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Journal of Strategic Information Systems 14 (2005) 245–268
Strategic Information Systems
www.elsevier.com/locate/jsis

Personal innovativeness, social influences and adoption of wireless Internet services via mobile technology

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Available online 9 August 2005

Abstract

Technology acceptance research has tended to focus on instrumental beliefs such as perceived usefulness and perceived ease of use as drivers of usage intentions, with technology characteristics as major external stimuli. Behavioral sciences and individual psychology, however, suggest that social influences and personal traits such as individual innovativeness are potentially important determinants of adoption as well, and may be a more important element in potential adopters' decisions. This paper models and tests these relationships in non-work settings among several latent constructs such as intention to adopt wireless mobile technology, social influences, and personal innovativeness. Structural equation analysis reveals strong causal relationships between the social influences, personal innovativeness and the perceptual beliefs—usefulness and ease of use, which in turn impact adoption intentions. The paper concludes with some important implications for both theory research and implementation strategies.

Keywords: Wireless Internet via mobile technology; Social influences; Personal innovativeness; Adoption intention; Technology acceptance model; Mobile data services

1. Introduction

Mobile commerce as the second wave of e-commerce is penetrating into various aspects of our life due to the latest improvement in wireless Internet services via mobile

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doi:10.1016/j.jsis.2005.07.003

technology (WIMT). As a consequence, a rapidly increasing number of organizations are making substantial investments in this new area. Nonetheless, the value of wireless Internet services will only be realized when consumers embrace WIMT as a desirable new system.

For years, research studies have empirically examined the determinants of IS usage (e.g. Davis, 1989; Mathieson, 1991; Moore and Benbasat, 1991; Taylor and Todd, 1995a; Thompson et al., 1994; Venkatesh and Davis, 2000). However, just as Karahanna and Straub (1999) pointed out, most studies on end-user beliefs and attitudes are conducted some time after the systems have been adopted. Consequently, the beliefs and external stimuli identified are mostly suitable for studying continued-use behavior. Even though initial adoption is the first step in long-term usage, the factors that affect usage may not be the same for initial adoption, or the degree of effect may vary.

In the information systems area, few researchers have addressed the issue of pre-adoption criteria. Identifying the pre-adoption criteria thus remains a critical issue in IS research. This has become more important for the adoption of wireless mobile systems. Wireless Internet services is at the stage of initial implementation via mobile devices such as PDAs and 2G, 2.5G and 3G mobile phones in the United States. The latest term for these type of services is mobile data services, covering communication services (e.g. emails, short message services), Web information services (e.g. weather information, sports, stock quotes), database services (e.g. telephone directories, map guides), entertainment (e.g. games, ring-tones), and commercial transactions (e.g. banking, stock trading, ticketing, online auction) (Massey et al., 2004). The web services seem to have the right success factors -right price, quick and easy to use. Yet, the expected adoption is not optimistic. According to a Yankee Group report (Wireless Data Use Still Limited in US, 2004), most US mobile users are not convinced of the need for mobile data services. Of the 2490 consumers surveyed, only 11% expressed strong interests in accessing primary email. Percentages of interest on other data services were all much lower. On a global scale, the US is forecasted as a developed market for mobile data services, along with Europe, Japan, Korea. Nevertheless, the m-commerce revenue as forecasted for the US is only 1.7 billion dollars for 2004, compared to 4.5 billion for Japan, 7.4 for Asia as a whole, and 4.6 for West Europe (Coursaris and Hassanein, 2002). Adoption research, therefore, is critical for identifying pre-adoption criteria and suggesting strategies for market development.

In the MIS field, explanations of why users behave in particular ways toward information technologies have been focused predominantly on instrumental beliefs such as perceived usefulness and perceived ease of use as drivers of usage intentions. Prior work in behavioral science and psychology, however, suggests that holistic experiences with technology as captured in constructs such as enjoyment, flow, and social image are potentially important explanatory variables in technology acceptance (e.g. Ajzen and Fishbein, 1980; Klonglan and Coward, 1970; Triandis, 1971; 1980). Researchers in MIS recently also suggest that factors influencing intention to use IS may vary, and the degree of influence of the same factors differs with different stages of adoption (Legris et al., 2003).

This study attempts to advance the theoretical understanding of the antecedents of early adoption. Specifically, the study investigates (1) to what extent individual perceptions toward WIMT is attributed to social influences; (2) to what extent individual perceptions

of WIMT is attributed to internal motivations; (3) whether internalization of social influences and personal tendency to try affect potential users' intention to adopt WIMT; and (4) whether behavioral beliefs such as perceived usefulness and perceived ease of use have primary explanatory power over user intention to adopt WIMT, as confirmed in a number of prior IT/IS studies.

This paper is organized into five sections. It first presents a relevant discussion of the theoretical framework concerning early adoption of IT/IS and the guiding hypotheses for the research. The paper then describes the methods used for carrying out the study. Data analysis results are described prior to an extended discussion. The paper concludes with the theoretical and practical implications of the findings, limitations, and recommendations for further research.

2. Theoretical framework and hypotheses

This study is interested in initial and early adoption of a new information system—WIMT. Adoption refers only to the initial acceptance of an object. Rogers (1983) classified adopters of innovations into five categories: innovators, early adopters, early majority, late majority, and laggards. For initial and early adoption, decision-making is exposed to variables other than those incurred by the technology itself and is more possibly influenced by those variables (e.g. Ajzen and Fishbein, 1980; Karahanna and Straub, 1999; Rogers, 1983).

Human adoption behavior has long been a topic in behavioral science. The Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB) (Ajzen and Fishbein, 1980; Ajzen, 1985; 1991) provide the theoretical framework for understanding human behavior. According to TRA and TPB, a person's action is determined by the intention to perform—a function of attitude and subjective norms, which can be traced back to a person's behavioral and normative beliefs. Behavioral belief refers to an individual's positive or negative evaluation of performing a certain behavior, while a normative belief is a person's perception of the social pressures to perform or not perform the behavior in question. The relative weights of these two types of beliefs may vary from person to person (Ajzen and Fishbein, 1980).

Influenced by TRA and TPB, theories such as the technology acceptance model (TAM) by Davis (1989) and some extended models based upon it, were developed to guide IS/IT acceptance research and practice since the 1980s. A commonality among all those theories supported by a substantial number of empirical studies is the direct association between changes in beliefs and changes in intentions and outcome expectancies. A meta-analysis of major technology acceptance studies published up to year 2001 (Legris et al., 2003) declared that early efforts concentrated on the identification of factors that facilitated IS use. TAM grouped the factors into a model to facilitate the analysis of IS use. For a long time TAM has helped to examine the mediating role of perceived usefulness and perceived ease of use and their relationships between systems characteristics (external variables) and the probability of system use (an indicator of system success). More recently, TAM2, the revised TAM, was expanded to include subjective norms as a determinant of perceived usefulness

(Venkatesh and Davis, 2000). Overall, TAM and TAM2, however, explained only 40% of a system's use. This meta analysis concluded that TAM is a useful model but has to be integrated into a broader one to enhance the predictive power. Corresponding to this criticism, a unified theory of acceptance and use of technology model (UTAUT) was developed recently (Venkatesh et al., 2003). Based on a thorough review of important user acceptance literature and eight prominent models including TRA, TPB, TAM, Motivational Model (MM), and Innovation Diffusion Theory (IDT), UTAUT is more comprehensive for assessing the likelihood of technology success and understanding the drivers of acceptance to proactively designed management interventions.

However, TAM and TAM2 were originally built to ease managing MIS activities in organizations by measuring the quality of delivered systems and addressing the central concern of IT adoption and use in the workplace (Davis, 1989; Venkatesh and Davis, 2000). Because of this purpose, over majority of the TAM-related studies used samples from various workplaces to investigate IT/IS implementation in organizations. TAM models have also been considered applicable for studying individual adoption especially when individual differences and social influence are concerned (Venkatesh and Morris, 2000). The number of studies using individual consumer samples in non-work settings was small, compared to the previous kind of study where job relevance, mandatory or voluntary organizational settings, work experience and management influence are of importance. Therefore, the suitability of these models for predicting individual, non-work related adoption behavior is still worthy of examination. In addition, despite the fact that social influence is more or less considered in the TAM2 and especially in UTAUT, it takes the form of normative forces in compliance with organizational goals (Stafford et al., 2004). Such influence is different from the social pressures on an individual consumer facing a free adoption choice. Further, those TAM related models focus on building a generic model for explaining general technology acceptance. A generic model may not explain the process of adopting a specific system accurately. Finally, the three TAM models neglect one important variable—the impact of personal innovativeness on adoption. Agarwal and Prasad (1998) proposed a new construct—personal innovativeness in information technology (PIIT), and illustrated its moderating effect on the antecedents as well as the consequences of individual perceptions about a new information technology. Then a few other studies (e.g. Agarwal and Karahanna, 2000; Thatcher and Perrewe, 2002; Lewis et al., 2003) followed to shed light on the fact that end-user perceptions are very often captured before adoption and vary with different dispositional characteristics. They argued for the need to focus our attention on holistic experiences with IT.

This study is a continuing effort in exploring the nature of influences from personal innovativeness and social environment over information systems and technology adoption. It examines the intention to adopt rather than actual adoption. Since implementation of WIMT is still at a primitive stage characterized by limited adoption and use; an investigation of the intention to adopt and its possible impacting factors will exert stronger predicting power. The rest of this section elaborates on the rationale for the theoretical constructs to be included in our research model and the hypothesized causal relationships among those constructs.

2.1. Social influences

Social influences in this study refer to perceived pressures from social networks to make or not to make a certain behavioral decision. In sociology, social network effects have been used to explain and understand a variety of organizational behavior phenomena, such as commitment and satisfaction (Krackhardt and Porter, 1985), job-related rewards (Bian, 1997; Burt, 1992; 1997; Granovetter, 1974), influence and power (Brass, 1984), and conflict (Labianca et al., 1998; Nelson, 1989). However, social network studies tend to view networks as formal social networks in organizational and work settings.

Social influences has been regarded a critical element in innovation diffusion literature as well (e.g. Cooper and Zmud, 1990; Klonglan and Coward, 1970; Laudon, 1985; Triandis, 1971). Support from influential others has an important impact on what action a potential adopter chooses to take because individuals adapt their attitudes, behaviors and beliefs to their social context (Salancik and Pfeffer, 1978). A common explanation is that an innovation creates uncertainty about its expected consequences for potential adopters. Individuals are generally uncomfortable with uncertainty and will, therefore, tend to interact with the social network to consult on their adoption decisions by informational and normative social influences (Burkhardt and Brass, 1990; Katz and Tushman, 1979; Katz, 1980).

A number of recent technology acceptance studies incorporated this construct into their operational models and found some empirical support (e.g. Agarwal and Karahanna, 2000; Green, 1998; Karahanna and Straub, 1999; Lewis et al., 2003; Lu et al., 2003b; Lucas and Spitler, 2000; Segrest et al., 1998; Taylor and Todd, 1995a; 1995b; Venkatesh and Davis, 2000; Venkatesh et al., 2003). Taylor and Todd (1995a,b) regarded social influences equivalent to subjective norm in TRA and defined this construct as other people's opinions, superior influences, and peer influences in their studies. This construct was later expanded to contain three elements—subjective norm, image, and voluntariness by Karahanna and Straub (1999). Based on in-depth analysis of the literature in sociology and psychology, they argued that while informational influence works through internalization (integrating information from expert sources into one's own cognitive beliefs), normative influence works through identification (image and compliance with social influences). Moore and Benbasat (1991) defines image as the extent to which the use of an innovation is perceived as enhancement of one's status in a social system.

TAM is evolving over time. Venkatesh and Davis (2000) revised the original TAM model into TAM2 to reflect the impacts of three interrelated social forces on an individual facing the opportunity to adopt or reject a new system—subjective norm, voluntariness, and image. TAM2 proposes that subjective norm and image can influence the cognitive belief of perceived usefulness, regardless of the context. In other words, users' perceptions about usefulness may increase in response to persuasive social information. TAM2 also proposes that subjective norm will have no significant direct effect on intention to use when system use is perceived to be voluntary. In the UTAUT model, social influences is further recognized as one of the four direct determinants of behavioral intention to use, together with performance expectancy, effort expectancy, and facilitating conditions (Venkatesh et al., 2003). The impact of social influences is

contingent on four moderators—gender, age, voluntariness and experience. Again, the social influences addressed in the UTAUT model are in the form of interactions with managerial personnel, supervisors, and peer workers, with a clear purpose to understand how employees select and use a technology innovation implemented in a specific organization.

Users of mobile devices may belong to various social circles. Social image is rendered critical for many people. When penetration of Web enabled mobile technology is not substantial, users may regard these devices as symbolic of fashion and wealth, and adopt these devices to enhance their sense of self-importance (Sarker and Wells, 2003). On a global scale, numerous examples can be cited. In many Asian countries, young people treat smart-phones as new fashion items to show off in public. In China, 73 percent of the executive class in big cities owned mobile phones early in 1998, not only for convenience but also as a symbol of social status (Samson and Hornby, 1998). Further, drawing upon social information processing theory, Fulk and his colleagues (Fulk, 1993; Schmitz and Fulk, 1991) suggest that information passed through individuals' social networks influences their perception of a target technology. Such influences are stronger in friendship networks which affect people's attitudes and sense of support and attachment (Brass et al., 1998). Typical in wireless mobile environment, for an individual to use the data services of a mobile device, a certain number of members of the subject's social network need to be users of the same features (Sarker and Wells, 2003). Recently, a cross-cultural study even found mobile handhelds being used for maintaining social connectedness among intimate friends (Jarvenpaa et al., 2003). This study vividly reflects the findings on friendship network in affecting the assimilation aspect of socialization.

We believe that an individual potential adopter of WIMT is exposed to informal social networks where each is part of his or her own circle of friends, members, and other important connections. This web of relationships affects an individual's opinions, decisions, and behaviors through interactions and communications. Such social influences can be explained by subjective norm and image which can affect an individual's evaluation of WIMT in terms of usefulness. Although Lewis et al. (2003) sought to explain for perceived usefulness from social aspects and found the expected relationship, they did not include image in their study. Moreover, the context used was Web-based Internet teaching tool. It will be interesting to see how much of the usefulness perception can be explained by subjective norms and image in the context of non-work related WIMT adoption.

Moreover, social influences may also help to shape an individual's estimation of his or her confidence in or ability to use a system well. In line with social information processing theory and the psychological pathways of internalization and identification, a potential adopter's perceived ease of use before any direct experience cannot to be exempted from social influences. Research indicates that wireless mobile Internet services are for convenience and efficiency (Siau et al., 2004a). If WIMT is socially believed hard to learn and hard to use, unavoidably it will more or less affect a member's intention toward adopting WIMT. WIMT may have to withstand the challenges of serving as an extension of wired Internet services. Hence, we develop the following three hypotheses:

H1: Social influences in the form of subjective norm and image have a direct positive impact on perceived usefulness.
H2: Social influences in the form of subjective norm and image have a direct positive impact on perceived ease of use.
H3: Social influences in the form of subjective norm and image have a direct positive impact on intention to adopt WIMT.

2.2. Personal innovativeness

In general innovation diffusion research, it has long been recognized that highly innovative individuals are active information seekers about new ideas. They are able to cope with high levels of uncertainty and develop more positive intentions toward acceptance (Rogers, 1983; 1995). In the late 1990s, a number of studies in innovation diffusion research, marketing, and social and individual psychology investigated the effect of personal traits on adoption behavior as an internal motivation stimulus (e.g. Agarwal and Prasad, 1999; Compeau et al., 1999; Jackson et al., 1997; Kanfer and Heggestad, 1997; Webster and Martochhio, 1992). Over the years, only a few really integrated personal traits into technology acceptance research, and even fewer into intention to adopt IT/IS innovations.

Drawing upon Rogers' theory of the diffusion of innovations, Agarwal and Prasad (1998) argued that individuals develop beliefs about new technologies by synthesizing information from a variety of media. For the same exposure to different types of media, individuals with higher personal innovativeness are expected to develop more positive beliefs about the target technology. Agarwal and Prasad believe that most proximate influence on an individual's cognitive interpretations of information technology is factors related to the individual. They described personal innovativeness as symbolizing the risk-taking propensity that exists in certain individuals and not in others. They named this influential personal trait variable on technology innovation adoption behaviors Personal Innovativeness in Information Technology (PIIT). PIIT is defined as the willingness of an individual to try out any new information technology. They added this individual difference variable as a new construct to Davis' original TAM model and hypothesized that individuals with higher levels of PIIT are expected to develop more positive perceptions about the innovation in terms of advantage, ease of use, compatibility, etc. and have more positive intentions toward use of a new IT/IS. This study for the first time developed and validated the measures for domain specific personal innovativeness and, thus, made it practical to explain and predict how domain specific PI influences IT/IS adoption.

Over the years, the test results concerning PIIT have not been consistent. Agarwal and Karahanna (2000) developed a multidimensional construct labeled cognitive absorption and posited this construct to be an antecedent of the two commonly recognized behavioral beliefs about technology use: perceived usefulness and perceived ease of use. In addition, they proposed that the individual traits of playfulness and personal innovativeness are important determinants of cognitive absorption. Using the World Wide Web as the target technology, they tested their research model and found PIIT and playfulness explaining

42% of the variance in cognitive absorption. But, neither PIIT nor playfulness were statistically significant predictors of perceived usefulness and perceived ease of use in their study.

Lewis et al., (2003) used survey entries from 161 faculty and instructors at a large, public university to examine influences from the individual, institutional, and social contexts in which they interact with IT. Retaining the constructs of perceived usefulness, ease of use and the impact of ease of use on perceived usefulness from TAM, they added two individual factors—self-efficacy and PIIT—to the model and hypothesized impacts of PIIT on perceived usefulness and ease of use. They found PIIT having significant relationships with perceived usefulness and perceived ease of use.

Lu (2003b) developed a conceptual framework to explain the factors influencing user acceptance of WIMT. Their model (WIMTAM) proposes that PIIT, along with a number of other factors, all determine user perceived short-term, long-term usefulness, and ease of use, which, in turn, influence user intention and attitude to adopt WIMT. Given the relative infancy of the WIMT technology under study and the voluntary assumption for individual adoption, they believe it appropriate to test PIIT as an influencing variable under new circumstances. They expect to see PIIT generating a strong impact on perceived usefulness and perceived ease of use as proposed by Agarwal and Prasad (1998).

For adoption of an IS innovation such as wireless mobile technology, most people do not have any or much knowledge and experience to help them form clear perception beliefs. Sheer boldness and curiosity in their characters may not only strongly amplify their perception of potential benefits, but also heighten their confidence in their capabilities to handle the technology under adoption. Meanwhile, because individuals with higher PIIT tend to be more risk-taking, it is also reasonable to expect them to develop more positive intentions toward the use of WIMT. Thus, the innovative disposition may very well serve as the primary and direct determinant for adoption decision, without much consideration to perceptions at all. Therefore, we propose:

H4: PIIT has a direct positive impact on perceived usefulness of WIMT.

H5: PIIT has a direct positive impact on perceived ease of using WIMT.

H6: PIIT has a direct positive impact on intention to adopt WIMT.

2.3. Perceived usefulness

This construct comes directly from the TAM model. Perceived usefulness originally refers to job-related productivity, performance, and effectiveness (Davis, 1989). Perceived usefulness complies with the explanation for near-term consequence given by Triandis (1980). Incorporating the concepts used in expectancy theory, Triandis (1980) explained that individuals evaluate the consequences of their behavior in terms of perceived usefulness and base their choice of behavior on the desirability of the perceived usefulness. Researchers also tend to compare this behavioral belief to relative advantages in Rogers (1983) innovation diffusion theory (Karahanna and Straub, 1999).

Prior research indicates that perceived usefulness is an important indicator for technology acceptance (e.g. Chau, 1996; Jiang et al., 2000; Taylor and Todd, 1995a). Perceived usefulness in some studies showed a direct effect on intentions to use over

and above its influence via attitude (e.g. Davis et al., 1989; Davis, 1993; Taylor and Todd, 1995a) and, in others, revealed a much stronger impact over future IT/IS use than ease of use (e.g. Keil et al., 1995; Subramanian, 1994). Meanwhile, a few studies did not find any significant impact of perceived usefulness on predicted future use of IS (Dishaw and Strong, 1999; Jackson et al., 1997; Lucas and Spitler, 1999). Entering the 21st century, a number of researchers started to test the TAM model for adoption of the more complex information systems including intranet (Horton et al., 2001), desktop video conferencing in virtual workgroups (Townsend et al., 2001), academic use of Internet (Seyal et al., 2002), low-cost portable system for postural assessment (Schaik et al., 2002), etc. The empirical findings in those studies provide additional support to the initial TAM model as viable for predicting use of those telecommunication systems. Perceived usefulness was found to have a significant stronger effect over adoption than perceived ease of use. However, none of those studies examined this construct in the context of non-work related individual adoption of an innovation. Assuming the TAM model is viable for explaining adoption perception, we thus hypothesize:

H7: Perceived usefulness has a direct positive impact on intention to adopt WIMT.

2.4. Perceived ease of use

Perceived ease of use is an individual's assessment of the extent to which interaction with a specific information system or technology is free of mental effort (Davis, 1989). It is one of the major behavioral beliefs influencing user intention to technology acceptance in both the original and the revised TAM models. This construct is posited to influence behavioral intentions to use through two causal pathways: a direct effect as well as an indirect effect through perceived usefulness. Empirical support for perceived ease of use as determinant of usage intention, however, has been inconsistent and of less significance, or no significance, compared to the support for perceived usefulness (Hu et al., 1999; Lucas and Spitler, 1999; Subramanian, 1994). Chau (1996) even excluded this construct from his modified TAM model. Nevertheless, other researchers believe that in the exploratory stage of technology use, ease of use plays an important role. Venkatesh (2000) once proclaimed that for any emerging IT/IS, perceived ease of use is an important determinant of users' intention of acceptance and usage behavior.

A few empirical studies tested ease of use as a predominant determinant of intention to adopt (e.g. Agarwal and Karahanna, 2000; Al-Ubaydli and Deans, 2003; Henderson and Divett, 2003; Lowry, 2002; Warren, 2002). A few confirmed that perceived ease of use, like perceived usefulness, is a pivotal factor. Some found this construct a more important determinant (e.g. Lowry, 2002). Others found this construct exerting a mediation effect (e.g. Henderson and Divett, 2003). On the other hand, a few studies examined its effect on perceived usefulness, together with social norms and PIIT (e.g. Igbaria et al., 1997; Lewis et al., 2003), but reached quite different conclusions. These findings may be situation specific and technology specific.

The degree of easiness perceived by the customers is recognized to be an important determinant for using WIMT. A recent survey done by Embedded Solutions among 800

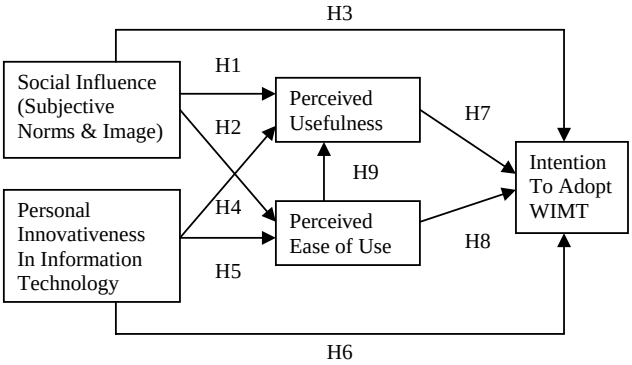


Fig. 1. Modified TAM for WIMT Adoption.

professionals in England revealed ease of use among the top five factors in order of significance for determining the use of wireless handheld devices (Clark, 2000). This point was again supported by several very recent studies on mobile data services and mobile commerce (e.g. Massey et al., 2004; Siau et al., 2004a; Ziefle, 2002). To keep in line with the literature in technology acceptance and mobile data services, we expect to see a significant impact of perceived ease of use on usefulness perception and adoption intention, and thus hypothesize that:

H8: Perceived ease of use has a direct positive effect on intention to adopt WIMT.
H9: Perceived ease of use has a positive effect on perceived usefulness.

2.5. Research model

To guide the present research, we developed a system-specific model integrating important elements from TAM (Fig. 1). This model proposes that the intention to adopt WIMT is a combined effect of perceived usefulness, perceived ease of use toward WIMT, social influences, and personal innovativeness. Both social influences and personal innovativeness also directly impact perceptions of usefulness and ease of use toward WIMT. The emphasis of this model is on explaining the antecedent beliefs of the perceptions and behavioral intentions. Our assumption is that personal attributes and social relationships are both important determinants of innovation adoption perceptions.

3. Methodology

3.1. Study context and sample

The target innovation for this study is WIMT that delivers data services directly into a mobile user's hand via wireless mobile handheld devices. The convergence of Web phones and PDAs is becoming a force as forecasted, with a wider range of capabilities

and endless potential to significantly change how businesses serve customers in the global market (Kutler, 2000; Siau et al., 2001). An increasing number of facts designate that such wireless mobile technology is helping to materialize the novel idea about m-communication, m-collaboration, and m-commerce in this country (Coursaris and Hassanein, 2002; Sarker and Wells, 2003). WIMT is appropriate for studying individual use for at least two reasons: First, it is a volitional technology that people use out of their own free will and not from any mandate. Second, this technology is still at its early stage of development and implementation (Lu et al., 2003b), and therefore, is suitable for identifying the nature of influences from individual differences and social networks, if any.

MBA students enrolled in a regional university in Texas in the academic year of 2002–2003 were surveyed online and offline during the final week of each semester. Those students were explicitly informed that we were interested primarily in their perceptions about WIMT and invited to respond as honestly as possible to the survey. Three hundred and fifty-seven of the 388 data entries were valid, securing an effective data return rate of 92 percent.

Of all the participants, 49 percent were males, 51 percent, females. With an average age of 31, the age range extends from 20 to 59. Eighty-four percent of the respondents hold full-time or part-time jobs. Over 77 percent ($N=277$) of the respondents had no experience accessing wireless Internet services via mobile handhelds such as PDAs and Web phones. Of those who had the experience ($N=80$), only one third had 6 months or longer experience with WIMT. Given the current status of WIMT use in the US, the reported descriptives of the participants indicate a representative sample (Coursaris and Hassanein, 2002; Wireless Data Use Still Limited in US, 2004). We are confident that the sample used in this study is likely to possess well-formed beliefs about information systems and technologies in general.

3.2. Survey instrument

To examine the conceptual constructs and hypothesized relationships, the survey questionnaire developed for WIMTAM was adopted for data collection (Lu et al., 2003a,b). The items for perceived usefulness were adapted from those developed and validated by Thompson et al. (1994). These measurements have been widely accepted in the literature and used by other researchers (e.g. Chau, 1996; Jiang et al., 2000). Items for perceived ease of use and for intention to adopt WIMT were originally created by Davis (1989, 1993). Slight modifications were made to fit the context of this study. PIIT was measured using the four-item scale developed by Agarwal and Prasad (1998), incorporating the suggested changes. Social influences was measured using modified variables on subjective norm and image by Venkatesh and Davis (2000) for testing TAM2. All the constructs in the research model were validated through items in prior research studies. Items were grouped under each construct in the questionnaire to ensure that the respondents follow the logical flow of ideas between the items. According to Davis and Venkatesh (1996), such a grouped format is better for predicting and explaining user behavior. The specific items in each scale are listed in Appendix A.

3.3. Operationalization of research variables

All the variables were measured on Likert-type, multiple-item scales. Responses were in the form of agreement, with 1 being strong disagreement to 7 being strong agreement. Selection of the scale was based on previous studies relating to conceptual construct operationalization (e.g. Agarwal and Prasad, 1998). Considering the fact that some respondents might not be familiar with wireless Internet via mobile devices, zero is added to the measurement scale to represent 'No reply.' All the cases of Zero were treated as missing data in data analysis to ensure genuine representation of the responses.

In order to ensure that the variables comprising each proposed research construct were internally consistent, reliability assessment was carried out using Cronbach's alpha. All the internal consistency reliability coefficients for research constructs under study range from 0.80 to 0.93, well above the commonly acceptable level of 0.70 (Nunnally, 1978).

To ensure content validity, an examination was made of the relevant literature. To further reduce the possibility of non-random errors, a pilot was conducted in May 2002 to examine the questionnaire for validity, completeness, and readability/understandability. As a result, several suggested changes to the questionnaire items were incorporated into this study.

AMOS 4.01 was used as the major statistical tool for model testing. The entire data analysis process engaged a two-stage approach recommended by Anderson and Gerbing (1988). At the first stage, we developed a measurement model using confirmatory factor analysis (CFA) to assess the extent to which indicators specified for each measure refer to the same conceptual construct. After an acceptable measurement model had been obtained, we built the structural equation model and examined the hypothesized causal paths among the constructs by performing a simultaneous test. This test helped us to observe whether the proposed conceptual framework had provided an acceptable fit to the empirical data.

4. Results

A normality check was first performed to ensure suitability of the empirical data for predetermined statistical analysis procedures. Of all the variables in the measurement model, univariate skewness values range from -1.676 to 0.458, with a mean of -0.464; univariate kurtosis values range from -1.147 to 3.352, with a mean of 0.244. According to Kline (1998), absolute values of univariate skew indexes greater than 3.0 and absolute values of the univariate kurtosis indexes greater than 8 are indications of extreme cases of violating normality assumption; the present data set is in the tolerable range for non-severe violation. Therefore, Structural Equation Modeling (SEM) procedures assuming multivariate normality are followed.

4.1. The measurement model

The psychometric properties of the scales are assessed in terms of internal consistency, convergent and discriminant validity, and item loadings. Before checking the internal

consistency of the scales, all the items were examined for consistency in wording. One item (PU1) under perceived usefulness and one item (PIIT3) under PIIT were worded negatively. Therefore, data under these two items were recoded. All the five constructs in the model are believed to exhibit very good internal consistency as evidenced by their reliability scores. A CFA measurement model was then created to check the model fit and convergent validity of each construct in the proposed model. This CFA model allows each construct to correlate freely with every other construct but with no causal relationships specified between the latent constructs. The measures used to assess model fit include Chi-square, degree of freedom, the X^2/df ratio, Normed Fit Index (NFI), Tucker-Lewis Index (TLI, equivalent to Non-Normed Fit Index), Comparative Fit Index (CFI), Root Mean Square Residual (RMSR), and Root Mean Square Error of Approximation (RMSEA). Since the sample size in this study is commonly considered big (>300), the Chi-square value and the related p value are neglected for their over sensitivity to the sample size (Joreskog and Sorbom, 1993). All the other criteria meet the recommended level (Chi-square/$df=2.180$, NFI$=0.908$, IFI$=0.948$, TLI$=0.929$, CFI$=0.947$, RMSEA$=0.058$) for a reasonably good fit.

Convergent validity is demonstrated when different items are used to measure the same construct. We empirically assessed convergent validity by examining the factor loadings and the relevant p values. Important descriptive statistics and correlations are listed in Table 1. According to the common rule of loading value greater than 0.50 for acceptability (Kline, 1998), only one item (PU1) loading had a lower than 0.50 cutoff value (0.33) and was deleted from further use. Thus, the desired convergent validity of the constructs is believed to have been achieved. For the variance extracted measures, values on five items fall slightly short of the recommended threshold (0.50). However, the variances on the remaining items all exceed the recommended criteria.

According to Kline (1998), discriminant validity is demonstrated when the estimated correlations of the factors that underlie sets of indicators supposed to measure different constructs are not excessively high (>0.85) or excessively low (<0.10). Table 2 lists all the correlation estimates between the associated constructs. None of the values exceeds these limits. Thus, the CFA model reflects an acceptable level of discriminant validity. So far the construct validity of the proposed model was supported.

4.2. The structural model

The structural model to confirm the hypothesized relations among the studied constructs was then built and examined. Model indexes indicate a moderately acceptable fit (Chi-square/$df=2.247$, NFI$=0.903$, IFI$=0.944$, TLI$=0.925$, CFI$=0.943$, RMSEA$=0.059$). Results show only a slight difference between the theoretical path model and the measurement model. Therefore, no modification was deemed necessary. Regression weights of path analysis reveal that seven relationships in the structural model are positive, as proposed. Two are not supported at the predetermined alpha value. These two relationships are the positive impact of social influences on intention to adopt WIMT (H3) and that of PIIT on intention to adopt WIMT (H6). Therefore, these two hypotheses are rejected in this study. The significant causal relationships supported by this study are displayed in Fig. 2. This figure also shows that 57 percent of the variance of the 'Intention

Table 1
Means, standard deviations, factor loadings, variance extracted and reliability

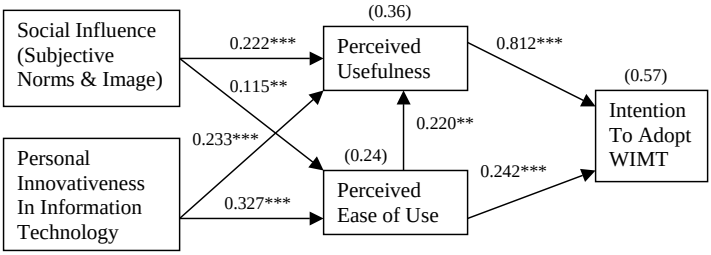
Construct and indicator	Mean	SD	Factor loading	Variance estimate	Cronbach alpha
Intention to adopt WIMT					0.93
IN1	5.71	1.32	0.93	1.74	
IN2	5.73	1.32	0.95	1.75	
Perceived usefulness					0.80
PU1			0.33 (deleted)		
PU2	4.72	1.49	0.57	1.50	
PU3	4.67	1.33	0.79	1.33	
PU4	5.04	1.22	0.78	1.23	
PU5	4.71	1.37	0.57	1.36	
PU6	5.53	1.14	0.72	1.13	
Perceived ease of use					0.80
PEU1	5.28	1.23	0.66	1.50	
PEU2	5.14	1.37	0.61	1.90	
PEU3	5.15	1.27	0.87	1.63	
PEU4	4.75	1.34	0.72	1.81	
Social influences					0.88
S1	3.50	1.64	0.76	2.69	
S2	3.72	1.63	0.75	2.67	
S3	3.59	1.78	0.82	3.16	
S4	3.13	1.64	0.88	2.68	
S5	3.14	1.59	0.88	2.54	
Personal innovativeness using information technology					0.82
PIIT1	5.11	1.38	0.82	1.91	
PIIT2	4.12	1.74	0.83	3.03	
PIIT3	4.89	1.67	0.51	2.80	
PIIT4	5.28	1.43	0.76	2.05	

to adopt WIMT' is explained by the specified explanatory constructs. The perceived ease of use, social influences and PIIT constructs together explained 36 percent of the variance in perceived usefulness. Social influences and PIIT constructs collectively explained 24 percent of the variance in perceived ease of use.

Table 2
Inter-construct correlations as discriminant validity

	Intention to adopt WIMT	Perceived usefulness	Perceived ease of use	Social influences	PIIT
Intention to adopt WIMT	1.000				
Perceived usefulness	0.667	1.000			
Perceived ease of use	0.433	0.454	1.000		
Social influences	0.382	0.521	0.300	1.000	
PIIT	0.392	0.474	0.457	0.269	1.000

Note: All the correlation values are significant at p-value of 0.000.



Note: Only significant relationships are shown. Numbers represent path coefficients.
** significant at p < .01
*** significant at p < .001
Variance explained in dependent variables is shown in parentheses.

Fig. 2. Results of path analysis.

5. Discussions

The proposed conceptual model was mostly supported by the empirical data. Path analysis results from Fig. 2 provide strong support for all the hypotheses except Hypotheses 3 and 6. The result of each hypothesis is summarized in Table 3.

The positive finding on Hypothesis 1, social influences in the form of subjective norm and image have a direct positive impact on perceived usefulness (path coefficient = 0.222, $p < 0.001$), strongly supports the propositions by Gefen and Keil (1998) and the relevant relationship established in TAM2 (Venkatesh and Davis, 2000). For the sample chosen, social influences in terms of subjective norm and image greatly impact non-adopters' perception of usefulness toward WIMT. This finding contradicts with the finding in Lewis et al., (2003) study. However, the social norms in their study

Table 3
Results of hypotheses testing

Hypothesis	Results
H1: Social influences in the form of subjective norm and image have a direct positive impact on perceived usefulness	Supported in this study
H2: Social influences in the form of subjective norm and image have a direct positive impact on perceived ease of use	Supported in this study
H3: Social influences in the form of subjective norm and image have a direct positive impact on intention to adopt WIMT	Rejected
H4: PIIT has a direct positive impact on perceived usefulness of WIMT	Supported in this study
H5: PIIT has a direct positive impact on perceived ease of using WIMT	Supported in this study
H6: PIIT has a direct positive impact on intention to adopt WIMT	Rejected
H7: Perceived usefulness has a direct positive impact on intention to adopt WIMT	Supported in this study
H8: Perceived ease of use has a direct positive effect on intention to adopt WIMT	Supported in this study
H9: Perceived ease of use has a positive effect on perceived usefulness	Supported in this study

mostly referred to influences from dean, department chair, peers and did not include social image. The support for Hypothesis 2, social influences' direct impact on perceived ease of use, confirms that internalization of social influences and sense of social image among friends also influence potential users' evaluation of whether wireless mobile technology is easy to use, although the magnitude is less (path coefficient = 0.115, $p < 0.01$). This finding is not included in any of the TAM studies we have reviewed. Lewis et al. (2003) recently proposed a similar relationship but failed to find empirical support in their study. In addition to the determinants of perceived ease of use as discovered in TAM related studies so far, our finding implies that influences from friends and important social connections is also a critical determinant at least for potential individual adopters of WIMT.

Our finding on Hypothesis 3 is negative ($p = 0.521$). This confirms the finding in UTAUT (Venkatesh et al., 2003) that when usage is not mandatory, subjective norm and sense of image seem to work through perceptions rather than intention. It seems that most potential and early adopters are more likely to base their adoption intentions on perceptions integrating their sense of image and opinions from their informal social network, rather than follow the fad blindly or merely for showing off in public or among friends. This finding does not support the findings by Karahanna and Straub (1999) that subjective norm is a significant determinant of intention to adopt.

Hypotheses 4 and 5 that a personal trait such as PIIT influences both perceived usefulness and perceived ease of use were both strongly supported in this study ($p < 0.001$). These findings confirm the positive relationships postulated by Agarwal and Prasad (1998). Lewis et al. (2003) had similar findings on PIIT which had a stronger effect on perceived usefulness. However, in our study, the stronger effect (0.326) is on perceived ease of use. On the contrary, in an earlier study by Agarwal and Karahanna (2000), the predictive effect of PIIT was not statistically significant on either perceived usefulness or perceived ease of use. It seems that the findings on PIIT so far are still sample and context specific.

Contrary to our prediction, the positive direct influence of PIIT over intentions to adopt WIMT (Hypothesis 6) was not supported by the empirical data ($p = 0.428$). In this study dispositional propensity as PIIT does not drive intention to adopt WIMT directly. Differences in PIIT are best uncovered in how WIMT is evaluated for adoption. Because of the educational level of the sample, the participants might tend to base their decision intentions more on rationality than on pure curiosity and bravery. The relationship between PIIT and intention to adopt a new IT as originated by Agarwal and Prasad (1998) needs to be tested in further research.

While perceived usefulness and ease of use both have significant impacts on intention to adopt WIMT (Hypotheses 7 and 8) in this study ($p < 0.001$), the predictive power of perceived usefulness (0.812) is much stronger than that of perceived ease of use (0.242) in terms of path coefficient value. This finding is in line with a number of previous TAM studies (e.g. Davis, 1989; Davis, 1993; Davis et al., 1989; Keil et al., 1995), but conflicts with others (e.g. Chau, 1996; Hu et al., 1999; Subramanian, 1994). These studies either failed to find perceived ease of use a significant determinant of predicted future use, or found it the only significant predictor of future use. Our finding seems to demonstrate that well-educated potential users put more emphasis on usefulness considerations than ease of use in evaluating WIMT for adoption.

The strong support for Hypothesis 9 ($p<0.001$), significant influence of perceived ease of use on perceived usefulness, confirms the findings in TAM and TAM2. The potential and early adopters of WIMT in our study find perceived ease of use an important factor in evaluating the system's usefulness, though the magnitude is not big (0.16). Our finding, however, contradicts with some previous findings (e.g. Agarwal and Karahanna, 2000; Lewis et al., 2003). Those studies failed to find perceived ease of use a significant predictor of usefulness. As revealed in mobile data services literature, ease of use is a primary drive for using a mobile device. Perhaps this fact to a certain degree can help to explain the significant relationship between perceived ease of use and perceived usefulness in this study.

The percentage of variance explained by perceived usefulness and ease of use seems to indicate that compared to influences from social networks and personal differences, the instrumental beliefs about WIMT are more explanatory on intention to adopt. Although both social influences and PIIT constructs significantly contribute to formation of these two perception beliefs, the variances explained are not very big, which indicates that other factors also contribute to the formation of the perceptions.

Finally, a regression analysis was conducted to identify possible relationships between PIIT variables and social influences. Five linear regression tests were performed separately using each social influences variable as a dependent variable and four PIIT variables as predictors. The test results reveal that in the chosen sample, those who were more likely to experiment with IT innovations were less influenced by their friends and other social connections. Those who were not active trying out new information technology, appeared to be more influenced by their friends and important connections. Although the variances explained by the predictors are not high (13.7, 10.2%), the co-relations are statistically significant ($p<0.01$) and should be meaningful in social sciences.

6. Conclusions and implications

This study investigated the nomological relationships among social influences, personal innovativeness, perceived usefulness, perceived ease of use, and intention to adopt a specific information system—WIMT. The research findings seem to draw the following conclusions:

Individual perceptions of usefulness and ease of use toward WIMT are significantly attributed to social influences from social networks and the sense of image. This conclusion reveals the importance of recognizing social influences. Successful implementation and promotion of WIMT to a certain degree relies on utilization of informal social networks and image impact.

Individual perceptions of usefulness and ease of use toward WIMT are significantly attributed to internal motivations to try. PIIT is an important internal stimulus influencing perceptions of WIMT. While PIIT influences both perceived usefulness and perceived ease of use significantly, the impact on the later is somehow stronger.

Neither social influences nor PIIT exerts any important direct impact on intention when adoption of WIMT is non-work related and purely voluntary. At least in this study, these

influences have to go through perceptions of usefulness and ease of use. However, the fact that 58 percent of the variance is explained by the specified explanatory constructs implies that the four selected antecedents on intention to adopt in this study are considered very important by the potential and early adopters of WIMT.

For adoption of WIMT, behavioral beliefs such as perceived usefulness and ease of use have primary explanatory power over user intention to adopt WIMT. The confirmed positive relationships between perceived usefulness and intention to adopt, between perceived ease of use and intention to adopt, between perceived ease of use and perceived usefulness once more affirmed the theoretical value of TAM in explaining innovation adoption. The findings on ease of use are particularly important for WIMT adoption.

Through this study we find that the TAM model integrated with PIIT is generally applicable for explaining WIMT initial adoption. However, because of the level of parsimony, it is still unable to generate more specific information for improving WIMT system and implementation. Literature and early research findings on mobile communications and mobile commerce reveal that concerns such as trust including security, privacy protection and system reliability (e.g. Lu et al., 2004; Siau et al., 2004b); system complexity in terms of functionality, design, data transfer speed and mobile device capability (e.g. Lu et al., 2003a); mobility, convenience, and cost (e.g. Siau and Shen, 2003; Siau et al., 2004b) have to be addressed to trigger a successful adoption. The TAM model needs to be expanded to include those unique features and concerns to provide more valuable guidance for WIMT implementation.

Theoretically, the findings in this study help to further our understanding of the nomological network among social influences, PIIT, perceptual beliefs as usefulness and ease of use, and intention to adopt. This study has revealed that both social influences and system-specific personality trait have an impact on perceived ease of use for non-work related individual adoption. The relationship between social influences and perceived ease of use has not been examined specifically in any of the earlier TAM related studies. Therefore, it is considered a unique contribution to the theoretical understanding of the perception process concerning ease of use. In addition, this study also confirms a number of important findings in the latest TAM studies.

From a business perspective, the successful, broad adoption of WIMT is critical for wireless system and service providers to achieve the desired productivity and the profits forecasted in their strategic plans. Being aware of the factors affecting WIMT adoption gives WIMT developers and providers an edge in developing their implementation strategies. For instance, service providers can emphasize service differentiation to make their services more useful and easier to use than their competitors'.

In fact, organizations have been constantly using technological innovations as an important strategy to maintain or enhance their competitiveness in business. Information and communication technology is playing an ever-widening role in an organization's sustainability of competitive advantage these days. In the advent of wireless mobile technology, organizations are finding themselves into a working environment increasingly supported by Wi-Fi today and Wi-MAX, web-enabled PDAs, 3G web phones in the near future. Thus, WIMT adoption which includes use of all types of web-enabled mobile devices is becoming an unavoidable organizational trend. It is important

to get prepared at the strategic level for this wave of wireless intrusion into organizations. This study, to a certain extent, highlights the importance of understanding the initial conditions when an information systems strategy is developed or an information system is implemented. Although this study primarily investigated ordinary individual potential adopters, it inevitably applies to individuals working in organizations, since any of them can be a potential adopter of WIMT with the support of the individual's organization. We learned from research that implementation of wireless mobile data services can be voluntary in organizations. Informal social network also exists in organizations together with the formal chain of command. A vivid example is the grape vine, which is often believed a faster communication channel. Thus, spreading positive implementation experiences via informal social network may be an effective way to complement formal promotion of WIMT adoption in organizations. We also learned that individual differences exist everywhere. Training and implementation programs should be designed to pay adequate attention to how to trigger potential users' inner motivation to try, in addition to the emphasis on the usefulness and ease of use of the innovation under consideration.

Specifically for marketing and implementation champions, the study results suggest that more attention should be focused on the importance of internal individual differences and social influences, and thus more targeted marketing strategies can be employed to attract potential individual users of wireless mobile data services. This study found that those who tend to wait to adopt WIMT are more vulnerable to social influences. According to this logic, in addition to providing stimuli or incentives to trigger motivation to try among potential users with different dispositional characteristics, marketers should also consider using pioneers or mobile users to attract potential users via social networks and have them properly rewarded. Meanwhile, they should collect information passed through formal and informal social channels to keep up with user needs and feedback. They should actively exercise positive influences through various social networks, channels and opportunities, such as word of mouth and informal seminars.

Owing to the dearth of research on the influential factors of WIMT adoption, this study should be regarded as exploratory in nature, and as such, its limitations should not be ignored. For instance, teenagers who are many times reported to be a major user group of WIMT were not included in the study. Therefore, this research provides only a snapshot of the current status of WIMT adoption for mature and well-educated early and potential adopters. Though we would expect similar results in other segments, future empirical research should verify the truthfulness of our findings. In this study, there was a potential for common method bias, since both the dependent measures and independent measures were from the same respondents. Therefore, future studies should pay more attention to overcoming the problem of common method variance. In addition, since perceived ease of use, social influences and PIIT together only explain 34 percent of the variance in perceived usefulness, while social influences and PIIT explain only 26 percent of the variance in perceived ease of use, effort should be made to examine other contributing factors as well. Meanwhile, to extend our knowledge of influence patterns from social norms and PIIT, further research should study if these two factors generate any direct impacts on intention to adopt.

Acknowledgements

The authors would like to gratefully acknowledge the insightful reviews and suggestions from Dr Sirkka Jarvenpaa and all the reviewers on the earlier versions of this article. Their comments have substantially helped to the paper improvement.

Appendix A. Survey items for the theoretical constructs under study

Intentions to adopt

Assuming I have access to WIMD, I intend to adopt it.
Given that I have access to WIMD, I predict that I would adopt it.

Perceived usefulness

Use of WIMD can decrease the time needed for my work/study/life tasks.
Use of WIMD can significantly increase the quality or output of my life.
Use of WIMD can increase the effectiveness of my performance.
Use of WIMD can increase the quality of output for the same amount of effort.
Considering all tasks, the use of WIMD could assist my work/study/life.
Overall, I find WIMD useful in my daily life.

Perceived ease of use

My interaction with WIMD is clear and understandable.
Interacting with WIMD does not require a lot of my mental effort.
I find it easy to get WIMD to do what I want it to do.
Overall, I find WIMD easy to use.

Social influences

People around me who use WIMD have more prestige than those who do not.
People who use WIMD have a high profile.
Using WIMD is considered a status symbol among my friends.
People who influence my behavior think that I should use WIMD.
My friends think that I should use WIMD.

PIIT

If I heard about a new information technology, I would look for ways to experiment with it.
Among my peers, I am usually the first to explore new information technologies.
I like to experiment with new information technologies.
In general, I am hesitant to try out new information technologies.

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