



. 1 .

Towards a Comprehensive Understanding of the Innovation-Decision Process

A Relational Model of Adopter Choice

ARUN VISHWANATH & HAO CHEN



Introduction



In almost all decision-making scenarios, individuals choose among multiple alternatives and utilize a personal valuation scheme to cognitively process and reduce the set of alternatives to one final choice. This basic facet of human decision-making is ignored by almost all models of innovation adoption. Most current approaches to modeling adoption focus on the individuals' decision to adopt a singular innovation that is pre-selected for them by the researcher prior to model testing. Moreover, these approaches assume that the valuations used by the adopters remain stable across time and space. In this chapter, we present a relational model of adoption, one that accounts for the adopters' relative choice among different innovations and the evaluative schema used to arrive at a final choice. The model is built on an associational framework of cognition, a concept that has been around since the time of Aristotle, where concepts are seen as related to each other through associative chains. The relational model provides the probabilities associated with the choice of an innovation from a basket of other innovations, along with the perceived attributes that drive this choice. In doing so the model provides a much more comprehensive and accurate assessment of the innovation-decision process.





Diffusion theory presents a demand side explanation of how and why an innovation diffuses through a social system (Rogers, 2003). The theory presents a broad framework that encompasses all the factors that could influence individual adoption and thereby the rate at which an innovation diffuses through a social system. The framework includes as predictors proximate factors such as change agent efforts and the adopters' volitional control over their adoption decision along with their perceptions of the attributes of the innovation. It also includes ultimate factors such as cultural norms and the types of communication channels that exist in the system.

Among the proximate factors, the perceived attributes of the innovation account for the majority of variance in the rate of adoption of an innovation (Rogers, 2003). Five attributes of innovations are considered key to a potential adopters' decision to adopt: the relative advantage of the innovation over preceding innovations; the compatibility of the innovation with other existing technologies; the complexity in learning to use the innovation; the perceived visibility or ability to vicariously observe its consumption; and the ability to test the innovation on a limited basis.

Given the relatively high influence of perceived innovation attributes on adoption, contemporary research has focused on just these factors and their impact on the individuals' decision to adopt an innovation or behavioral intent. To their credit, this research has developed precise measures (based on alpha reliability that exceeds 0.90 in many cases) and designed strong measurement models that consistently explain over 70% of the variance in the individual's intent to adopt an innovation, using just a handful of independent measures. The amount and quality of work has been so precise that many scholars have questioned the need to further study diffusion. Thus, it appears that diffusion research has reached a saturation point.

The goal of this chapter is to evaluate whether this is truly the case. Have we reached a point where we can successfully predict whether an individual would adopt an innovation? Can we comprehensively explain how an individual arrives at an adoption decision, or are we just able to explain a subset of a larger process? In this chapter, we argue for the latter. We contend that innovations exist in a spectrum of choice and adopters usually compare the relative value of competing innovations while deciding on the innovation they intend to adopt. We further argue that this comparative choice process varies depending on the adopters' personality and other proximate factors. These important facets of the adoption decision process are ignored by the current models of adoption, which instead focus on a singular innovation and the absolute per-



ceptions of adopters regarding that innovation. We believe that this is because of the limitations of present approaches to empirical measurement that have in turn resulted in an incomplete and inaccurate representation of the adoption decision process. Hence, neither the process of adoption nor the individual decision to adopt an innovation is well understood.

In this chapter we argue for a focus on the adopters' choice among innovations instead of their absolute behavioral intent and present a comprehensive approach to modeling this choice process. We begin the chapter with an examination of the present approaches to modeling the decision to adopt an innovation followed by the limitations of these approaches. Next we present a relational model of adopter choice that we believe better represents the innovation choice process, followed by a methodology that is best suited to test this model. Finally, we present an empirical examination of our relational model along with conclusions and implications for future diffusion research.

Models of Adoption

The extant models that explain the individuals' decision to adopt an innovation can be broadly classified based on their measurement and modeling approaches. One approach is to derive the proximate measures that predict adoptive intent on a study specific basis. This can be thought of as a traditional modeling approach and is rarely used in current diffusion research. This approach drew from the social-psychological tradition of behavioral measurement, espoused by models such as Fishbein and Ajzen's (1975) Theory of Reasoned Action (TRA), and was advocated by Rogers (1964). Researchers in this tradition would derive their measures using focus groups or other projective techniques and utilize factor analysis and OLS regression techniques to refine the measures and accord relative value weights to the independent measures (e.g., Leung & Wei, 1999).

This approach, though exploratory, had three inherent advantages. First, the measures that were derived had high content validity because they were drawn directly from the study population. Second, this approach could be easily extended to study the diffusion of any technology or innovation. Third, researchers would often include and at other times uncover additional constructs during the exploratory process and therefore the approach provided a richer understanding of the adoption decision process.

The second, more contemporary approach to modeling adoption is to utilize a-priori scales and measures. This approach is confirmatory and employs

structural equation modeling and other techniques aimed at validating the fit between empirically derived data and a predefined research model. A root of this approach can be found in the Technology Acceptance Model (TAM) (Davis, Bagozzi & Warshaw, 1989) from the management information sciences (MIS). The model is presented in Figure 1. TAM was built to explain the acceptance of computing technology by end users within organizations. The model draws from the TRA framework and distinguishes between the perceived beliefs about software-based innovations and the end users' behavioral intent. According to TAM, the end users' intent to accept an innovation is best predicted by just two instrumental attributes of innovations: their perceived ease of use and perceived usefulness. Perceived ease of use refers to the degree of effort required to learn to use the technology and is similar to the diffusion theoretic concept of complexity. Perceived usefulness refers to the user's subjective judgment of the utility of the prospective technology in increasing his or her job performance within the organization; it closely parallels the relative advantage factor from diffusion theory. Because complex technologies with steep learning curves reduce the perceived utility of the technology, in TAM, perceived ease of use influences usefulness. Together, these two instrumental beliefs mediate the influence of external factors on the user's intent to adopt the technology, which, in turn, predicts actual adoption.

In communication science, Vishwanath and Goldhaber (2003) presented a hybrid model that combined the TAM-based instrumental factors along with the diffusion theoretic factors such as observability and compatibility. Also included were factors such as change agent contact, media ownership, and media use, which mediated the influence of external demographic factors on the innovation specific beliefs; the innovation specific beliefs then directly influenced behavioral intent.

There were many subsequent modifications and additions to TAM from within the MIS field that culminated in the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). According to UTAUT, four beliefs about an innovation are core determinants of an individual's intent to adopt: performance expectancy, effort expectancy, social influence, and facilitating conditions. Performance expectancy and effort expectancy are similar to the innovation-diffusion constructs of relative advantage and perceived complexity, respectively; social influence is similar to the construct of image, while facilitating conditions taps into the innovation-diffusion construct of compatibility. Of these, facilitating conditions is considered the least important because its influence is not significant in the presence of performance expectan-

cy and effort expectancy. Factors such as gender, age, experience, and voluntariness of use are thought to mediate the influence of these four core determinants on behavioral intent.

This contemporary approach to diffusion modeling also has a number of advantages. First, the models are robust and parsimonious. They account for a large percentage of intention (close to 70%) while using just a handful of measures. This makes the model particularly popular and appealing from an applied standpoint. Second, the measures developed are readily available and easily adapted to varying study contexts. This makes it not only easy to apply these measures but also justify their use, the latter being an important expectation of reviewers and journal editors. Not surprisingly, TAM and UTAUT are the most widely used models of adoption. These models have been applied to the study of a range of technological innovations ranging from Personal Digital Assistants (PDA) in hospitals (Vishwanath et al., 2008) to the adoption of information communication technologies within households (Dwivedi, Williams & Venkatesh, 2008).

Despite their advantages, the traditional and contemporary approaches to the measurement and modeling of adoption suffer from at least three major limitations. First, the use of either approach involves a trade-off. In the traditional approach, scholars have to choose between methodological rigor and the ability to measure nuanced variations in adopters' intentions. In the contemporary approach, the trade-off is between a parsimonious, good fitting research model and an explanation that is anything other than the obvious. Consider the case of a policymaker who utilizes TAM to explain to an organization that the technology the organization implements should be easy to use and useful. These instrumental features are but the most obvious minimum requirements that users would expect from anything that they adopt, be that new software, a complex innovation, or a coffee pot.

A second limitation of the modeling approaches is that these models assume that the same sets of finite, unidimensional valuations of potential innovations apply regardless of when, where, and by whom an innovation is potentially adopted. In other words, regardless of whether you are in Poughkeepsie or Panama, only perceived ease of use and usefulness would matter to you as an adopter. Empirical evidence, however, suggests otherwise. Within the MIS realm, studies that have tracked user preferences have found that users use different valuations prior to and after implementation (Karahanna, Straub & Chervany, 1999). Likewise, research in communication has shown that early adopters and later adopters cognitively conceptualize technologies they adopt

differently (Vishwanath & Chen, 2006). Hence, it is very likely that different types of adopters use different dimensions of valuation to understand an innovation. This might be the case for employees within organizations as well as for the average individual consumer. For instance, upper management when evaluating a technology might consider price as the determinant of its usefulness; students might value social influence and image instead of ease of use; or later consumer adopters might value trialability over all other factors. Of course, these issues are potentially less significant among individuals who have little control over their decision to adopt (this would include prisoners and individuals in line functions in an organization), but for most individuals who are outside these constrained contexts, the extant diffusion models tend to underestimate the differences in valuations that ultimately influence their decision to adopt.

A final limitation is that all the different behavioral models of adoption focus on the potential adopters' decision to adopt a singular innovation that is often preselected for them by the researcher prior to model testing. That is, all the models are absolute models of intent rather than models of relative choice. In almost all human decision-making scenarios, however, individuals choose between multiple alternatives and utilize a personal valuation scheme to cognitively process and reduce the set of alternatives to one final choice (Simmons, 1974). Likewise, innovations exist in a spectrum of choice, and potential adopters utilize different valuation schemes to reduce the set of alternatives to one choice innovation that they eventually adopt. All the models of adoption ignore this fundamental aspect of adopter decision making.

Of course, one could argue that diffusion theoretic constructs of perceived compatibility and relative advantage capture relative valuations between alternative innovations. These constructs, however, measure the relationship between an innovation and one it supersedes. So the choice between competing innovations is clearly underestimated.

The primary reason for ignoring the choice processes in the manner in which choice is measured and modeled. While behavioral intent and beliefs are easily measured using metric measures, choice is always a categorical variable. Hence, choice between more than a few variables, while easy to measure, poses a challenge to modelers who use standard regression-based approaches that require metric data. Multidimensional scaling techniques provide an alternative means for accurately measuring and modeling such choice processes. This, however, needs a fresh view of the adoption process that can accommodate these modeling techniques. In the next section, we present a relational model of adopter choice that presents such an approach.

A Relational Model of Adopter Choice

The relational model of adopter choice models the associational process by which potential adopters choose an innovation from among multiple alternatives. These associational processes are fundamental to human cognition: the human mind organizes all stimuli based on their conceptual similarity with other objects, such that objects that are similar are more closely associated than those that are dissimilar. Such a view of cognition exists since the time of Aristotle (Anderson, 1983) and is frequently used as a basis for social and cognitive science research (Barnett, 1988; Carley, 1986; Shah et al., 2004; Vishwanath & Chen, 2006). Hence, the associational view is ideal for structuring and representing the interrelationships between multiple innovations.

Barnett and Siegel (1988) extended this associational perspective to explain the diffusion of innovations within social systems. The associational perspective draws from older conceptualizations of the collective consciousness by Durkheim (1895) and views diffusion as a cognitive process and innovations as combinations of associative elements of thought among collections of individuals in a system. New innovations provide an opportunity for new linkages or rearrangements of elements that have not been previously associated. As an innovation spreads through a social system, the conceptual configuration shared by the members change thereby altering their associative structures. The degree of reorganization of the associative elements is a function of the amount of information members of that system receive about the innovation (Woelfel & Barnett, 1982). Innovations that cause a minimal change in the associational structure tend to be closely related. Hence, the resultant associations indicate the compatibility with the values, past experiences, and needs of the potential adopter.

Our relational model of adopter choice extends this associational view to the study of multiple innovations, their relative associations with regard to each other and the individual adopter. These relationships are structured and presented as associations on a space that is empirically derived to reflect the preference of each adopting segment. The dimensions in the space reflect the valuation schemes of the adopting segment. Further, our relational model draws on the balance of forces or equilibrium concept of choice (Woelfel, 1975) and locates an ideal point on the space. This ideal point is essentially the average of the coordinate scores for an axis across all the dimensions on that space. Innovations that are most likely to be adopted are those that are closest to this ideal point. The relationships between innovations are measured by

comparing the distance between innovations and the ideal point in the dimensional space.

Figure 2 presents a simple example of our relational model on a two-dimensional space. While the space has been represented on two dimensions for simplicity, it can be represented in as many dimensions as there are concepts in that space. In the example, the x axis represents “price” and the y axis represents “observability.” Since the dimensions are empirically generated, differences in valuation schemes can be easily ascertained and mapped. For instance, if early adopters place a higher value on price and later adopters instead value trialability, these could be empirically determined and represented. There are five innovations represented by dashed vectors in the figure: BlackBerry (4,4), Sony PlayStation 3 (PS3) (6,2), and Amazon’s Kindle (-2, 7). The equilibrium concept would locate the ideal point, closest to (4,4,3), and in this simple example, iPhone lies closest to the point, denoted by the solid vector. Hence, other factors being equal, the potential adopter would choose an iPhone; moreover, the adopter would compare iPhones with BlackBerrys and contrast them using price and observability.

The simple model could be expanded to accommodate any number of innovations along with a host of preferred attributes. Concepts representing individual attributes could be derived from the literature or elicited from the study population using projective techniques. The data to test the model could be empirically derived using paired comparisons that would provide a metric estimate of relationship among the innovations. Our relational model, thus, provides a quantitative approach to the study of adopters’ relative choice among innovations: it accounts for the relationship among innovations, the relative preferences among them, as well the evaluative schema used to arrive at those preferences. The next section presents the methodology that is ideal suited to test this model.

Methodology

The test of the relational model requires a measurement system that meets the following requirements (Barnett, 1988; Barnett & Siegel, 1988; Vishwanath & Chen, 2006): (1) the links among a set of elements must be measured in terms of the similarity (or dissimilarity) among the elements. The measurement system needs to be capable of relating technologies to each other; (2) the measurement system needs to be holistic and capable of simultaneously measuring all integrated dimensions and produce a complete description of the relation-

ships between technologies within and across different concepts; (3) it must involve consensual measures that allow for predictions at both the individual and the aggregated or system level; and (4) in order to make possible calculations of the rate of change and/or degree of differences between associations of adopters and non-adopters, the measurement scheme must ideally be at the ratio level.

The Galileo system satisfies all these demands (Woelfel & Fink, 1980). The Galileo system is an integrated methodology for metric multidimensional scaling using paired distance judgment data (Woelfel & Fink, 1980). Rice and Rogers (1984) recommend its use to describe the changes in conceptual structures of adopters of information technologies. Beninson-Germano et al. (1988) used the Galileo system to examine the adoption of automated ordering systems in the pharmaceutical industry.

Galileo measurement begins by measuring dissimilarities among a set of concepts describing a domain, defined by these concepts, using paired comparison (every possible pair of the concepts' dissimilarities are measured). So given N concepts, the dissimilarity among $N(N-1)/2$ pairs of symbols is estimated by respondents. In Galileo measurement, the "self" or "me" is also included as a concept since it provides a reference frame to understand the position of ego relative to the other concepts. Respondents are provided with a known distance estimate and instructed to judge the distances between pairs of concepts in proportion to this standard distance. The instruction is generally of the form, "If the distance between x and y are u units, how far apart are concepts a and b ?"

The empirical distance data collected yields a matrix of concept dissimilarities. This matrix is transformed into a scalar products matrix that is double-centered to establish the origin at the centroid of the distribution. The matrix is then decomposed to achieve a coordinate matrix whose columns are orthogonal axes (dimensions) and rows are the projections of the concepts on the dimensions (Woelfel & Fink, 1980). Since the coordinates for the items represent the least-square balance points for the items relative to each other, the distances between objects (their coordinates) can be taken to indicate the conceptual similarity between the items. Thus, the greater the reported distance, the greater the conceptual differentiation, and vice versa.

In the relational innovation choice model, the innovation that is closest to the "self" in the collective space would be the innovation that is most preferred. In other words, innovations that are preferred are those that are maximally close to the individual, self point, i.e., have a distance of 0 from the self.

Hence, an adopter's likelihood of choosing an innovation from among other innovations can be predicted as follows:

$$P(x) = 1 - \frac{S_x}{S_x + S_y + S_z} \quad [\text{Equation 1}]$$

Where "P(x)" represents the probability of choosing innovation x, and S_x, S_y, S_z are the aggregate distances between the self and innovation's x, y, z, respectively, across all dimensions.

The Galileo system's multidimensional scaling method is considerably more precise when compared with traditional scale measurements. Gillham and Woelfel (1977) experimentally measured the precision of a Galileo-type pair-comparison instrument against other scaling methods. They found that even in extreme cases, when the Galileo ratio procedures might be only 50% reliable, it still generated about 2.70 times more reliable information when compared with a 10-point semantic differential scale, even if the semantic differential scales contained no random error (Woelfel & Fink, 1980). A vast body of communication, linguistic, and cross-cultural research has demonstrated the reliability and theoretical validity of the Galileo system (Barnett & Woelfel, 1988; Kincaid et al., 1983; Vishwanath & Chen, 2006, 2008). In the next section we present an empirical test of our relational model of adopter choice using the Galileo system.

Empirical Test of the Relational Model of Adopter Choice

Data and Operations

To test the relational model, data were gathered from undergraduate communication 101 students at the University of Buffalo. Subjects responded to a web-based questionnaire that contained the Galileo measures. The instrument asked respondents to consider the distance between internet and television to be 50 units. Using this referent, respondents were asked to estimate the distances among 105 concept pairs (15 concepts including "myself"). Table 1 presents a list of concepts used in the study.

Wherever possible, primitive concept terms were generated to reflect diffusion theoretic attributes of innovations. For instance, perceived complexity was represented by the term "easy to use," technological efficacy was represented by the term "ability to use," social influence was represented by family and

friends. Constructs such as observability, trialability, usefulness, and purchase were represented as concepts by simply using their construct names. Three innovations were included: BlackBerry, PlayStation 3 (PS3), and iPhone.

The data for the study were collected November 14–21, 2007. At the time of the data collection, the iPhone was a relatively new innovation, and it was less than five months since it had been launched in the U.S market. The data collection netted 349 usable responses (57% female). In addition to measuring the Galileo data, respondents' technological innovativeness was measured using the six-item Domain-Specific Innovativeness scale (Goldsmith & Hofacker, 1991). Sample items in the measure read, "I am generally the first among my friends to purchase a new technological product," "Compared to most of my friends, I own more technological products," and so on. Items were measured using a 1–5 response scale (1 = strongly agree). The scale netted an alpha reliability of 0.91 ($mean = 2.91, sd = 0.88$). Respondents scoring in the first quartile of the innovativeness scale ($mean\ values\ less\ than\ 2.34$) were treated as early adopters, and the rest of the respondents were treated as later adopters. The mean distance matrix for early adopters is presented in Table 2 and for later adopters, in Table 3.

Results

Early adopter space. For early adopters, the scaling procedure resulted in 15 dimensions (13 real dimensions). Figure 3 presents the early adopters' space. Table 4 presents the spatial coordinate matrix for early adopters. The results report the findings for the first three dimensions because they are more easily visualized and because they account for close to half the variance in the data.

The first dimension is anchored by the attributes Affordability and Ease of Use, with the self concept leaning towards affordability. On this dimension, the technology closest to the self concept was BlackBerry (2.4 units), followed by iPhone (14 units), followed by PS3 (18.62). In 2007 when these data were collected, within the U.S., a BlackBerry could be purchased for under \$100 (at no cost with some cell phone plans), a new iPhone cost \$399, and PS3 cost \$599.

The second dimension is anchored by the attributes Purchase and Affordability, with the self leaning towards purchase. On this dimension, the technology closest to the self concept was iPhone (4.9 units) followed by PS3 (9.36 units) and BlackBerry (14.34 units). This suggests that early adopters in our student sample are most likely to purchase an iPhone or a PS3. BlackBerry, positioned for business users, is the least likely to be purchased.

The third dimension is anchored by Observability and Affordability, with the self leaning towards observability. On this dimension, the self concept was closest to iPhone (1.98), followed by PS3 (2.59) and BlackBerry (6.11). Hence, for early adopters the iPhone would have the highest observability or social cachet followed by the PS3. In contrast, a BlackBerry would have relatively low social value.

Later adopter space. For later adopters, the scaling procedure again resulted in 15 dimensions (13 real). Figure 4 presents the late adopters' space. Table 5 presents the spatial coordinate matrix for later adopters. The results report the findings for the first three dimensions because they are more easily visualized and they account for close to half the variance in the data.

For later adopters, the first dimension is anchored by the attributes Affordability and Ease of Use; again the self leaned towards affordability. On this dimension, the technology closest to the self concept was BlackBerry (7.23 units), followed by iPhone (16.39 units), followed by PS3 (18.81). This finding paralleled the early adopter results.

The second dimension is anchored by the attributes Friends and Family and Affordability; the self concept leaned towards friends and family or social influence. On this dimension, the technology closest to the self concept was iPhone (5.47 units) followed by PS3 (9.26 units) and BlackBerry (13.37 units). This suggests that social influence is an important driver for later adopters while in contrast, for earlier adopters, vicarious consumption was more important.

The third dimension is anchored by Observability and Purchase with the self concept leaning towards observability. On this dimension, the self concept was closest to iPhone (4.25), followed by BlackBerry (4.97) and PS3 (5.53 units). Hence, for later adopters an iPhone followed by a BlackBerry would have relatively high observability, while a PS3 would have a relatively low social value.

Comparing early adopters and later adopter spaces. The comparison of early and later adopter spaces began with an evaluation of the overall spread of concepts within each space. This was done using the trace of the coordinates, the sum of the overall eigenvalues for each eigenvector matrix. For early adopters, the trace was 3,590, and for later adopters the overall sum was 4,634.

Next, the concepts that differentiated early and later adopters the most were estimated using the angles between the concept vectors across all the dimensions. Since the cosine of the angle between vectors reflects the correlation between them, smaller angles signify that the vectors are highly correlated or moving in the same direction. Table 6 presents the angles and

correlations between the concept vectors for early and later adopters. Actual use (39.5 degrees), easy to use (30.9 degrees), and compatibility with existing technologies (30.5 degrees) had the lowest correlations. Friends and family (14.8 degrees), self (15.7 degrees), and ability to use (16.9) had the highest correlations and deviated the least.

A similar comparison of the angles between the first three dimensions for early and later adopters confirms that the two adopting segments utilize different sets of evaluative dimensions: the first dimension correlated the most (angle 12.6 degrees), followed by the third dimension (17.38 degrees); the second dimension deviated the least (24.5 degrees).

Finally, the likelihood of choosing each innovation was computed using equation 1 and using the coordinate distances between the innovations and the self on first three dimensions. Based on this, the early adopters in our sample had a 72% likelihood of choosing an iPhone while later adopters had a 65% likelihood of choosing an iPhone. While both segments had an equal likelihood (around 70%) of choosing a PS3, later adopters had a slightly higher (62%) likelihood of choosing the older innovation, the BlackBerry, over early adopters (56%).

Discussion

The empirical test of the relational model in many ways converges with the diffusion theoretical expectations for early and later adopters. Early adopters in our sample were much closer to actual purchase or adoption than later adopters. Moreover, the overall early adopter conceptual space was denser and less varied compared with later adopters, potentially because early adopters have greater awareness and knowledge of new technological innovations. Consistent with user acceptance research, the innovation's ease of use was an important consideration for early and later adopters. Furthermore, concepts such as actual use, easy to use, and compatibility significantly varied between early and later adopters. Differences in actual use and ease of use potentially reflect early and later adopters' personality-based differences in innovativeness and technological efficacy. The variances in the compatibility concept potentially reflect differences in how early and later adopters conceptualize the relationships between various technologies, an aspect that was empirically demonstrated by Vishwanath and Chen (2006).

The relational model, however, diverges from diffusion and user acceptance

theories. The relational model demonstrated that early and later adopters utilized different sets of evaluative dimensions while considering innovations. Early adopters in the study weighed affordability against ease of use, purchase intent against affordability, and observability, i.e., the image or social cachet of the innovation against affordability. In contrast, earlier adopters weighed affordability against ease of use, friends and family members, i.e., what others in the social network thought about the innovation against affordability, and observability against purchase intent. Interestingly, the user acceptance factor of perceived usefulness was not a significant factor. Nor were diffusion theoretic factors such as compatibility or relative advantage. Instead the economic evaluation of the innovation's affordability was recurrently important and central to early and later adopters. Besides this, observability or image, social influence, and ease of use were the factors considered by early and later adopters of innovation.

These conclusions should be interpreted in light of the following limitations. First, the study utilized a student sample for the empirical data. This was done primarily for convenience and because students provided us with homogeneous, controlled samples. Students, however, tend to be skewed in favor of adopting innovations, an issue that could account for some of our results. Additionally, the survey utilized brand names of technologies as concepts. This could have induced respondents towards considering issues such as observability and friends and family. The use of brand names could have also influenced individual consideration of price and affordability. Finally, the analysis relied on just the first three spatial dimensions and their coordinates. A more accurate understanding of adopter decision making would be netted by considering all the dimensions in the associational space as well as the influence of external factors such as Apple's advertising and of interpersonal influences from other adopters. The findings of the model are therefore preliminary, and additional research is necessary to validate and extend our findings. Future research using innovations as concepts (e.g., cell phone, home phone, and pagers), representative samples of adults, and more attributes could easily validate the model.

The relational model of adopter choice, however, provides a fresh approach to the study of adopter decision making. The model and the methodology makes it possible to study the absolute influence of an innovation's attributes on adopter intent while simultaneously accounting for the relative associations between the different innovations considered during this decision-making process. Similar to traditional diffusion models, the relational model can be applied in an exploratory manner, but it is more dynamic because it can

account for the process by which adopters choose between any number of innovations and their evaluations of these innovations. Also, similar to contemporary intention models, the relational model can be used to confirm the evaluative dimensions found across different studies. Further, because the approach relies on simple, primitive definitions of concepts, the measures can be easily extended and compared against other domains of study in virtually any social system. Finally, since the model provides predictive probabilities of adopters' final choice, the veracity of these predictions can be easily confirmed on a posteriori basis. Thus, by accounting for the choice between different innovations, the relational model provides a more comprehensive understanding of the adopter decision-making process. This aspect of innovation decision making is the least well understood and, in many ways, one of the most important facets of the adopter decision-making process.

Tables and Figures

Table 1. List of concepts used in the study.

Useful
Easy to use
Friends and family
Compatible with existing technology
Observable
Triable
Purchase
Use
Ability to use
Apprehension
BlackBerry
iPhone
PS3
Myself
Affordable

Table 2. Mean Distance between Concepts among Early Adopters.

CONCEPTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Useful	0.00														
2. Easy to use	18.52	0.00													
3. Friends and family	17.81	24.31	0.00												
4. Compatible	17.15	18.67	23.79	0.00											
5. Observable	20.12	19.33	21.38	19.46	0.00										
6. Trialable	21.52	23.40	22.50	21.10	25.17	0.00									
7. Purchase	20.88	20.48	24.12	21.44	23.15	20.50	0.00								
8. Use	18.38	16.88	21.13	23.58	18.77	19.02	21.79	0.00							
9. Ability	20.65	18.29	21.65	24.19	21.44	19.38	23.79	20.77	0.00						
10. Apprehension	22.19	22.40	21.56	23.33	22.33	25.33	23.62	19.56	26.23	0.00					
11. BlackBerry	21.83	19.35	23.29	22.19	21.15	22.79	28.88	23.23	20.54	25.31	0.00				
12. iPhone	23.23	20.23	24.87	20.54	21.38	19.48	26.21	21.21	19.02	20.65	24.21	0.00			
13. PS3	27.85	21.15	27.77	20.73	21.31	22.44	25.87	22.62	20.58	24.00	25.44	23.42	0.00		
14. Myself	20.42	21.87	17.81	19.08	19.58	20.69	23.25	19.96	21.56	23.96	23.48	24.58	26.21	0.00	
15. Affordable	26.50	26.83	25.73	25.56	22.79	23.85	27.50	26.58	23.60	25.83	23.73	29.38	29.56	26.31	0.00

Table 3. Mean Distance between Concepts among Later Adopters.

CONCEPTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Useful	0														
2. Easy to use	20.52	0													
3. Friends and family	25.45	27.73	0												
4. Comparable	22.54	24.22	26.82	0											
5. Observable	27	26.55	25.38	25.25	0										
6. Trialable	25.54	24.63	29.97	26	24.78	0									
7. Purchase	27.77	28.56	30.95	25.88	27.51	24.88	0								
8. Use	17.73	20.22	26.42	24.31	26.41	21.88	21.04	0							
9. Ability	18.67	19.76	25.51	22.53	25.61	23.79	24.97	19.08	0						
10. Apprehension	31.22	26.55	27.95	25.65	25.5	25.44	28.86	25.72	28.89	0					
11. BlackBerry	23.77	23.68	31.58	20.52	24.75	25.33	26.81	23.32	22.77	26.17	0				
12. iPhone	22.87	22.16	32.8	19.42	25.01	25.01	28.5	23.37	23.17	25.22	22.33	0			
13. PS3	29.86	23.04	29.61	20.46	23.91	24.85	27.09	25.81	23.55	26.22	30.23	31.11	0		
14. Myself	20.55	23.16	21.56	22.84	21.61	25.09	25.95	23.26	23.15	23.77	28.15	28.44	28.68	0	
15. Affordable	29.19	31.58	28	28.56	27.38	27.62	24.16	26.74	26.23	27.08	29.54	34.39	32	25.33	0

Table 4. Spatial Coordinates for Early Adopters on the First Eight Attribute Dimensions.

	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6	Dimension 7	Dimension 8
Useful	4.93	-6.59	-2.96	-4.29	3.16	3.38	4.20	-0.38
Easy to use	5.25	-0.30	-3.44	-1.64	5.21	7.96	0.24	0.39
Friends and family	-9.32	-4.93	-3.11	-2.81	-5.12	-3.65	-4.00	0.35
Compatibility	2.38	-1.80	-0.13	0.82	9.49	-7.05	6.58	0.28
Observability	-0.68	1.83	-5.49	4.38	4.50	-1.04	-4.96	-6.49
Triability	0.91	0.95	10.69	-4.95	-4.92	-2.85	3.11	4.08
Purchase	0.26	-9.50	10.40	3.41	4.40	5.02	-0.06	-0.85
Use	1.66	-4.19	-1.48	0.02	-4.44	5.54	-4.65	3.03
Ability to use	2.10	6.36	2.88	-7.19	-3.08	3.56	-3.74	-5.09
Apprehension	0.72	-4.65	-5.36	11.38	-7.55	-0.01	2.88	3.04
BlackBerry	-3.02	9.96	-6.69	-4.73	2.24	2.09	2.96	6.87
iPhone	8.73	0.53	-2.57	-2.27	-7.42	-2.35	7.42	-6.71
PS3	13.14	4.99	2.01	3.90	1.82	-4.37	-6.74	3.68
Myself	-5.49	-4.38	-0.59	-4.29	1.84	-7.56	-5.06	-0.09
Affordable	-11.69	11.71	5.85	8.25	-0.11	1.35	1.81	-2.11

Table 5. Spatial Coordinates for Later Adopters on the First Eight Attribute Dimensions.

	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6	Dimension 7	Dimension 8
Useful	-3.98	-4.64	-2.44	-9.68	3.14	3.70	3.10	-1.81
Easy to use	5.99	-0.55	-4.05	-5.15	2.59	6.93	-1.90	1.53
Friends and family	-11.49	-6.48	-3.72	-1.35	-3.90	-5.25	-7.45	-1.82
Compatibility	4.40	0.89	-1.65	-0.23	6.64	-8.64	6.68	1.29
Observability	-0.10	3.83	-5.75	4.81	2.27	-4.44	-7.15	-6.47
Trialability	2.55	4.27	8.32	-3.98	-7.81	-2.55	0.50	5.26
Purchase	0.17	-5.48	13.59	5.03	4.32	4.46	1.81	-1.27
Use	0.87	-5.59	1.76	-1.40	-2.89	9.36	-0.76	1.89
Ability to use	1.01	4.73	1.96	-7.57	-1.86	4.11	-3.06	-5.13
Apprehension	1.31	-1.38	-5.53	12.27	-9.23	-3.39	1.99	5.83
BlackBerry	-0.15	7.16	-6.70	-2.83	3.68	4.81	7.37	6.35
iPhone	9.21	-0.75	-5.98	-2.75	-3.42	0.20	12.22	-7.24
PS3	11.73	3.04	3.80	4.91	3.30	-4.33	-9.97	4.16
Myself	-7.09	-6.22	-1.73	-2.11	2.54	-6.65	-4.53	-0.52
	-14.43	7.16	8.13	10.02	0.63	1.69	1.15	-2.06

Table 6. Relationship between Concepts between the Early and Later Adopter Spaces.

Concept	Early adopters' magnitude	Later adopters' magnitude	Scalar products	Vector correlation	Angle
1	13.75	16.30	203.40	0.91	24.90
2	13.12	16.10	181.41	0.86	30.90
3	15.75	20.54	312.74	0.97	14.80
4	14.02	15.22	183.84	0.86	30.50
5	13.58	17.29	217.50	0.93	22.10
6	14.62	17.13	220.39	0.88	28.30
7	17.03	18.93	299.87	0.93	21.50
8	13.28	14.22	145.80	0.77	39.50
9	14.08	14.47	195.75	0.96	16.10
10	16.46	19.00	288.09	0.92	23.00
11	16.42	17.71	258.56	0.89	27.30
12	15.84	18.39	264.64	0.91	24.70
13	17.75	19.40	329.86	0.96	16.70
14	14.85	15.89	227.28	0.96	15.70
15	19.86	21.24	401.76	0.95	17.70

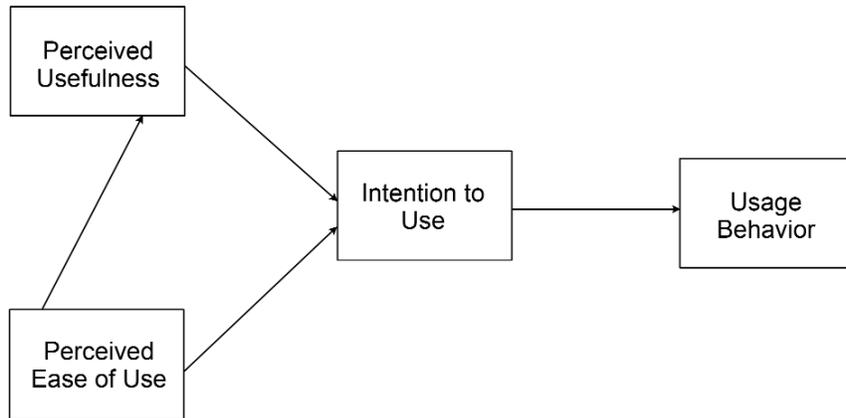


Figure 1. The Technology Acceptance Model (TAM).

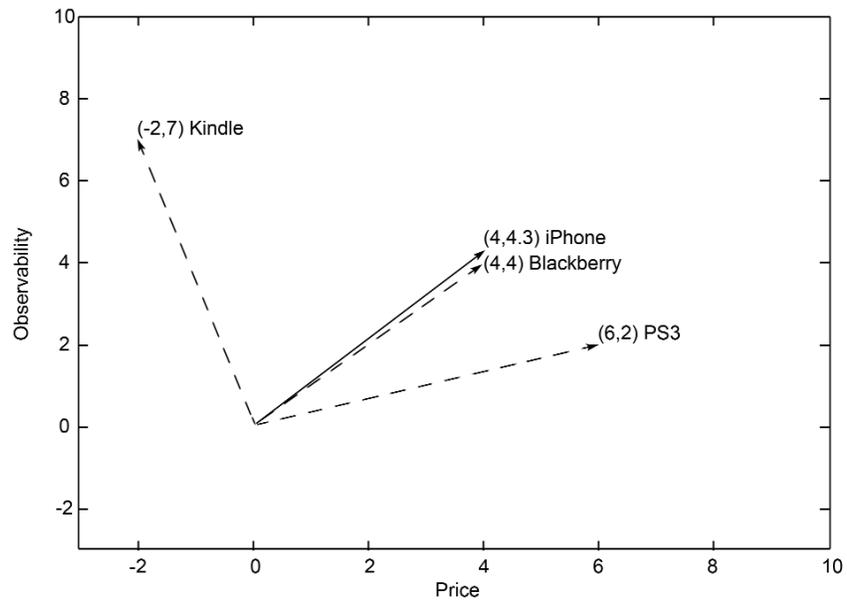


Figure 2. Two-dimensional Representation of the Relational Model of Adopter Choice.

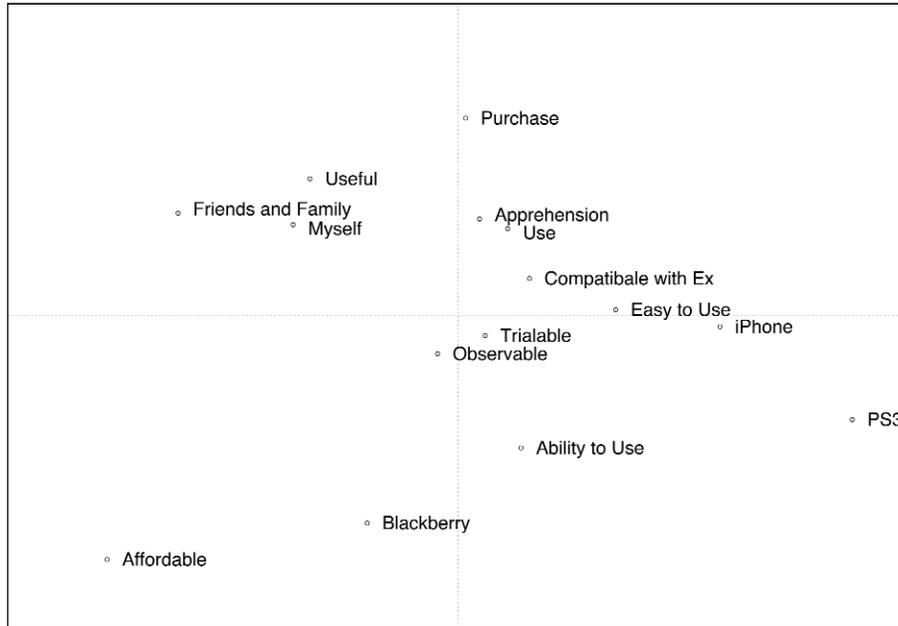


Figure 3. Early Adopters' Space.

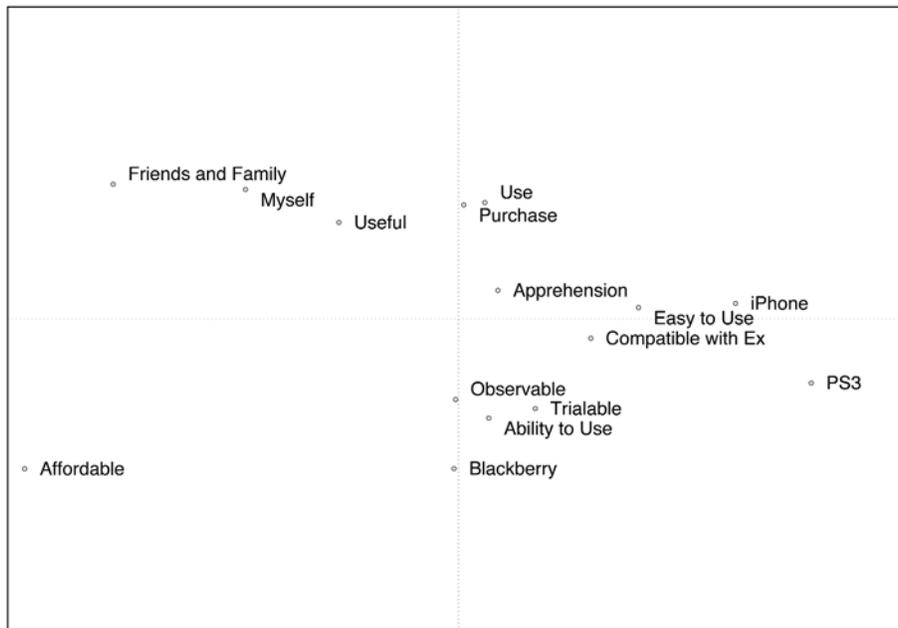


Figure 4. Later Adopters' Space.

References

- Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.
- Barnett, G. A. (1988). An associational model for the diffusion of complex innovations. In G.A. Barnett & J. Woelfel (Eds.), *Readings in the Galileo System Theory, Methods and Applications* (pp. 55–74). Dubuque, IA: Kendall/Hunt.
- Barnett, G. A. & Siegel, G. (1988). The diffusion of computer assisted legal research systems. *Journal of the American Society for Information Science*, 39, 224–234.
- Barnett, G. A. & Woelfel, J. (Eds.). (1988). *Readings in the Galileo System*. Dubuque, IA: Kendall/Hunt.
- Beninson-Germano, M., Barnett, G. A., Dinkelacker, J. W., & Downing, K. W. (1988). Automated ordering in the pharmaceutical industry. In G.A. Barnett & J. Woelfel (Eds.), *Readings in the Galileo System* (pp.265–294). Dubuque, IA: Kendall/Hunt.
- Carley, K. A. (1986). An approach for relating social structure to cognitive structure. *Journal of Mathematical Sociology*, 12, 137–189.
- Davis, F. D., Bagozzi, R. P. & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, 35, 982–1003.
- Durkheim, E. (1895). *The division of labor in society*. New York, NY: Free Press.
- Dwivedi, Y. K., Williams, M. D., & Venkatesh, V. (2008). A profile of adoption of information & communication technologies (ICT) research in the household context. *Information Systems Frontiers*, 10, 385–90.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.
- Gillham, J., & Woelfel, J. (1977). The Galileo system of measurement. *Human Communication Research*, 3, 223–234.
- Goldsmith, R. E., & Hofacker, C. F. (1991). Measuring consumer innovativeness. *Journal of the Academy of Marketing Science*, 19, 209–221.
- Karahanna, E., Straub, D. W., & Chervany, N. L. (1999). Information technology adoption across time: A cross-sectional comparison of pre-adoption and post-adoption beliefs. *MIS Quarterly*, 23, 183–213.
- Kincaid, D. L., Yum, J. O., Woelfel, J., & Barnett, G. A. (1983). The cultural convergence of Korean immigrants in Hawaii: An empirical test of a mathematical theory. *Quality and Quantity*, 18, 59–78.
- Leung, L., & Wei, R. (1999). Who are the mobile phone have-nots? Influences and consequences. *New Media & Society*, 1, 209–226.
- Rice, R. E., & Rogers, E. M. (1984). New methods and data for the study of new media. In R. E. Rice (Ed.), *The new media: Communication, research, and technology* (pp. 81–99). Beverly Hills, CA: Sage.
- Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.
- Shah, D. V., Kwak, N., Schmierbach, M., & Zubric, J. (2004). The interplay of news frames on cognitive complexity. *Human Communication Research*, 30, 102–120.
- Simmons, P. J. (1974). *Choice and demand*. New York: John Wiley.
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27, 425–478.

- Vishwanath, A., Brodsky, L., Shaha, S., Leonard, M., & Cimino, M. (2009). Prescriber attitudes toward PDA prescription-assistance technology. *International Journal of Medical Informatics*, 78, 330–339.
- Vishwanath, A., & Chen, H. (2006). Technology clusters: Using multidimensional scaling to evaluate and structure technology clusters. *Journal of the American Society for Information Science & Technology*, 57, 1451–1460.
- Vishwanath, A., & Chen, H. (2008). Personal communication technologies as an extension of the self: A cross-cultural comparison of people's associations with technology and their symbolic proximity with others. *The Journal of the American Society for Information Science & Technology*, 59, 1761–1775.
- Vishwanath, A., & Goldhaber, G. M. (2003). An examination of the factors contributing to adoption decisions among late diffused technology products. *New Media & Society*, 5, 547–572.
- Woelfel, J. (1975). Theoretical issues and alternatives: A theory of occupational choice. In J. S. Picou & R. E. Campbell (Eds.), *Career behavior of special groups* (pp. 41–61). Columbus, Ohio: Merrill.
- Woelfel, J. & Barnett, G. A. (1982). Multidimensional scaling in Riemann Space. *Quality and Quantity: A European Journal of Methodology*, 16, 469–491.
- Woelfel, J. & Fink, E. L. (1980). *The measurement of communication processes: Galileo theory and method*. New York: Academic Press.