cohon and Cohon, 1975; Zedeck, 1971).

(3) Finally, a third approach is to use an analytic procedure to examine differences between individuals grouped on the basis of some hypothesised moderator variables (Bennett and Harrell, 1975; Ghiselli, 1960, 1963; Hobert and Dunnette, 1967).

Basically, there are two types of moderator variables. One type influences the validation model by affecting the strength of the relationship and the second modifies the form of the validation model. The moderators used in our meta-analysis influences the strength of the relationship between criterion and predictor variable, but they are not significantly related to either of them. Thus, we have taken the third approach to

Organizational characteristics	System characteristics	User personal characteristics	Other variables
Competitive environment[ab]	Accessibility[ab]	Age[a]	Argument for change[ab]
End-user support[ab]	Access cost[ab]	Awareness[ab]	Cultural affinity[b]
Group's innovativeness norm[a]	Compatibility[ab]	Cognitive absorption[ab]	External computing support[ab]
Implementation gap[ab]	Confirmation mechanism[a]	Computer anxiety[ab]	External computing training[ab]
Internal computing support[ab]	Convenience[ab]	Computer attitude[ab]	Facilitating conditions[ab]
Internal computing training[ab]	Image/interface[ab]	Computer literacy[ab]	Subjective norms[a]
Job insecurity[ab]	Information quality[a]	Educational level[ab]	Situational normality[ab]
Management support[ab]	Media style[ab]	Experience[ab]	Social influence[ab]
Organizational policies[a]	Navigation[b]	Gender[ab]	Social pressure[ab]
Organizational structure[ab]	Objective usability[b]	Intrinsic motivation[ab]	Task technology fit[ab]
Organizational support[ab]	Output quality[ab]	Involvement (situational/intrinsic)[ab]	Task characteristics[ab]
Organizational usage[a]	Perceived attractiveness[ab]	Personality[ab]	Vendor's co-operation[ab]
Peer influence[ab]	Perceived complexity[a]	Perceived developer's responsiveness[ab]	
Peer usage [a]	Perceived importance[a]	Perceived enjoyment[ab]	
Training[ab]	Perceived software correctness[a]	Perceived playfulness[b]	
Transitional support[ab]	Perceived risk[ab]	Perceived resources[a]	
	Relevance with job[ab]	Personal innovativeness	
	Reliability and accuracy[ab]	Role with technology[ab]	
	Response time[ab]	Self-efficacy[ab]	
	Result demonstrability[ab]	Shopping orientation[ab]	
	Screen design[ab]	Skills and knowledge[ab]	
	Social presence[ab]	Trust[ab]	
	System quality[ab]	Tenure in work force[ab]	
	Terminology[ab]	Voluntariness[ab]	
	Trialability[ab]		
	Visibility[ab]		
	Web security[ab]		

Notes: [a]proposed to affect PU; [b]proposed to affect PEOU

Table III.
External variables proposed to affect the internal beliefs (PU and PEOU)

examine differences between individuals grouped on the basis of some hypothesized moderator variables. In such a situation, the error term is posited to be a function of the moderator variable. When the number of potential moderator variable is large, however, blind application of meta-analysis can produce superfluous results

(Hunter and Schmidt, 1990). To avoid the capitalization of chance problems, Hunter and Schmidt (1990) suggest that only theory-suggested moderator variables be tested. In this study, we focus on the moderating effect of subject type, method type, measurement of usage, and the type of technology tested.

Subject type

Researchers have raised concerns about the generalizability of student-based findings across the consumer population (Burnett and Dunne, 1986). Students' restricted age range, limited experience with the technology, relatively low income, and different motivations for the use of technology have resulted in students being portrayed as atypical users. Students have also been portrayed as having yet-to-be-solidified cognitive structures that make them more susceptible than are others to reference group influence (Park and Lessig, 1997). More important, these distinctions could translate into differences in how the two groups of users assess and perceive the technology being tested or how they react to satisfying and dissatisfying use of that particular technology. Finally, research using students as subjects has been conducted in environments in which the use of technology is voluntary (Davis *et al.*, 1989; Mathieson, 1991; Taylor and Todd, 1995). However, many behaviours in organizations, particularly those related to the use of technology, are not volitional (Ram and Jung, 1991). These possibilities suggest that the subject type could account for some variance in the effect sizes of TAM variables.

Method type

An additional element reported in the literature that could account for variance in the magnitude of the effect size is whether researchers use an experimental or survey approach. Each approach has characteristics that could contribute to the variance observed across estimates of relationship strength. Experiments, for example, can control the level of the factors to which the participants are exposed and can offer the control necessary to eliminate potential confounds. However, experiments compromise on realism when they use fictitious stimuli under artificial conditions. A field-study survey approach may offer less control over the assignment of subjects to the levels of a factor but may be more realistic because it is based on real offerings under natural technology usage conditions (Tabachnick and Fidell, 1996). The degree to which the differences that characterize surveys and experiments bias estimates of association will be examined explicitly in the meta-analysis presented in Part 2.

Type of technology tested

The IS literature suggests that the variation in technology/application type may influence users' frames of reference and thereby the meaning and scaling of TAM constructs (Doll *et al.*, 1998). Applications can be considered as "useful" if they contribute to accomplishing the end-user's purpose, and "easy to use" if the effort required making use of the application is modest relative to the end-user's frame of reference. Goodhue and Thompson (1995) refer to purpose as the end-user's task, and argue that task characteristics (through system-task fit) influence user evaluations.

Cross-validation studies of the TAM have been careful to analyze responses separately for each type of application, implicitly recognizing that there may be difference across applications (Adams *et al.*, 1992; Davis *et al.*, 1989; Doll *et al.*, 1998). Four types of applications have been widely tested in the TAM

literature: communication systems, general purpose systems, office systems, and specialized systems (Lee *et al.*, 2003b). These systems are used for different purposes (i.e. objectives) and differ in the efforts required to use them. The purpose of the application or its comparative advantage (i.e. relative effort over alternative means of meeting the user's task requirement) may affect the user's frame of reference (Doll *et al.*, 1998), i.e. PU or PEOU may not have the same meaning for specialized software as it does for the internet. Similarly, that if the technology is inherently relatively easy to use, PEOU will have less or no impact on usage (Subramanian, 1994).

Studying the moderating effect of technology type will be important for IS researchers who are attempting to assess the overall value or impact of different form of technologies, and will considerably widen the scope of application.

Measurement of usage

System usage is one of the most frequently proposed (DeLone and McLean, 1992) and widely used measure of IS success in empirical MIS research (Zmud, 1979). The most common forms of system usage measures found in the literature are subjective (self-reported) and objective (actual usage or frequency recorded by the computerized system) measures. Although most prior studies on the TAM relied on subjective measures of technology usage, an objective measure has many advantages over a self-reported measure. Objective measure can rule out the reporting biases due to selective recall (Davis *et al.*, 1992) and inaccurate estimation (Collopy, 1996). Moreover, using objective measure avoids inherent methodological problems such as common-method bias, hypothesis guessing, and indistinguishable causation, associated with retrospective self-reported measures (Straub *et al.*, 1995; Szajna, 1996).

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