A COMPARISON OF THE DIFFERENT VERSIONS OF POPULAR TECHNOLOGY ACCEPTANCE MODELS: A NON-LINEAR PERSPECTIVE

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1. INTRODUCTION

The acceptance, adoption, and use of technology at an individual level are ripe topics in information systems (IS) literature. Although there are earlier works, the first technology acceptance models of acceptance of technology appear in the 1970s. These models try to understand how users accept and use a technology. When users are introduced to a new technology, many variables affect their choice about how and when they will use it (Fishbein & Ajzen 1975). Currently, however, this is still a research line in clear growth. An examination of the technology acceptance literature discloses that some academics are confident that the acceptance of technology has scarcely been reached (Bauer & Kenton 2005; Franklin & Molebash 2007; Hew & Brush 2007), while others propose that it has been more effective in some cases than others (Drucker 2006; Hughes & Ooms 2004). Affirmations on the acceptance of technology are frequently founded on models made available by the technology acceptance literature (Ifenthaler & Schweinbenz 2013). Its success is due to the fact that technology has become the heart of economic growth. At first these studies were mainly related to the entrance of the first computers in workplaces. Over time, technologies, and especially computers, have been applied to almost all human activity. Not only have we found applications in offices, but also in industry, agriculture, medicine, and leisure. Nowadays, the most recent models have focused on the adoption of new technologies by consumers. The fact that these models explain the success or failure of new technologies makes them a tool of utmost importance.

In this work, the technology discussed is Internet on mobile phones, in Chile, an emerging country where this technology has been recently adopted, but is experiencing a tremendous boom. Specifically, international statistics show that the proportion of people using the Internet has been increasing in Chile. These data exceed the regional average and are double the mean scores of developing countries. Currently, this figure is very near to the value of some European countries (ITU 2013).

In recent decades, beginning with the Theory of Reasoned Action (TRA) a multitude of models trying to explain the acceptance of technologies have been appearing in the academic literature. But do these models really explain a better reality than the first ones? Have there been significant advances with the different versions and improvements of models? What this paper actually offers is a comparison of the different versions of popular technology acceptance models: TRA, TAM and UTAUT. Some articles have reviewed different studies involving the Technology Acceptance Model (TAM) (Yousafzai, Foxall & Pallister 2007a, 2007b), trying to evolve toward an integrated vision of TAM, or looking for moderating effects in TAM constructs (Schepers & Wetzels 2007). Similarly, the Unified Theory of Acceptance and Use of Technology

(UTAUT) has been revised through statistical meta-analysis to investigate its performance (Nüttgens et al. 2011). However, as far as we know, the comparison and assessment between TAM, TRA and UTAUT developments have not been published. Furthermore, one of the major drawbacks of most models covered in these themes is that relations between the variables and constructs of the models are assumed as linear. New structural equation models (SEM) techniques which can use non-linear relationships to estimate these models can vary in the results obtained with linear relations (Schumacker & Marcoulides 1998).

The main objective of this work is to analyze the evolution of technology acceptance models using non-linear relationships between variables. This objective has been decomposed into other operational objectives:

- To quantify the improvement in the explanation of use and intention to use through the different models of technology acceptance based on its explanation levels.
- To compare if assuming non-linear relationships in the models improve the goodness of fit and quality of the models.

This work makes various contributions to the literature on the acceptance of technology within the IS scope. Firstly, it provides a complete and chronological view of the evolution of the most popular models of acceptance and use of technology, from the 1970s to the present day. From a theoretical point of view this study discusses the justifications on the variations and improvements in models, and from an empirical point of view it debates improvements in the explanation of use of new technologies in statistical indicators provided by SEM.

Secondly, the vast majority of research published to date is based on SEM assuming linear relationships between variables, based both on variance models, such as Partial Least Squares (PLS), or covariance models, such as EQS, LISREL, and AMOS. New software for the application of SEM based on PLS has been recently released which allows using non-linear relationships between the constructs included in models. This improvement can be particularly relevant in social sciences such as Marketing, Management or IS where the behavior of individuals and the relationships between constructs do not have to be necessarily linear (Moosbrugger et al. 2009; Schumacker & Marcoulides 1998), it is reasonable to consider that there will be improvements on existing knowledge using this new technique of non-linear relationships. Nevertheless, there is currently a lack of works comparing the results of SEM linear and non-linear models (Cariou, Verdun & Qannari 2014). Numerous interactions, including relationships concerning social variables, are non-linear and their shape is known as a U-curve or inverted U-curve. In this configuration one variable influences another in a way that points to a maximum or minimum value, where the effect is either maximized or minimized, respectively. An S-curve is also very usual in socio-economic relationships (Kock 2013). Therefore, trying to estimate real non-linear coefficients with estimated-linear coefficients leads to biased and inconsistent estimates of the models.

Thirdly, this work provides an application with a sample of users of a Latin American country: Chile. The vast majority of currently published works have been carried out with Asian and Anglo-Saxon cultures, mainly from the United States of America and the United Kingdom. We believe that validating the theoretical models in other cultural contexts is an important contribution.

To achieve the goals the work is structured in the following way. Firstly, we carry out a review of the literature on models of acceptance and use of technology, focusing on TRA, TAM, and UTAUT models with their respective expansions and modifications. Secondly, we deal with the problems of non-linear SEM from a theoretical point of view. Thirdly, the empirical work is shown, describing the sample, variables and statistical tools employed. Fourthly, the statistical results of the tests performed are collected and discussed. Finally, the main conclusions of the work are provided and its main limitations are listed as well as future research lines.

2. CONCEPTUAL BACKGROUND

To understand why people accept or reject a technology has become one the main lines of research in the IS scope. This is partly because of the development of computers in virtually all facets of life, in the past four decades. This is evidenced by the multitude of theoretical models that have attempted to address this objective: TRA proposed by Fishbein and Ajzen (Fishbein & Ajzen 1975), TAM suggested by Davis (Davis, Fred D 1986), TAM2 proposed by Venkatesh and Davis (Venkatesh & Davis 2000), TAM3 recommended by Venkatesh and Bala (Venkatesh & Bala 2008), UTAUT proposed by Venkatesh, Morris, Davis and Davis (Venkatesh et al. 2003), and UTAUT2 planned by Venkatesh, Thong and Xu (Venkatesh, Thong & Xu 2012). These and other authors have developed a relevant research stream trying to improve the explanatory models. This research line was born with TRA, it was developed with the various models of TAM, and it was recently updated with UTAUT. Next, we make a brief approximation to these models. After that, a review of non-linear models applied to SEM is offered.

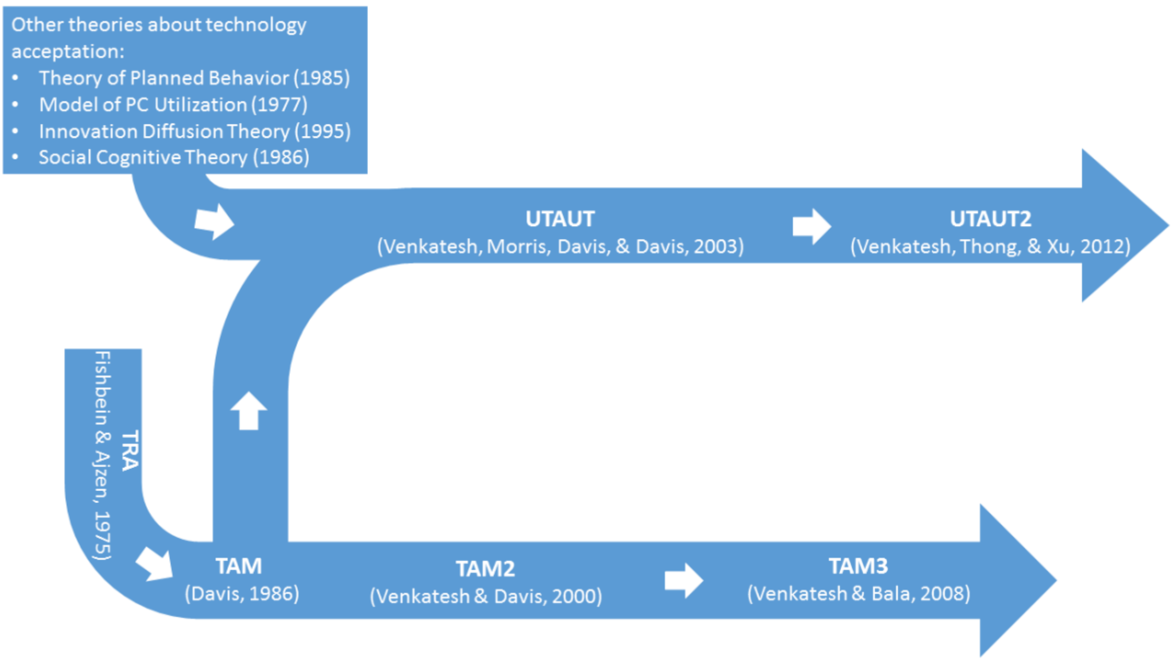

Figure 1. Evolution of theories about technology acceptation.

2.1. Theory of Reasoned Action

TRA was one of the first models that studied acceptance of technology. From social psychology, TRA analyzes the determinants of conscious behavior (Ajzen & Fishbein 1980; Fishbein & Ajzen 1975). According to this theory, the specific behavior of a person is determined by his/her intention to carry out this behavior; this is called behavioral intention (BI). At the same time, this BI is determined by his/her attitude (A) and the subjective norms (SN) relating to the conduct in question (Figure 2).

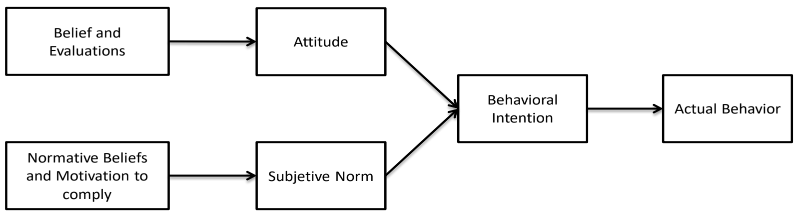

Figure 2. Theory of Reasoned Action (Fishbein & Ajzen 1975)

TRA is a general model, not designed for a specific behavior or technology, which has allowed it to be applied to countless fields. A particularly notable feature of TRA from the point of view of BI is that any other factors that influence behavior do so only indirectly by influencing A, SN or their relative weights. This implies that TRA mediates the impact of uncontrollable environmental variables and controllable intentions on user behavior.

2.2. Technology Acceptance Model

TAM model was developed by Davis (Davis, Fred D 1986). It is an adaptation of TRA specifically tailored for modeling user acceptance of IS. The goal of TAM is to provide an explanation of the determinants of computer acceptance that is general, capable of explaining user behavior across a broad range of end-user computing technologies and user populations. At the same time it is both parsimonious and theoretically justified. TAM was formulated to identify a small number of fundamental variables suggested by previous research, dealing with the cognitive and affective determinants of computer acceptance. TAM uses TRA as a theoretical backdrop for modeling the relationships between these variables. Specifically, TAM is based on two particular beliefs, perceived usefulness (PU) and perceived ease of use (PEOU), as the main antecedents of computer acceptance. Like TRA, TAM maintains that the use of computers is determined by BI, although it differs from TRA in that BI is determined by PU, as well as A, toward using the system. In the same way, TAM does not include the construct SN used by TRA because of its uncertain theoretical and psychometric status (Figure 3).

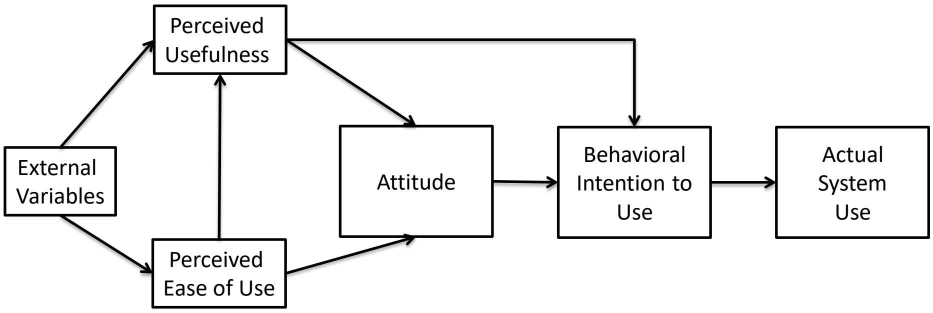

Figure 3. Technology Acceptance Model (Davis, Fred D 1986).

Later, Davis (Davis, F. D. 1989) found that PU and PEOU exert a strong impact on BI, and the effect of A decreases with time. With this argument they decided to remove the latter construct from the TAM model. When Venkatesh and Davis (Venkatesh & Davis 1996) analyzed the antecedents of PEOU, they no longer included A in the model (Figure 4).

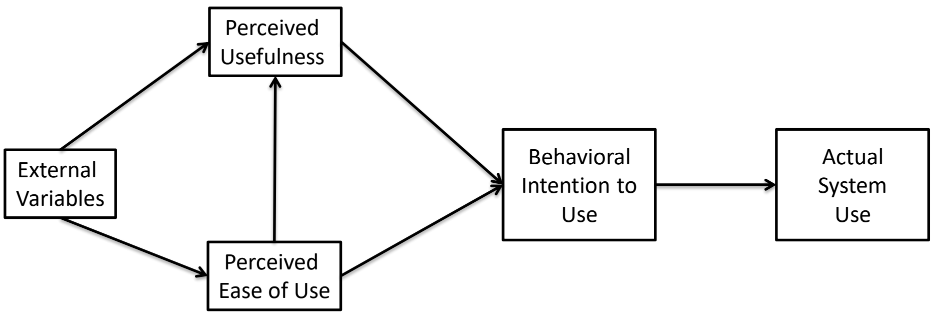

Figure 4. Technology Acceptance Model (Venkatesh & Davis 1996).

Over time, the TAM model has been implemented in a variety of contexts, beyond the mere acceptance of computers in the workplace. Therefore, TAM has become well-established as a robust, powerful, and parsimonious model for predicting user acceptance. The first of the extensions of TAM, the so-called TAM2 (Venkatesh & Davis 2000), is based on the expansion of the antecedents of PU. Across the many empirical tests of TAM, PU has consistently been a strong determinant of BI. Using TAM as the starting point, TAM2 incorporates additional theoretical constructs spanning social influence processes (SN, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and PEOU). It should be emphasized that the inclusion of SN affects both BI directly and through PU (Figure 5).

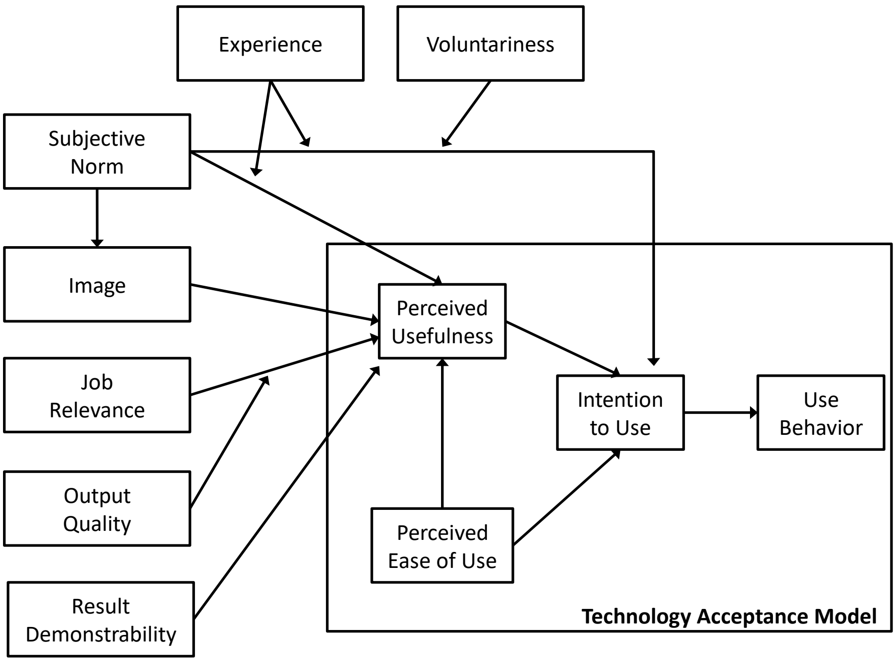

Figure 5. Technology Acceptance Model 2 (Venkatesh & Davis 2000).

Later on, and having the same intention as in TAM2, to complete the model incorporating the antecedents of the original TAM, Venkatesh and Bala (Venkatesh & Bala 2008) developed TAM3. More specifically, if TAM2 added the antecedents of PU, TAM3 was enlarged by the constructs that precede PEOU and which were already set forth in (Venkatesh & Davis 1996) and (Venkatesh 2000). In particular, building on the anchoring (computer self-efficacy, computer anxiety, computer playfulness, and perceptions of external control) and adjustment framing (perceived enjoyment and objective usability) of human decision making, Venkatesh and Bala (Venkatesh & Bala 2008) developed a model of the determinants of PEOU (Figure 6).

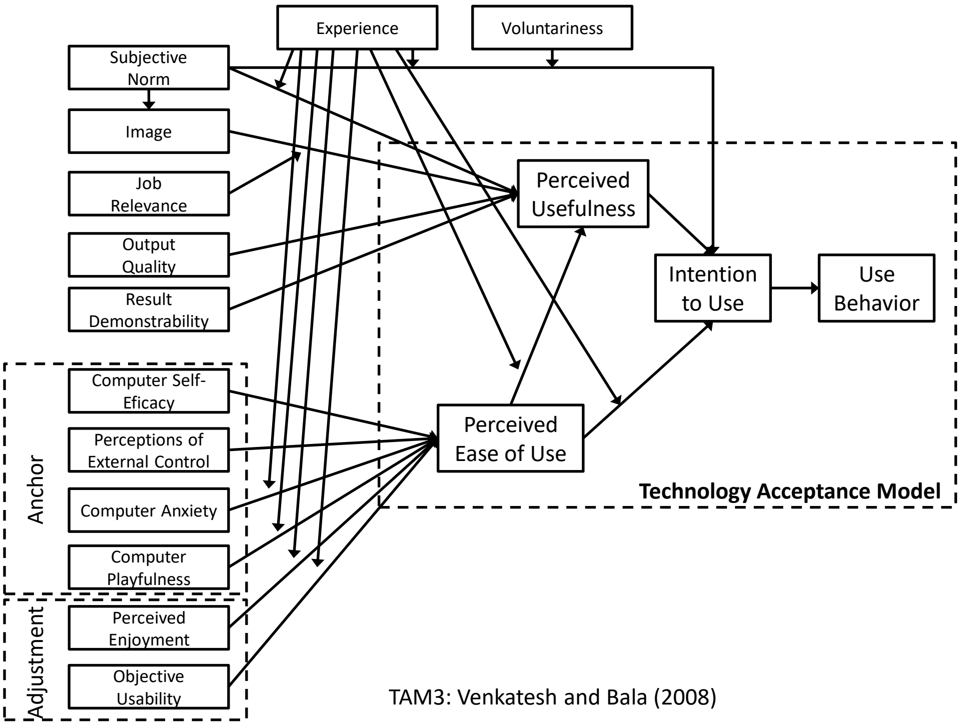

Figure 6. Technology Acceptance Model 3 (Venkatesh & Bala 2008).

Finally, TAM models in the last decades have been widely used, extending their application to a multitude of technologies, especially to website applications. TAM models have found a lot of support within the literature. Proof of this are more than 4100 citations inside the Social Science Citation Index database in November 2013, and more than 17600 identified by Google Scholar for the article of Davis (Davis, F. D. 1989).

2.3. Unified Theory of Acceptance and Use of Technology

As mentioned above, the explanation of the use and acceptance of a new technology has become one of the main lines of research within the literature of IS. As a result, in addition to TRA and TAM many models have appeared. This development has contributed to the fact that many researchers publish ad hoc models, mixing concepts of various theories, or using only those most favorable to their objectives without considering the contributions of other alternatives. Consequently, Venkatesh and other authors (Venkatesh et al. 2003) affirmed that there is a need for a review and synthesis in order to progress toward a unified view of user acceptance. For this reason, they reviewed the acceptance literature and discussed eight prominent models: TRA, TAM, the motivational model, the theory of planned behavior (TPB), a model combining TAM and TPB, the model of PC utilization, the innovation diffusion theory, and the social cognitive theory. They empirically compared the eight models and their extensions. Based on them, they formulated a unified model that integrates elements across the eight models. Finally, they empirically validated the new model to give greater consistency to their contribution. By encompassing the combined exploratory power of the individual models and key moderating influences, UTAUT advances cumulative theory while retaining a parsimonious structure (Figure 7).

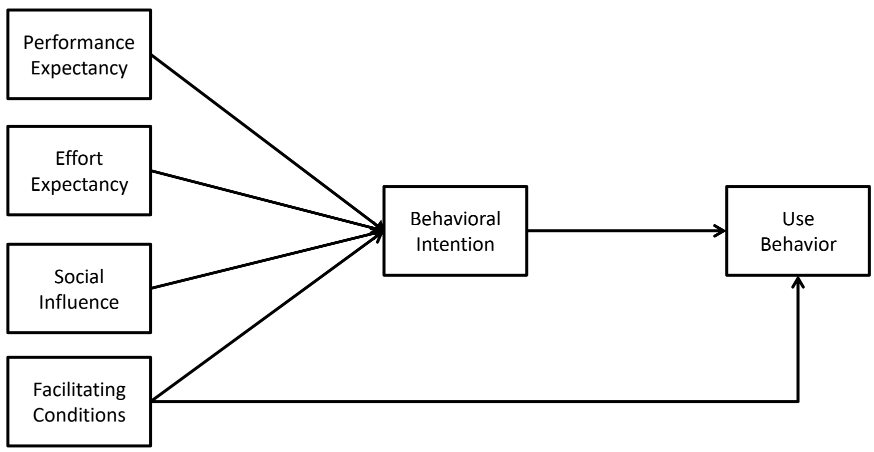

Figure 7. Unified Theory of Acceptance and Use of Technology (Venkatesh et al. 2003).

UTAUT pointed out four constructs that play a significant role as direct determinants of user acceptance and usage behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions. These four constructs directly affect BI. As well as TRA and TAM, BI directly affects the use of the technology (U). On the other hand, unlike TRA and TAM, BI is not the only direct antecedent of U. Furthermore, the facilitating conditions directly determine U.

UTAUT has distilled the critical factors and contingencies related to the prediction of behavioral intention to use a technology and to technology used primarily in organizational contexts. Over time, UTAUT has served as a baseline model and has been applied to the study of a variety of technologies in both organizational and non-organizational settings. However, like TAM and TRA, UTAUT is designed from an internal perspective of the organization. That is, developed from the point of view of the implementation of new technologies within organizations. For this reason the constructs which form it have a distinctly utilitarian character. While the various studies contribute to understanding the utility of UTAUT in different contexts, there is still the need for a systematic investigation and theorizing of the salient factors that would apply to a consumer technology use context.

On the basis of UTAUT, a new model is built designed to be applied in the context of consumer technologies. This is the so-called Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) proposed by Venkatesh and others (Venkatesh, Thong & Xu 2012). Three new determinants of BI are added to the constructs already employed by UTAUT: hedonic motivation, price-value and habit. In addition, the habit construct is also related to U.

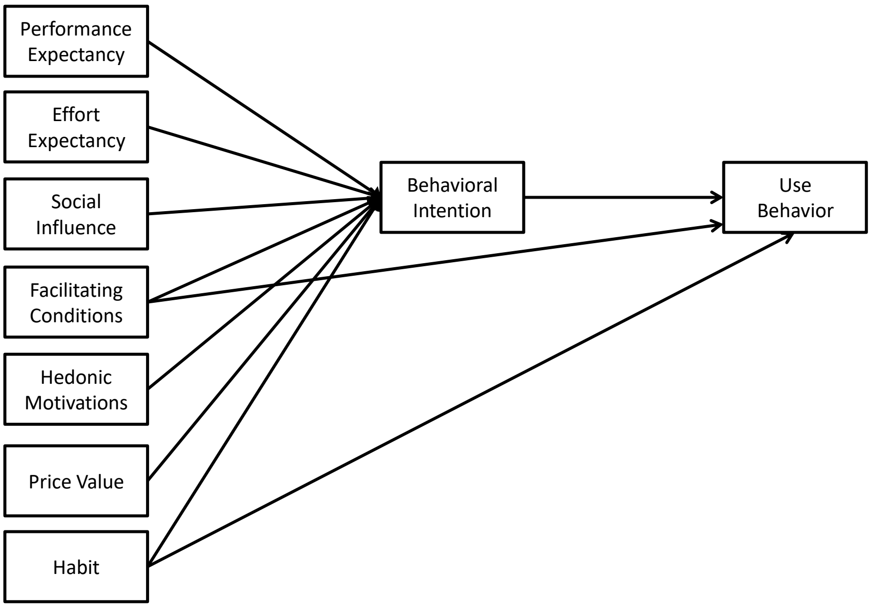

Figure 8. Unified Theory of Acceptance and Use of Technology 2 (Venkatesh, Thong & Xu 2012).

2.4. Non-Linear SEM in IS Models

Non-linear structural equation modeling (SEM) is gaining more and more interest in the context of IS models and other closed disciplines (Schumacker & Marcoulides 1998). Non-linear SEM offers many benefits compared to linear SEM, but it is more difficult to conduct and is interfered by methodological problems. Some estimation procedures have been developed recently. These procedures intend to provide unbiased and efficient parameter estimates for the non-linear effects (Moosbrugger et al. 2009).

One of the most critical complications of nonlinear SEM is the multivariate non-normality of the non-linear terms. This circumstance has two potential consequences. Firstly, acceptable estimation approaches should take the multivariate non-normality unequivocally into account. Secondly, if an estimation technique is used under the supposition of normally distributed indicator variables that does not consider non-normality, the robustness of the models should be examined meticulously (Moosbrugger et al. 2009).

The other big problem of non-linear SEM is multicollinearity. In non-linear SEM the correlation between latent predictor variables is usually greater than the correlation between manifest indicator variables because of the decrease caused by the unreliability of the indicators. As a consequence, as the multicollinearity grows, the estimation is more problematic, estimates are biased, and standard errors can be estimated incorrectly (Kelava et al. 2008; Moosbrugger et al. 2009).

The literature classifies SEM methods into two classes: covariance and variance-based (PLS) (Gefen, Straub & Boudreau 2000; Haenlein & Kaplan 2004). PLS is currently one of the most used SEM tools in social sciences, especially in areas such as management, marketing and IS (F. Hair Jr et al. 2014; Hair et al. 2012). This is due to PLS having some benefits over covariance models:

a) it always produces a solution; b) variables are not required to fit multivariate normality and large samples; c) it permits the estimation of parameters in models with formative latent variables. However, one of the biggest problems of both approaches is that they suppose linear relationships between the variables. Conversely, most relationships between variables in social and economic sciences are non-linear (Cariou, Verdun & Qannari 2014; Weidlich 1991). One of the few types of software that allows non-linear relationships (concretely, U-shape and S-shape) between latent variables in the SEM approach is WarpPLS 3.0 (based on PLS regression) (Kock 2010).

3. METHODOLOGY

A comparison of PLS (linear model) and WarpPLS (non-linear model) has been run for each acceptation of technology model: TRA, TAM0, TAM1, TAM2, TAM3, UTAUT, UTAUT2. The data set collects the information of mobile Internet users. WarpPLS 3.0 is the software used to run all the analyses. Some of the advantages of WarpPLS: (1) it estimates model fit indices; (2) it provides scatter plots of each of the relationships between latent variables; (3) it offers variance inflation factor coefficients (Kock 2010).

The survey was carried out with mobile internet users from Chile in the month of November 2012. The survey was presented in Spanish to interviewees. Previously the questionnaire was translated from English to Spanish and then back to English to safeguard correspondence in translation. Subsequently a pilot test was conducted to test the survey. We used a non-random sampling method: quota sampling method, on the basis of age range and gender of the Chilean internet users. 501 valid questionnaires were collected, 46.9% females and 53.1% males.

The scales applied to measure the latent variables (LV) of the model have been tested previously (Davis, F. D. 1989; Venkatesh et al. 2003; Venkatesh, Thong & Xu 2012) and they have been adapted to the case of mobile internet. All of them were measured through seven-point Likert-type scales. The scale ranged from "never" to "many times per day" for use behavior, and from "strongly disagree" to " strongly agree" for the other items. All of them are reflective LV, and only U is a formative LV (all items of the scales are presented in Annex 1).

4. RESULTS

The main objective of this study is not to confirm the relationships between the constructs of each model, but to compare the goodness of fit, through some indicators, between each acceptation of the technology model and between PLS and WarpPLS. In addition, all the constructs have acceptable levels of validity and reliability in the models analyzed. If the aim is to observe whether one model has an improved fit than another, then the model fit and quality indices are a suitable set of measures linked to model superiority.

The results of data analysis are presented in Tables 1 and 2. We present the results of different indicators of model fit: average path coefficient (APC), average R square (ARS) and average variance inflation factors (AVIF). In addition, the R^2 of U and BI and Goodness of Fit (GoF) are presented.

Adding new LV into a model will usually raise the ARS. Nonetheless, that will normally lead to a diminution of APC because the path coefficients associated with the new LV will be smaller. Thus, the APC and ARS will compensate each other, and both of them will only rise if the LVs added to the model improve the total predictive and explanatory quality of the model. The AVIF index will grow if other LV are added to the model enlarging its multicollinearity. In addition, the GoF index is the square root of the product between the average communality index and the ARS. IF GoF values are equal to or greater than 0.36 the model has a high explanatory power (Kock 2013).

Table 1. Comparison of models using linear relationships.

Model	**R^2 U**	**R^2 BI**	**GoF**	**APC**	**ARS**	**AVIF**
TRA	0.196	0.614	0.589	0.436	0.405	1.141
TAM0	0.196	0.639	0.571	0.434	0.398	1.578
TAM1	0.196	0.402	0.517	0.440	0.331	1.651
TAM2	0.196	0.441	0.517	0.260	0.318	1.438
TAM3	0.196	0.441	0.549	0.245	0.375	1.401
UTAUT	0.232	0.441	0.524	0.276	0.337	1.470
UTAUT2	0.247	0.640	0.606	0.161	0.443	1.975

In Table1 the R^2 of U is the same in the TRA and all the TAM models, but increases in UTAUT and UTAUT2. However, the R^2 of BI is highest in UTAUT2 and TAM0. The best GoF is for UTAUT2 followed by the TRA models. It is suggested that AVIF be lower than 3.3, mainly in models where most of the variables are measured through two or more indicators. Although ARS and AVIF indices are higher in the UTAUT2 model than in the TRA or TAM models, these values are within the recommended thresholds. This is because of the greater number of latent variables included in the UTAUT2 model. However, the most important idea is that the R^2 of U (0.247) in the UTAUT2 model is the highest of all of them (26% better than the TAM models and 10.6% better than the UTAUT model), and taking into account that explaining use of the new technology is the main aim of all these models, UTAUT2 is the best model, and has a very good model fit and quality indices.

Table 2. Comparison of models using non-linear relationships.

Model	**R^2 U**	**R^2 BI**	**GoF**	**APC**	**ARS**	**AVIF**
TRA	0.223	0.616	0.599	0.446	0.420	1.178
TAM0	0.223	0.642	0.581	0.444	0.412	1.557
TAM1	0.223	0.421	0.534	0.458	0.353	1.557
TAM2	0.223	0.460	0.531	0.264	0.335	1.411
TAM3	0.223	0.460	0.564	0.250	0.397	1.418

UTAUT	0.266	0.460	0.544	0.288	0.363	1.403
UTAUT2	0.278	0.643	0.618	0.165	0.461	1.918

The results offered in Table 2 are in line with those of Table 1. The best R^2 of mobile Internet use is achieved by UTAUT2 (0.278, 24.66% better than the TAM models and 4.5% better than the UTAUT model), also using non-linear relationships between the LVs of each model. Furthermore, UTAUT2 has a very good model fit and quality indices, as have the rest of models. But, if we compare each model of Table 1 to the same model of Table 2, we can find that the R^2 of U are higher in models from Table 2. This means that considering non-linear relationships between the LVs of all the models improves the explanation level of each model (13.77% of improvement in the TAM models, 14.66% in UTAUT and 12.55% in UTAUT2). An example of an individual improving the relationship between two constructs can be seen in Annex 2.

5. DISCUSSION

Both of the two objectives of this study have been achieved. Firstly, we have shown that the UTAUT2 model obtains a better explanation power (26% better) than the rest of the technology acceptance models in our sample of mobile Internet users. This is true for linear PLS and for non-linear PLS. It is a remarkable the fact that the sample is made up of end-users of mobile Internet, and this is a consumer use context. They are not employees of firms who have to compulsorily adopt a new technology. TAM and TRA models were specified for other contexts. This study validates the better performance of the UTAUT2 model in a consumer use context. This fact is very relevant because many studies are based on the consumer use of social network sites, search engines, websites, etc. The problem is that these consumer-focused technologies have been tested and modeled through models created for other contexts and this fact could lead to biased conclusions. Price-value, habit and hedonic motivations are variables that should be taken into account in technologies oriented toward consumers (Venkatesh, Thong & Xu 2012).

According to the results of this study, TAM developments do not improve previous versions of TAM, and even worsen the R^2 of behavioral intention of use. When attitude is removed from TAM1 model, the R^2 of behavioral intention of use drops more than 34%, and the R^2 of use remains constant. Therefore, the new versions of TAM do not seem to offer a better explanation for the acceptance of new technologies than TAM0. If the aim of these model developments was to improve the explanation of use of new technologies, it seems that they do not achieve this objective. With regards to attitude, it is likely that when TAM models are not applied to consumers but to employees or students who are obliged to use a technology, attitude does not play an important role. But when TAM models are applied to final consumers, voluntary intentions toward using the technology could be a key element for explaining behavioral intention. When the use of technology is voluntary, attitude gains weight in the relationship with behavioral intention of use (Yousafzai, Foxall & Pallister 2007a). Despite the expectations of improvement of TAM models a decade ago (Lee, Kozar & Larsen 2003), these results show that there have been no significant improvements, at least applying the methods with voluntary users.

The second objective was to compare the performance of models using linear relationships between each construct vs. using non-linear relationships between them, for each one of the models. Results show that all models have a better explanation power using non-linear relationships than with the traditional approach. The improvements of the R^2 of use ranged between 12% and 15% in all models. In addition, the fit and quality indices were still very good in all cases. This is an interesting result because the use of non-linear PLS is novel and not many applications using WarpPLS have been published. Some recent studies (Schmiedel, vom Brocke & Recker 2014) indicate the advantages of this statistical tool, such as permitting non-linear relationships between constructs and providing a set of model goodness-of-fit statistics. To sum up, these results indicate that using non-linear relationships in technology acceptance models could be an improvement in this research topic. This study offers some interesting comparisons that can provide theoretical controversies in the years to come about the advantages and shortcomings of UTAUT2 and non-linear PLS.

The technology acceptance models revised in this study rely both on the Theory of Reasoned Action (Fishbein & Ajzen 1975) and on the Theory of Planned Behavior (Ajzen 1991). These theories indicated that the best predictor of people's behavior is their intention to perform the behavior. Specifically, in a technology acceptance context, Turner and other authors performed a systematic literature review with a total of 73 articles, and found that behavioral intention fruitfully predicted actual usage (Turner et al. 2010). Nevertheless, for some authors the relationship between intention and behavior is insufficiently validated by empirical research (Nistor 2014). Due to this, caution should be taken using these models in other contexts outside management information systems in a business setting (Turner et al. 2010).

In this study, the data was collected from users of mobile Internet services: a context outside of a business setting where the voluntariness must be a variable to be considered. Since the use of these services is not mandatory, the correlation between the behavioral intentions of an individual and his/her subsequent behavior is explicitly supported by the literature in the general global context (Sheppard, Hartwick & Warshaw 1988), and also in the technology acceptance context (Venkatesh et al. 2003). In particular, the process of acceptance of these services is an ongoing phenomenon. The users consume these services at present because of their intentions to use them in the past and their current intentions are a predictor of future use. While today they have adopted these services, it is possible that in the future they will stop doing so. Consequently, the behavioral intention variable is capturing their intention to continue using mobile Internet services.

6. IMPLICATIONS AND FUTURE RESEARCH

The penetration rate of mobile Internet in Chile is over 55% of Chile's population. Data released by the Sub-secretary of Telecommunications in 2014 suggest the market is at this time facing modernization—that is, current mobile phone users are switching to advanced mobile devices such as smartphones. These are statistical data that reflect human behavior. But what causes these changes? TAM and UTAUT models have been widely used in many contexts and countries, trying to explain why people adopt new technologies. The question is to confirm if these kinds of models are good explainers of this adoption. This paper tries to answer this query in relation to a technology that is rapidly increasing the Internet adoption of millions of people around the world: Internet mobile. We cannot imagine the radical changes that humans are experiencing because of being connected to the Internet everywhere and all the time. All attempts to understand this process better are relevant and necessary.

Furthermore, this study has other implications. Firstly, it offers a comprehensive review of the evolution of the most popular models of acceptance and use of technology. From a theoretical point of view, this study debates the explanations about the variations and improvements of these models. From a practical standpoint it debates the developments in the explanation of use of new technologies using goodness of fit indices provided by the statistical tool. Secondly, the bulk of the research published to date is based on SEM approaches assuming linear relationships between latent variables. New software based on PLS allows us to use non-linear relationships between the constructs contained within the models. This advance can be particularly pertinent in social sciences where the actions of people and the relationships concerning constructs do not have to be inevitably linear (Moosbrugger et al. 2009; Schumacker & Marcoulides 1998). Thirdly, this work offers an application with a sample of users from a Latin American country: Chile. The majority of articles published about this topic have been carried out with European, Asian and Anglo-Saxon cultures. We consider that confirming these models in other cultural situations is an essential contribution.

One of the limitations of this study is related to the low levels of the R^2 of use in all the models, although the R^2 of behavioral intention to use mobile Internet is close to the typical values (Venkatesh et al. 2003; Venkatesh, Thong & Xu 2012). The measures of use of this study are based on Venkatesh et al. (Venkatesh, Thong & Xu 2012). However, the explanatory power is considerably lower in our research. Perhaps the explanation is that Chilean mobile users simply use more traditional calls instead of Internet services on their mobile devices than other cultures where this technology is more usual and established. Low levels of the R^2 of use may be due to the fact that with mobile internet, aspects such as the social influence, hedonic motivations, perceived utility or perceived ease of use have a direct influence on use, while the tested models do not estimate direct influences on use.

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Annex 1: measurement instrument

Items [a]	
Attitude toward using (ATT)	
ATT1	Using mobile Internet services is a good idea.
ATT2	Using mobile Internet services is a wise idea.
ATT3	I like the idea of using mobile Internet services.
Behavioral intention (BI)	
BI1	I intend to continue using mobile Internet services in the future.
BI2	I will always try to use mobile Internet services in my daily life.
BI3	I plan to continue to use mobile Internet services frequently.
Computer Anxiety (CANX)	
CANX1	Mobile Internet services do not scare me at all.
CANX2	Working with mobile Internet services makes me nervous.
CANX3	Mobile Internet services make me feel uncomfortable.
CANX4	Mobile Internet services make me feel uneasy.
Computer Playfulness (CPLAY)	
CPLAY1	When I use mobile Internet services, I feel spontaneous.
CPLAY2	When I use mobile Internet services, I feel creative.
CPLAY3	When I use mobile Internet services, I feel playful.
CPLAY4	When I use mobile Internet services, I feel imaginative.
Computer Self-Efficacy (CSE)	
CSE1	I could complete the job using mobile Internet services if there was no one around to tell me what to do as I go.
CSE2	I could complete the job using mobile Internet services if I had just the built-in help facility for assistance.
CSE3	I could complete the job using mobile Internet services if someone showed me how to do it first.
CSE4	I could complete the job using mobile Internet services if I had used similar technologies before this one to do the same job.
Effort expectancy (EE)	
EE1	Learning how to use mobile Internet services is easy for me.
EE2	My interaction with mobile Internet services is clear and understandable.
EE3	I find mobile Internet services easy to use.
EE4	It is easy for me to become skillful at using mobile Internet services.
Facilitating conditions (FC)	
FC1	Mobile Internet services is compatible with other technologies I use.
FC2	I feel comfortable using mobile Internet services.
Hedonic motivation (HM)	
HM1	Using mobile Internet services is fun.
HM2	Using mobile Internet services is enjoyable.
HM3	Using mobile Internet services is very entertaining.

Habit (HT)	
HT1	The use of mobile Internet services has become a habit for me.
HT2	I am addicted to using mobile Internet services.
HT3	I must use mobile Internet services.
Image (IMG)	
IMG1	People who use mobile Internet services have more prestige than those who do not.
IMG2	People who use mobile Internet services have a high profile.
IMG3	Having mobile Internet services is a status symbol.
Performance expectancy (PE)	
PE1	I find mobile Internet services useful in my daily life.
PE2	Using mobile Internet services helps me accomplish things more quickly.
PE3	Using mobile Internet services increases my productivity.
Price value (PV)	
PV1	Mobile Internet services are reasonably priced.
PV2	Mobile Internet services are good value for money.
PV3	Overall, the use of mobile Internet services delivers good value.
Job Relevance (REL)	
REL1	In my job, usage of mobile Internet services is important.
REL2	In my job, usage of mobile Internet services is relevant.
REL3	The use of mobile Internet services is pertinent to my various job-related tasks.
Result Demonstrability (RES)	
RES1	I have no difficulty telling others about the results of using mobile Internet services.
RES2	The results of using mobile Internet services are apparent to me.
Social influence (SI)	
SI1	People who are important to me think that I should use mobile Internet services.
SI2	People who influence my behavior think that I should use mobile Internet services.
SI3	People whose opinions I value prefer that I use mobile Internet services.
Use behavior (UB)	
USE1	Usage frequency for Short Message Service.
USE2	Usage frequency for games apps.
USE3	Usage frequency for browsing on websites.
USE4	Usage frequency for mobile electronic mail.

(a) The items were measured on a 7-point Likert scale. The scale ranged from "never” to "many times per day" for use behavior, and from " strongly disagree" to " strongly agree" for the other items.

Annex 2: Example of improvement by considering nonlinear relationships

The relationship between computer self-efficacy and perception of ease of use in the TAM3 model is an example of improvement associated with considering nonlinear relationships in technology acceptance models: If we consider this relationship as linear, then its beta is -0.073 and its effect size is 0.017, however, if we consider this as a non-linear relationship, then the magnitude of its beta increases to -0.124, and its effect size consistently increases to 0.040. Figure 1a shows the linear relationship and Figure 1b shows the non-linear relationship.

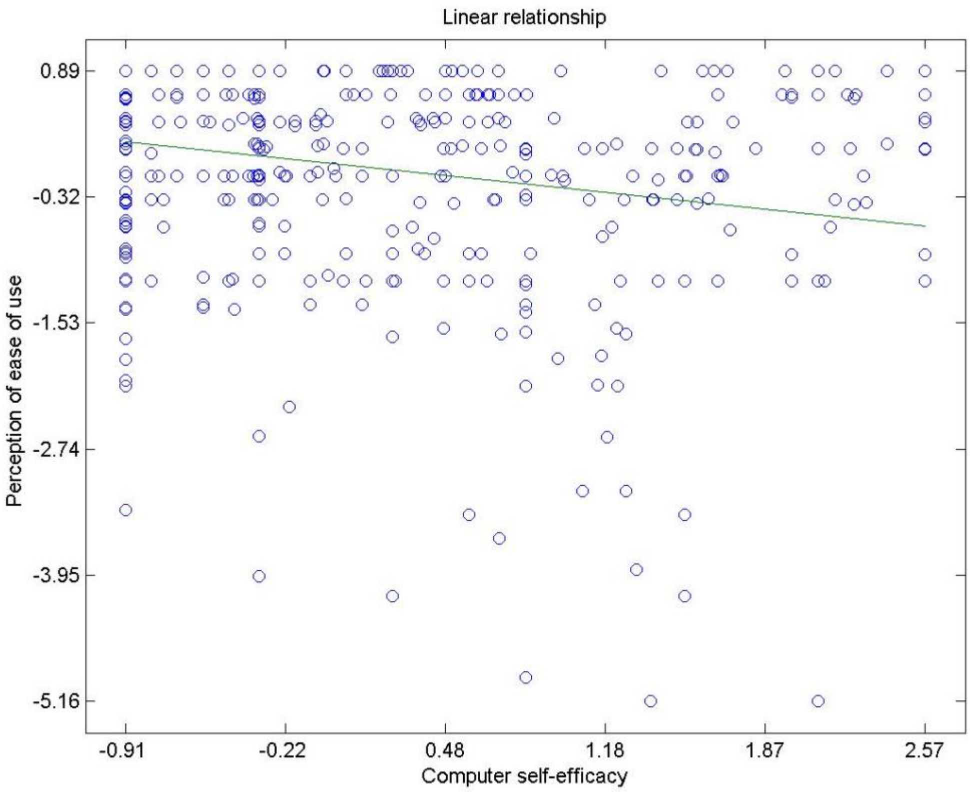

Figure 1a: Linear relationship between computer self-efficacy and perception of ease of use in TAM3 model.

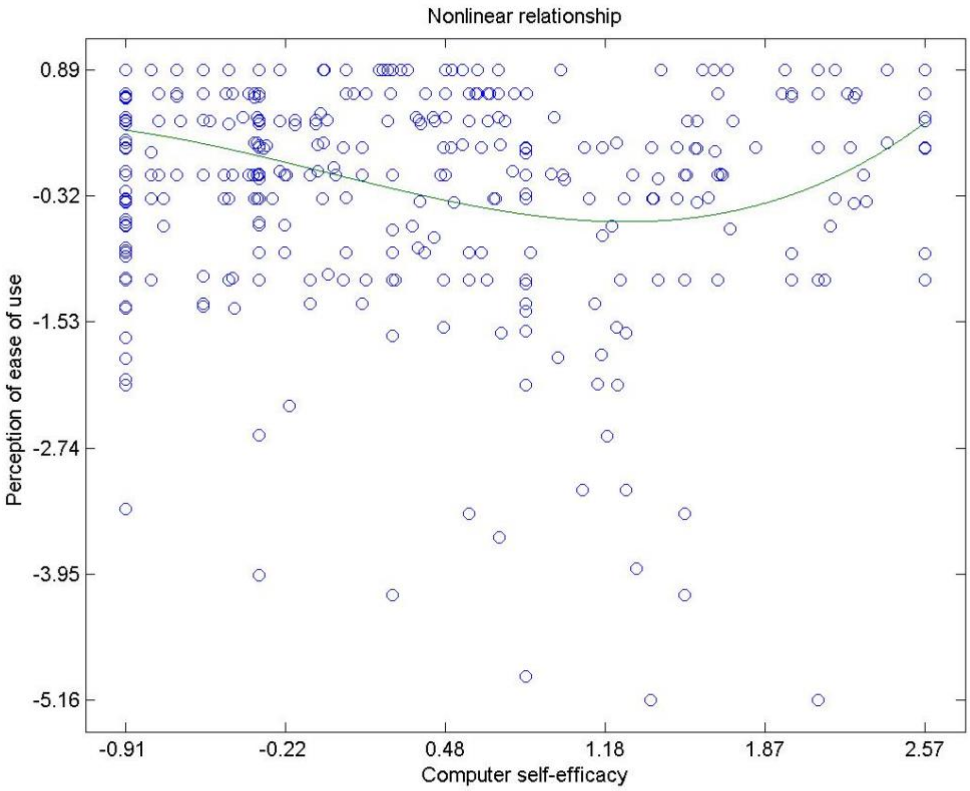

Figure 1b: Nonlinear relationship between computer self-efficacy and perception of ease of use in TAM3 model