THE DIFFUSION OF HOME COMPUTING PHENOMENON: A LONGITUDINAL ANALYSIS OF PATTERNS OF USE

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(Franco Nicosia and Alladi Venkatesh)

Introduction

No technology in recent memory has aroused as much national and global interest as the computing technology (Scientific American l995). The new digital age, now augmented by the ubiquitous and powerful microcomputers, is variously described as "the mode of information" (Poster 1990), "the cyberculture" (Escobar 1994), and the like. While the role of personal computers in transforming work environments is generally well known and has been discussed in detail by several scholars (Attwell l992; Boland, Tenkasi and Te'eni l994; Danziger l979; Griffith and Northcraft l994; King l983; Kling l980, Kling 1995; Kraemer, Dutton and Northrop l980; Olson l983; Kraut l989; Orlikowski l992, Sproull and Kiesler l995), similar scholarly inquiry with regard to home use has been less systematic, although not absent (Dholakia, Mundorf and Dholakia l994). For example, under the general rubric of computing in the home, researchers have investigated issues such as the profile of innovators (Dickerson and Gentry l983), symbolic dimensions of the new technology (Turkle l984), the nature of computer diffusion (Dutton, Rogers and Suk-Ho l987, Rogers l985), social psychological factors affecting computer use (Mcquarrie and Langemeyer l987), educational use of computers at home by children (Psychology Today l984, Giacquinta, Bauer, and Levin l993), post-adoption analysis of homecomputers (Venkatesh and Vitalari l987), gender differences in use of computers (Ruddell l993), and telecommuting and work at home (Kraut l989, Venkatesh and Vitalari l992). There are also international perspectives on home computer use (Bakke l993, Berg and Hagersklaer l987, Bjerg and Borreby l994, Josiet l988, Miles l988, OECD l992, Proulx l990).

Our present study, while building on earlier cited work, aims to advance our knowledge in three ways. First, we propose a theoretical model of "household-technology fit" as a conceptual basis for understanding household behavior as it pertains (a) generally, to the technologies of the household and (b) specifically, to the use of home computers by households, which is the focus of this study. Second, we provide a longitudinal analysis of computer use in the home using a "national panel" of households which gives us some important insights into the home computing phenomenon over time. The study is further enriched in this regard by a comparison between computer owner households and non-owner households. Third, we fill the gap in the diffusion literature which has traditionally emphasized "product adoption" while paying insufficient attention to "product use."

Computer Revolution and The Home - Promise and Potential

Indeed, what was hailed as a home computer revolution by the popular media more than a decade ago (Newsweek l982, TIME l983) did not materialize in the predicted manner, and the rhetoric of the revolution remained muted for a few years (Business Week l990). However, there has been a recent resurgence of this phenomenon giving the term, "information revolution," a greater currency and legitimacy (Blatteberg, Glazer and Little l994; Business Week l994; Fortune l994). This shift may be related to the recent advances in the merging of computer, communication, and information technologies leading to some new developments: interactivity (Davids l994), multimedia (Fetterman and Gupta l993, Goble l994), virtual reality (Biocca l992; MacDonald and Shneiderman l994), information highway (Brody l993), and to many practical possibilities not envisioned before. While it is always advisable to greet the hype in the popular press with a grain of salt, more objective accounts of the impact of computing/information technologies on the daily lives of consumers and citizens seem to suggest that the impact is more real than illusory (Atkin l993; Sawhney l993; Bjerg and Borreby l994). With increasing predictions and possibilities of the fusion of various technologies, it is now appropriate to evaluate their initial impact on the American household. In order to gain a deeper understanding of the vicissitudes in the diffusion of computer use at the household level, it is important to examine several related issues in a systematic fashion. In this study--which is a part of and extension to a larger project funded by the National Science Foundation--we investigate the diffusion of home computer use[1] in a national sample of households using a longitudinal analysis.

Study Purpose and Rationale

The purpose of the study is (a) to present a theoretical framework guiding our understanding of technology diffusion in the home, (b) to report the results of an empirical (longitudinal) investigation of computer use among American households and (c) to develop some key theoretical insights regarding the anticipated diffusion of the new technologies of computing and information based on the findings from this study and additional programmatic research of the authors. The theoretical insights of our study will enable us to make generalizations about household behavior with respect to various household technologies.

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[1] **The term "diffusion of home computer use" is not to be confused with "diffusion of home computers," although they are related and each of them has implications for the other. In this study, we are examining actual use of the computers in the home.**

The notion that computers can transform the life of the ordinary individual has been debated both as a real possibility and fictitious fantasy for some time (Dertouzos and Moses l981; Dutton, Rogers and Suk-Ho l987; Escobar l994; Toffler l980; Venkatesh and Vitalari l985; Wriston l992). Those who consider this a possibility essentially argue that a number of human and household tasks can easily be automated or digitized and therefore computerized (Bedrosian and Bedrosian 1994). These activities primarily occur in the task environment (home management, record keeping, home-utility controls and financial management etc.). Computers can also impact work-at-home, children's education and home entertainment, and when one adds to this scenario the current integration of computing, information, and communication technologies, the possibilities appear to be quite immense (Silverstone and Hirsch l992; Marx l994). Yet, there are some critics who claim there is too much hype or too little substance, and that too many vested interests are driven by technological considerations with no real understanding of the real needs of the consumer (Kling l995). In the past, this view was not without a basis; simply observe how the home market for computers plummeted in the late eighties and the early nineties (Business Week l990). Things seem to have changed rather dramatically, and now we are once again in the midst of a major social transformation. As Scardigli (l992) observed, the first phase of the digital revolution at home was one of "prophesies and great maneuvers," or the period of social imagination. We have now entered the second phase which he terms, “social realism.”

In sum, while the new technologies may not have followed the intended trajectory predicted in the early eighties, there is less doubt now about their transformational power and impact. In other words, what we are concerned here is with the potential for change given the inherent possibilities that underscore the new technologies.

Theoretical Issues

Technology: Adoption-Use Perspective

This paper examines the interface between the technology and the user (i.e. the household) after the technology is adopted. On a general level, our study is cast in the emerging research stream that has been variously labeled as product “consumption,” “possession,” “use,” and “experience,” terms which suggest a broader framework that extends beyond product acquisition and facilitates the understanding of consumer behavior in its fuller dimensions (Arnould and Price l993, Belk, Wallendorf and Sherry l989; Deighton 1992; Mick and Fournier 1995; Richins l994; Schouten 1991). More specifically, our work is associated with the growing emphasis in diffusion research

on *product use* information as a key variable in explaining consumer acceptance of new technologies. For example, in suggesting new directions for diffusion research, Gatignon and Robertson (l985) stated that "the speed of diffusion of technological innovation depends on the consumer's ability to develop new knowledge and new patterns of experience." They make even a stronger statement in their later paper, "...Because the emphasis is on technological innovation, adoption is not the only relevant concern of diffusion research. The *degree of use* [authors' italics] of that technology is an important variable that describes the extent of diffusion of that innovation..."(Robertson and Gatignon, l986).

In our earlier work, we argued that in the case of technologically oriented products (e.g. home computers), and in situations where consumers have neither a prior knowledge nor the ability to categorize products meaningfully, the decision to buy a technology is less revealing than the decision governing the use of the technology after adoption (Venkatesh and Vitalari l987; Venkatesh and Vitalari l992). In other words, researchers are more likely to develop a better understanding of the nature of consumer behavior by studying how consumers actually behave with respect to high technology products, and how the dynamics of this relationship develops over time.

In terms of other technology-based empirical research, which is rather limited, Von Hippel's (l977, l982) earlier work in the industrial settings is a clear demonstration of how customer inputs based on actual product use have led to industrial innovations. In the consumer context, Price and Ridgway (l986) empirically tested the concept of use-innovativeness, and employed a use-innovative measure to differentiate between innovative and non-innovative users. Similarly, Ram and Jung (1991) observed the satisfaction levels of the users of various home-based technologies after continued use over time. More recently, Mick and Fournier (l995) proposed an in-depth analysis of consumer satisfaction resulting from the use of technologies in “everydaylife.”

Thus, by studying the use behavior over time, researchers seem to be in a better position to generate meaningful insights about the later adoption behavior. As an evolving technology, the home computer fits this new framework most aptly. The microcomputer is a technologically complex product and requires considerable training and skills, and time to acquire these skills, in order to exploit its potential. Furthermore, few household products are as diverse or complex as the computer. The determinants of its initial adoption may not necessarily explain its continued use, nor do the anticipated uses exactly match the actual use patterns.

Programmatic Nature of the Study and Context

Figure 1 is a tool to assist the reader in understanding the context of the study reported here. We began studying the adoption and use of computers in the early eighties (Figure 1, Box 1). The results of this study and a synthesis of existing literature (Figure 1, Box 2) from family sociology and new-home economics provided the theoretical basis for a large study of home computer use funded by the National Science Foundation which is the focal point of this paper (Figure 1, Box 3). After completing the NSF study, we undertook a small sample ethnographic field study to gain additional insights into the nature of household/technology interface (Figure 1, Box 4). This enabled us to sharpen our theoretical model (see Figure 2) to be discussed later. Accordingly, the programmatic nature of our work has given us the theoretical apparatus to understand not only the nature of computer use in the home, but how all of this fits into the overall household behavior with respect to domestic technologies.

General Theoretical Approach to the Present Study and the Household As the Unit Of Analysis

In this study, the unit of analysis is the household. Specifically, our study examines the theory of household behavior in the context of technology use, and utilizes some emerging theoretical notions pertaining to the study of technology/user-household interface. Although the household is the site of major consumption decisions, research on household consumption behavior has not received as much attention from consumer researchers as it deserves (Sherry 1995, p.). Refreshingly, however, over the last few years, there have been some important contributions from consumer researchers on "family purchase decision" processes pointing to a growing trend in household consumer research (Beatty and Talpade 1995; Belch, Belch and Ceresino 1985; Corfman and Lehman 1987; Foxman, Tansuhaj and Ekstrom 1989; Qualls 1987; Webster 1995; Wilkie, Moore-Shay and Assar 1992). Nevertheless, the focus of these studies is on product adoption rather than product use. Of course, there are studies with an emphasis on broader issues of household consumption but they are rather limited (Heisley and Levy 1991; Schaninger and Danko 1993; Wallendorf and Arnould 1991).

In an earlier work that employed a socio-historical perspective, Nicosia (l975; l983) theorized that the adoption and use of technologies by households were socially and culturally mediated. He argued that institutions, such as family, school, and place of work, provide the basic norms and heuristics that foster the technological culture within a society. A similar argument was also postulated in later studies (Venkatesh and Vitalari l984; Venkatesh l985). The notion of socially mediated technological culture as the basic framework for studying the relationship between the user (an individual or an organization) and technology has emerged as a powerful concept in

different fields (Kling l995; Kling and Scachi l982; Shapiro l988) Recently, Bakke (l988) introduced the notion of social mediation in the diffusion of electronically organized services. Thus, the social context is fundamental to the study of technology adoption and use. To aid our understanding of these issues, we have formulated the following research questions for our study. Specific hypotheses are developed in a later section under research design.

Research Questions

1. How can we theorize about the social/organizational characteristics of the household and the household/user interface with technologies as a consumption process? How can this general framework of household-technology behavior be translated to the specific context of the home computer?

2. What are the major uses of the computer at home?

3. What characteristics of the household account for computer use at home?

3. What characteristics of the users are relevant in determining computer use at home?

5. What perceptions do people have about the computer?

6. What theoretical and practical implications can we draw from the study that will assist us in formulating ideas about technology diffusion and use in the context of the home?

A Theoretical Framework: Household/Technology Interface

Although research on household technology is limited in the consumer literature, some key studies have been reported over the past few years (Nickols and Fox l983; Oropesa l993; Strober and Weinberg l980). Typically, these studies have focused on the purchase decisions of families in regard to household technologies (e.g. kitchen appliances) and/or the use of technologies primarily as time saving devices. While these studies provide some important and useful theoretical background for our work, there are three ways in which our approach differs from or extends their work. First, we investigate the actual use of technology, not just the purchase decision or incidence of ownership. Second, we examine how technology fits into the over all consumption context of household behavior and not just on time savings. Finally, we consider the social context of technology adoption and use to be a key element of our theoretical framework.

Once we go beyond consumer research, we find that several researchers have formulated basic theoretical notions about the social, economic, and cultural aspects of technology utilization in

various contexts ranging from communities, organizations, households, and across individuals. We refer to our previous work which discusses these concepts in some detail (Nicosia l975; Venkatesh l985; Venkatesh and Vitalari 1984, l990).

We now identify some key issues from previous studies and follow this up with a presentation of our own model (Figure 2). Previous work in this area can be classified into four primary streams.

First, the socio-technical systems theory views an organization (in our case the household) as a social system, and technology as an autonomous environmental system that acts on the social system as an external agent (Hedberg and Mumford l975; Danziger l979; Danziger and Kraemer l986). This view is a product of systems theory which was a reigning paradigm in the social sciences during the fifties up until the mid-seventies. This approach has been criticized as being too deterministic and considering technology only as external to the adopting organization, and the organization/technology interface merely as the meeting point of two independent systems. In other words, the socio-technical systems approach fails to recognize that technology is interior to the household environment (although produced physically outside of the home) and not external to it, and that there is a dynamic relationship between the two. As Woodward (l994) has shown, technology is neither neutral nor autonomous but is integral to the social character of the (social) system.

The second approach, which is more common among organizational theorists and social constructivist theorists in Europe, views technologies as socially embedded processes (Cronberg l994; Kling l980, l995). That is, unlike the socio-technical systems approach which views technology as autonomous and outside the social organization, the social-embeddedness theory examines technology as integral to the social organization. The basic position here is that no technology can be examined in isolation but only in the social context of its use and not its physical origin. We take this position in the current study, utilizing the underlying idea and applying it specifically to the household.

The third approach is based on the extensions of the new-home economics (Becker l976) which consider technology in the context of household production and consumption (Berk 1980). In this view, technologies are viewed as time (and/or cost) saving devices, and households as optimizers of time/cost-allocations based on household preference functions. This is a valuable framework for understanding household behavior, and more importantly, to assess the task environment within the household.

The fourth stream of research is reflected in the time-budget studies and is closely related to the third stream. Robinson is credited with the main contributions to this area (1977, l980, 1990). The focus here is on developing a scheme of time allocation by households for various household activities. The approach is more descriptive, analytical, and data rich, but not too theoretical. In other words, time-budget studies allow researchers to draw some conclusions about how household time allocation patterns change temporally and cross-sectionally, but there are no adequate theoretical explanations for these changes.

A synthesis of previous work in these three areas of research (Berk l980, Hardyment l988; Morgan et al l966; Nicosia l975, l983; Nickols and Fox l983; Oropesa 1993; Vanek l978; Strober and Weinberg l980) suggests that the household may be viewed as a social system divided into task environment and non-task environment, and technologies as part of the social system. The basic approach here may be described as structural/functional. Typically, households, or members of a household, appropriate technologies to perform a variety of activities within these two environments. One objective of using these technologies is to increase time savings or achieve other efficiencies specific to the situation. This is particularly true of task oriented technologies (washer, dryer, vacuum cleaner etc.,). Household members also use technologies with the purpose of relaxing and experiencing the aesthetic enjoyment associated with watching TV or listening to Stereo music. With the structural/functional perspective of technology-use serving as the springboard, we have expanded our theoretical design into a structural/dynamic model (see Figure 2) of household-technology interface, which is the focal model for our present study. Our structural/dynamic model resembles the structuration models proposed by Giddens(1979) and Bourdieu (l984) and applied to larger macro contexts. Our model, based on earlier theories and our prior work, was developed and refined during the ethnographic field work conducted by one of the authors at the conclusion of the major NSF study (see Figure 1, box 4 and Appendix 1)[2]. Using the method of thick description, The ethnographic field work was designed to understand how families behave with respect to technologies in their everyday lives.

Household Technology Fit Model

[2] **The complete ethnographic study is available upon request. The ethnographic work is incorporated here primarily in the development of the theory/model as shown in Figure 2. For the empirical analysis, which will appear later, we will report mainly on the survey data using a longitudinal panel but will interpret the results using the theoretical model. The only ethnographic data that we will employ in the empirical analysis is in the section on "Internal Household Diffusion of Computer Use."**

The basic principle operating in this model (Figure 2) is the idea of technological fit within a household structure. The model is a search for this fit, that is, to determine what conditions are necessary, and what conceptualizations are appropriate for technology to fit into the household. The model is not limited to any particular technology, but is applicable to different technologies within the household.

In this model, we conceptualize the household as a social organization and represent it both structurally and dynamically. Structurally, the household consists of six components: sub-environments or the social spaces in which the family lives, specific activities within the sub-environments, technologies that permit the activities in the sub-environments, actors (members of the household) engaged in the activities, household composition and demographics, and time allocation for technology use. The term, "dynamically," refers to the interaction between these various components.

The notion of the sub-environment is key to our study. It is the first component of the model. The term environment suggests that members of the household occupy a certain social and physical space. These environments are not mutually exclusive but conceptually distinct. On the basis of our ethnographic work, we have been able to identify the following sub-environments as pertaining to our study:

Food Management
Household Maintenance/Finance
Leisure/Recreation/Entertainment
Social/Family Communication
Work/Employment
Family Development/Well-Being

The second component of the model is a set of household activities performed in each sub-environment. Collectively, they constitute the activity space.

The technologies of the household are the third component of the model and linked to the sub-environment by their location in the social space, and to the set of activities by their functionality. Collectively, the technologies constitute the technological space. Not only is it logical and necessary to put technologies in each sub-environment as part of the structural aspect of the model, but the structure of the sub-environment is such that a given technology may belong to more than one sub-environment. Thus, computers are shown (see Figure 2) in more than one sub-

environment (family development (children's education), leisure and recreation, work/employment, and household maintenance/finance). Similarly, automobiles and telephones are also embedded in multiple sub-environments.

The fourth component refers to the members of the household who are a key component of the model for without them the social and technological spaces have no meaning. While the members of the household collectively occupy the sub-environments space, none has equal participation in them. For example, adults are more likely to be involved in cooking within a household as compared to children, and therefore are considered the central actors within that environment.

The fifth component is the household composition and the demographics of the household. This component is particularly critical if one were to study the changing family structure over its life cycle.

The final component of the model is time allocation for various activities using the technologies.

The "dynamic" aspects of the model are next on the agenda. That is, it is necessary to address the issue of how this model functions in practice and how the components are related to each other.

Figure 2 exemplifies the fit of a technology into the social organization of the household, as defined by the sub-environments. Household technologies may either compete with or complement each other within the same sub-environment or across sub-environments.

The model relies on the basic idea that domestic technologies (e.g. computers) must fit the social space of the household and, specifically, they have to fit the perceptual and physical space of the sub-environments in which they are located. This fit is achieved when the members of the household are able to perform the activities within a given sub-environment. The notion of fit is very central to our conceptualization of the household/technology interface and requires that the following four conditions be satisfied in respect to the technology and the sub-environment.

Condition A: The sub-environment must be salient to the household.

Example: In families with children, the Family Development environment will be very salient.

Condition B: The technology must be seen as significant or important for the sub-environment. That is, the technology must be seen as contributing to the performance of an activity within the

sub-environment. As a corollary, in the event that a technology is designed to replace an existing technology the replacing technology must be seen as performing at a superior level than the existing technology.

Example: The computers must be seen as being useful to children's education.

Condition C: There must be at least one member of the household who uses the technology in a given sub-environment. For our purpose, a member may include hired help.

Example: Households with children are more likely to have children's educational software than families without children.

Condition D: The technology must be easy enough to operate by members of the household who occupy the particular social space.

Example: This condition is a key component because the complexity of computing technology might limit or restrict the members' use of it, even if they have a need for it.

It is important to point out that just because a technology belongs to more than one environment, it does not mean it has a stronger position within the household compared to a technology that belongs to only one sub-environment. For example, in our field work, when asked to name the two most important technologies in the home, a majority of our respondents cited the refrigerator as the most important technology followed by the telephone. When we analyzed our in-depth probings, we found that the meanings of these technologies to the users appeared to be that the refrigerator represents food and, therefore, survival, while the telephone represents communication and, therefore, social interaction. The refrigerator example is particularly interesting because it demonstrates that a technology might belong to only one sub-environment and be most salient for that environment, and, therefore, considered most critical to the household. At the other extreme, a technology might belong to many sub-environments and still have low salience in all of them. Alternatively, another technology might belong to multiple sub-environments and might be salient to a sub-set of these. In the case of computers, we show in Figure 2 that the computer can theoretically fit into all the sub-environments. The question that needs to be answered is how salient is it in each of the sub-environments that it is located.

How does the model help us understand computer use? First, it is based on the perspective of the user, that is, the emic perspective, rather than being imposed from outside.

Second, related to the first, the household-technology model enables us to examine computers not merely from the point of view of the technology but from an understanding of the household behavior. That is, what we have proposed is not a technology-driven model but a user(household)-oriented model.

Third, our household-technology model looks at a whole range of technologies, giving us an opportunity to examine computers in relation to other technologies. During the ethnographic field work, it became very clear that in order to understand the adoption/use issues of computers, one must view the total technological space of the household. Otherwise, very little insights will be gained by looking at computers alone.

Finally, the total fit of the computer into the sub-environment, that is, the ability to satisfy all the conditions (A to D), reveals its use potential.

Home Computer-Specific Framework

The model specified in Figure 2 provides a comprehensive theoretical framework for the study of household/technology fit and interface. Embedded in that model is a specific model (see Figure 3), that is, specific to computer and partly is based on earlier reported work (Vitalari, Venkatesh and Gronhaug l985, Venkatesh and Vitalari l987). This model is subject to the same conditions (conditions A through D) of technological fit described earlier. Following is a brief description of the computer-specific model.

The model contains three stages: adoption, use and impact. Some earlier studies found that the level of initial expenditures on computer hardware and software were determined by demographic factors, especially occupation and income (Dutton, Sweet and Rogers l988). Within this level of expenditures, the configuration of the computer system will be determined by the household structure (e.g. presence of children or no children) and the initial usage needs (e.g. word processing, education, games) according to the sub-environment where the computer might fit. Given computers' versatility that enables their fit into multiple sub-environments, the portfolio of applications will also be determined by the household structure and needs. We have shown that the two variables "higher usage" and "different uses" are determined accordingly.

In addition, it can be argued that different uses will lead to different levels of satisfaction, and the higher the level of satisfaction the higher the usage over time. Thus, the relationship between the level of satisfaction and usage is bi-directional. By the same token, the level of satisfaction is a

function of the size of the (computer) memory, which is a strong indicator of its performance potential. The model also demonstrates that higher levels of satisfaction and higher levels of usage lead to additional expenditures on additional hardware and software. Should the household composition and needs change over time, this will have an impact on their additional purchase. In the model, we have shown this relationship through the intervening variable "different uses" to suggest that the effect of changing household structure can also lead to changing use structure. The relationship between satisfaction from use and repeated use, or positive feedback, is very well established in the consumer literature. Specifically, in the case of consumer technological porducts, we refer to the recent work by Mick and Fournier (l995).

Finally, our model shows that, computers, over time, impact (similar to automobiles and TV in the past) the lifestyles and value systems within the household. For example, computer technology will determine how time is spent on various other activities in the home. Since time allocation patterns are central to lifestyle changes, the impact of computers on family lifestyles is not a trivial matter.

In this paper, we do not test the model as shown in Figure 3 in its entirety. Rather, the model provides the necessary theoretical grounding for our study in operationalizing the household structure variables and technology use variables.

Present Study - Variable Selection and Operationalization

In the selection and operationalization of the variables, we refer to the models specified in Figures 2 and 3. These two models have guided us in identifying the specific determinants of computer use. We have already presented the logic of the two models and in this section focus on the operationalization of some specific aspects. As stated earlier, the first model describes the technological fit between the household and different technologies. Thus, the home computer occupies a bounded but significant technological and social space. Similarly, in the model presented in Figure 3, which has three components, Adoption-Use-Impact, our main interest is in the Use component. Accordingly, we have operationalized the relevant independent variables for our study by grouping them into four categories: Household-Structural, Individual-User, Attitudinal, and Technological. The variable of interest is Computer Use. Table 1 provides a complete list of the variables, their hypothesized relationship to the computer use, and their fit with models shown in Figures 1 and 2. Following is a discussion of these specific groups of variables as they pertain to the present study.

Household-Structural Characteristics: Given the focus of this study, it is necessary to differentiate between the household as a social structure and the individual member within the structure. While both Giddens(1979) and Bourdieu (l984) provide the theoretical mechanisms for structuration at a macro level, the operationalization of their models to more micro phenomena (e.g. household) is not as simple. In the sociology of consumption literature, social structure is recognized as a key element (Nicosia and Mayer l983). Additionally, Blau was one of the first researchers to explicitly discuss structural effects as distinct from individual effects (l982). According to Blau, structural effects refer to "the influences on conduct exerted by the distribution of attributes in a group, independent of the influences exerted by an individual's own attributes" (l982). Structural effects have also been discussed by other researchers using different terminology: compositional effects (Davis l961) and contextual effects (Goode l969), structuration effects Giddens l976, Bourdieu l984). Regarding the mediation effects of individual behavior, Blau (1982) identifies two types of effects--direct and inverse. Specifically, 'direct' structural effects in the environment reinforce the effect of an individual's attributes on the behavior. Inverse effects refer to the case when structural effects run counter to the individual effects.

In the present study, we identify the following household-structural characteristics: number of persons in the family, number of children in the family, marital status of the respondent, employment status of the spouse, annual household income, and type of dwelling (rent or own).

Household-structural characteristics are included because, as stated in earlier, our unit of analysis in the study is the household, and computing in the home is considered a household activity (see discussion, Figure 2) that encompasses the potential uses of the computer for home management, children's education, and electronic communication.

Since the computer can potentially be used by all the family members, it is clear that the larger the household the greater the use of the computer. *We, therefore, hypothesize that the size of the household is positively related to computer use. As a corollary, we hypothesize that computer use increases with the number of users*. It is important to note that the household size and the number of users may be correlated but they are not equivalent, for it is conceivable that in a household with three members there may be only one user and in a household of two both may be the users.

A similar relationship can be assumed between computer use and the presence and ages of children. That is, given the likelihood that families prefer their children to be computer literate, *we hypothesize that the number of children will be positively related to computer use*.

Additionally, the employment status of the spouse is material in the following way; if the spouse is employed outside the home, he/she may have less time for the computer, and the total household use may be reduced. On the other hand, if the spouse's outside employment requires computer use at home, the total use may indeed increase. Given that it can go either way, *we are unable to specify the direction of the relationship between computer use and the employment status of the spouse*.

Finally, other things remaining equal, the type of dwelling (i.e. rent or own) may determine the level of computer use because rental homes are smaller in size and, therefore, may be less conducive to extensive computer use. At the same time, younger, unmarried individuals are likely to be living in rental dwellings by virtue of their life cycle position but could still be using the computers. Since our sample consists of more married people, *we hypothesize a positive relationship between house ownership and computer use*.

Individual Characteristics: Our previous exploratory research has shown that in the early stages of computer adoption, a primary user dominates computer use in a given household, and this individual is also the most knowledgeable about computers among the members of the household. Given this person's significant role, his or her characteristics become central to the understanding of the home computing phenomenon and in the diffusion of computing within the home. Research also shows that there is a (male) gender bias in terms of who the computer users are but this may be due to the fact that the computer is a recent phenomenon. However, with the passage of time this is likely to be less of an issue. In terms of the gender of the user, *we hypothesize that men are likely to be using the computer more than women*. *As a corollary, we hypothesize that sons will use computers more than daughters*.

Under individual characteristics, we have not only included the standard demographic descriptors but other behavior variables such as (a) time spent on paid work, (b) reading computer related magazines, (c) watching TV and (d) pleasure reading. Some earlier studies have shown that these variables may have an influence on computer use at home (Vitalari, Venkatesh, Gronhaug l985).

Regarding the age of the user, the relationship between age and computer use is not clear. The only thing one might be able to say is that people in the higher age brackets (sixty or above) are less likely to be using the computer because of a possible lack of prior exposure. On the other hand, in lower age categories it is not clear that one can unequivocally state what the relationship is between age and computer use. *We are therefore unable to hypothesize the direction of the relationship between age and computer use in our sample because all the respondents are adults*.

We consider education to be positively related to computer use because educational levels imply higher rates of literacy. *We hypothesize a positive relationship between level of education and computer use*. *Similarly, previous computer training is hypothesized to be positively related to computer use*.

We hypothesize negative relationship between hours of job related work and computer use. This is based on the notion that, given the finite amount of time in a day, if people spend more time at the place of work, the time they can spend on computer at home is correspondingly reduced. *Based on similar reasoning, we hypothesize negative relationship between watching TV and computer use, and pleasure reading and computer use. On the other hand, we hypothesize positive relationship between time spent on reading computer magazines and computer use*. This is because, those who read computer magazines are likely to be computer enthusiasts and are therefore more likely to spend time on computers.

Attitudinal Constructs: We developed three basic attitudinal factors of the principle user with the potential to influence the use of the computers (Table 1). The specific items of each variable are shown in Table 2 and discussed later in the results section. All the items were selected on the basis of a pretest. The first variable, called Instrumentalism, reflects the intrinsic functional value of the computers. Essentially, the computer is viewed as a tool designed to accomplish specific tasks. The rationale for this follows from the general discussion on the model presented in Figure 2 emphasizing the utilitarian aspects of technology. The second variable, labeled Symbolism, represents the imagery of the computer as a status conferring phenomenon and the attributed meaning of its centrality to the life of the household. The importance of this variable for computer adoption and use was discussed in depth by Turkle (l984). The third factor, called Satisfaction, measures the level of satisfaction with three aspects of the computer, the general system consisting of the hardware and software, operating ease and flexibility, and other peripheral aspects of computing. In our discussion of the computer-specific model presented in Figure 3, we pointed out the importance of level of satisfaction in facilitating continued computer use. *We hypothesize that all the three attitudinal constructs are positively related to computer use*.

Technology Factor: The technology factor refers to the role of the technology in determining the nature of the computer use. The variables included here are the length of computer ownership, the total amount spent on computers, and the types of computer use (education, game, job related work, word processing, electronic communication, and home finance). In Figure 2 we have shown that the computer occupies multiple sub-environments and can be used for different applications. Here are some examples of applications:

-Household Maintenance/Finance: Home Finance (Home banking or Check Writing)
-Leisure/Recreation: Computer games
-Social/Family Communication: Electronic Communication (online services), Word Processing (Family Correspondence)
-Work/Employment: Word processing, Electronic Communication
-Family Development/Well-being: Children's Education

Regarding the hypothesized relationships of technology variables, our position is as follows. *In terms of specific applications of the computer, in an obvious theoretical gesture, we hypothesize positive relationship between the various computer applications and the level of computer use. The amount spent on the computer indicates the level of commitment to the technology and is therefore hypothesized to be positively correlated with computer use.* In terms of length of ownership, in a previous study, we found that among some users, computer use was high in the initial stages and declined after a year so. We also found an opposite trend in some other cases. *We are therefore unable to hypothesize the exact direction of the relationship between length of ownership and computer use.*

Research Design and Data Collection

This study is part of a larger NSF study for which the sample included both households with computers and a matching control group of households without computers.[3] The present research focuses on the computer use patterns of the focal group (computer households), although some references will be made to the control group (non-computer households) for comparison purposes on issues other than computer use. The use of longitudinal designs, used in this study to collect the data, is well known to in social science research (and in particular marketing) as a means of observing phenomena over time (Bucklin and Carman l967; Coleman l955; Crider l973; Crouchley l987; Diggle 1994; Ferber l953; Lazarsfeld l948; Middgley and Dowling 1993; Nicosia l965; Winer l983).

Sample Design

In constructing the panel for this study, an important consideration was the necessity of ensuring that we were able to determine longitudinal patterns among computer users. Consequently, it was decided that serious computer user-households, who would have made a reasonable if not

[3]

substantial investment in computer hardware, would furnish the necessary longitudinal data. It was critical, therefore, that certain computer households be excluded from the study: those with low end machines and limited application possibilities, who would be more likely to discontinue computing activity after the initial novelty wore out. This was motivated by the need to minimize sample attrition which is one of the most vexing problems of panel construction. A national (US) panel of computer households was constructed from a residential database provided by a marketing research agency specializing in personal computer products and located in La Jolla, California. Letters of invitation along with a preliminary screening questionnaire were sent to 4000 home-based computer owners in the database. Approximately 1500 (38%) responded, and 900 were selected after careful scrutiny based on demographic and computer ownership data. Because of cost considerations, a sample size of 614 was finally chosen. Based on the demographic characteristics of the computer-owner households, a matching national sample of 293 non-computer households was selected from a list purchased from Survey Sample Inc., Connecticut.

Data Collection Instruments: Survey Questionnaire and Time Diary

A questionnaire developed specifically for telephone interviewing was the survey instrument. Two versions were developed, one for the computer owner households and the other for non-owner households, although both had overlapping questions as well as questions specific to each sample. These surveys were pretested by a marketing research agency in Los Angeles. The categories of information included in the questionnaire were: demographics and households specific data (both samples), employment/lifestyle data (both samples), prior computer training and experience (both samples), computer purchase/ownership data (owner sample), computer use data by type of use and user (owner sample), attitudes toward computing and computers (both samples), satisfaction with computers (owner sample), reasons for non-ownership and future plans for computer acquisition (non-owner sample). The general design and content of the questionnaire were maintained for the duration of the longitudinal study, however, depending on the requirements, some items were removed and others added from each survey sequence to the next. Such changes were kept to a minimum.

In addition to the telephone questionnaire, considered to be the main data collection survey instrument, a subsample of the computer households (about 200) was selected to record their actual use of the computer over a one week period. Time sheets were distributed to these households one month following each set of data collection giving detailed instructions about how each family member should complete them. The purpose of the time sheets was to compare the

actual use obtained from the time diary with self-reported use obtained during the telephone survey. While the telephone interviewing extended over four sets of data collection, time sheets of actual computer use was limited to only two sets in consideration of reducing additional burden felt by the respondents.

Data Collection

Data were collected via telephone interviews using the computerized system, CATI developed at the University of California, Berkeley. At the time the computer-household panel was formed, each household designated a respondent based on who the primary user of the computer was. In the case of the non-owner control sample, the choice was left to the household. Four sets of interviews, six months apart, were conducted.

Sample Attrition

As expected, sample attrition occurred from on set of interviews to the next, the greatest drop occurring between the first and the second wave. The sample sizes for the four sets of interviews were 614 (100%), 450(73.4%), 490(80.4%), 458 (74.1%). The average sample attrition of 23.83% is thus lower than the attrition reported in national surveys of this type. As a comparison, the sample attrition for the non-owner sample was much higher: 31.2%, 43% and 51% in Waves 2,3 and 4, respectively. A more systematic analysis of attrition bias is provided later in the data analysis section.

Data Analysis

Data analysis will proceed in two parts. The first part includes descriptive statistics on user profile, computer acquisition information, various aspects of computing use and attitudes towards computing. Where appropriate, comparisons will be made with the non-computer sample. In the second part, a longitudinal analysis of computing use is presented using econometric methods incorporating probit correction procedures for sample attrition. We believe that the presentation of detailed descriptive statistics is very useful in a study of this kind. First, it provides rich insights into the nature of the longitudinally collected data. Second, there is always the possibility that much useful information is lost when using statistical techniques. Third, the descriptive statistics reveal some key differences between computer-households and non-computer households. In short, the two sets of information (descriptive and statistical) complement each other and enhance our understanding of this new phenomenon of computing in the home. Finally,

for reasons of space, tables are not provided for the descriptive analysis but the results are summarized in Figure 4.

Descriptive Statistics

Demographic Profile

In both the computer households and non-computer households, the chief respondent to the survey was male (85% and 77%). In the computer households this meant that the male respondent was also the principal user. Over 85% of the sampled respondents were married and a large percentage in both samples (73% and 62%) had a minimum of college degree. The median ages of the respondents in each group were 41 years and 44 years with a great majority of them in the 26-45 age group. Most respondents held full-time jobs outside the home (72% and 73%). In terms of occupation, about half in the computer sample identified themselves as professionals (compared to 41% in the non-computer-owner sample). The non-computer sample included more retired people and workers (15 to 5%).

In terms of household characteristics, over 60% in both samples had children. Among these, at least 80% had one or two children. The median family income was $45,000 for the computer households and $47,000 for the non-computer households.

Demographically speaking, both samples overall were comparable (albeit by design), consisting of middle and upper-middle class households, and highly educated respondents belonging to professional and managerial occupational groups.

Computer Ownership Profile

In Wave One, 83% of the households in the sample reported owning one computer, while 16% reported owning two computers and 1% three or more computers. By Wave Four, these percentages had changed dramatically to 74%, 22% and 4% respectively. The data suggest that over time, households accumulate computers similar to the way they accumulate TVs and telephones.

Reasons for Buying a Computer:

The reasons for buying a computer varied, with 59% reporting job-related work and word processing, 20% citing children's education/entertainment and 11% mentioning non-job related word-processing. Of less importance were, home finance, games/entertainment, adult education, family record keeping and information services.

In contrast, non-computer households offered two major reasons for not buying a computer: 46% stated the reason, "no use for it at home" and 30% said "cost not justified". As for acquiring a computer in the next six months, 74% of the respondents said it was unlikely and 26% stated it was likely. The anticipated major applications for the would-be buyers were, job related (55%), followed by educational use (16%) and home management (13%).

The results point out the interesting idea that computers are viewed primarily as a work related productivity oriented tool and secondarily as an educational tool, and the reason why people had not bought one is because they had perceived neither a job-related need nor an educational need at home.

Computer Uses by the Household

Comparison Between the Self-Reported Data and Time-Diary Data

Before we present the actual use information, a note on the comparison between self-reported data and time diary data would be in order. We found a high positive correlation between the two. The two sets of self-reported data were compared with the corresponding time-diary data. Although the actual sample size selected for the time diary data was 200 in both periods, the yield was 185 and 158 respectively. We compared the data from those households who were common to both self-report survey and time diary survey. For the first period, we found that the mean hours of computer use per week were 20.6 and 22.2 respectively, indicating no statistical difference. For the second period, the mean values were 18.9 and 20.3, once again indicating no statistically significant difference between the self-report data and time diary data.[4] As for the correlation values, they were 0.67 and 0.62, both of which were significant at .001 level. What is interesting is that there was underreporting of computer use in self-support survey in both instances. The overall conclusion is that the self-reported data and the time diary data were in agreement. There is a reason for this high degree of convergence between the two sets of data. In our study, we found that the principal user of the computer in the household accounted for nearly 70% of the total use. If the incidence of use was more widely distributed among the members of the

[4] **Upon reflection why there is no significant difference between the self-report data and time diary data, one possible explanation is that, as it becomes cllear later, the person giving the information on the phone is also the principal user who accounts for 70% of the total use. Under the assumption that (s)he may not be able to give accurate figures for the other members of the family, one can also eqiually assume that (s)he will be able to provide more accurate figures of his or her own use. In other words, mathematically speaking, the zone of error between the self-report data and the time-diary data is only 30% which is a minor part of the total use.**

household and less concentrated, we would have probably found less agreement between the two sets of data. In the remaining portion of the paper, we will use only the self-report data because it is available for the entire sample.

Some General Patterns of Computer Use:
For the computer owner sample, the mean hours/week of reported computer use per household is 18.38 hours in Wave One gradually declining to 16.48 hours in Wave Four. This represents a 10% decline in computer use over a period of about two years.

In families with children, 83% of the households with sons reported using the computer in Wave One while only 68% of the households with daughters reported the same. The mean use for these two categories across all the four waves are 5.03 hours and 3.11 hours per week, respectively.

In every household, there is a major user who accounts for 70% of the total use. Invariably, this is a male adult member of the household. The demographics also reveal that considerably more men use computers for job related activities compared to women. However, even though half as many women as men use computers, women's mean job related use is 60% compared to their husbands. This would suggest that once women begin using the computers, the differences between men and women are likely to diminish.

As for specific uses, job related computer use is the most dominant (See separate discussion below on job related work at home). This is followed by children's use of computers for a variety of applications. The four major uses of the computer are math (59%), word-processing (58%), writing computer programs (52%), and spelling (48%).

Of all the households in the panel, 55% report using the computers for entertainment and games. However, the mean reported hours declined from 4.35 hours to 3.51 hours per week over the four waves. The results indicate that entertainment and game use of the computer closely follows the educational use but declines more rapidly over the same period of time.

The actual use of computers for keeping track of household finances is rather low (1 hour per week).

Electronic communications (e.g. On-line services) have inspired a great deal of interest in regards to the use of home computers. It can be easily imagined that a home computer fitted with communications equipment and supported with access to powerful information services could

provide the household with a new window to the world. It is not surprising, therefore, to note that nearly 40% of our sample reported using the computer for outside communication. For this sample of users, the mean usage rate was about 2.45 hours per week in Wave One rising to 3.52 hours in Wave Four. Thus, the increase in the mean use from Wave One to Wave Four is quite substantial (50%). The results, in general, indicate an increase in the use of communications capabilities within the home, which in turn parallels the growing interest in data communication networks, society wide.

The use of the home computer to manage household activities is considered to be an advanced application, but this was a rather low level activity in the current study.

Job Related Work at Home

Because of the nature of the technology being studied, work at home is a particularly significant issue. Accordingly, we attempted to investigate some basic notions regarding job related work at home.

Motivation for Working at Home:
In exploring this aspect, only respondents with outside jobs are included in this section of this analysis while the self-employed/home-based workers, whose choice to work at home is not necessarily optional, are excluded. Results reveal that nearly 80% of the computer owners worked at home in addition to their work outside, while only 50% (or less) of the non-computer owners did so. This difference is statistically significant.

Computer owners gave four major reasons for working at home: "flexibility/convenience," "can work quietly/freedom from interruptions," “has increased productivity,” "gives control over my job.” Two underlying themes appear to motivate computer-owners. They want to work at home so that (a) they can have greater control over their work, and (b) they can show greater productivity. Non-computer owners are primarily motivated by one main reason, to catch up on unfinished work. Thus, the reasons for working at home are not the same for both groups, leading to the conclusion that the differential response pattern is (perhaps) due to the presence (or absence as the case may be) of computers at home.

Time Spent on Work-at-Home:
The mean hours of job related work at home is 8.4 hours per week for the computer group and 3.9 hours for the non-computer group, which is a 53% difference between the groups.

Preference for and Satisfaction with Working at Home:
Computer owners show greater preference for working at home compared to non-owners (87% to 67% respectively). Similarly, computer owners expressed greater levels of satisfaction with working at home, 56% of them stating they were "satisfied a lot" compared to only 24% of the non-owners.

One effect of working at home may cause some social concern. A large number of respondents reported that the opportunity to work at home has indeed increased the number of working hours in the home without necessarily decreasing the working hours at the office. Obviously, job-related work seems to intrude on family time.

Summary of the Descriptive Statistics

Clearly, from the descriptive statistics, it can be stated that home computers are used primarily for work purposes followed by educational uses for children. Moreover, computer owners express greater satisfaction with, and have a greater preference for, working at home when compared to non-owners. Thus, in terms of the sub-environments (Figure 2), computers fit quite well in the "Work/Employment" environment and to a slightly lesser extent in "Family development" environment as a result of the educational emphasis. Finally, the growing use of computers for electronic communication would reveal that the "Family Communication" environment may be targeted for growth.

Attitudes Toward Computers

Data were gathered from computer owners and non-owners on their attitudes toward computers and computing. We present three attitudinal constructs in Table 2; Computer Symbolism (4 items), Instrumentalism (5 items) and Satisfaction (9 items). For the first two constructs, opinions were sought from both the owners and non-owners and for the third construct only the owners' attitudes were gathered. All the items were measured on a five point scale including a neutral mid-point, with the response categories, Strongly Agree to Strongly Disagree for Symbolism and Instrumentalism, and Very Satisfied to Very Dissatisfied for Satisfaction. The reliability measures for the three scales were 0.73, 0.79 and 0.60 which are considered acceptable. Table 2 gives all the items and percentage values for Waves 1 and 4. In general, we found low within group variability from wave to wave and have, therefore, decided against presenting data from all four waves. Generally speaking, both computer owners and non-owners have similar views toward computers. Although the direction of their views is the same (with a few exceptions), the difference lies in

how strongly some views are held. Secondly, there is a greater variability in some of the views of computer owners over time suggesting that learning effect has taken place.

Computer Symbolism: Both groups feel quite strongly that computers are not like any other household appliances. They also agree, less strongly however, that computers have a status value, but this view weakens with time for computer owners. In addition, both groups strongly believe that those who are not knowledgeable about computers are falling behind. This became quite clear in our field work. Here is how a proud parent described his daughter's computer abilities:

"Lisa is only eight years old, but she's already ahead of her friends when it comes to computers...They come to our place and Lisa teaches them a lot of stuff. You know how it is. Kids are better off playing with computers than watching TV."

The two groups disagree the most over the issue of home life without computers. Compared to non-owners, computer owners are more supportive of the statement that it is difficult to imagine home life without computers. This feeling strengthens with time indicating an increase in their dependence on computing technology.

Computer Instrumentalism: Both groups believe computers are more useful in the office, although they also believe computers are useful at home as well. Owners hold this latter view more strongly than non-owners. In addition, a large proportion of the computer owners (93%) agree that computers have increased the amount of work that they can do. As is expected, more computer owners (61%) compared to non-owners (49%) support the idea that computers save time at home. Despite this positive perception, neither group believes that computer households are run more efficiently than non-computer households. We found some exceptions to this view in our field work. Here is how a female respondent, a 28 year old financial analyst, described her situation:

"I use the computer a lot. I am the keeper of all the financial records at home and I can't imagine how I managed all this when I didn't have a computer."

Satisfaction With Computer Use:

An overwhelming majority (Wave One, 88% and Wave Four, 90%) of the computer owners indicate a general satisfaction with the way the home computer has lived up to their expectations, and an equally high proportion of respondents express satisfaction with hardware reliability. However, when it comes to software quality and software availability, satisfaction drops to about 60%. And, the level of satisfaction declines even more considerably in regards to the more

operational aspects of computing. Only 48% in Wave One are satisfied with the operating instructions, 45% with the software manuals and 48% with the time it takes to enter data into the computer. For Wave Four, the satisfaction levels of operational aspects decline still further. The greatest dissatisfaction (about 70% in all waves) is with the lack of standardization among operating systems.

This leads to the conclusion that, although most users are satisfied with their computer, they are not especially happy about the operational aspects on a day to day basis. It may be that the average user is able to adapt to the computer environment despite the problems. In our ethnographic work, one male respondent said:

> "When I have a problem with my computer at work, I can seek technical help...and it's fixed in no time. At home, sometimes I get stuck...I can't afford professional help...the manuals are hard to read, but I manage somehow, I can't afford to keep the computer idle."

It is also conceivable that the typical user finds the computer to be useful enough, and that the benefits outweigh the costs of using the computer. Finally, the computer user is perhaps quite knowledgeable enough, and through self-training or trial and error, is able to overcome the problems of operating the computer.

In the next section, we will explore the determinants of computer utilization using a longitudinal data analysis.

Internal Household Diffusion of Computer Use

We also explored how computer knowledge, familiarity, and use patterns diffused among the family members. In particular we were interested in parent to child situation. Here are some findings under different conditions. The data for this section is based on ethnographic field work (see Apendix 1) and the results must be considered tentative.

Case 1. Household membership consists of both parents and children of both sexes.

1.1 If both the parents are knowledgeable about the computers, the internal diffusion of knowledge about computers within the household follows the pattern of father-to-son, and mother-to-daughter.

1.2 If only one of the parents is knowledgeable, the pattern is not clear.

Case 2. Household membership consists of both parents and a child (or children) of either sex but not both sexes.

2.1.If both the parents are knowledgeable, the diffusion is similar to 1.1 above.
2.2. If only one of the parents is knowledgeable, the gender bias does not prevail and cross-gender diffusion occurs.

Case 3. Household membership consists of a single parent and children of both sexes.

3.1 If the parent is knowledgeable about computers, cross-gender diffusion occurs.

Case 4. Children are knowledgeable but parents are not.

4.1 Neither gender bias nor child-to-parent diffusion occurs.

Other aspects of internal household diffusion, including spouse-to-spouse diffusion were not examined in any detail. However, in our ethnographic field work, we found a tendency which suggests that diffusion among spouses was not common.. In our current field work, it has become more common to see children being the principal users of computers in some families instead of their parents. This changes the diffusion issue in some cases from parent-to-child, to child-to-parent (see Case 4 above)..

Statistical Analysis

The objective of the statistical analysis is two-fold. First, it aims to implement the procedures discussed in the Appendix 2 to the panel data. Second, it helps to determine which of the variables specified in Table 1, under the four categories (household-structural, individual, attitudinal and technological), best explain computer use at home.

The results of the analysis are presented in Tables 3 and 4. Table 3 is a statistical analysis of panel attrition. It covers Waves 2 through 4 and contains information on the attrition probability estimation using both probit and OLS procedures. Table 5 shows the results of the regression estimation for all four waves. In Table 4, no correction factor is included for Wave 1, since, by definition, there is no attrition. For the remaining three waves, we provide three types of results: regression estimates without any correction for bias, and regression estimates with probit and OLS corrections. In both tables, values are furnished only for those variables which are significant at .05 probability level or less.

Analysis of Attrition

There are three occurrences of sample attrition in our four wave data. The greatest attrition was observed between Waves 1 and 2 when the sample size decreased by 27% from 613 to 450. The sample sizes for Waves 3 and 4 were 493 and 458, respectively. Earlier work on panel analysis shows that the highest attrition occurs between Waves 1 and 2 and stabilizes later on. The average attrition across the four waves is 24%.

All of the attrition equations (Table 3) are significant, and there is also considerable similarity between probit and OLS procedures. From Table 3, it can be seen that the most number of variables which account for attrition or non-attrition are found between Waves 1 and 2. This is to be expected because it is the point of highest attrition. The results lead to the conclusion that people who rent their homes, who have higher education, and have higher incomes are more likely to drop out. Furthermore, people who spend more time at their job tended to drop out toward the later half of the survey. These findings are consistent with previous longitudinal studies that show people at the two ends of the income scale drop out of panels at a higher rate than those who are in the middle. Since our sample consists of upper income households (relative to the general population) to begin with, we have to interpret this to mean that people who are leaving are at the top of the income categories in the general population. The fact that people who rented their dwellings (as opposed to owning) should not come as a surprise because they are a more mobile group as compared to owners. When we couple this finding with the fact that staying in the panel is correlated with age, it seems that the people who stay in the panel are slightly older and own their homes.

Additional factors account for staying in the panel. Among the structural variables, the important ones are, number of computers users in the family, and home owners. As for the individual characteristics, the variables affecting whether respondents remain in the panel are gender (male), age (older people), and those who read computer magazines. The last variable may imply that people who read computer magazines are perhaps computer enthusiasts and have an interest in the study. Attitudinal variables also play a part; people with more positive attitudes toward computers are also more likely to stay in the panel. Finally, the households who either use the computers for multiple applications or who spend more on computing activity (lagged use variable) are more likely to stay in the panel.

Estimation Equations and Results

The estimation equations are presented in Table 4. For Wave 1, we include only the estimations from ordinary least squares (OLS) regression procedure. For the other waves, three sets of data are presented: regression estimation without correction for bias, estimations with probit correction, and OLS correction. The correction factor (designated by equation 10 in the Appendix 2) is shown at the bottom of the columns for Waves 2, 3 and 4.

The equations are all statistically significant at the .001 level. However, the correction factor is significant only in one case, in Wave 3. An examination of the regression coefficients obtained from the three methods for any given wave reveals little difference between the methods. This suggests that the structural variability is unaffected because there is practically no attribution bias.

Following is a discussion of the structural, individual, attitudinal and technological variables that account for computer use.

The number of users in the household is positively related to computer use, whereas the size of the household is not significant, indicating that household size is not as meaningful of a variable. Obviously, a relationship exists between these two factors but one can not be used as a substitute for the other. Similarly, the number of children is less significant than the number of users, suggesting the same kind of reasoning. Household income shows a slightly negative effect initially but is not significant any more. Rental dwelling versus owned home did not make a difference to the degree of computer use.

In terms of individual characteristics, the important variables are employment hours per week (positive), and reading computer material (positive), and previous computer training (positive). Education seems to have a slight negative relationship but this is not significant. Age has a positive effect but only at the end of the fourth wave. Pleasure reading has a positive effect. Most of these relationships are as hypothesized except for pleasure reading which was positive. What is perhaps most noteworthy is that people who spend more time on work also spend use computers more. Clearly this relationship suggests that computers are viewed and used as work oriented tools.

The next set of variables are attitudinal variables which are positively related to computer use. Computers are once again viewed in terms of both instrumental and symbolic terms. The results also suggest that greater satisfaction leads to greater computer use. Finally, as shown in Table 4, technological variables which include job related use, word processing use and electronic communication use, are positively related to computer use.

As expected, lagged hours significantly influence computer use. That is, the greater the use of a computer in a particular wave, the greater is also its use in a subsequent wave. The expenditures on computing are also positively related to computer use, suggesting a mutually reinforcing relationship between the two.

Overall, the results support the hypothesized positive relationships; hours of employment (positive), work related use, number of users, lagged hours, positive attitudes, electronic communication use, and the amount spent on computing all contribute to computer use.

Discussion of the Results

The discussion of the results are based on both the descriptive data and the results of the longitudinal analysis, and in terms of the models presented in Figures 2 and 3.

We began with the notion that as new technologies are introduced into the market place, the likes of which are not seen before, an appropriate framework for studying the diffusion of these technologies should include an "adoption-use" perspective. In the case of home computers (an example of a discontinuous innovation), a systematic study of their uses will reveal the nature and extent of their adoption. In addition, the technology must fit in the household environment, and the fit is ultimately determined by the use patterns of a given technology. With this rationale to guide us, we set about an analysis of household panel data on computing in the home.

Both the perceptions and behavior of the respondents suggest that computing in the home is a specialized activity. A main reason for this is that computers are not yet fully integrated into the social environment of the household. For example, while the respondents view computers as being useful at home, they also perceive them as being more useful in work settings (i.e. the office). This is further reinforced by the finding that the major use of computers at home is work related.

The nature of the relationship between the computer and work-at-home is also complex. For example, not only do computer owners tend to work at home more than the non-owners, the reasons why they work at home are also different. While computer owners work at home to increase productivity and exercise greater control over their work environment, non-owners tend to work at home to catch up on unfinished work. The fact that computing at home permits this new dimensionality to work-at-home is quite significant. First, it suggests that at least in certain

professions work is portable, and second, the wall of separation between work life and home life may not be as rigid as before.

Furthermore, the fact that people who work longer hours at their job also tend to use computers more indicates a direct relationship between an individual's involvement in his/her job and job related activity at home. These results lead to the conclusion that computers at home increase job related work and extend the work environment beyond its traditional confines.

Computers are also used for children's education, albeit to a lesser degree than work related use. In our sample, 65% of the households have children and 80% of this group report using computers for educational purposes. If we were to directly compare the number of households that use computers for education with households that use the computer for work, the results would be distorted and show a higher magnitude of difference between these two uses. A more correct measure, therefore, is the proportion of homes that use computers for children's education among the 65% of the households have children.

Both the educational and work related uses of computers in the home connect the household to external environments (e.g. work settings and educational institutions) thereby differentiating computers from other household technologies. Clearly, computing technology fits into the Work/Employment environment and Family Development environment as described in Figure 2.

The study also demonstrates a positive relationship between external telecommunication links and computer use. Fundamentally speaking, it suggests that as long as the computer is a stand alone unit, its use is somewhat limited. However, once it is used to access external data bases and communication sources, its use increases explaining the dramatic rise and popularity of new on-line services.

Finally, there is a clear gender orientation in the use of computer at home. Our study revealed this gender bias; male adults outnumber female adults in job related use at home, and male children outnumber female children in educational use. Moreover, this male orientation has an interesting consequence for the diffusion of computing technology. For example, we found that the internal household diffusion of computer knowledge follows gender lines. However, there appears to be nothing inherent either in the computer technology or the user that would perpetuate a gender gap. Indeed, Rudell's (l993) recent work shows that the gender gap has narrowed considerably in the past few years. Even in our study, our descriptive statistics show that, although the rate of female participation in computing activity is low, once women get involved in computing the gap

diminishes quite rapidly. In fact, in the industrial sector, the gender bias seems to be operating in the opposite direction. For example, according to the US Bureau of Census (l991), 32% of men and 43% of women use a computer at work. In fact, it has been pointed out by Wright and Jacobs (1994) that there has been a virtual "ghettoization" of computer work in industry where more and more women are using computers and routine computer work is becoming a low status female occupation. A second aspect of gender orientation is that the internal diffusion of computer knowledge in the household seems to follow gender lines.

A related aspect is how well the computers have been integrated into the household. In contrast to other household technologies, our results show that computers have not been integrated into the social context of the household (See repondents attitudes as reported in Table 2). Although these different domestic technologies may be differentially used by male and female members of the household, the reasons have more to do with the division of labor rather than specific skills. One of our female respondents categorically stated, "I work all day on the computer and I'm sick of it...I want to come home and relax." In other words, what is at issue is not computer skills per se, or whether men or women are better with computers, but the meanings people attach to computers as part of their life's central themes.

Theoretical Analysis of the Results

For the theoretical analysis, we refer to the models in Figures 2 and 3. Earlier in the paper, we introduced the concept of technological fit and the conditions under which it occurs. We have modeled the household in terms of sub-environments in which family members perform household activities and use the various household technologies to assist them in performing those activities. In order for the technological fit to exist, the sub-environment must be relevant to the household, and the particular technology must be salient within the sub-environment. Also, there must be members of the household who can use the technologies.

Our results clearly show that one major use of the computers is job-related; that is, computers primarily fit into the Work/Employment sub-environment. In fact, 70% of the computer use in the household is explained by the use in this sub-environment. To a lesser degree, computers are used for children's education and for communications outside the home. These results show that as computers become salient to more sub-environments, their acceptance within the home will increase appreciably, and this trend is already evident. The implication of this result to the theory of diffusion of technology is quite profound. First, it raises questions about the notion of "diffusion in use," which, unlike the concept of diffusion of adoption, has not been a major research topic in consumer literature. In reference to Figure 2, it suggests that diffusion within the

home can be studied both structurally and dynamically. For example, if the diffusion of computing takes place from one sub-environment to another, this suggests a structural diffusion. On the other hand, if diffusion takes place between the members of the household, say, from parent to child or one spouse to another, or between neighbors, this suggests a dynamic diffusion. In our study, we saw some evidence of gender based diffusion in use. We believe there are more aspects to technology diffusion within the household which have not been investigated here.

An equally important aspect of the current research is that it highlights the fact that computers have become the foremost technology to bridge the domestic world with the world of work. This has far reaching implications to our conceptualization of the relationship between work and family life in the industrial world. For over a hundred years, these domains have remained separate under the industrial model, clearly separating and shaping our views about the technologies of worklife and family life. By bringing the work-oriented computer technology into the home, we are witnessing the merging of these two separate domains for the first time in the industrial world. Four explanations are offered to shed some light on this transformation.

First, of all the sub-environments shown in the model, the Work/Employment sub-environment is the only one that can conceivably be perceived as “alien” to the family life. That is, to the extent that families look at work as something that belongs to the non-domestic part of their life, the computer may itself be seen as a non-domestic technology--this, in spite of the fact the computer is physically located in the home. Some of our respondents actually state that they do not consider computers to be domestic technologies.

Second, although computers were not integrated into the domestic environment for nearly a decade, there now have been dramatic shifts in the way computers have migrated into the home. In terms of the present model, this can be interpreted to mean that computers are beginning to occupy a significant space in sub-environments other than “Work/Employment.” We would like to call this the “domestication of the computer,” or equally, it represents the “computerization of the household.” In our study, households with electronic communication links to the outside world were found to have a higher propensity to use computers. Theoretically speaking, this is a transformation of the traditional industrial model to a postindustrial model in which the work and family life are no longer strictly separated. As such, this evolution requires us to develop new ways of interpreting the work and home environments to incorporate this emerging technology.

Third, computers have given rise to a new culture, which is variously termed as "the mode of information (Poster (1990), or the “cyberculture” (Escobar 1994) and the like. The diffusion of

computer technology, therefore, into the home and its ubiquitous use is likely to result in the reconfiguring of the consumer culture in terms of the emerging computer culture.

Fourth, our study clearly reveals the current gender orientation of computer technology. However, this bias has already begun to diminish in two major ways. For example, in a study currently in progress by the current authors, both gender and age are becoming less of a significant factor in computer use. It is no longer possible to state that computer technology is either a male or adult technology exclusively. However, it still holds true that men are more likely than women to use computers (and related technologies) for some time. Recent trends also show that children are major users of computer technology. Thus, for the first time in the history of humankind, children instead of adults are emerging as the possible primary users of a major technology.

Finally, the interface between technology and the household is bi-directional. Computer technology is already making a powerful impact on family life, and simultaneously, the household members are actively shaping the character of technology by determining how it may be used within the home. This notion of a bi-directional relationship between the user and technology has not been addressed in the consumer literature. This is possibly because of our past preoccupation with product purchase or adoption behavior.

Conclusions and Implications of the Study

This study intersects two main themes, household consumption behavior and the emergence of new information technologies. The combination of these two themes converge into a scheme of knowledge pertaining to household behavior in regard to technology adoption and use. Given that household behavior has been an understudied area in the field of consumer research, we believe that our study makes a modest but significant contribution to this area both theoretically and empirically.

Further, the present research describes the social transformation taking place in the diffusion of information technology to all sectors of our society. In particular, recent developments suggest that the "home" is the site of the future application of these technologies. With this growing realization, many companies are investing in the home market, and they seem to be doing so without a full understanding of household behavior. In this context, it is important to note that the household adoption of technologies is different from organizational adoption of technologies, and the standard industrial models would not be appropriate for the household market. The technological fit model (Figure 2) is intended to describe at least in part the special differentiating

character of the household. It is also important to remember that households are basically conservative institutions, and unlike business organizations, do not undergo constant or dramatic changes because of market imperatives.

Finally, although the model we have proposed in Figure 2 was developed in connection with technology use at home, it must be apparent that, with only minor modification, it can be easily to applied to household consumption behavior in a more general context. Given that the household consumption behavior has been a rather neglected area of research (Sherry 1995, p), we believe that we have provided an impetus for researchers to examine household consumption using this model and extending to it to other consumption contexts. Parenthetically, we might add that this model is being used in a cross-cultural research study (Figure 1, Box) to examine household use of technologies.

Appendix 1

Ethnographic Field Work

The ethnographic field work for this study was conducted in three cities in Northern California (Berkeley, Richmond and Oakland) and in Greater Los Angeles and Orange County. The interviews were conducted in the homes of 28 families who owned computers. The families belonged to middle class professional groups and varied in terms of family size and family life cycle stage. The interviews were tape recorded and ranged from any between 2 1/2 to 3 1/2 hours. In some cases, the interviews were also video-taped with the permission of the respondents. Five of the interviews involved children and four of the interviews involved both husband and wife. Although the focus of the study was computers, the interview protocol included questions on other domestic technologies with a view to gaining theoretical insights into the nature of household-technology fit. The following is the interview protocol. The full ethnographic study is available upon request.

APPENDIX 1 - ESTIMATION OF THE DETERMINANTS OF COMPUTER USE

Model Structure

Let the total number of hours of computer use per week be the dependent variable and let

$$y_n = x_n ß + \varepsilon_n \qquad n = 1....N \qquad \text{——— (1)}$$

where y_n is the number of hours of computer use for the nth household in a given wave i, ß is a vector of coefficients, x is a vector of explanatory variables, and ε_n is a random error term, distributed $N(0, \sigma^2\varepsilon)$.

It is quite likely that those who use the computers less in one wave also show less enthusiasm to participate in the next wave. Thus there is a relationship between participation in a prior wave and attrition, or the error term ε_i and the error due to attrition, say, δ.

It is also likely that the terms between two waves are related, that is, those who tend to over-report (under-report) the hours of computer use in one wave perhaps tend to over-report (under-report) in the next wave. Thus it is possible that ε_i are correlated in two successive waves.

It is well known that because of the problems of attrition and reporting errors, regression estimates in equation 1 will be biased. Recently, Hausman and Wise (l976, l979), Heckman (l979), Kitamura and Bovy (l987) and Winer (l983) and others have developed bias correction procedures.

We can illustrate the relationships between the error terms before discussing the correction procedures. Let us examine, as an example, Wave 1 error term ε_1, Wave 2 error term ε_2 , and the attrition error term δ. The chronological relationship between these three error terms can be viewed as follows (Kitamura and Bovy, l987):

ε_1 ε_2

δ

The above illustration suggests that the Wave 1 error term, ε_1, influences the attrition error term, δ and the Wave 2 error term, ε_2. Additionally, ε_1 and δ jointly influence ε_2.
Kitamura and Bovy (l987) propose estimation procedures using corrections based on $E(\delta/\varepsilon_1)$ and $E(\varepsilon_2/\varepsilon_1$, given the value of δ) for estimating the model for Wave 2.

An approach which is structural but not chronological simply evaluates the covariance between the error term of the structural model, ε_i and the attrition error term, δ. Thus we have the following relationship:

ε_i <----------> δ

Whether one uses the chronological representation or the structural representation the ultimate result seems to be the same. The derivation for the structural representation as developed by Winer (l983) is less cumbersome and will be used in this paper. We give the main points of this estimation procedure and refer the reader to Winer's paper for fuller development.

Let the structural model for a given wave be specified by

$$y_n = x_n\beta + \varepsilon_n$$

as before in equation 1.

Let $D_n = 1$ if y_n is observed for a household in the panel, and $D_n = 0$ if y_n is not observed due to attrition. Assume that y_n is observed ($D_n = 1$) if

$$d_n = \alpha y_n + x_n\gamma + w_n\theta + \mu_n \geq 0 \qquad \text{_____(2)}$$

where y_n and x_n are as before, W_n is a vector of variables that influence the household to be in the model but do not affect the value of y_n.

Dropping subscripts we shall rewrite d, as

$$d = (x\beta + \varepsilon) + x\gamma + w\theta + \mu \qquad \text{_____(3)}$$

$$= x(\alpha\beta + \gamma) + w\theta + \alpha\varepsilon + \mu$$

By setting $(\alpha\beta + \gamma) = \Pi$ **and** $\alpha\varepsilon + \mu = \delta$ **we can restate equation (3) as follows:**

$$d = x\Pi + w\theta + \delta \qquad \text{_____(4)}$$

For households who remain in the panel the equation can be rewritten as

$$E(y/x, D = 1) = x\beta + E(\varepsilon/x, D = 1) \qquad \text{_____(5)}$$

where E(.) is the expected value operator. Based on Johnson and Katz (l970, p.81; l972, p.112) we can show that

$$E(\varepsilon/x, D = 1) = E(\varepsilon/x, \delta \geq - x\Pi - w\theta) \qquad \text{_____(6)}$$

Winer (l983) has further shown that

$$E(\varepsilon/X, \delta > - x\Pi - w\theta) = \frac{\text{cov}(\varepsilon, \delta)}{\sigma_\delta} \cdot \frac{f\left(\frac{x\Pi + w\theta}{\sigma_\delta}\right)}{F\left(\frac{x\Pi + w\theta}{\sigma_\delta}\right)} \qquad \text{----(7)}$$

Thus one can see that the critical value in panel estimation is the covariance between the structural error, ε**, and the attrition probability error,** δ**.**
If cov (ε**,** δ**) =** 0**, the whole expression on the right side of the equation is non-zero. If cov (**ε**,** δ**)** $\neq 0$**, the term drops from equation 5 and the estimator of ß is unbiased.**

If we let

$$\frac{\text{cov}\ (\varepsilon, \delta)}{\sigma_\delta} = \lambda$$

and

$$\frac{f[(X\Pi + W\theta)(\sigma_\delta)^{-1}]}{F[(X\Pi + W\theta)(\sigma_\delta)^{-1}]} = z \qquad \text{_____(8)}$$

then equation 5 becomes,

$$E(y/X,\ D=1) = X\beta + \lambda z \qquad \text{_____(9)}$$

and the estimation equation is

$$y = X\beta + \lambda z + \zeta,\ \zeta \approx N(0,\ \sigma_\zeta^2\ ) \qquad \text{_____(10)}$$

According to Winer (l983), two procedures, which are shown below, are available to estimate equation 10; one based on probit correction (Heckman l979) and the other based on OLS correction (Olsen, l979).

Procedure 1:

1. Estimate equation 4 using probit analysis on the whole sample and set $d = 1$ **for the household in the sample and** $d = 0$ **for the dropout.**

2. From the parameters of step 1 (Π, θ **and** σ_δ **) estimate** z **in equation 8 for each household still left in the sample.**

3. The estimate of z, z **is then used in the equation 10 to estimate** λ **and** β **by ordinary least squares.**

Procedure 2.

If we assume that δ, the attrition error is distributed uniformly over [0,1], the equation 10 can be written as

$$y = x\beta^* + \lambda^* z^* + \zeta^* \qquad \text{(11)}$$

where $\lambda^* = \dfrac{\text{cov}(\varepsilon, \delta)}{\sigma_\delta} (\sqrt{3})$ **and**

$z^* = (x\Pi + w\theta) - 1$, **$\Pi$ and θ are computed using OLS.**

Now, the three steps are,

1. **Estimate equation 4 using OLS on the whole sample with** $d = 1$ **for the household still in the sample and** $d = 0$ **for a dropout.**

2. **From Π θ in step 1, construct** $d = (x\Pi + w\theta)$

3. **Let** $z^* = d - 1$ **and estimate β^* and λ^* in equation 11 using OLS.**

In this analysis both procedures will be adopted and compared.

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