

**Intra-Unit Diffusion: Model Development and an Empirical Test of  
How Consumers Integrate Information Technology into the Household**

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**August, 1999  
CRITO Working Paper**

**This research was conducted under a grant from the National Science Foundation  
(Grant No. IRI-9619695)**

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## 1. INTRODUCTION

The purpose of this research is to introduce a conceptual model of intra-unit diffusion as a framework for the study of how technology diffuses within a unit of adoption. Specifically, the focus here is on the development of an intra-unit diffusion model and testing of the model to household application and use of computer and the Internet. The theoretical framework underlying the model is best described as a structural model of adoption-use-disadoption. The model's implications for theorizing about technology in the home and new product developments are also discussed.

## 2. BACKGROUND AND RATIONALE

Research on diffusion of innovation in marketing dates back to the late 1960's (Bass 1969). Since then there has been a continuous flow of theoretical and empirical work in this area. At the risk of simplification, one might say that the single most common theme in most of this research pertains to how an idea diffuses across a population of individuals within a given time. According to Everett Rogers (1995), diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 5). The underlying idea is that there is a population of adopters, distributed across a social system, whereby messages concerned with a new idea are spread throughout the relevant population by the process of interpersonal communication often mediated by mass media. The diffusion of an idea starts to move from one person or an entity (e.g., an organization) to the next person or entity until it reaches a critical mass, a point at which the diffusion is self-sustaining and rapidly disperses throughout. For our purpose here, this diffusion paradigm is labeled *inter-unit diffusion* (as opposed to *intra-unit diffusion*, which is the focus of the study).

Marketing researchers have made impressive contributions to the inter-unit diffusion paradigm, especially with regard to forecasting the rate of adoption for new products, the perceived attributes of an innovation and its effect on purchases, and the impact various combinations of marketing strategies have on product launches (see Mahajan et al. 1990, 1995 for review). Since the main concern of marketing has

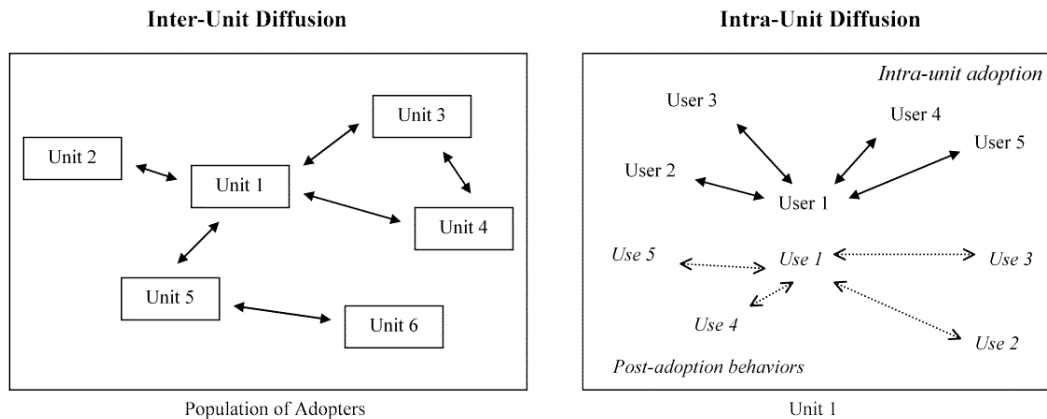
been primarily the adoption and penetration rates, inter-unit diffusion has received greater attention over the past three decades.

### **Diffusion Theory: Some Unexplored Issues**

However, an aspect of diffusion that is important but often overlooked by marketing scholars is the *intra-unit diffusion*. Inter-unit diffusion, as mentioned earlier, is the process by which an innovation moves from one unit (adopter) to another. On the other hand, the concept of intra-unit diffusion deals with how an innovation diffuses within a unit of adoption (as opposed to how it spreads across units of adoption). It seeks to understand how the innovation, once adopted, is integrated into the unit of adoption through innovation *use*. Recently, some researchers have voiced their concern of the limited perspective inherent in the inter-unit model (Ram and Jung 1990, Ridgeway and Price 1994). They argue that to fully appreciate diffusion of innovation, we need also to examine intra-unit diffusion (Dutton et al. 1985, Lindolf 1992, Rogers 1995). As Robertson and Gatignon (1986) argued, “Because the emphasis is on technological innovation, adoption is not the only relevant concern of diffusion research. The degree of use of that technology is an important variable that describes the extent of diffusion of that innovation” (p. 3).

The importance of the distinction between inter and intra-unit diffusion can be traced to the fact that adoption does not necessarily imply that the diffusion of innovation has taken place in a complete sense (Anderson and Ortinau 1988, Lewis and Seibold 1993). Rather, through out the life cycle of the innovation, dis-adoption and abandonment occur and thus the act of purchase or adoption does not guarantee that the innovation will be successfully continued. For diffusion to be considered complete, the innovation must be put to continuous use by the unit of adoption for some time. Therefore, both inter and intra-unit of diffusion are crucial to the understanding of the diffusion process in that they a) complement each other and b) complete the diffusion process. Figure 1 is a heuristic scheme that differentiates the two diffusion processes.

**Figure 1: Intra vs. Inter Unit Diffusion**



**Adoption Units Defined**

The unit of adoption in intra-unit diffusion can vary in size and scope from large organizations, small departments, households, and individuals. For adoption units larger than individuals, the model examines who within the unit uses the innovation and how are the innovations used. For example, when a department acquires new office innovation, the intra-unit diffusion model inquires into the process by which employees of the department accept and use the innovation. Further, it also explores how the innovation is put into practice, the applications for which the innovation has been applied, and the rate and pattern of usage for the innovation and its changes. When dealing with individuals, intra-unit diffusion reduces to inter-unit diffusion with regard to adoption. However, what remains open to inquiry is how the individuals use the innovation and how (s)he integrates the innovation into daily life.

For the purpose of discussion and analysis, we have chosen the household as the unit of interest. The choice of household as locus of study is largely due to the fact that majority of innovations that are introduced annually are targeted for home consumption. Moreover, there is a complex dynamic in the home regarding communication networks, household structure, and other household technologies that are often understudied by consumer researchers but provide fertile ground for theorizing. The key issues that are addressed in this paper are

1. What are the important theoretical and methodological differences and similarities between inter-unit diffusion and intra-unit diffusion?

2. What is an appropriate model of intra-unit diffusion?
3. Given that the interest of intra-unit diffusion is on the integration of innovation in the home, by what process does this integration take place? What are the factors that influence how innovations are integrated into the household?
4. What managerial implications can we draw for product development from the study of intra-unit diffusion?
5. What methodologies are appropriate for the investigating intra-unit diffusion?

### **3. COMPARISON OF INTER AND INTRA-UNIT DIFFUSION MODELS**

Before introducing the intra-unit diffusion model, it would be useful to compare and contrast the theoretical and methodological differences with inter-unit diffusion model, the current paradigm of diffusion research. The intention here is to highlight the differences as points of departure and accent the similarities so the two models may be integrated within the diffusion framework. The constructive position is to view the two models as complementing each other, where understanding of one provides insights into further development of the other, and together they complete the picture of the diffusion process. The difference between the two models is wide ranging from the sample of study to research questions asked and marketing strategy implications. Despite the differences, there are some theoretical themes that are common among these two models and some concepts are even wholly interchangeable. However, because the initial research question and the investigative approach taken differ, the intra-household diffusion model takes on a distinct flavor from adoption models. The section below is a brief summary of the similarities and differences between the two models. They are also summarized in Table 1.

**Table 1**

Issues	Inter-Unit Diffusion	Intra-Unit Diffusion
<p><i>Focus and Theoretical Issues</i></p>	<p>*** Adoption Process and Pre-adoption process (e.g., knowledge -&gt; persuasion -&gt; decision -&gt; implementation -&gt; confirmation)</p> <p>*** Rate of penetration, time of adoption, and role of marketing agents that impacts them.</p> <p>*** Segmentation of population (e.g., innovators, early adopters, early majority, late majority, laggards)</p> <p>*** Perceived innovation characteristics (e.g., relative advantage, trialability, observability, complexity)</p> <p>*** Two-step model in which mass media influence opinion leaders, which influence a set of followers.</p> <p>*** Word of Mouth Effect - Diffusion occurs within a social system with similar set of values and norms.</p> <p>*** The diffusion process generally follows S-shape pattern where at point of critical mass the diffusion takes off. The exact shape is determined by the nature of the innovation.</p> <p>*** Individual decision processes follow a hierarchy of effects model in a cumulative sequence.</p> <p>*** Individual traits and characteristics can determine the rate or timing at which the individual adopts the innovation.</p> <p>** Diffusion determined by the fit of innovation with other technology already possessed in terms of - schematic fit - relative advantage - switching cost</p> <p>Applicable to continuous and discontinuous innovations, though most studies focuses on continuous innovations</p>	<p>* Post adoption usage in terms of - Variety of use - Frequency and duration of usage And how these behaviors changes</p> <p>** Width (who in the unit adopts) and depth (number of units adopted / upgrades) within the unit.</p> <p>* Types of users</p> <p>** Perceived technological characteristics and symbolism of the innovation and the benefits from usage.</p> <p>* Two-stage model in which adoption is the pre-condition for intra-unit diffusion.</p> <p>* Cohesion - Effects of personal communication network on individual's usage behavior.</p> <p>* Internal Dynamics - Interaction of adopting unit and other structural characteristics' impacts on the diffusion of innovation for the HH and the individual.</p> <p>** Effects of knowledge and skills on usage behavior - Product familiarity - Product experience</p> <p>** Role of use innovativeness</p> <p>* Fit of the technology within the overall organizational technological configuration - complementary - competitive</p> <p>* Role of use satisfaction in sustaining continuous usage behavior</p> <p>Most applicable to discontinuous innovations where usage pattern has not been established</p>

**Table 1 (cont.)**

<b>Issues</b>	<b>Inter-Unit Diffusion</b>	<b>Intra-Unit Diffusion</b>
<i>Assumptions</i>	<p>Innovation is fixed and does not change over the diffusion process</p> <p>Implicitly assumes that adopters of the innovation will use it in manner that is consistent with the intent of the producers</p>	<p>Innovation does and often changes over its life cycle</p> <p>For some innovations, particularly discontinuous innovations, adopter's use often changes in the process of integrating the innovation and the use may or may not be anticipated by the producers of the innovation</p>
<i>Major Dependent Variables</i>	<p>Who adopts</p> <p>When they adopt</p>	<p>Who uses</p> <p>How often they use</p> <p>Why they use</p> <p>How benefited from using</p>
<i>Sample of Study</i>	<p>Across unit of adoption</p> <p>Across population</p> <p>Across time</p>	<p>Within unit of adoption</p> <p>Within individual</p> <p>Across time</p>
<i>Marketing Strategy Implications</i>	<p>*** Forecast of market penetration rate</p> <p>Effects of marketing mix variables</p>	<p>** Design of the innovation</p> <p>Impact of the innovation on the unit of adoption</p> <p>Satisfaction with the innovation</p>

\*\*\* Extensively investigated in past

\*\* Some existing research

\* No existing research found

### **Focus and Theoretical Issues**

The existing diffusion research seeks to answer several different research questions. Among the questions asked are the pre-adoption and the adoption process (Rogers 1995). The focus on the process is because it has long been recognized that an individual's decision about an innovation is not an instantaneous act (Greenleaf and Lehmann 1995). Rather it is a process that occurs over time, consisting of a series of actions and decisions that start from knowledge that may eventually lead to adoption. This behavior consists essentially of dealing with the uncertainty that is inherently involved in deciding about a new alternative to those previously in existence. Models that deal with the adoption process are based on the hierarchy of effects (i.e., knowledge -> persuasion -> decision -> implementation -> confirmation), a highly cognitive process where each stage of the process can be affected by different communication

channels (Ray 1973). Although such model is a useful schematic, it has been criticized that its appropriateness seems to vary with types of innovation under question.

The intra-unit diffusion model extends beyond the process that influences adoption. The focus is on what happens after adoption has taken place. In particular, the research question is 1) who uses the innovation within unit of adoption, 2) how is the innovation used in the unit of adoption, how often is it used, and how does the usage change over time. The focus on post-adoption process is associated with the growing emphasis in diffusion research on product use information as a key variable in explaining consumer acceptance of new technologies (Venkatesh and Vitalari 1987, Lindolf 1992, Lewis and Seibold 1993). The model is cast in the emerging research stream that has been variously labeled as product “consumption,” “use,” and “experience,” terms which suggests a broader framework that extends beyond product information search and acquisition (Belk et al. 1989).

As a further point of departure from the adoption perspective, intra-unit diffusion examines how the innovation fits into the existing consumption system. A major barrier to diffusion occurs if the innovation is not compatible with the existing consumption system, in which case the innovation may be “disadopted.” Examining how the innovation is used and the frequency or rate at which it is used, lends insight into how the innovation fits into the household consumption scheme and it evolves over time.

Other areas of interest in past diffusion research have been the rate of penetration, timing of adoption, and the potential market for the innovation. Research in these areas tends to focus on forecasting of the success of the innovation and the role of marketing agents in impacting its success (Mahajan et al. 1995). Typically, the S-shaped diffusion curve is adopted for this purpose with exact functional form determined by the type of innovation under question and the assumed diffusion process involved (Mahajan and Peterson 1985).

With exception of few studies (e.g., Rao and Yamada 1988), most work in this area use the concept of adoption in a rather limited way to refer to a single decision. In other words, the typical models of diffusion assume one unit of adoption per household under investigation. In such a case, once the household adopted an innovation, it is assumed that everyone in the household has adopted the

innovation. However, for many consumer products, this may not be the case. The innovation under question may not necessary be used by everyone in the household and for some products, repeat purchase is the key to adoption (Mahajan et al. 1990). Therefore, the maximum long-run diffusion potential appears to be a function of both width and depth of adoption (Gatignon and Robertson 1985). Thus, instead of examining the rate of penetration and the potential market size, a focal point of the Intra-Household Diffusion is on who in the household adopts and the number of units (or related products/upgrades) adopted within the household. These interests have been labeled as the width and depth of adoption.

The existing diffusion literature also extensively examines the segmentation of adopters. Based on the fact that individuals in a social system do not adopt an innovation at the same time but adopt in an over-time sequences, individuals can be classified into adopter categories on the basis of when they first begin using the new idea or product. Generally, five categories have been assumed and they consist of innovators, early adopters, early majority, late majority, and laggards (Rogers 1995). The usefulness of identifying these segments is that diffusion research typically favors a two-step model. In the two-step model, it is assumed that innovators and early adopters are more risk taking and prone to influences of mass media. In turn the innovators and early adopters will influences the rest of the population into adopting the innovation through word-of-mouth effect (Robertson 1971). Thus for the marketer, it is important for them to target the innovators and early adopters through their media selection and let them influence others who are more risk averse and less prone to the effects of advertising.

Parallel to the segmentation scheme of adoption, Intra-Household Diffusion also segment innovation users into different categories. However, unlike adoption, the segmentation is not defined unidimensionally by the relative time of adoption. Rather, users can be segmented multidimensionally based on their usage behaviors. The frequency with which users use the innovation and the reasons for which they use the innovation are two of the dimensions that can be used for segmentation purposes. Like adoption, once user categories have been identified, they can then be profiled for category characteristics on the bases of demographic and psychographic variables.

Intra-unit diffusion also assumes the existence of network effect (i.e., word-of-mouth). Similar to adoption process, the model operates under the principle that diffusion is a social process that consists of an individual A who knows something about an innovation and an individual B who does not yet know. Therefore the social relation between A and B can in part determine whether individual B learns about the innovation. However, unlike adoption, the word-of-mouth effect is not a discrete event in time, in that it occurs once before adoption takes place and influences only flow from early adopters to late adopters. Rather, after adoption has taken place, word-of-mouth can take place continuously in influencing usage behaviors. Early adopters of innovation may also be influenced by late adopters (and vice versa) to learn about new usage opportunities for the innovation or new product upgrades. Each individual can play both the roles of information provider and receiver for the innovation under question instead of just one role as in adoption.

In studying the adoption of innovation, one stream of research seeks to understand the perceived characteristics of the innovation (e.g., relative advantage, trialability, observability and complexity) as it relates to the rate of adoption (Rogers 1995). Generally, it is found that if the innovation fits schematically with existing products already consumed, has high relative advantage and low switching cost, it will diffuse at a higher rate than innovations that do not have these characteristics (Dickerson and Gentry 1983). In this view, technology is seen as exogenous to the adopting unit. Models of this type do not presume interactions between the innovation under question and other technologies within the adopting unit. There is a parallel to perceived innovation characteristics in the intra-unit diffusion model. However, the model views the technological characteristics more broadly beyond the perceived characters of the innovation to include the symbolic dimensions of the innovation and its technological fit and interactions with other technology with the unit. Technology is viewed in this perspective as a system of tools and tool-using behavior (not just the product). It is premised on the notion that technology is a means to achieve practical and symbolic ends and therefore must be viewed in both utilitarian terms and the social context in which it is embedded. Because the focus is on the use of the technology, the model must provide an understanding of use in relation to other technologies that compete for use. This is a

significant departure from current adoption models because here technology is viewed endogenously, and its use is jointly determined by the social context of use and its interaction with other household technologies.

### **Assumptions**

Although not explicitly stated, inter-unit diffusion model assumes that the innovation is fixed and does not change over the diffusion process. It further assumes that the adopters of the innovation will use it in manner that is consistent with the intent of the producers. However, intra-unit diffusion does not make these assumptions. Instead, it presupposes that the innovation often does change during its life cycle and that such changes often have direct impact on the diffusion process within the unit of adoption. In addition, the intra-unit diffusion model assumes that for some innovations, particularly discontinuous innovations, adopter's use often changes in the process of integrating the innovation and that their use may or may not be anticipated by the producers of the innovation.

### **Sample of Study**

The sample of study for most diffusion research has three major themes, across household units, across population, and across time. By far the most common unit of study is individuals (i.e., across population) because individuals are more accessible in terms of survey studies. For example, if the household is the adopting unit, one member of the household is surveyed to represent the response of the entire household. The overwhelming focus on the individual as the unit of analysis in diffusion, while largely ignoring the importance of the individual's network relationships, is often due to the assumption that if the individual is the unit of response, he or she must consequently be the unit of analysis. The focus on individuals offers some interesting insights into the adoption phenomenon, such as the psychological characteristics of adopters and the cognitive processing of the adoption process. When viewed across a large collection of individuals, it also provides a means of segmenting the population into adopter categories.

Unlike inter-unit diffusion, the unit of study for intra-unit diffusion is within the adoption unit, within the individual, and across time. By within the unit, we mean collecting data for all members of the

adoption unit and by within individual we mean collecting individual data over time. The use of within household sampling is the distinguishing feature of intra-unit diffusion and reflects the sociological nature of the model. For example, when adopting the household as the sampling unit, the model makes the assumption that individual behavior does not represent the household, rather there are nuances of the household that can only be captured when the behavior of every member of the household is probed. Further, in a typical household, the children may be heavy users of the family computer while the mother is a light occasional user and the father is a non-user. If we only take the behavior of the head of the family (i.e., the father) as representative of the household behavior, we are grossly misrepresenting the actual computer usage in the data and ignoring the complex dynamics of household behavior. Thus while surveying across household and within household can furnish us with the same rate of product adoption (which household owns a computer at home), only within household sampling can tell us something about product usage behavior of the household and reconstruct the sociological context of the technology.

### **Marketing Implications**

Finally, the marketing implications of the two models differ. The aim of the marketing adoption model is to forecast the rate of penetration and the potential market for the innovation (Mahajan et al. 1995). In the process of this endeavor, the hope is to determine the appropriate marketing mix variables such as advertising and channel requirements that will assist the adoption of the innovation in reaching its maximum potential promptly. With few exceptions, the aim of the marketing strategy under the adoption model is rarely on designing the innovation, rather the innovation is taken as exogenous and given, with little room for change. The study of innovation usage in the intra-unit diffusion model seeks to provide a different set of marketing strategy implications. Through the understanding of how people actually use the innovation, the aim is to develop intuitions on the design of the next generation of the innovation. Additionally, the model also examines the impact of the innovation on household activities, life style and use satisfaction. Together, marketers can take this information as input for refinement of the innovation that are more pertinent for household use.

#### **4. INTRA-UNIT DIFFUSION: MODEL DEVELOPMENT**

To reiterate, the primary focus of the intra-diffusion diffusion model is to study the usage of the innovation. Usage can be broken down into three basic components, who is using it, why are they using it, and how often are they using it. The first component, who uses, is referred to here as intra-unit adoption. The other two components, why and how often it is used, is collectively labeled post-adoption behavior (see Figure 1 above).

##### **Intra-Unit Adoption**

When the unit of adoption is larger than the individual user such as household or organization, we can enrich the definition of diffusion to include multiple adoption decisions within the unit (see Figure 2 – dimension labeled adopters within the unit of adoption). The basic research question posed here is how do innovation diffuses across members of the adoption unit? That is to say, who in the unit is the first to adopt the innovation and how do other members come to adopt the innovation over time, if at all. It is important to point out that for some innovations, once adopted, it does not automatically imply that every member of the adoption unit is capable or willing to use it. The personal computer offers an excellent example in which a significant percentage of the computer owning household members do not use it, relative to other technologies (e.g., telephone, television, Kraut et al. 1998). When over time, most or all of the members of the adoption unit use an innovation, it is assumed that the innovation is well diffused within the unit.

##### **Post-Adoption Behavior**

From prior works, we can conceptualize usage as having two equally important dimensions, frequency and variety (Ram and Jung 1989). Usage frequency refers to how often the product is used, regardless of the different applications for which it is used. Variety refers to the different ways in which the product can be used. To illustrate this with an example, consider two consumers, both are using the Internet for two hours a day. The first consumer uses the Internet only for work purposes; the second

consumer uses the Internet for work, for personal correspondences, to shop for Christmas gifts, etc. Both have the same usage frequency, but the second consumer exhibits more usage variety.<sup>1</sup>

Within the present conceptualization of usage variety, distinctions can be made for two types of usage variety: creative re-use and multiple use (Hirschman 1980; Price and Ridgeway 1982). Creative reuse involves using a previously adopted product in a single novel way. An example of this behavior would be using an old coffeepot for flower vase. In this regard, the usage decision may be based solely on an economical reason or may be a demonstration of personal creativity. Multiple use entails using a product in a wide variety of ways (not necessarily but often in more than a single novel way). An example would include the use of the Internet discussed earlier. Motivations for this level of usage variety often are beyond simple economic reasons or the need to express creativity; they may involve varied and complicated factors and often depend on the features of the product.

The present distinction between frequency and variety parallels the breadth and depth of diffusion suggested by Gatignon and Robertson (1985) in which they define breadth of diffusion as the number of people within adoption units who uses the product and depth as the amount of related products purchased. The definition provided by Garignon and Robertson (1985), however, focuses on product purchase within the context of the first purchase diffusion. Dutton, Kovaric, and Steinfield (1985) offered similar dimensions of usage in the context of personal computers: frequency of usage (light vs. heavy, regular vs. irregular) and variety of usage (high vs. low). However, none of these authors have empirically tested the determinants of usage have leaving them open for future research.

Empirically, usage frequency and usage variety are likely to be correlated since the more ways a consumer uses a product, the more likely the product will be used frequently. Theoretically, however, we can differentiate and contrast the two dimensions on several characteristics. First, usage variety may be driven by product features and its interaction with the variety of usage situations. Usage frequency, on the other hand, is dependent on the task requirements of the consumer (Ram and Jung 1990). Second,

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<sup>1</sup> It is important to distinguish between “usage variety” and “variety seeking.” The former deals with different reasons for using the same product regardless of the brand of the product. The latter deals with using different

high usage frequency may signal routinized needs (narrow range and heavy use), while high usage variety is associated with variety seeking behavior (wide range and light use) (Ridgeway and Price 1994). Third, usage frequency is likely to be limited by the amount of hours that the consumer is able to devote to certain tasks. Research on time budget studies indicates that time allocations are relatively inflexible and that certain amounts of time are devoted to leisure activities, home production, and market work (Leuthold 1981; Vitalari, Venkatesh, and Gronhaug 1985). Thus frequency of usage is limited naturally by allocable time, while variety of usage suffers no such restriction and is limited only by the ways the consumer can think of to use the product. Finally an increase in variety of usage (vs. frequency) is likely to have a positive effect on the market development of the product and to promote new innovations within the product line (Von Hippel 1982, 1986). The higher the sophistication of the product and the more ways in which consumers can use it, the higher the diffusion potential of the product. Similarly, the more ways the product are used, the more motivations manufactures have to expand the features and develop complementary product lines.

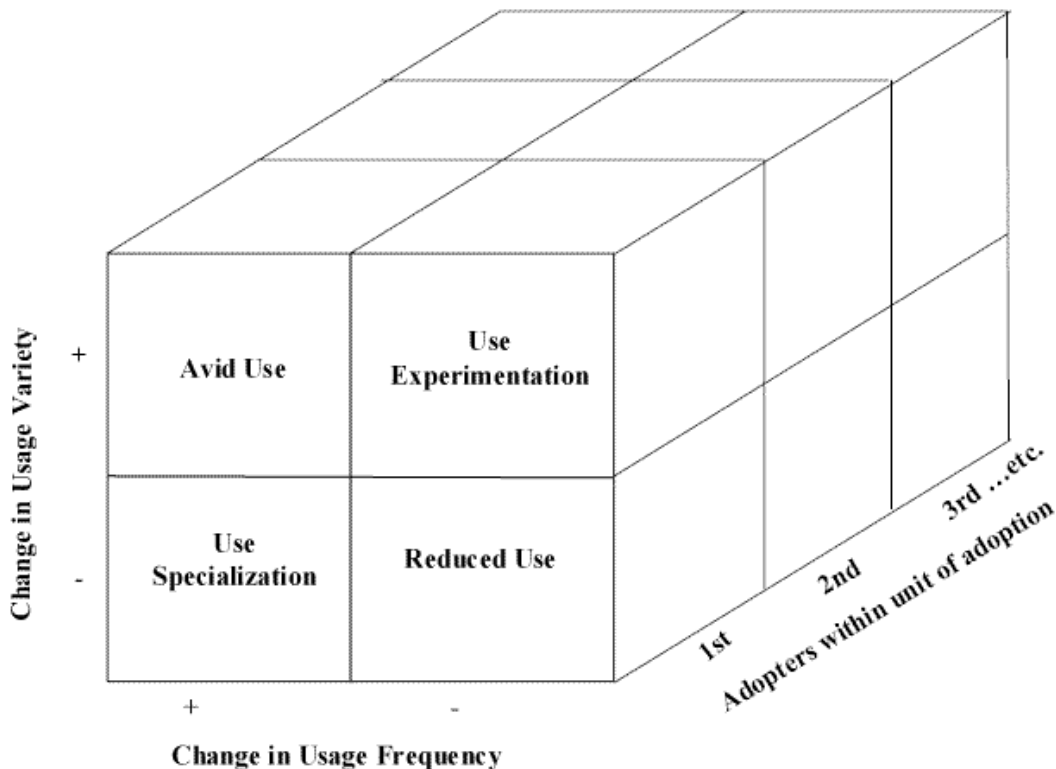
To motivate the discussion further, frequency and variety, though theoretically distinct dimensions of usage behavior, are equally important in studying how consumers use computers. As Dutton et al. (1985) argued, studying any one aspect of usage behavior in isolation ignores the richness and complexity of the issues involved. Because different combinations of frequency and variety produce different usage behaviors, one dimension should not be examined without consideration of the other.

The multidimensional definition of usage allows us to investigate one aspect of intra-unit diffusion, namely the change in usage patterns. Using the two dimensions of use, variety and frequency, change in usage behaviors can be conceptualized as four different patterns. As illustrated in Figure 2: 1) avid use – increase in both variety and frequency, 2) use specialization – decrease in variety but increase in frequency, 3) use experimentation – increase in variety but decrease in frequency, and 4) reduced use – decrease in both variety and frequency.

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brands of the same product but for the same reason.

**Figure 2: Multidimensional View of Diffusion**



The most common expectation regarding the change in usage behavior can be characterized as increase in variety of use and frequency/rate of use, or avid use as depicted in Figure 2. For example, a person may begin personal computing in a limited way, using few popular productivity applications (e.g., word processing and spreadsheets) and progressively branch out to graphics, video games etc. Moreover, the progression from productivity application into wider variety of applications may be accompanied by increasingly higher amount of time spent computing. In such a case, we can make the argument that the innovation, personal computer, is increasing being integrated into daily life and high amount of use diffusion has taken place (Venkatesh 1996).

Actual patterns of innovation utilization are likely to be far more variable as users might limit their use over time. In a common evolution of computer usage, the beginning stages might better be described as use experimentation, where through a process of trial and error, users exploit various computing applications and evaluate, based on their needs, whether to continue or discontinue particular application. After encountering various usage scenarios, the user eventually reaches an equilibrium stage

and establishes a stable usage pattern. In many instances, the resulting usage may be described as use specialization, whereby the use of the innovation is limited to a number of applications, but it is used extensively. Such is the case of the anecdote that computer is just a fancy word processor.

Finally, a fourth possible scenario is decrease in both variety and frequency/rate of use from the time of adoption, or reduced use. In such a case, the innovation was not found to fit the user's needs, thus usage declines and the innovation may eventually be "disadopted," such as the computer that collects dust in the garage.

To briefly summarize, this section defined three dimensions of diffusion within the intra-unit diffusion framework: 1) diffusion across members of the adoption unit, 2) diffusion across usage variety, and 3) diffusion across usage frequency. The first dimension is dubbed intra-unit adoption and the other two is labeled post-adoption behavior. The next section proposes a general model of intra-unit diffusion for post-adoption behavior, focusing on the two dimensions of diffusion in usage variety and usage frequency. The model proposes the antecedent factors that promote or hinder the post-adoption diffusion process for the individual, and addresses some of its consequences.

### **Model for Post-Adoption Behavior**

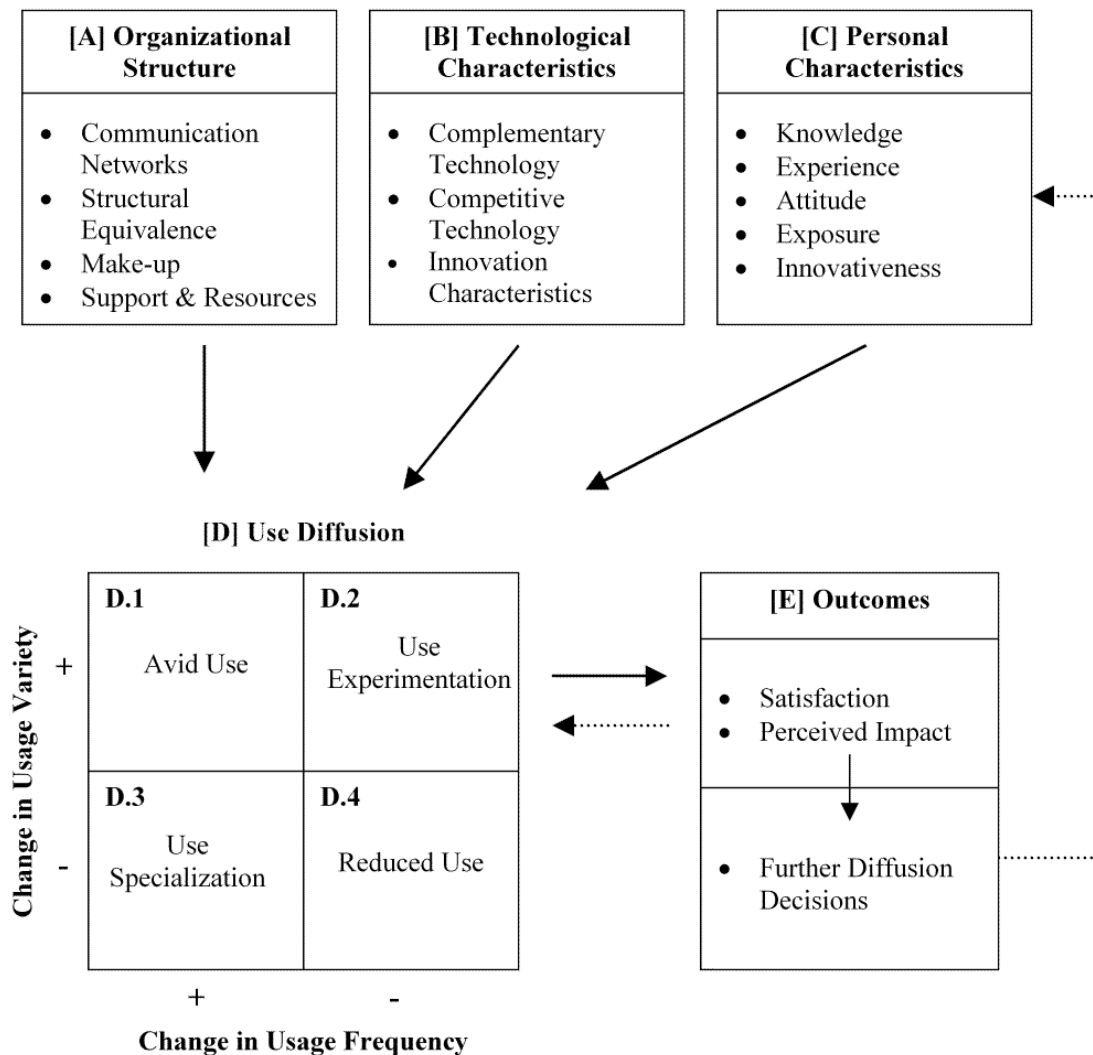
The intra-unit diffusion model for post-adoption behavior is shown in Figure 3. The most important distinguishing characteristics of this model, versus the inter-unit diffusion model, are twofold. First is the application of the multidimensional view of changes in usage diffusion. As argued earlier, usage behavior has not been pursued in prior diffusion research, but is crucial to the understanding of the entire diffusion process. Second, the model explicitly links the outcome of changes in usage behavior to future adoption decisions. This link provides us with understanding of how adopting one innovation can be related to the adoption of other related innovations.

A brief description of the intra-unit diffusion for the post-adoption behavior is as follow. For the purpose of clarity, we will examine the post-adoption behavior at the individual level with the understanding that intra-unit diffusion model is an aggregate of all individuals in the unit. Diffusion is the outcome of the different patterns of changes in the individual's usage decision over time. The

individual's usage decisions are influenced by several antecedent factors, particularly the organizational context in which the user is operating in, the technological characteristics of the innovation itself, and characteristics of the individual user. The resulting usage diffusion is seen to impact the individual user's satisfaction with the innovation and the impact which (s)he perceives the innovation has on his/her activities. These perceptions in turn influence future adoption decisions regarding related innovations.

The objective now will be to elaborate on the antecedent factors and its impact on usage diffusion. A set of propositions will be developed for research on the intra-unit diffusion of information technology (computers and the Internet) within the context of the household.

**Figure 3: Intra-Unit Diffusion Model: Post-Adoption Behavior**



How innovations will be used, how much and to what ends, are often the source of major differences in expectations among researchers and theorists interested in information technologies (IT) and its social and psychological implications. Therefore there are as many antecedent factors as there are research questions and equally numerous ways in which it can be grouped. For clarity, these antecedent factors have been classified according to their primary stress on the determinants of IT use. It should be stressed here that this classification is introduced for conceptual reasons and that few researchers operate by solely investigating one factor.

First is the organizational structural factor of the user. By organizational structure, we mean structure of the social unit in which the user is operating. What is of interest here is the make up of the social unit, the interactions and communication patterns among members of the unit, and the technological support and resources that the social unit provides for the user. Diffusion of any kind is inevitably a social process that involves an individual A who knows something that individual B does not know (Czepiel 1974). Therefore, the social relation and communication between A and B have a great deal to do with how B uses the innovation. Besides acting as a source of influence, members of the unit may also act as resources and knowledge support for the user to experiment with novel uses of complex technologies. However, users of technological innovations can often become functionally fixated with the innovation and tend to use it in familiar or routine ways in the absence of external influences (Warlop and Ratneswar 1993). When the communication is solely within the social unit, it can act as a barrier to usage diffusion because members of a close social unit seldom exhibit unique knowledge that others in the unit do not possess. Thus the social relation to outside members is often an important aspect of influences in determining usage behaviors.

The second antecedent factor is the technological characteristics of the technology under question and the technological makeup of the adopting unit. The position here is that technologies are not always used in isolation but often in conjunction with other technologies (e.g., TV and VCR) where use of one reinforces the use of other. Thus interactions among technologies are relevant in determining how individual technology will be used. The total technological make up of the adoption unit is especially

important when the focus is on use because while some are complements in use, other may be competing for use (computer and TV). The technology itself also exerts influences on changes in usage behavior because technology is not a static object, rather it evolves through upgrades and peripherals thus potentially causing changes in usage patterns.

The third antecedent factor is personal characteristics. The knowledge and experience of the user is important in determining the degree of usage and usage pattern changes. In addition, personal innovativeness also impacts the level of use for the innovation (Midgley and Dowling 1978, Hirschman 1980). Personal exposure to media and innovation outside the adoption unit is also posited to impact the diffusion of use within the unit.

### **Key Research Questions**

The previous discussion leads to the following questions regarding the diffusion of a particular technology (i.e., computer and the Internet) within a specific unit (i.e., the household). The questions will be framed in the context of household adoption and use of computer and Internet technology.

- (R1) How does innovation diffuse across members of the household? How does computer use in the home change over time (i.e., across members of the household and across household activities)?
- (R2) What is the level of integration of the computer and Internet technology in the household?
- (R3) What is the role of household structure in the intra-unit diffusion?
- (R4) What is the nature of communication between members of the household regarding the innovation? How can the communication be captured with network analysis?
- (R5) What is the frequency and variety of usage displayed by each member of the household?
- (R6) What are the determinants of usage for each individual and members of the household as a whole?
- (R7) What is the technological makeup of the household and its impact on usage?
- (R8) What is the relationship between use diffusion and level of satisfaction?

## 5. RESEARCH METHODOLOGY

Past studies of diffusion have generally adopted one of two methodologies, cross-sectional or longitudinal, depending on the level of aggregation the researchers were investigating. If the unit of analysis is on the individual or household level, most studies use the cross-sectional approach (e.g., Dickerson and Gentry 1983; Robinson et al. 1997). However, if the research is focused on industry level diffusion, as in the case of product penetration, longitudinal data are the norm (e.g., Sinha and Chandrashekar 1992; Takada and Jain 1994). The difference between the two lies in the fact that aggregate longitudinal data are used mostly to study firm level marketing strategies and their impact on consumer product purchases. When using aggregate data, any findings relating to the individual consumer's diffusion processes are made by inferences and are not tested directly. Cross-sectional data afford direct testing of individual level adoption processes, but the method suffers from respondents' recall biases when the issue of interest is changes to usage patterns over time (Ram and Jung 1994).

Although it is generally preferable to collect longitudinal data if one really wants to investigate the diffusion process (Rogers 1995), collecting longitudinal data at the individual or household level tends to be a difficult and costly method for most researchers. Attempts to collect longitudinal data typically involve time-diary data methodology whereby the respondents keep diaries of their usage activities (Wind and Lerner 1979). However, this methodology may suffer from inaccurate recording by participants. Because maintaining a diary requires considerable effort by participants, the time frame for the diary is often kept short, making observation of usage pattern changes difficult. To deal with these multiple research design issues and others that were raised a new method of time-diary data collection that is augmented by a national survey study was used. The data collection was conducted in conjunction with a larger National Science Foundation project titled "National Outlook for Automation in the Home II" at the University of California, Irvine.

The significance of the methodology is threefold: First, this is the first large-scale study of IT usage contexts. Secondly, this study employed a large national sampling scheme that provides an external validity for research findings (McGrath 1972). Finally, the use of extended time-diary data

solved some of the methodological issues that plague research in this area. The following sections provide details of the data collection for this study.

### **Sampling Design and Data Collection**

Data collection was carried out in March of 1999 after a pretest of the survey instrument (November 1998). The final data collection used a national survey augmented with a diary panel. The total sample for the survey consisted of 1200 households geographically distributed across the U.S. Of the 1200 households, 900 are computer owners, the effective sample size for the analysis, and 300 are non-owners. The sample design was a multi-stage stratified cluster design. The first step in the design was to divide the U.S. into distinct geographic districts. From within each geographic district, further sampling clusters were drawn based on income level and urban vs. suburban districts. Based on current population data on computer ownership, the penetration of computers in the U.S. is estimated to reach 60 percent by 1999 with strong bias towards high-income households (Nielsen Media Research 1996). To maximize the sampling opportunity for inclusion of computer owners, it was determined that the target population to be households with an annual income of at least \$35,000. Once the various sampling clusters were identified, a random digit dialing method was used to contact potential respondents. From each sampling cluster, a number of respondents were contacted that is proportional to the U.S. census figures.

Once a respondent was identified, telephone interviews were conducted using Computer Assisted Telephone Interviewing program (CATI). The benefit of CATI is that it facilitates the interviewing processes and minimizes recording errors. Actual respondents for the telephone interview were selected based on the key informant technique. The person in each household contacted who is most knowledgeable about computers served as the informant and was asked to provide information about the usage behavior for all computer users in the household. The only criteria for selecting the informant was that (s)he be an adult (18 years or older). At the end of the interview, each household informant was asked to participate in the time-diary portion of the data collection. Therefore, the time-diary portion of the study is a sub-sample of the survey study.

For participants in the time-diary study, a computer disk were distributed to them that contain AppTrack, software developed specifically for the purpose of this study. What AppTrack does is automate most of the mundane record-keeping tasks that are typically required of the diary participants. AppTrack automatically keeps a log of who uses the computer, the name of the application that was used, the date and time the application was used, the duration of usage, and why it was used. This limits the efforts required of the participants to responding to a multiple choice question at the end of using any application, thus most of the tasks that plague time-diary research are shifted from the participants to the software.

## 6. PRELIMINARY FINDINGS

The aim of this preliminary analysis is to test the effects of the various antecedent variables that affect post-adoption usage diffusion. The preliminary analysis of the intra-unit diffusion model was conducted with a multinomial logit model of the form:

$$\Pr(Y_i = j | \mathbf{c}_i) = P_{ij} = \frac{\exp(\mathbf{c}'_i \mathbf{b}_j)}{1 + \sum_{j=1}^J \exp(\mathbf{c}'_{j=1} \mathbf{b}_j)}$$

where:

- $Y_i$  = usage diffusion pattern for the  $i^{\text{th}}$  individual ( $i = 1, 2, \dots, I$ )
- $j$  = 3 different post-adoption usage diffusion outcome (avid use, use specialization, use experimentation) and reduced use is the control category
- $\mathbf{x}'$  = the vector of independent variables
- $\beta_j$ 's = covariate effects specific to the outcome category

In the following, I present the descriptive results of my study. The analysis using the multinomial logit model is still in progress and will be available within a month or so.

Initial analysis indicates that diffusion of use, as defined above, is a prominent phenomenon.<sup>2</sup> Overall, 75% of respondents reported using the computer more often and 65% reported using the computer for more reasons since the time of adoption [R2 above]. Further, 55% of respondents reported that they experienced an increase in both the rate at which they use the computer and Internet at home and

the reasons for which they use it. The biggest change in reasons for use indicated by respondents are accessing the Internet, from 39.2% at the time of computer adoption to 76.6% at the time of interview, followed by family games and entertainment (68.0% vs. 85.7%) and personal financial management (46.8% vs. 56%) [R2].

The relationship between diffusion of use and the independent variables of interest were analyzed with a multinomial logit analysis as described above. Compared with reduced use, the control category, avid use and use specialization are associated with the degree of communication with immediate social networks. Further communication with members outside the household, specifically co-workers and other technical supports, also contributes to usage diffusion [R5, R7]. The technological make-up of the household also seems to impact usage diffusion pattern. In particular, ownership of complementary technology (e.g., digital camera, electronic organizers) positively contributes to the likelihood of avid use and use specialization compared to reduced use [R7, R8]. Similarly, individual's innate innovativeness, expertise, and exposure to computers outside the household is positively related to avid use and use specialization [R7]. Although not significant, exposure to mass media was found to be positively related to avid use, use specialization, and use experimentation [R7].

Finally, relation between use diffusion and satisfaction with computers and Internet and its perceived impact were examined. Users who experienced avid use reported the highest level of satisfaction and perceive the computer and Internet having the greatest impact on their daily lives. The second highest groups of users (in both satisfaction and perceived impact) are those that experienced use specialization, followed by use experimentation and reduced use [R9]. All differences are significant.

Because glimpses from preliminary analysis offers encouraging support for the Intra-Household Diffusion model, subsequent analysis will continue along the same line by focusing on the nature of usage diffusion, the effects of the antecedent factors and their boundary conditions. In particular, it will seek to address changes in technology and the pattern of network communication and their impact on the

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2 The following findings refer to research question on page 20.

integration of technology into the home. Future analysis will emphasize network data analysis with the following focus:

- Who is the expertise in the home and who is not?
- Who talks to whom and who is connected in the household network?
- The above issue will be analyzed using gender, generational and expertise structures.

Data analysis is expected to conclude by September 1999 with final write-up completed by December 1999. It is the hope of this study that research findings can provide insights into how information technology can be marketed to households and points to direction of future technological developments by identifying trends in how technologies are used within the context of the home.

## REFERENCES

- Anderson, Robert L. and David J. Ortinau (1988), "Exploring Consumers' Postadoption Attitudes and Use Behaviors in Monitoring the Diffusion of a Technological-Based Discontinuous Innovation," *Journal of Business Research*, 17, 283-298.
- Bass, Frank M. (1969), "A New Product Growth Model for Consumer Durable," *Management Science*, 15(Jan.), 215-227.
- Belk, Russell W., Melanie Wallendorf, and John F., Sherry Jr. (1989), "The Sacred and the Profane in Consumer Behavior: Theodicy on the Odyssey," *Journal of Consumer Research*, 16(1), 1-38.
- Czepiel, John A. (1974), "Word-of-Mouth Processes in the Diffusion of a Major Technological Innovation," *Journal of Marketing Research*, 11(May), 172-180.
- Dickerson, Mary Dee and James W. Gentry (1983), "Characteristics of Adopters and Non-Adopters of Home Computers," *Journal of Consumer Research*, 10(Sept.), 225-235.
- Dutton, William H., Everett M. Rogers, and Suk-Ho Jun (1987), "Diffusion and Social Impacts of Personal Impacts of Personal Computers," *Communication Research*, 14(2), 219-250.
- Dutton, William, Peter Kovaric, and Charles Steinfield (1985), "Computing in the Home: A Research Paradigm," *Computers and the Social Sciences*, 1, 5-18.
- Gatignon, Hubert and Thomas S. Robertson (1985), "A Propositional Inventory for New Diffusion Research," *Journal of Consumer Research*, 11(4), 849-867.
- Greenleaf, Eric A. and Donald R. Lehmann (1995), "Reasons for Substantial Delay in Consumer Decision Making," *Journal of Consumer Research*, 22(2), 186-199.
- Hirschman, Elizabeth C. (1980), "Innovativeness, Novelty Seeking, and Consumer Creativity," *Journal of Consumer Research*, 7(3), 283-295.
- Kraut, Robert, Tridas Mukhopadhyay, Janusz Szczypula, Sara Kiesler, Bill Scherlis (1998), "Communication and information: Alternative uses of the Internet in the Households," *Conference Proceedings on Human Factors in Computing Systems*, 368-375.
- Leuthold, Jane H. (1981), "Taxation and the Consumption of Household Time," *Journal of Consumer Research*, 7 (1), 388-394.
- Lewis, Laurie K. and David R. Seibold (1993), "Innovation Modification During Intraorganizational Adoption," *Academy of Management Review*, 18(2), 322-354.
- Lindlof, Thomas R. (1992), "Computing Tales: Parents' Discourse About Technology and Family," *Social Science Computer Review*, 10(3), 291-309.
- Mahajan, Vijay and Robert A. Peterson (1985), *Models for Innovation Diffusion*, Newbury Park, CA: Sage Publications.
- Mahajan, Vijay, Eitan Muller, and Frank M. Bass (1990), "New Product Diffusion Models in Marketing: A Review and Direction for Research," *Journal of Marketing*, 54(1), 1-26.

- Mahajan, Vijay, Eitan Muller, and Frank M. Bass (1995), "Diffusion of New Products: Empirical Investigations and Managerial Uses," *Marketing Science*, 14(3) 79-88.
- Mahajan, Vijay, Eitan Muller, and Rajendra K. Srivastava (1990), "Determination of Adopter Categories by Using Innovation Diffusion Models," *Journal of Marketing Research*, 27(1), 37-50.
- McGrath Joseph E. (1972), "Dilemmatics: The Study of Research Choices and Dilemmas," in *Judgment calls in research*, Eds. Joseph E. McGrath, Joanne Martin, and Richard A. Kulka., Beverly Hills: Sage Publications.
- Midgley, David F. and Grahame R. Dowling (1978), "Innovativeness: The Concept and Its Measurement," *Journal of Consumer Research*, 4(March), 229-242.
- Nielsen Media Research (1996), *Home Technology Report*.
- Price, Linda L. and Nancy M. Ridgeway (1982), "Use Innovativeness, Vicarious Exploration and Purchase Exploration: Three Facets of Consumer Varied Behavior," in *AMA Educator's Conference Proceedings*, Ed. Bruce Walker, Chicago, IL, American Marketing Association, 56-60.
- Ram, S. and Hyung-Shik Jung (1989), "The Link Between Involvement, Use Innovativeness and Product Usage," *Advances in Consumer Research*, Vol. 16, Ed. Thomas K. Srull, Hawaii: Association for Consumer Research, 160-166.
- Ram, S. and Hyung-Shik Jung (1990), "The Conceptualization and Measurement of product Usage," *Journal of Academy of Marketing Science*, 18(1), 67-76.
- Ram, S. and Hyung-Shik Jung (1994), "Innovativeness in Product Usage: A Comparison of Early Adopters and Early Majority," *Psychology and Marketing*, 11(1), 57-67.
- Rao, Ambar G. and Masataka Yamada (1988), "Forecasting with a Repeat Purchase Diffusion Model," *Management Science*, 34(6), 734-753.
- Ridgeway, Nancy M., and Linda L. Price (1994), "Exploration in Product Usage: A Model of Use Innovativeness," *Psychology and Marketing*, 11(1), 69-84.
- Robertson, Thomas S. and Hubert Gatignon (1986), "Competitive Effects on Technology Diffusion," *Journal of Marketing*, 50(3), 1-12.
- Robinson, John P., Kevin Barth, and Andrew Kohut (1997), "Social Impact Research: Personal Computers, Mass Media, and Use of Time," *Social Science Computer Review*, 15(1), 65-82.
- Rogers, Everett M. (1995), *Diffusion of Innovations*, New York, NY: The Free Press.
- Sinha, Rajiv and Murali Chandrashekar (1992), "A Split Hazard Model for Analyzing the Diffusion of Innovations," *Journal of Marketing Research*, 29(February), 116-127.
- Takada, Hirokazu and Dipak Jain (1994), "Cross-National Analysis of Diffusion of Consumer Durable Goods in Pacific Rim Countries," *Journal of Marketing*, 58(April), 48-52.
- Venkatesh, Alladi (1996), "Computers and Other Interactive Technologies for the Home," *Communications of the ACM*, 39(12), 47-54.

- Venkatesh, Alladi and Nicholas P. Vitalari (1987), "A Post-Adoption Analysis of Computing in the Home," *Journal of Economic Psychology*, 8, 161-180.
- Vitalari, Nicholas P., Alladi Venkatesh, and Kjell Gronhaug (1985), "Computing in the Home: Shifts in the Time Allocation Patterns of the Households," *Communications of the ACM*, 28(5), 512-522.
- Von Hippel, Eric (1982), "Get New Products from Customers," *Harvard Business Review*, March-April, 117-122.
- Von Hippel, Eric (1986), "Lead Users: A Source of Novel Product Concepts," *Management Science*, 32(7), 791-805.
- Warlop, Luk and S. Ratneshwar (1993), "The Role of Usage Context in Consumer Choice: A Problem Solving Approach," in *Advances in Consumer Research*, Vol. 20, Eds. Leigh McAlister and Michael L. Rothschild, Provo, UT: Association for Consumer Research, 377-82.
- Wind, Jerry and D. Lerner (1979), "On the Measurement of Purchase Data: Survey Versus Purchase Diaries," *Journal of Marketing Research*, 16(Feb.), 39-47.