The moderating role of prior experience in technological acceptance models for ubiquitous computing services in urban environments

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ABSTRACT

Ubiquitous computing services constitute a new information technology that can be used in thousands of potential applications and environments. Ubiquitous computing is also changing the classic paradigm of information technology as it is forcing social and cultural changes. Determining factors affecting the use of ubiquitous services is essential to correctly define the characteristics of new value added services. However, this study investigates not only these factors, but also the moderating effect of previous experience. Due to the technological nature of ubiquitous services, previous experience alters the way in which potential users face these services. Findings suggest that previous experience changes the way in which antecedent relates to basic TAM constructs. The derived research models and empirical results also provide valuable indicators for future research and managerial guidelines for the successful adoption of ubiquitous computing services.

Keywords:
Ubiquitous computing
Technological acceptance model (TAM)
Urban environments
Structural equation modeling

1. Introduction

Ubiquitous computing is an emergent computing paradigm that improves quality of life and enriches human civilization by integrating computers, humans and objects [1,2]. It is a new vision in which computers will be embedded in our natural movements and interactions with our environments — both physical and social, helping to organize and mediate social interactions wherever and whenever these situations might occur [3]. Since ubiquitous computing was first conceptualized by Weiser of the Xerox Palo Alto Research Center [2], it has become a leading trend in information technologies and systems. The rapid diffusion of ubiquitous computing has been accelerated by the quick advances in smart technologies like wireless communication technologies, sensors for determining locations, automatic identification technologies, and flexible software architectures [4–6].

The emergence of ubiquitous computing provides a rich and exciting opportunity for future research [7]. First, ubiquitous computing is currently in an early stage of development. Therefore, it entails studying something that it is not completely developed. Researchers in this field are still “dreaming” and “creating problems” as much as they are solving problems and recording and theorizing about effects. Research in ubiquitous computing requires transcending the traditional barriers between social and technical as well as levels of analysis—individual, team, and organizational [7]. As technology becomes more embedded and integrated with mobility, the barriers between social and technical aspects become blurred. A paradoxical outcome of ubiquitous computing is that it is simultaneously very personal and extremely global. Thus, a complete understanding of its impacts cannot be gained at a single level of analysis [7,8].

The shift toward ubiquitous computing poses multiple novel technical, social, and organizational challenges. At the technology level, there are several unresolved technical issues concerning the design and implementation of

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computing architectures that enable dynamic configuration of ubiquitous services on a large scale. New challenges will also emerge in terms of how one should design and develop ubiquitous services. Unexplored challenges will also emerge at the border between the technical and the social: some issues are to be left outside the technical implementation to be addressed by social negotiation and due process; other issues should be addressed during technical design.

Despite its widespread use, there are few studies related to the use of ubiquitous computing. In [9], authors make use of extended technology acceptance model (TAM) introducing the concept of convenience. In this paper, TAM is extended considering several other constructs and measuring previous experience with wireless LAN, although it is not incorporated as a moderating variable. Kim et al. [10] have investigated the factors that influence the use of ubiquitous computing and U-business value, considering system, information and service qualities as the major factors affecting the use of ubiquitous computing. In general, most of the studies related to technology acceptance of ubiquitous computing applications are focused on incorporating additional variables and considering specific applications. For instance, acceptance of mobile commerce has been studied incorporating constructs like trust, cost, social influence and variety of services [11,12]. Mobile payment has been considered in [13], obtaining a strong support for the effects of compatibility, individual mobility, and subjective norm.

This study is mainly focused on studying the moderating role of experience on the intention of using ubiquitous technology. Although non-adopter do not have a prior experience using this kind of applications, they are known in the sense that they have seen how other people make use of ubiquitous computing applications like GPS or public transport information. Therefore, they do not have a direct experience using ubiquitous computing applications, but they know the possibilities they can provide. The paper tries to investigate about the differences of experienced and non-experienced users with respect to the intention of using an emergent technology.

The rest of the paper is organized as follows: Section 2 reviews previous literature on ubiquitous computing. Section 3 presents a research model and hypotheses. Research methods and data analysis are described in Section 4. Section 5 includes model testing and empirical results. The final section discusses research findings and implications.

2. Ubiquitous computing overview

Radical improvements in microprocessor cost-performance ratios have pushed computing process forward while drastically reducing computing-device form factors, enabling us to embed computers in many parts of our environments [14]. In 40 years this change has transformed the early large "computing machines" into compact devices that enable, mediate, support, and organize our daily activities [3]. Ubiquitous computing considers a vision of people and environments, augmented by computational resources, which could provide information and services anytime, anywhere, with any computer devices [15]. This evolution has recently been accelerated by improved wireless telecommunication capabilities, open networks, continued increases in computing power, improved battery technology, and the emergence of flexible software architectures [3].

One of the primary technologies in ubiquitous computing is context-aware computing, which consists of the automatic acquisition of sensible context surrounding users, providing information or services on users' behalf [15]. In the context-aware computing area, context is any data that can be sensed by computer devices and is deliverable by sensor networks [15,16]. Mobile and pervasive computing are terms that derive from context-aware computing. Although both terms are often used interchangeably, they are conceptually different. Mobile computing is fundamentally about increasing our capability to physically move computing services with us. As a result, the computer becomes an ever-present device that expands our capabilities to inscribe, remember, communicate, and reason independently of the device's location [3]. The main limitation of mobile computing is the availability of information as we move.

Pervasive computing is about making our lives simpler through digital environments that are sensitive, adaptive, and responsive to human needs. Far more than mobile computing, this technology will fundamentally change the nature of computing, allowing most objects we encounter in daily life to be "aware," interacting with users in both the physical and virtual worlds [8]. This concept implies that the computer has the capability to obtain the information from the environment in which it is embedded and utilize it to dynamically build models of computing of specific environments into dedicated computers or, more generally, by building generic capabilities into computers to inquire, detect, explore, and dynamically build models of their environments. The process is reciprocal: the environment can and should also become "intelligent" in that it also has a capability to detect other computing devices entering it. This mutual dependency and interaction result in a new capacity of computers to act "intelligently" upon and within the environments in which we move. This is the very idea of pervasive computing, an area populated with sensors, pads, badges, and virtual or physical models of the physical and social/cognitive environments.

Ubiquitous computing represents an ideal mixture of mobile and pervasive computing, including both the high mobility of mobile computing and the high level of embeddedness of

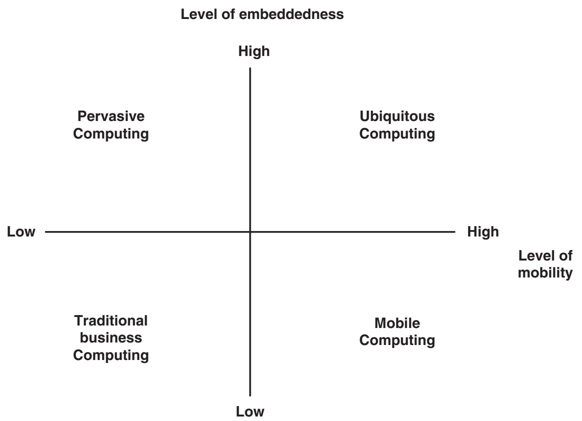

Fig. 1. Dimensions of ubiquitous computing.

pervasive computing. Fig. 1 locates ubiquitous computing using level of mobility and level of embeddedness as the main categorization features.

3. Research model and hypotheses

As one of the primary technologies in ubiquitous computing, context-aware computing automatically acquires sensible context surrounding users and proactively provides information or services on users' behalf [15].

A context-aware service automatically provides personalized information or services on the user's behalf by utilizing a context subsystem as well as typical information system components, such as database subsystems, application subsystems and dialog subsystems. In the context-aware computing area, context is any data that can be sensed by computer devices and is deliverable by sensor networks [15,16].

In the past decade, many context-aware services have been proposed [17,18,19]. Some context-aware services such as location-based services have been commercialized and are being used more widely. Investigating who will be more likely to accept the technology then becomes a key issue, for both commercial and research interests. However, even though several researchers investigated how context-aware systems perform with actual users, the studies were limited as user tests only [20]. Empirical research still lags on what factors determine users' acceptance levels of a context-aware service. As the number of context-aware services increases, determining the causality of service acceptance levels will increasingly become a key factor in predicting overall system success. Yet, research that directly examines users' level of acceptance of context-aware computing technology is still rare [15]. Evidence that shows what psychological concepts affect the users' intention in using the context-aware services is still rare, despite its importance to make the services actually deployable [15].

Hence, in this paper we analyze how individual differences affect users' intentions to use context-aware services within different contexts. Examining which user profile dimensions are useful in market segmentation is crucial, and hence should be considered in deploying the context-aware services.

We focus on five dimensions as direct determinants to intention to use (Contextual Pressure, Fee, Personal Innovativeness, Ease of Use, and Useful), and on four dimensions as indirect determinants (Self-efficacy, Perceptions of Intelligence, Perceptions of Socialness and Enjoyment). Most studies have paid little attention to its influences on user behaviors. Prior works only considered perceived usefulness, perceived enjoyment, and perceived ease of use that are conceived as important constructs in the traditional IS environments [21–23]. This study proposes a theoretical framework integrating these one into Van der Heijden's model [24] to understand the effective role of these ones in intention to use, firstly, and useful, finally.

Based on the theory of reasoned action [25], TAM (technology acceptance model) posits two perceptual factors, perceived usefulness and perceived ease of use, as key predictors of a user's attitude toward IS. However, researchers on IS noted that TAM's fundamental constructs do not fully explain the user's behavior in a non-working setting [26–28]. Moreover, studies that included these factors not only contribute to the understanding of usefulness and ease of use, but they also yield a larger variance [29]. So, to capture the hedonic feature of a hedonic-oriented IS in a non-working place Vander Heijden extended the original TAM by integrating perceived enjoyment [24]. The study examined how the hedonic nature of websites influences on website acceptance. Nevertheless, actually, when comparing to Van der Heijden's model in our context of study, as happened in TAM, it is necessary to take into account another dimension to explain it. We proposed the previously mentioned.

We also examine the moderating role of prior experience in user behaviors. Following to Kim et al. [30], this study investigates the differences in determinants for the adoption decision stages and the continued usage decision stages to capture the moderating effect of prior experience. There are few works that articulated the differences in a user's perceptions between voluntary IS acceptance and continuance [31,32]. So, for example, Ha et al. [31] extended TAM to include an emotion variable and measured the moderating effects of prior experience, gender and age on game adoption; and Yu et al. [32] compared the factors influencing t-commerce adoption between experienced and inexperienced users. Consequently, the analysis of previous experience provides a good opportunity to advance our knowledge of the different criteria in voluntary IS acceptance and continuance [30].

The proposed research model is illustrated in Fig. 2.

Perceived usefulness is defined as the degree to which an IS is perceived as providing benefits in performing certain activities [33]. The motivation-oriented perspective views the user's perception of usefulness as a measure of extrinsic motivation [34]. It has been widely known that systems' perceived usefulness has a direct influence on the intention to use an information system, as prior research claimed [35–42].

Nass et al. [43] found that people respond socially to computing technology even when they believe that they should not. Further, Reeves and Nass [44] suggest that ‘all people automatically and unconsciously respond socially to media even though they believe that it is not reasonable to do so’. People have been found to use social rules and respond differentially to computers with different voices [45], to invoke common gender stereotypes [46], to feel psychologically close or connected with a computer [47], to respond to computer personalities in a similar manner as they respond to human personalities [48], and even to respond to flattery [49]. In accordance with Nass et al. [50], when a computer was identified as a team-mate, participants perceived the computer to be friendlier and more like them, cooperated more and perceived information from the computer to be of higher quality.

More recent goal of using the context-aware service is that the system proactively understands a user's needs before users themselves do by having computers automatically understand the user's real physical world, and ultimately the system provides useful responses on behalf of the user [51,52]. Hence, we would expect that perceived usefulness has a positive influence on intention to use context-aware service.

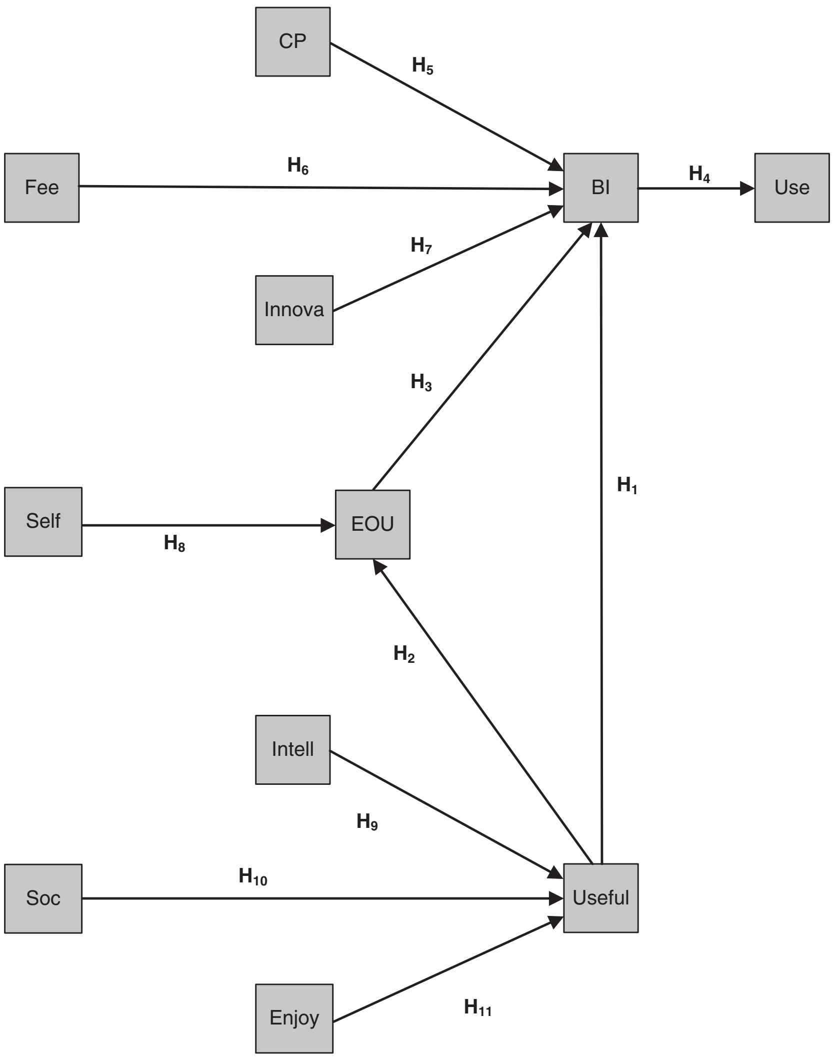

Fig. 2. Research model.

Hypothesis H1. *"Useful" has a positive correlation with "intention to use"*.

Previous works have shown that, as theorized in the original TAM, perceived usefulness has both a direct effect and an indirect effect via ease of use on intention to use [21,23,27,53]. In addition, the Van der Heijden's model [24] provides some evidence that it has an indirect impact on intention to use through perceived ease of use as well as perceived enjoyment. In the case of Mobile Data Services (MDS), it is also expected that perceived usefulness would affect intention to use both directly and indirectly via perceived ease of use and perceived enjoyment. So, for example, recent research as Kim et al. [10] analyzed the relationship between useful and ease of use in MDS, and the results showed that this magnitudes were positively related. Therefore, we posit:

Hypothesis H2. *"Useful" has a positive correlation with "ease of use"*.

Perceived ease of use refers to the degree to which a user perceives that an IS is easy to understand and use [33]. A technology that is perceived to be easier to use would facilitate its acceptance and use [10].

In the past decade, applied research using TAM explains the important effect that perceived ease-of-use has on intention to use [33,36–38]. Based on the theory of reasoned action [25], TAM posits two perceptual factors, perceived usefulness and perceived ease of use, as key predictors of a user's attitude toward IS. This attitude, in turn, leads to the user's IS adoption intention [33]. The attitude is a psychological tendency expressed by evaluating a particular entity in terms of the degree of positiveness about IS. However, a great deal of research on TAM shows that this attitude only weakly mediates the user's perceptions of IS adoption behavior, and TAM retains its robustness even without including attitude [26].

Moreover, previous research on TAM has demonstrated the validity of this model across a wide variety of corporate IS [54,55], however, researchers on IS noted that TAM's fundamental constructs do not fully explain the user's behavior in a non-working setting [26,54,55].

Consistent with prior research, it is tested that perceived ease-of-use will have a positive effect on intention to use. As Radner and Rothschild [56], we assimilate the definition of "ease" to "freedom from difficulty or great effort". Moreover we claim, as Davis [33,35] that "all else being equal an application perceived to be easier to use than another is more likely to be accepted by users".

Hypothesis H3. *"Ease of use" has a positive correlation with "intention to use".*

Research has consistently shown that intention to use is the strongest predictor of actual use [15]. Zmud [57] had categorized individual characteristics around information technology usage and implementation into three categories: cognitive style, personality and demographical variables. Davis et al. [35] posited that an individual's perception of a particular system's ease-of use is anchored to one's general computer self-efficacy at all times.

Hypothesis H4. *"Intention to use" has a positive correlation with "use".*

The notion of perceived sensitivity on contextual pressure is rooted in the concept of stress and neuroticism in psychology. Schuler and Jackson [58] define stress as the uncertainty that occurs at the organizational, unit, group and individual levels. In addition to the concept of stress, neuroticism could be another clue to understand perceived sensitivity on contextual pressure. Neuroticism is a key determinant in theories based on the Big Five model. Neuroticism's facet scales include anxiety, hostility, depression, self-consciousness, impulsiveness and vulnerability [15]. There are many psychological researches about these previous context pressure terms, some of them in relation with the intention of the patients. So, Bolger and Schilling [59] propose a hierarchical linear model that represents the relationship between neuroticism, daily stressors and daily distress in everyday life. In general, in these one, experiencing negative feeling such as negative affectivity tends to relate to high-neuroticism [60], which can cause an individual to engage in self-defeating behavior. By the other hand, Kwon et al. [15] assume that high-perceived sensitivity to contextual pressure would correlate to high-neuroticism levels in a situation where context is limited, and expect that those who tend to be highly sensitive will be more likely to find it difficult to use a context-aware service under contextual pressure. Consequently and the same than these previous works, we expect that as perceived sensitivity on contextual pressure increases, it will positively affect intention to use.

Hypothesis H5. *"Context pressure" has a positive correlation with "intention to use".*

Perceived fee refers to the amount of economic outlay that must be sacrificed in order to obtain a product or use a service [61]. For IS in an organizational setting, users are not concerned with the cost of IS use since the cost is borne by the organization. However, since the fee of MDS use is paid by the users, the monetary price of MDS may exert an important influence on MDS user behavior. Perceived fee is the extent to which a customer believes that using a product or service is expensive, and it is the internalization of the objective monetary cost. Kim et al. [10] empirically showed that perceived fee is negatively related to adoption intention toward MDS. Lately, Kim et al. [10] proposed that perceived fee would affect intention to use in two ways: (1) by indirectly influencing intention to use through perceived usefulness and perceived enjoyment, and (2) by directly influencing intention to use. The direct effect suggests that perceived fee could be a potential barrier to decrease the likelihood of the user's intention to adopt and use MDS. The indirect effect is explained as stemming from a situation where, other things being equal, the cheaper the MDS is to use, the more useful and enjoyable it can be. In the consumer behavior literature, perceived monetary cost exerts a negative effect on the user's perceptions and evaluation [62]. Thus, it is expected that perceived fee will serve as a critical predictor in forming MDS behaviors. There is no research that examines the change in the relative strength of the link between perceived fee and intention to use in terms of prior experience [10]. In this line, we hypothesized that

Hypothesis H6. *"Perceived Fee" has a positive correlation with "intention to use".*

Agarwal and Prasad [63] argued that personal innovativeness is important for examining the acceptance of information technology innovation. They defined personal innovativeness as 'the individual willingness to try out any new information technology'. They assumed that a person at a high level of personal innovativeness might be a risk-lover or early adopter, so that personal innovativeness affects the user's behavior or intention to use the new technology [15]. In accordance with these authors we suggest that personal innovativeness on the context-aware service will positively influence over intention to use.

Hypothesis H7. *"Personal innovativeness" has a positive correlation with "intention to use".*

Self-efficacy has been widely used in explaining individual differences [64–67]. Bandura [68] mentions that self-efficacy is the belief in an individual's capabilities to organize and execute a specific task, required to produce given attainments. Compeau and Higgins [64] manifest that computer self-efficacy refers to the judgement of one's capability to use a computer. Its focus is on judgements of what might be done in the future versus what one has done in the past. Moreover, it does not refer to simple component subskills, like formatting disks. Rather, it incorporates judgements of the ability to apply those skills to broader tasks. Self-efficacy is not a measure of skill; rather, it reflects what individuals believe they can do with the skills they possess [15].

Application-specific self-efficacy is defined as an individual perception of efficacy in using a specific application or system within the domain of general computing. Prior research on user acceptance of technology focused on examining the effects of general application-specific self-efficacy on perceived ease of use [69], exploring its role as an anchor for the subsequent development of ease of use perceptions [70]. In this line, Fenech [71] conducted research to predict web usage by examining perceived ease-of use factors adding computer self-efficacy to enhance the predictability of the model, and gained the enhanced model. According to Igbaria and Iivary [67], self-efficacy directly affects perceived ease-of use. Agarwal et al. [66] mentions that self-efficacy is an important factor of the antecedents of perceived ease-of-use. Thus, hypothesis H8 reflects the influence of self-efficacy toward perceived ease-of-use.

Hypothesis H8. *"Self efficacy" has a positive correlation with "ease of use".*

Perceptions of intelligence occur when the individual perceives knowledge, purpose and/or intelligence within the technology. This is often the case when interacting with a decision support system or other system intended to provide insight into, or answers to, specific decision-making scenarios [72]. It reports a sense of usefulness.

Hypothesis H9. *"Perceptions of intelligence" has a positive correlation with "useful".*

Individuals interacting with the technology experience emotional responses, such as joy, anger, fear, security, usefulness, … [72]. In this sense, Bates [73] argues that these perceptions of emotions are a key element in creating the illusion of social character. The term 'socialness' has been used to describe the phenomenon of users treating technology or technology interfaces as social actors; that is, the user perceives that the interface exhibits life-like attributes associated with personality or emotion. In our study, ubiquitous computing social perceptions refer to the extent to which consumers detect socialness on ubiquitous computing services and applications. Perceptions of socialness occur when an individual interacting with a computer senses cues that suggest that the computer is responding to his or her actions in a distinctly social manner. The broad scope of research into this construct has shown that socialness within an interface can be readily perceived, whether the technology is a simple text-based interface or a technologically rich set of components including pictorial representation, natural language processing and other artificial intelligence capabilities [45,72,74]. It has been previously used to study consumers' shopping experiences with online providers [75,76] or face-to-face market transactions [77].

Adults responded socially to computer programs as if they were responding to another human including flirting with a computer program in an online community [78,79]. In this context, computers can be seen as more depersonalizing and more powerful than human counterpart [80].

Hypothesis H10. *"Perceptions of socialness" has a positive correlation with "useful".*

Enjoyment refers to the extent to which the activity of using a computer system is perceived to be personally enjoyable in its own right aside from the instrumental value of the technology [34].

Davis et al. [34] investigated the relative effects of extrinsic and intrinsic motivation source on intention to use. They found that enjoyment and usefulness mediated the influence of perceived ease of use on intention [81]. Later, Venkatesh [69] showed that the effect of enjoyment on ease of use became stronger as users gained more direct experience with the system. An interaction intrinsically enjoyable or interesting will cause the individual's attention to be focused on the activity; encouraging curiosity for discovering new chances and features [82,42]. Gefen, Karahanna, and Straub [83] noted that understanding the role of perceived enjoyment is an

Table 1
Reliability, internal consistency and convergent validity for the experienced users' model.

Constructs and indicators	Weight	Loading	t-Statistic
CP (ρc = 0.821, AVE = 0.607)			
CP1	0.5402	0.8831	23.70
CP2	0.3619	0.7183	8.34
CP3	0.3755	0.7255	8.67
Fee (ρc = 0.838, AVE = 0.637)			
F1	0.7400	0.9326	3.55
F2	0.5995	0.6965	3.77
F3	0.3786	0.7447	3.55
Innova (ρc = 0.902, AVE = 0.755)			
PI1	0.3104	0.7706	16.43
PI2	0.3983	0.9067	55.35
PI3	0.4340	0.9208	63.62
Intell (ρc = 0.811, AVE = 0.589)			
I1	0.5422	0.7889	9.93
I2	0.4337	0.8197	15.34
I3	0.3162	0.6886	9.94
Self (ρc = 0.831, AVE = 0.627)			
SE1	0.3732	0.7756	4.05
SE2	0.5866	0.9277	8.46
SE3	0.2572	0.6466	14.33
Soc (ρc = 0.846, AVE = 0.651)			
S1	0.6949	0.8296	11.08
S2	0.2746	0.9167	7.96
S3	0.4783	0.6517	5.71
Enjoy (ρc = 0.853, AVE = 0.661)			
E1	0.3442	0.6750	23.14
E2	0.3877	0.8607	43.82
E3	0.4909	0.8876	8.66
Useful (ρc = 0.908, AVE = 0.623)			
U1	0.1974	0.7544	18.17
U2	0.2135	0.7760	19.57
U3	0.2168	0.8252	22.76
U4	0.2170	0.8071	17.17
U5	0.2247	0.8237	23.36
U6	0.1961	0.7456	14.14
EOU (ρc = 0.909, AVE = 0.713)			
EU1	0.3348	0.8308	19.12
EU2	0.2532	0.8422	17.43
EU3	0.2270	0.8392	17.74
EU4	0.3672	0.8661	19.71
IU (ρc = 0.844, AVE = 0.646)			
IU1	0.4482	0.8511	28.85
IU2	0.4514	0.8754	37.40
IU3	0.3354	0.6682	7.57
Use (ρc = 0.874, AVE = 0.777)			
SU1	0.4517	0.8327	18.34
SU2	0.6721	0.9282	49.29

important avenue of research to pursue [10]. Previous considerations lead to the following hypothesis:

Hypothesis H11. *"Enjoyment" has a positive correlation with "useful"*.

4. Methodology and data analysis

In order to test these hypotheses, we have selected ubiquitous urban computing services as a case study. Urban environments offer the elements to build large-scale, ubiquitous computing environments [84,85]. Urban infrastructure includes hundreds of electronic equipments spread over the city, from traffic light regulators and panels to surveillance cameras and equipments for traffic parameter estimation, connected through an urban data network [86,87]. The collected information is usually transmitted for supporting traffic management administrators in making decisions, taking appropriate actions to alleviate congestions, and improving the global performance of the traffic network [88]. However, this information can also be distributed to citizens using smart phones and vehicular systems to provide new value added services. In fact, some urban computing services are available today, like GPS, pedestrian navigation systems [89] or public transport information [90].

The proposed model was empirically tested by using survey data collected from 285 inexperienced users and 150 experienced users. The questionnaire used a 1–7 Likert-type scale to examine the considered latent factors (see Appendix A). The questionnaire includes a brief explanation about ubiquitous computing and provides some real and available examples like GPS, public transport information or general operations using smart phones (airport check-in, indoor location systems, touristic information, etc.). Experienced users are those who have previously used a similar ubiquitous application like the ones provided.

Structural equation modeling (SEM) has been used to find the structural relationship among various factors and their measurement variables. SEM has become one of the most widely used multivariate statistical tools in various areas, including psychology, educational studies, and behavioral sciences [91–93]. Among SEM approaches, we have selected Partial Least Square (PLS) mainly because the required assumptions of the observed variables and the sample size are much smaller than in covariance-based SEM [82]. The conceptual core of PLS is an iterative combination of Principal Component Analysis relating items to dimensions, and path analysis permitting the construction of a causal model. The objective in PLS is to maximize the explanation variance. The hypothesizing of relationships between dimensions and items, and among different dimensions is guided by the previous literature in this field [94]. The estimation of the parameters representing the measurement and path relationships is accomplished using Ordinary Least Squares (OLS) techniques.

5. Results

Experienced and non-experienced users have been separately analyzed to extract some conclusions about the moderating effect of experience on the derived model.

5.1. Experienced users

As a stepping procedure for the SEM model analysis, a Cronbach alpha test was performed to prove reliability, showing a 0.7 or greater value on every factor. Following the two-step analytical procedure [95], the measurement model is first examined, and then the structural model. The rationale of this two-step approach is to ensure that the conclusion on structural relationship is drawn from a set of measurement instruments with desirable psychometric properties. The measurement model is evaluated in terms of reliability, internal consistency, convergent validity, and discriminant validity (Tables 1 and 2).

- Individual item reliability. In general, one would like to have each indicator sharing more variance with the component score than with the error variance. This condition implies that loadings should be greater than 0.70. Loadings of 0.5 and 0.6 are acceptable if there are additional indicators in the block for comparison basis [96]. The prior condition was met in this study, as shown in Table 1.
- Internal consistency was evaluated using composite reliability (ρc) developed by Fornell and Larcker [96]. A construct is considered reliable if ρc is at least 0.70, as shown in Table 1.
- Convergent validity indicates the extent to which the items of a scale that are theoretically related should have a high correlation. Convergent validity was evaluated for the measurement scales using the Average Variance Extracted (AVE) for each dimension [96], that should exceed the variance due to measurement error for that dimension (i.e., should exceed

Table 2
Discriminant validity for the experienced users' model.

	CP	Fee	Innova	Intell	Self	Soc	Enjoy	Useful	EOU	IU	Use
CP	**0.607**										
Fee	−0.145	**0.637**									
Innova	0.267	−0.083	**0.755**								
Intell	0.295	−0.181	0.100	**0.589**							
Self	0.183	−0.060	0.196	0.520	**0.627**						
Soc	0.316	−0.213	0.388	0.481	0.423	**0.651**					
Enjoy	0.399	−0.049	0.344	0.544	0.474	0.429	**0.661**				
Useful	0.385	−0.077	0.261	0.504	0.493	0.452	0.591	**0.623**			
EOU	0.032	0.100	0.126	0.139	0.222	0.236	0.186	0.232	**0.713**		
IU	0.358	−0.156	0.539	0.231	0.234	0.458	0.380	0.383	0.207	**0.646**	
Use	0.405	−0.132	0.519	0.318	0.342	0.490	0.265	0.412	0.140	0.488	**0.777**

0.50). All the measures meet the recommended levels (see Table 1).

- Discriminant validity is the extent to which the measure is not a reflection of another variable. Discriminant validity is indicated by low correlations between the measure of interest and the measures of other dimensions. Evidence of discriminant validity of the measures can be verified using the squared root of the Average Variance Extracted for each dimension higher than the correlations between it and all other dimensions [96]. As summarized in Table 2, the square

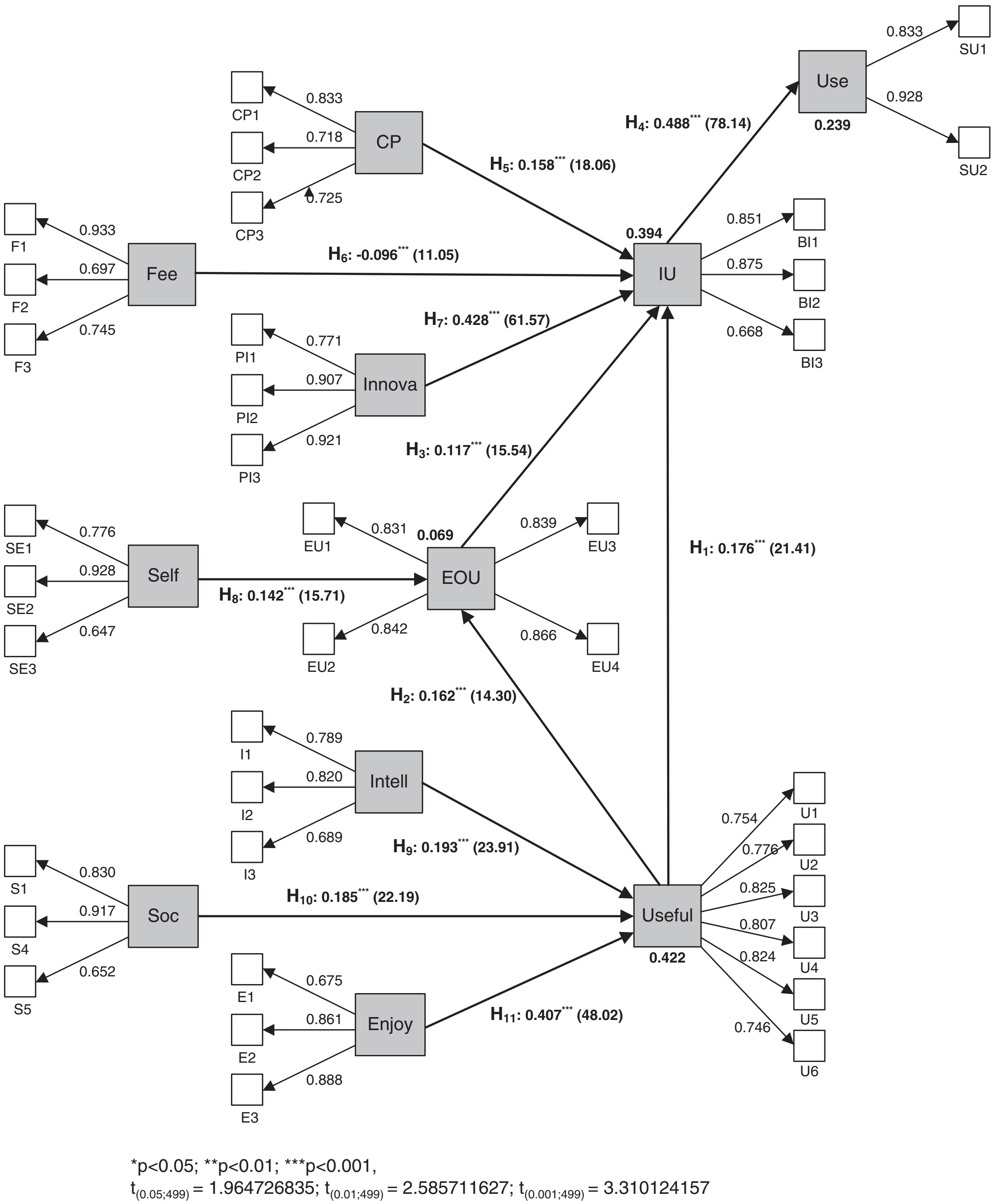

Fig. 3. Measurement and structural model for experienced users.

root of Average Variance Extracted for each dimension (on the diagonal) is greater than the correlations between the dimensions and all other dimensions. The results suggest an adequate discriminant validity of the measurements.

Next, the structural model is examined. The research model was tested using PLS-Graph v.3.0 [97]. The model was estimated using the maximum likelihood method. Fig. 3 depicts fit statistics, overall explanatory power, and estimated path coefficients. To assess the statistical significance of the path coefficients, which are standardized betas, a bootstrap analysis was performed. Bootstrapping provides an estimate of the variability of the parameters in a final model. The use of bootstrapping, as opposed to traditional t-tests, allows the testing of the significance of parameter estimates from data which are not assumed to be multivariate normal. Subsamples are automatically generated from the existing data by removing cases from the total data set generated by the 150 users. The number of random subsamples to be generated is set by the analyst. For this study, the number of bootstrap subsamples was set at 500. PLS estimates the parameters of each subsample and "pseudovalues" are calculated by applying the bootstrap formula. Fig. 3 shows that all the paths proved to be significant at the p-value 0.001 level. All the hypotheses about relationships among dimensions were supported.

5.2. Non-experienced users

The same procedure has been applied to the questionnaires obtained from the 285 non-experienced users. Again, the measurement model is evaluated in terms of reliability, internal consistency, convergent validity, and discriminant validity (Table 3 and 4). Adequate values have been obtained, following the same considerations exposed for the previous model.

However, important differences have been obtained for the structural model detailed in Fig. 4. In particular, hypotheses H3 and H6 are not supported.

Regarding hypothesis H3, most empirical studies have provided some evidence that the link between perceived usefulness and intention to use is stronger among experienced users than inexperienced users [40]. This is because the efficacy and capabilities of IS can be more confidently assessed by users with prior experiences with IS. In the consumer behavior discipline, the user's perceptions of efficacy and usefulness of a product or a service are more confident and solid as experience accumulates [98]. Thus, perceived usefulness formed by prior experience may predict intention to use better than that formed by second-hand experience.

Moreover, Davis et al. [35] found that perceived ease of use plays a critical role in forming the user's intention to use after 1 h of IS use, but it has no effect on intention to use after 14 weeks of usage. For instance, lower familiarity with MDS may result in increasing levels of mental and physical effort. However, the strength of the relationship between perceived ease of use and intention to use becomes weaker as the user's understanding of how to use MDS increases by virtue of their prior experiences with MDS. Thus, Kim et al. [30] hypothesized: Perceived ease of use has a weaker impact on continued usage intention than adoption intention. Theirs results are similar to ours. So, for inexperience users, there is non-significant path between ease of use and intention to use.

Table 3
Reliability, internal consistency and convergent validity for the non-experienced users' model.

Constructs and indicators	Weight	Loading	t-Statistic
CP (ρc = 0.821, AVE = 0.607)			
CP1	0.4900	0.8551	26.83
CP2	0.4597	0.8056	16.07
CP3	0.3465	0.6639	15.43
Fee (ρc = 0.852, AVE = 0.660)			
F1	0.2014	0.7048	2.75
F2	0.5843	0.8977	3.45
F3	0.4068	0.8238	3.38
Innova (ρc = 0.889, AVE = 0.727)			
PI1	0.4027	0.7992	27.01
PI2	0.3815	0.9023	67.60
PI3	0.3918	0.8537	32.55
Intell (ρc = 0.844, AVE = 0.645)			
I1	0.4777	0.7839	36.63
I2	0.6078	0.8712	16.01
I3	0.3997	0.7489	12.28
Self (ρc = 0.825, AVE = 0.613)			
SE1	0.3795	0.7002	15.01
SE2	0.5973	0.8882	9.04
SE3	0.4001	0.7491	5.72
Soc (ρc = 0.799, AVE = 0.571)			
S1	0.6302	0.8413	30.74
S2	0.4955	0.7211	9.66
S3	0.4097	0.6982	13.02
Enjoy (ρc = 0.863, AVE = 0.679)			
E1	0.2699	0.7059	43.40
E2	0.4400	0.8644	62.56
E3	0.4906	0.8904	14.96
Useful (ρc = 0.927, AVE = 0.678)			
U1	0.1945	0.8198	31.06
U2	0.2231	0.8773	48.64
U3	0.2061	0.8550	40.99
U4	0.2072	0.8076	31.57
U5	0.1906	0.8051	30.72
U6	0.1950	0.7732	26.83
EOU (ρc = 0.885, AVE = 0.659)			
EU1	0.3936	0.8450	24.34
EU2	0.3227	0.8372	24.61
EU3	0.2975	0.8207	17.20
EU4	0.2114	0.7388	10.58
IU (ρc = 0.894, AVE = 0.738)			
IU1	0.3776	0.8574	46.62
IU2	0.3685	0.8630	44.00
IU3	0.4190	0.8576	46.67
Use (ρc = 0.857, AVE = 0.749)			
SU1	0.5426	0.8474	35.01
SU2	0.6139	0.8833	46.45

Regarding hypothesis H6, it may be difficult for inexperienced users to judge the level of a service fee imposed since an MDS usage fee will be charged according to the volume of data transmitted and the amount of contents used [30]. Therefore, users with no prior experience encode a usage-based fee based on uncertain information. On the other hand, users with prior experience have a richer understanding and more concrete knowledge of the MDS fee structure, and therefore the certainty of the usage fee should increase [30]. Recent consumer surveys [99,100] show that users with prior experience consider the usage-based fee of MDS as excessively expensive, so they decide to discontinue to use it. As users accumulate the negative information of the usage fee, the negative role of a usage-based fee is more enduring than that of the user with no prior experience [101]. Thus, experienced users have more readily accessible memories, resulting in a negatively stronger relationship between perceived fee and behavior intention [30].

6. Discussion and implications

In this study, the theoretical framework for ubiquitous computing services in urban environments context has been formulated and empirically tested. The proposed model is tested on each of the two considered groups: experienced and inexperienced users.

The fit indices indicate that the proposed model explains both inexperienced and experienced groups better and more widely than the TAM or the Van der Heijden's model [24]. In addition to the model fit, the proposed model surpasses the other previous models in explaining variance in adoption intention and continued usage intention toward ubiquitous computing services. Taken together, these results strongly suggest that the proposed model is a more reasonable representation of ubiquitous computing user behaviors than the other models. So, the obtained results show that all of the analyzed hypotheses about relationships among dimensions were supported in the case of experienced users, if we extend TAM considering several other constructs and measuring previous experience with wireless LAN. Nerveless only two hypotheses, H3 and H6 are not validated in the opposite case: inexperienced users. So, in this last context, first, ease of use hasn't a positive incidence over intention to use, and second, we can't test that perceived fee has a positive incidence over intention to use.

The lack of a significant link between perceived ease of use and intention to use for this group of users contradicts some prior TAM studies which have found this relationship to be significant [36–38,56]. However, some empirical studies have provided some evidence that the link between perceived usefulness and intention to use is stronger among experienced users than inexperienced users [40]. This is because the efficacy and capabilities of IS can be more confidently assessed by users with prior experiences with IS. In the consumer behavior discipline, the user's perceptions of efficacy and usefulness of a product or a service are more confident and solid as experience accumulates [98]. Similar results to ours were hypothesized by Kim et al. [30]: Perceived ease of use has a weaker impact on continued usage intention than adoption intention.

With respect to H6, we think that it may be difficult for inexperienced users to judge a service fee since a ubiquitous service use is usually charged according to the volume of data transmitted and the amount of contents used, for example. Therefore, users with no prior experience encode a usage-based fee based on uncertain information. On the other hand, users with prior experience have a richer understanding and more concrete knowledge of element of ubiquitous computing services such as the MDS fee structure, and therefore the certainty of the usage fee should increase [30].

Important implications for users of ubiquitous computing services in urban environments are provided in this study. Many IS practitioners have argued that the key barrier of IS acceptance or continuance is perceived ease of use due to the lack of user friendliness of IS [30]. The traditional approach toward increasing usability has focused on perceived ease of use. However, the findings of this study suggest that users are deterred more by other dimensions as context pressure, innovativeness, socialness, intelligence, self-efficacy, enjoyment or perceived fee, than by perceived ease of use. In line with our findings, for example, consumer surveys showed that a high price keeps many users from trying MDS if they are not sure about it [99]. Moreover, innovativeness and enjoyment represent the strongest predictors of ubiquitous computing services behaviors for both groups, and its effect increases over time.

So, on one hand, personal innovativeness is seen as an important determinant of cognitive absorption and then it, in turn, affects perceived ease of use and perceived usefulness [65]. Agarwal and Prasad [63] argued that personal innovativeness is important for examining the acceptance of information technology innovation. They assumed that a person at a high level of personal innovativeness might be a risk-lover or early adopter, so that personal innovativeness affects the user's behavior or intention to use the new technology. Agarwal et al. [66] determined too that personal innovativeness with information technologies affects beliefs about general and specific computer self-efficacy, and has a positive effect on perceived ease of use. In conclusion, as prior research demonstrates, we

Table 4
Discriminant validity for the non-experienced users' model.

	CP	Fee	Innova	Intell	Self	Soc	Enjoy	Useful	EOU	IU	Use
CP	**0.607**										
Fee	−0.203	**0.660**									
Innova	0.209	0.012	**0.727**								
Intell	0.382	−0.024	0.123	**0.645**							
Self	0.391	0.087	0.221	0.526	**0.613**						
Soc	0.517	0.008	0.255	0.596	0.547	**0.571**					
Enjoy	0.504	0.079	0.259	0.518	0.580	0.547	**0.679**				
Useful	0.516	0.092	0.263	0.528	0.547	0.568	0.602	**0.678**			
EOU	0.152	0.124	0.052	0.194	0.278	0.290	0.177	0.307	**0.659**		
IU	0.384	−0.096	0.554	0.288	0.289	0.464	0.342	0.402	0.105	**0.738**	
Use	0.371	−0.022	0.488	0.301	0.376	0.474	0.340	0.415	0.131	0.549	**0.749**

find that innovativeness is significant in using ubiquitous computing services in urban environments.

On the other hand, perceived enjoyment represents an intrinsic motivation, and several previous researchers have found a significant role of it in intention toward MDS [21,23,27,30,31,39]. In fact, in accordance with our study, Kim et al. [30] demonstrated that the link between perceived enjoyment and intention to use is stronger. Moreover Gefen,

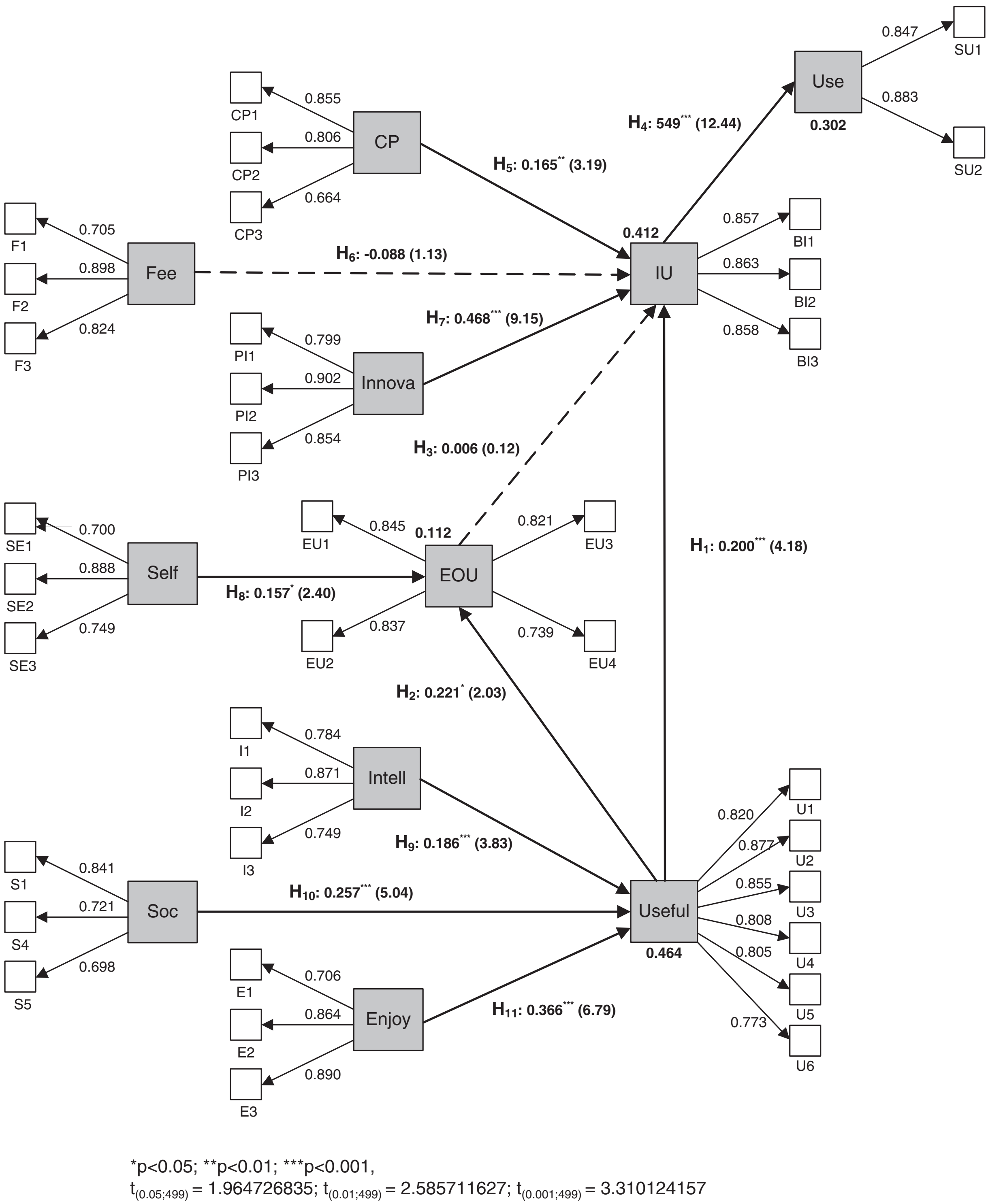

Fig. 4. Measurement and structural model for non-experienced users.

Karahanna, and Straub [83] noted that understanding the role of perceived enjoyment over time is an important avenue of research to pursue.

Another dimension with a strong impact in our model is socialness. This dimension, as a difference to the previous ones, is higher in experienced user than inexperienced users of ubiquitous computing services. These results, in accordance with Johnson et al.'s findings [72], suggest that people do indeed have different social perceptions of computing technology and that there is a large variation in perceptions along the continuum, with few people found at either extreme. Moreover, the broad scope of research into this construct has shown that socialness within an interface can be readily perceived, whether the technology is a simple text-based interface or a technologically rich set of components including pictorial representation, natural language processing and other artificial intelligence capabilities [45,74].

In definitive, ubiquitous computing services developers need to understand the significant role of these new dimensions, and must pay close attention to improving the user's perception of the usage of them.

Understanding the mechanism leading to ubiquitous computing user behaviors is critical to its diffusion [102]. The findings of this study help managers to understand the different criteria between inexperience and experience users in urban environments, resulting in facilitating more efficiently targeted marketing for ubiquitous computing services in each group. For example, for users with prior experience, the hedonic features of these one are enhanced by providing them with new fun and enjoyable services. By addressing the key drivers in each group, the providers can ensure profitability by retaining their users.

7. Conclusions

This study develops a theoretical framework incorporating new dimensions into Van der Heijden's model to provide a better theoretical understanding of the direct and indirect effects of these one on user's intention to use. Based on the above discussions, a theoretical framework is presented. In accordance with Kim et al. we also examine the moderating role of prior experience in user behaviors.

The proposed model is conducted as a preliminary test using survey data from 285 inexperienced users and 150 experienced users, and the data is analyzed using PLS. The reliability, internal consistency and convergent validity of our results have been tested.

The obtained results let us confirm a technological acceptance model for ubiquitous computing services in urban environments further of TAM or Van der Heijden's model. Part of our results agrees with the study of Kim et al.: 1) there are some significant differences in the relative influence of the determinants of intention toward ubiquitous computing services depending on prior experiences; 2) there is a stronger link between perceived enjoyment and perceived usefulness for users with prior experiences; 3) there is no significant link between perceived ease of use and intention to use for inexperienced experiences contradicting some prior TAM studies which have found this relationship to be significant.

As a cross-sectional study of inexperienced and experienced users, this study may not fully capture the dynamics of their ubiquitous computing services adoption and continued usage decision processes. This is a limitation of this study. Therefore, the findings should be viewed as preliminary evidence with respect to the varying criteria that dominate the different stages of its decision process. Further research needs to examine how the key factors of the same users evolve temporally.

Another limitation of the study is the smaller sample size of 150 for the group of experienced users. Although it is usually recommended for SEM a minimum of 200–250 sample size, PLS can work with smaller sample sizes. A heuristic rule of thumb states that sample size should be at least ten times the largest number of formative indicators or ten times the largest number of paths impacting into a latent variable, whichever is the greatest value. This threshold is accomplished in this work, where this value is below the experienced users sample size.

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Appendix A

Context pressure:

- CP1. I feel anxious if I am not able to acquire any of the services offered by the new technological systems on the market.
- CP2. I feel excluded if I am not able of using the most fashionable services offered by the new technological systems.
- CP3. The use of the services offered by the latest technological systems increases my good reputation among my friends circle.

Perceived fee:

- F1. The price of ubiquitous systems and devices is generally high.
- F2. The price requested by ubiquitous computing services is high.
- F3. The quality-price rate of ubiquitous computing systems is generally high.

Personal innovativeness:

- PI1. Whenever I hear something about a new service offered by a technological system (PDA, mobile, PC …), I always try immediately to find the way to achieve it.
- PI2. In my group of friends, I am usually the first to try the new services released for technological systems.
- PI3. In my group of friends, I'm usually the one who provides information about new services offered by technological systems.

Perceptions of intelligence:

- I1. The use of services offered by technological tools provides me an effective learning.

- I2. The use of services offered by technological tools helps me to solve professional problems.
- I3. The use of services offered by technological tools helps me to find and meet people (messenger, chat, video conferences, …).

Self efficacy:

- SE1. The use of services offered by technological tools facilitates me the problem understanding and problem solving.
- SE2. The use of services offered by technological tools facilitates me doing presentations and expositions.
- SE3. The use of services offered by technological tools increases my leisure time by reducing the time I have to devote to my work.

Perceptions of socialness:

- S1. The use of services offered by technological tools improves my self-learning through experience.
- S2. The use of services offered by technological tools allows me virtually interacting with people.
- S3. The use of services offered by technological tools allows me effectively answering to any issue using help menus.

Enjoyment:

- E1. I have a good time when using services offered by technological tools.
- E2. It is very interesting using services offered by technological tools.
- E3. I think it is fun using services offered by technological tools.

Useful:

- U1. The use of services offered by technological tools allows me finishing my tasks faster.
- U2. The use of services offered by technological tools increases the effectiveness of my work.
- U3. The use of services offered by technological tools makes my work easier.
- U4. The use of services offered by technological tools increases my performance.
- U5. The use of services offered by technological tools increases my productivity.
- U6. The use of services offered by technological allows me controlling the performance of my tasks.

Ease of use:

- EU1. Learning to use the services offered by the technological systems seems very easy.
- EU2. Being an expert or acquiring skills in the use of services offered by the technological systems seems very easy.
- EU3. It is easy for me to interact with technological systems.
- EU4. The use of the services offered by technological systems is, in general, very easy.

Intention to use:

- IU1. I usually have a positive attitude toward services offered by technological systems.
- IU2. I usually show interest on emergent service based on ubiquitous technology.
- IU3. I usually try to acquire new technological systems and services when they are released.

Use:

- SU1. I often use the services offered by the technological systems through the week.
- SU2. I usually explore the possibilities offered by current technology.

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