

## **The Diffusion of an Online Social Networking Application**

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## Abstract

*Two limitations have been identified in the diffusion of innovations model [4]. 1) It fails to consider the perceived adaptability and changeability of the innovation. 2) It ignores the effect of adoption thresholds in individuals' personal networks on their actual adoption. Hypotheses were formulated to test the association between perceived adaptability and other attributes of the innovation [1], and between network threshold and adoption rate [2]. A group of users of an online social networking service (N = 34) were recruited as participants. The analysis of valid responses from 18 participants suggests that the perceived flexibility for personalization, customization and invention of an innovation moderates the influence of other perceived attributes on the adoption rate of the innovation, and that adoption thresholds in personal networks are not significantly related to individuals rate of adopting the innovation and their position in the global adopter category.*

## 1. Introduction

In 1962, Everett M. Rogers published the first edition of *Diffusion of Innovations*. Since then, the innovations diffusion model has been used by some scholars as a paradigm to study a wide range of diffusion processes. For example, marketing research has found individual innovativeness to be a strong factor in categorizing adopters [3, 4]. Health scholars have confirmed the influence of both mass media exposure and interpersonal influence on adoption decisions in diffusion process [5]. Finally, much research in information systems and communication has replicated the positive association between the perceived attributes of innovative technologies and faster user adoption [6-8].

Meanwhile, the comprehensiveness of the classic diffusion model has become its major weakness [9]. More often, researchers have found it too broad and vague to account for variables unique to diffusion processes in different disciplines. Hence incremental additions and refinement are suggested. Marketing researchers such as Bass and Van de Bulte have advanced mathematical models that predict the timing of sales growth based on refined global coefficients quantifying external influence on

adoption and interpersonal influence on imitation among consumers [10-12, See 13 for a review on modeling]. Researchers of information technology have synthesized the Rogers diffusion theory with other models such as Technology Acceptance Model (TAM), Social Construction of Technology (SCOT), and Actor-Network Theory (ANT) to study the effect of a wider array of variables such as perceived usefulness, financial risks, and organizational and cultural environment about the innovation at different stages of diffusion process [14-21]. Researchers have also attempted to extend the scope and range of the diffusion process by examining the diffusion of clusters or generations of innovations [22, 23], considering the actual deployment (assimilation) or discontinuance in the post-adoption process at organizations [24-27], and studying non-adoption behavior [28-30]. These studies quantified the various processes of social influence and imported constructs from other social sciences, hence increasing the applicability of the diffusion of innovations model in areas beyond rural sociology.

These studies, however, do not radically challenge the focus of the classic diffusion model on the roles of individual characteristics and stable attributes of innovations in the diffusion process. In response, it has been pointed out that with its overt emphasis on the adoption side of diffusion, the diffusion model wrongly assumes that an innovation is made equally accessible for all targeted potential adopters of the social system and remains unchanged throughout the diffusion process [1]. On the other hand, the strong focus of the classic diffusion model on individual attributes is also criticized, as diffusion processes that involve more complex of contexts of interpersonal influence are observed. Based on the law of imitation [31], Hamblin et al [32] argued that adoption decisions are based not on individual experiences, but rather on the observational and symbolic learning of the behavior of others in the social system. Such imitation generates expectations of benefits and costs of an invention that can be compared to its alternative competitions, resulting in either adoption or desertion of this invention. The concept of speculative imitation was refined by Granovetter in his formulation of the threshold model of collective behavior, which argues that individuals make decisions on actions based on the portion of others who have acted [33, 34]. Continuing with the study of contagion in diffusion, researchers have

introduced the concepts of reciprocal interdependence and network effects to explain the salient effect of imitation in the adoption of interactive innovations such as media and telecommunication services [35-37]. To bridge the gap between interpersonal influence on the local level (threshold) and system level (network effect), Valente integrated previous studies and introduced the concept of adoption threshold in social networks, suggesting that individuals' adoption rate and their adopter category in the social system are determined by the proportion of peer adopters and structures of their personal networks, rather than by their own characteristics [2, 38].

These studies represent a potential paradigm shift because they stress the context for an innovation to be distributed and for interpersonal influence to take place. First, the context of innovation diffusion includes the condition for an innovation to be introduced and distributed over a technical and marketing infrastructure, and the possibility for an innovation to adapt to the changing needs and environment of individuals throughout the diffusion process [1]. Second, the contextualization of interpersonal influence entails the study of social networks as a major channel of information and knowledge seeking [39, 40] and interaction-induced behavior change [41]. Individuals' adoption processes are related to the adoption pattern of their personal networks [2]. Such relationship is based on both direct and indirect exposure to potential adopters in individuals' networks, therefore direct interpersonal influence and network structure should both have an effect on individuals' adoption decisions [42-44]. In turn, the association between personal attributes and adoption decisions should be put into the context of social networks that individuals partake, and individuals' innovativeness should be measured both within their local networks and in the global social system.

The present article examines these two contextual constructs by analyzing the diffusion of an Internet-based social networking service. Built upon open source codes and protocols, the Internet has become a massive platform for innovative applications to be distributed at a price or for free. In the meantime, it has also given rise to a large number of communities of interest that are built on personal contact [45]. These features make the Internet an appropriate environment to explore how an innovation is configured and distributed, and how interpersonal influence takes place in individuals' social networks. Indeed, Brown, Hamblin et al and Valente have mostly based their formulations on the diffusion of material innovations through

geographically bounded face-to-face communication [46]. This exploration would yield substantive updates for their formulations, given the changes in how innovative services are marketed and how individuals communicate with each other on the Internet. These substantive updates can form the basis of further theoretical amendments to the original diffusion model.

## 1.1. Conditions of Innovation

The classic diffusion of innovations model states that innovations are basically new ideas that are communicated among potential adopters. To reduce uncertainty about these new ideas, individuals actively acquire information and form assessment about the innovation from their personal experiences and personal networks. It is assumed that an innovation is equally accessible and has steady characteristics, so that individuals could form reliable perceptions or beliefs about the innovation. Therefore, the perceived attributes of an innovation, which include relative advantage, compatibility, complexity, trialability, and observability, influence the rate of adoption together with other contextual factors such as communication channels, social systems and change agent contact [47, pp. 221-225].

A problem with this model is that an innovation is assumed to remain unchanged throughout the diffusion process with a stable set of perceived attributes. It is an afterthought that individuals may usually adapt the innovation to their own needs and environments in a process called reinvention. Rogers defines reinvention as "the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation", and admits that it used to be ignored as noise in most early diffusion research [47, p. 180].

The possible solution to the contradiction might be that since the re-inventability of an innovation is an attribute by design, it should be an intrinsic quality that affects potential adopters' perception of the overall qualities of the innovation. Adaptability is perceived and expected, not discovered in the implementation stage. Such perception and expectation might have an unexpected effect on adoption decisions. Arguing that innovation is a continuous process, Brown holds that higher adaptability of an innovation actually leads to a slower rate of adoption because a) extra time is needed to adapt the innovation to a variety of markets, and b) potential adopters expect further improvements or adaptations [1]. This formulation, however, ignores the role of interplay between the adaptability of an innovation and its other attributes

such as perceived complexity and compatibility in the innovation-decision process. Research has shown that users adopt innovations if only some attributes are perceived to be currently compatible, regardless of possible changes in other attributes in the future stages of diffusion [48].

The contrasting formulations by Rogers et al and Brown reveal that adaptability needs to be examined in the context of other important perceived attributes of innovations. Research on Adaptive Structuration Theory (AST) [49] has discovered the association between faithful appropriation of a technology and its other attributes such as usefulness and ease of use [50]. Depending on how the designed flexibility changes the perception of these attributes, adaptability would then either accelerate or delay adoption. That is, the perceived re-inventability of an innovation should have a moderating effect on the association between other perceived characteristics and the rate of adoption.

Based on previous research, Moore and Benbasat identified five key sets of attributes that explained the most variance in adoption rate [51]. These perceived attributes are relative advantage, compatibility, complexity, trialability and observability. Research has revealed there are three types of adaptation: personalization, customization and invention [52]. The flexibility for these three activities can be constructed as the attribute of perceived adaptability. Research in AST has also suggested the construct of faithfulness of technological appropriation as a measurement of user assessment about technology structuration [50]. Whether an innovation can be modified and adapted in a way that fits individuals' needs regardless of the faithfulness to its original design intent, therefore, should be integrated as a construct of adaptability that moderates adoption decisions based on other perceived attributes.

Hypothesis 1 (H1): The perceived adaptability of an innovation moderates the effects of the perceived 1) relative advantage, 2) compatibility, 3) complexity, 4) trialability, and 5) observability on the rate of adoption of the innovation.

## 1.2. Context of diffusion

Adoption decision is shaped by both external influence of mass media and internal influence unique to one's social groups. The classic diffusion model often frames the internal influence as the direct, dichotomous relationship between opinion leaders and followers [47] or between influentials and imitators [12]. As sociodemographic attributes differentiate one's access to mass media or other external influence, the direct interaction between

innovators and imitators is often shaped by the interplay of both similarity and difference in their demographical characteristics [47]. As a result, individuals' rate of adoption is mainly a function of their personal attributes, which are often compared to adopters in and across entire social systems as predictors of their status as early or late adopters [11, 53].

This model does not contextualize the interpersonal influence of more complex forms within the structured pattern of communication and imitation in individuals' social networks. Research has revealed that both direct contact and indirect communication affect adoption decisions within social networks [40, 43]. The reason is that the structural positions held by individuals in social networks induce behavior change with regards to innovation adoption [44, 54]. Therefore the structure of individuals' networks, particularly the structure of peer adopters, should have an impact on individuals' adoption decision, and should serve as the context for understanding their innovativeness. Based on the theory of threshold of collective behavior [34], Valente proposed a model that uses network threshold— the proportion of adopters in an individual's personal network at the time of adoption for the individual —as a key predictor for this individual's innovativeness and their global adopter category [2]. After testing the model on previous data, Valente found that individuals' network thresholds are associated with their adopter category, indicating a positive relationship between individuals' innovativeness at local and global level. Based on this formulation, two simple hypotheses are formulated.

H2: The network adoption thresholds of individuals are positively related to their relative rate of adoption of an innovation.

H3: The network adoption thresholds of individuals are significantly related to their adopter category in the entire social system.

A major difficulty in measuring adoption thresholds in the context of the Internet is the definition of online social networks. Such online networks could be built both as a reinforcement of pre-existing social relationships, and as a bridging community of interest and practice [45]. This indicates that personal networks on the Internet could accommodate both similarity and difference in social status and demographic variables, or both homophily and heterophily. This conforms to Rogers' formulation that real-life personal networks should allow for both homophily and heterophily so that communication flows and imitation could occur [47]. Therefore individual demographical attributes could

still hold important explanatory power for adoption behavior, albeit not directly and explicitly in the context of network thresholds. Valente has found that individuals both having low network threshold and being early adopters tend to have more exposure to mass media and serve as opinion leaders, hinting at an association between network threshold-based innovativeness and demographical attributes [2]. But in general, threshold models of collective behavior have not specifically examined how personal thresholds are determined by individual attributes, although threshold categorization might provide a useful framework to understand such individual attributes [38]. It is then necessary to examine the relationships among individuals' demographic attributes, network thresholds, and their innovativeness. Research questions are formulated for this exploratory purpose.

RQ1: What is the relationship between individuals' demographic attributes and their network thresholds?

RQ2: What is the relationship between individuals' demographic attributes and their innovativeness?

## 2. Method

### 2.1. Participants

The participants were 34 current users of an online social networking service on a popular social networking website. They were recruited through an advertisement post on the discussion board of the service developer page. No incentives were offered for participation.

According to data from the valid cases, the mean age of the sample ( $N = 19$ ) was 25.83 years,  $SD = 4.09$ . 47.4% of them were females and 52.6% were males. 68.4% of the sample had a bachelor's degree or more advanced education. 52.6% of the sample were White/Caucasian, 31.6% Asian/Pacific-Islander, and 5.3% were either Latino/a, Native American, or African American. The average family income of the sample was \$58,076 ( $N = 6$ ).

### 2.2. Instruments and Procedure

Visual Bookshelf is a free webpage plug-in application. Developed by a third-party company, it was launched on June 30, 2007, and currently listed in the category of Education on the Apps page of the website Facebook.com. On the introduction page of the application, individuals can view which of their friends have already installed this application. Once added to users' own homepage, it can be used to

share book review and recommendations among friends in individuals' networks. At the time the recruitment advertisement was posted on November 5, 2007, there were 29,450 daily active users, according to the website statistics.

The adoption items assessed the time of adoption by asking participants to recall the number of days they have been using the service. Based on the timestamp of the survey response, the value was then retrospectively compared to the time of the launch of the application to estimate the approximate time of adoption.

The five perceived attributes of innovation were assessed with the scale developed by Moore and Bendasat [51]. These attributes are relative advantage, compatibility, complexity (ease of use), trialability, and observability (visibility). Due to the limited scope of the present study, a shortened scale of 16 items was used as suggested by Moore and Bendasat.

Faithfulness of Appropriation (FOA), a widely used 5-item scale in structuration studies, was adapted to assess individuals' perception of the extent to which the use of an innovation could deviate from its intent [50]. In addition, statements about the perception of the flexibility for individuals to engage in three types of adaptation - personalization, customization and invention - as identified and defined by Desouza et al were used as single items [52]. For all the items, a 7-point Likert scale ranging from "extremely disagree" to "extremely agree" was used as the response format.

The adoption threshold was assessed by asking participants to record the total number of their friends on their personal pages and recall the number of friends who have added the same application right before participants did it. The ratio between the latter and the former value is used to estimate the personal network threshold in percentage. Participants were also asked to directly estimate the percentage of their networks who have added the app before they did.

## 3. Results

### 3.1. Measurement Results

There were 18 valid cases which provided data for the dependent variables. The average rate of adoption of the application Visual Bookshelf was 107.7 days counting from its first launch on Facebook.com on June 30, 2007,  $SD = 46.09$ . Categorized by the standard deviations of adoption rates from the mean, 5.6% of the sample were early adopters, 16.7% were early majority, and 77.8% were late majority users. Computed by dividing the

number of friends who added the application before participants and the number of total friends participants had at time of adoption, the average network threshold was 0.13 ( $N = 17$ ), or 13% in percentage,  $SD = 0.24$ . One case had a computed threshold value greater than 1. It was recoded as system missing, as it reflected errors in the estimation of a percentage value. The self-estimated and reported network threshold was on average 0.06 ( $N = 19$ ), or 6% in percentage,  $SD = 0.1$ . The correlation between the two measurements was not significant,  $r = 0.14$ , *ns*. Therefore they were used separately as dependent variables as required by hypotheses and research questions.

### 3.2. Condition of Innovations

Hypothesis 1 posits that the perceived adaptability of an innovation has a moderating effect on the relationship between the perceived attributes of the innovation and the rate of adoption. This was tested with pair-wise comparisons of the magnitude and statistical significance of the  $R^2$  statistics in different multiple regression models with the same dependent variable of the adoption rate. The first model contained only the five perceived attributes as the independent variables. The second model added the measurements of adaptability, and their multiplicative products with each of the five attribute predictors as the interaction terms.

The regression model with only the attributes of the innovation as the predictor variables was not significant,  $F(5, 12) = 2.06$ , *ns*. The linear combination of these predictors explained 46.2% of the variance in the adoption rate ( $R^2$ -adjusted = 0.24), but this relationship was not significant. This non-significant simple model (Model 1) was then used as the baseline for comparison with models with respective interaction terms.

### 3.3. Interaction effect of Faithfulness of Appropriation

The interaction effect of the Faithfulness of Appropriation (FOA) was not significant. When the interaction terms between these attributes variables and the FOA variable were introduced, the full model (Model 2) was not significant,  $F(11, 6) = 1.1$ , *ns*. The combination of innovation attributes, FOA and their interaction terms explained 67% of the variance in the dependent variable, but such positive change in the  $R^2$  as a result of the addition of the interaction terms was not significant,  $\Delta R^2 = 0.21$ ,  $p = 0.71$ .

### 3.4. Interaction effects of personalization, customization and invention

Personalization was defined as the degree to which one modifies the product to suit his or her current needs. The linear combination of this variable and its interaction terms with innovation attribute variables was significantly related to the adoption rate,  $F(11, 6) = 5.21$ ,  $p < 0.05$ . Among the predictor variables in the interaction model (Model 3), compatibility ( $\beta = -4.25$ ,  $p < 0.05$ ) and trialability ( $\beta = -6.76$ ,  $p < 0.05$ ) were significantly negatively associated with the time it took for individuals to adopt the innovation, and ease of use ( $\beta = 5.54$ ,  $p < 0.05$ ) was significantly positively associated with the adoption time. The linear combination of the independent variables explained 90.5% of the variance in the adoption rate ( $R^2$ -adjusted = 0.73). Compared to 46.2% of the variance non-significantly explained by attribute variables in Model 1, the dramatic change in the  $R^2$  statistic in Model 2 as result of introducing the interaction terms between flexibility for personalization and the five attributes was significant,  $\Delta R^2 = 0.44$ ,  $p < 0.05$ .

Customization was defined as the degree to which one modifies the product to suit his or her environment. The combination of this variable, the five attribute variables and their respective interaction terms had a significant linear relationship with the adoption time,  $F(11, 6) = 4.88$ ,  $p < 0.05$ . In the regression model (Model 4), compatibility ( $\beta = -3.00$ ,  $p < 0.05$ ) and trialability ( $\beta = -4.95$ ,  $p < 0.05$ ) were significantly negatively associated with the number of days for individuals to adopt the innovation. Their interaction terms with customization flexibility had effects of reverse direction. The linear combination of attribute variables, flexibility for customization and their interaction terms explained 89.9% of the total variance in the dependent variable ( $R^2$ -adjusted = 0.72). Again, this change in the  $R^2$  statistic was significant as compared to Model 1,  $\Delta R^2 = 0.44$ ,  $p < 0.05$ .

Finally, invention refers to the degree to which one modifies the product to have new functions or options for it. The combination of this variable, the five attribute variables and their interaction terms was significantly associated with the adoption time,  $F(11, 6) = 6.84$ ,  $p < 0.05$ . In the Model 5, one significant regression coefficient was trialability,  $\beta = -2.01$ ,  $p < 0.05$ , and the other was the interaction term between this attribute and invention flexibility,  $\beta = 1.83$ ,  $p < 0.05$ . The linear combination of attribute variables, invention flexibility and their interaction terms

explained 92.6% of the total variance in the time it took for the innovation to be adopted ( $R^2$ -adjusted = 0.79). Compared to Model 1, the change in the  $R^2$  statistic as result of the introduction of the interaction effects of this dimension of innovation adaptability into the regression model was significant,  $\Delta R^2 = 0.46, p < 0.05$ .

In sum, the analysis supported the hypothesis that the flexibility for an innovation to be personalized, customized and invented moderates the association between the perceived attributes of the innovation and its adoption rate, but such moderation effects had varying significance among these dimensions of innovation adaptability. Wherever this moderation effect is significant, the interaction terms between these adaptability variables and attribute variables have effects on the adoption time that are contrary to the first-order effects of attribute variables. The detailed comparisons of regression coefficients are presented here in Table 1.

Table 1

<i>Model Comparisons of Variance, Multiple Correlation, and Regression Coefficients</i>					
	Model 1	Model 2	Model 3	Model 4	Model 5
<b>ANOVA</b>					
<i>F</i>	2.06	1.10	5.21*	4.88*	6.84*
<i>DF</i> <sub>Regression</sub>	5	11	11	11	11
<i>DF</i> <sub>Residual</sub>	12	6	6	6	6
<i>Sig.</i>	0.14	0.48	0.03	0.03	0.01
<b>Multiple Correlation Coefficients</b>					
$R^2$	0.46	0.67	0.91	0.90	0.93
$\Delta R^2$		0.21	0.44*	0.44*	0.46*
<i>Sig.</i> <i>F</i>		0.71	0.04	0.05	0.02
Change					

\*  $p < 0.05$

Model 1: Base model with only attribute variables

Model 2: Interaction model of FOA

Model 3: Interaction model of Personalization Flexibility

Model 4: Interaction model of Customization Flexibility

Model 5: Interaction model of Invention Flexibility

### 3.5 Conditions of Diffusion

Hypothesis 2 posits that there is a positive relationship between individuals' network thresholds and their rate of adoption of an innovation. This was tested with a simple regression model that examined the linear relationship between the network threshold percentage and the relative adoption time. The analysis showed that there was no significant relationship between the adoption rate and the network threshold variable, either computed as the ratio of adopters and total friends in individuals'

personal networks or directly estimated by the respondents. The computed network threshold variable explained only 0.2% of the variance in the dependent variable,  $F(1, 14) = 0.03, ns$ . Hypothesis 3 posits that there is a positive relationship between the adopter category of individuals and their network thresholds. The ANOVA first indicated that the global categorization of adopters among early adopters, early majorities and late majorities was not related to the computed local thresholds relative to individuals' own personal networks,  $F(2, 13) = 0.07, ns$ . The ANOVA then showed that the adopter category was neither associated with the self-estimated network thresholds,  $F(2, 15) = 1.79, ns$ . The factor of adopter category explained 19.2% of the variance in this dependent variable. But because Levene's Test of Equality of Error Variances indicated that these groups had unequal variances,  $F(2, 15) = 7.47, p < 0.01$ , it is unclear how the adopter categorization in general contributed to this correlation coefficient.

Research question 1 explores the relationship between individuals' network thresholds and their demographic characteristics. The analysis suggested that the set of demographical predictor variables of age, gender and education was not linearly related to personal network thresholds. Research question 2 inquires about the similar relationship between individuals' adoption rates and their demographical attributes. The analysis suggested that the combination of demographical variables explained 35.8% of the variance in the time it took for individuals to adopt an innovation, but such combination was not linearly significant,  $F(3, 13) = 2.42, ns$ .

## 4. Discussion

### 4.1. Overview

The results suggest that the degree to which an innovation can be appropriated regardless of its original design intent (Faithfulness of Appropriation) has no influence on the linear relationship between the perceived attributes and adoption time of the innovation. But the flexibility for the innovation to be personalized, customized and reinvented does. Specifically, individuals tend to adopt an innovation faster if it is more compatible with their existing use pattern or life style, if it can be more easily tried before adoption decisions are made, and confusingly, if it is less easy to use. Such relationships are moderated by the flexibility for the innovation to be personalized, customized or reinvented: the effect of perceived attributes only becomes significant when

the modification flexibility is factored in, and their interaction with the modification flexibility have opposite effects on the adoption time.

The results also suggest that there is no significant relationship between individuals' network adoption thresholds and their relative rate of adoption. The relative position of these individuals in the innovativeness categories has no association with the portion of adopters in individuals' personal networks. And the age, education and gender of individuals are not significant predictors for how fast individuals adopt an innovation, and how individuals make adoption decisions based on the adoption portion in their networks.

## 4.2. Limitations

This study suffers from both theoretical and methodological limitations. The hypothetical moderation effect of adaptability is confined to the five major attributes, and it neglects other important attributes that have been identified in diffusion research in information systems such as perceived risk, efficiency, and cost (Beise, 2004; Cha et al., 2005; Hinnat & O'Looney, 2003).

The hypothetical correlation between the adoption pattern at the local level of personal networks and the global level of total potential adopters is weakly established. Because not all members of the local networks are involved in and affected by the diffusion process, it is hard to convincingly define the individuals' adoption decision as a function of the pattern of adoption or non-adoption in such networks.

An obvious methodological limitation is the small sample size, which weakens the power and validity of some of the results in the study. A more serious methodological limitation derives from the lack of update and valid measurements that discriminately capture the attributes of technologies perceived in new context of design and use. The adaptation of existing scales in diffusion research, in spite of the efforts at remaining loyal to the original texts in the scale and reflecting the new contexts, makes the scale items awkward and confusing for some participants. The most serious validity problem is presented in the measurement for the adaptability of innovations, for which no valid measurements are available and unreliable measurements have to be used.

## 4.3. Implications

This finding confirms the important role of the re-inventability or adaptability of an innovation in its

diffusion process. The relationships between the perceived attributes of an innovation and its adoption rate are moderated by the flexibility for the innovation to be personalized, customized or reinvented. In other words, the adoption of innovations with different degrees of modifiability is influenced by their perceptive attributes in different ways. To name two extreme examples: a highly modifiable product might be more quickly adopted even if its other perceptive attributes are not optimal, and a product of low adaptability might take longer to be adopted even if it is perceived to be compatible and advantageous.

Adaptability needs to be systematically factored in the influence of perceived attributes of an innovation on its diffusion rate, a major construct in the diffusion of innovations (Eastin, 2002; H. Lee, Smith, & Grimm, 2003; Vollink et al., 2002) and technology acceptance (Hsu et al., 2007; Wu & Wang, 2005; Yi et al., 2006) respectively. A higher degree of modifiability might either accelerate (Rogers, 2003) or impede (Brown, 1981) the adoption rate for an innovation. The key to this divergence might lie in the moderation effect of modifiability on several important attributes such as compatibility and trialability which have been identified as significant predictors of adoption decision (Vishwanath & Goldhaber, 2003; Wei, 2006b; Wu & Wang, 2005). This effect suggests that innovation-decision process is a dynamic one in which individuals adopt and adapt technologies to their own needs and environment within a given structure of preconfigured attributes and functions of the technologies, as proposed by domestication theory (Silverstone & Haddon, 1996) and the social shaping of technology theory (MacKenzie & Wajcman, 1999).

On the other hand, the study fails to support the association between adoption thresholds in local networks and global adoption rate identified by Valente (1995, 1996) in his study of the diffusion of different technologies among physical personal networks in different national settings. A possible explanation is that personal networks based on interest and friendship on the Internet are different from the physical personal networks based on face-to-face contact and specific activities that were studied by diffusion researchers. On the one hand, the formation and boundary-setting of these networks are based on loosely defined friendships, and not on the geographical and economic ties usually associated with common activities such as the adoption of a specific technology. So the membership and relationships in these online networks are different (boyd, 2006; Golbeck, 2007; Wellman et al., 2003).

On the other, the consequences or benefits of adoption and communication flow in these networks are less salient and vivid for perception and imitation because of the reduced communicative cues (Walther & Parks, 2002) or because of the lack of authenticity in the virtual presence of the adoption object (K. M. Lee, 2004).

In summary, this study reveals that it is important to analyze the conditions and contexts for an innovation to be diffused and adopted. Individuals adopt an innovation based on their perceptions of its major attributes, but such decision process is highly moderated by how the innovation is perceived to be modifiable. Therefore the perceived attributes of an innovation should not be defined as fixed and stable predictors of diffusion process. The modifiability of the innovation is a perceived and expected quality that influences the adoption decision prior to its implementation. Also, individuals' personal networks might not have a significant effect on adoption decisions if the adoption pattern within the networks is harder to be detected and thus harder to have an influence on the peers. This entails a careful definition and examination of personal networks in different communication contexts and their actual influence on individual adoption decisions.

The diverging support for the hypotheses from diffusion data collected in an Internet context suggests that new technologies might influence components in the diffusion of innovations in different ways. The perceived attributes are still significant predictors of the adoption rate when the innovation is distributed on the Internet. But the adoption and communication pattern within personal networks on the Internet fails to influence adoption decisions as significantly as they do in physical settings. This distinction indicates that the study of the diffusion of innovations in a new technological environment such as the Internet needs to treat components of the diffusion processes with separate sets of constructs and models that are appropriately borrowed from research on the affordance of technological design (e.g. Gibson, 1977; Norman, 2002) and social psychological analysis of group behavior on the Internet (e.g. Postmes, Spears, & Lea, 1998; Spears, Lea, Corneliussen, Postmes, & Ter Haar, 2002)

#### 4.4. Future Research

Future research on the diffusion of technological innovations should first focus on the construction and validation of measurements that accurately and validly capture the attributes of innovations that serve various purposes in different contexts. Despite the

robustness of the widely used scales developed by Moore and Bendasat (1991), Rogers (2003) calls for researchers to develop their own scales because of the fast pace of innovations in many fields. Scholars have strategically modified the Moore and Bendasat scale, and merged it with measurements from other theories such as Technological Acceptance Model and Uses and Gratifications model. But serious efforts should be made in the tradition of diffusion research to construct measurements that reflect perceptive changes in the diffusion of innovations in new communication environments at both individual and organizational levels.

Theoretically, numerous researchers have attempted at combining the classic diffusion model with other disciplines of research (Alcouffe et al., 2007; Dayton, 2006; Hinnat & O'Looney, 2003; Vishwanath & Goldhaber, 2003; Yi et al., 2006). A alternative area of future research would be to examine how the constructs from other models interact with the classic attribute variables and moderate the explained variance in the adoption rate. Conceptually, this effort entails the exploration of how the classic diffusion process interferes and interact with external processes of how technologies are designed, afforded and appropriated, how individuals are psychologically and socially predisposed in their exposure to new technologies, and how organizations manage the internal and external structures of resources and relationships to adopt technologies. Broadly defined, these processes are the technical, social and organizational contexts for the classic diffusion process which traditionally contains one static innovation and many individuals with the option of either adopting or not adopting. The study of these contextual processes hopefully would reveal paths to an updated diffusion of innovations model.

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