# A Longitudinal Examination of Internet Diffusion and Adopter Categories

**Robert J. Lunn & Michael W. Suman**, USC Annenberg Center for the Digital Future, US

**Abstract**

The examination of Internet utilization data with a series of "snapshot" cross-sectional studies (Rogers, 1995) provides an easily understood summary of how Internet usage diffused in the United States over time. Unfortunately, snapshot cross-sectional research designs can lead to under-conceptualizations with respect to the underlying Internet diffusion process. Classical literature shows us that the technology diffusion process is inherently complex, usually involving heterogeneous populations, and is correspondingly under-conceptualized through the use of single summary percent utilization figures. In this initial examination of data from the longitudinal Digital Future Project we examine how United States Internet diffusion, including attitudes, opinions, and behaviors for the same 453 subjects, varied over a seven year period (2000 - 2006). We find six distinct adoption (3), non-adoption, discontinuance, and intermittent usage patterns. We describe these adoption groups in terms of their different demographic and behavioral characteristics. We also expand on traditional Internet diffusion studies by demonstrating how amount of access (hours per week) increases as a function of time across the same respondents.

**Keywords**: panel data; internet diffusion patterns; usage rates; change trajectories; United States.

## Introduction

A prerequisite for classifying systems is a conceptual framework within which a system's properties can properly be codified (Klir, 2001). The conceptual framework underlying Internet adoption provides the basis for all subsequent analytical work. Individuals in a social system do not universally adopt innovations at the same time. Because of this it is useful to categorize individuals on the basis of when they first began using an innovation. Classical diffusion literature (e.g., Rogers, 1995) points out that diffusion groups vary based on whether or not adoption has occurred, when individuals adopt, and whether adoption is followed by discontinuance. Studying the adoption of innovations provides a means of tracking social and behavioral change as new concepts, technology, and ideas disseminate throughout the social system. Studying the diffusion process gives "life to a behavioral change process. Conceptual and analytical strength is enhanced by incorporating time as an essential element in the analysis of human behavior change" (Rogers, 1995, p98). In this study we examine the adoption of the Internet in the United States using a panel research design tracking the same respondents Internet usage, attitudes, and opinions over a seven-year (2000 to 2006) period. While the USC Annenberg Center for the Digital Future has published yearly cross-sectional results, this article provides a first look at some longitudinal panel aspects of that data.

Longitudinal panel research is inherently more resource intensive, time consuming, complex, and methodologically challenging than traditional repeated measures cross-sectional research designs. With cross-sectional data results are quickly obtained. However, with longitudinal data the focus is on the form of the adaptive process for the same individuals over time. With a two wave longitudinal panel study one can detect change; with three waves one can determine if change is more or less linear or non linear. However, since most diffusion processes follow an S-shaped diffusion pattern (Rogers, 1995), we often require more than three waves of data to truly understand the change trajectory.

There have been many studies on the Internet that use cross-sectional data, but there are substantial advantages that accrue from using true longitudinal data. For example, respondents can serve as their own controls. Causal relationships can often be established using longitudinal panel data. Longitudinal panel data also allows researchers to distinguish how individuals change over time as opposed to changes in cohort behavior over time (Singer & Willett, 2003). An illustrative example serves to clarify this point. Using our data in a repeated measures cross-sectional analysis we find that average hourly Internet usage increased by 86% over seven years for the 19 to 24 year old age cohort. However, looking at the same 19 to 24 year old individuals over the same seven years, we find that average Internet hours of usage actually increased by 39%. The two results tell us different things. Using the data in a cross-sectional research design approach indicates that the 19 to 24 year old age cohorts of 2000 and 2006 are experientially different. For example, the 19 year old in 2006 was 13 in 2000, whereas the 19 year old in 2000 was 13 in 1994. The amount of time children spent using computers increased by one-third just from 1998 to 1999 (Subrahmanyam, Kraut, Greenfield & Gross, 2000). Hence, the 19 year old of 2006 would be expected to have a higher Internet usage rate because they started using computers earlier and more extensively than the 19 year old of 2000. Using the data in a longitudinal panel design approach tells us more accurately that the Internet use growth rate for 19 to 24 year old individuals from 2000 to 2006 was about six percent per year (5.6), not twelve percent (12.3) per year as indicated with the repeated measures cross-sectional cohort analytical approach. This is a significant difference of approximately 120 percent.

Our focus in this first look at longitudinal panel data is on verifying the existence of traditional innovation adoption groups with respect to usage of the Internet from 2000 through 2006. Our second focus concerns how Internet usage grows over time for the different adoption groups. Our third focus is looking at demographic differences between the different diffusion groups.

modified. Basically, profitability is still being promoted and also the fact of reaching the highest possible share rates. The range reorganization is a need for the digital revolution to move forward.

## Methods

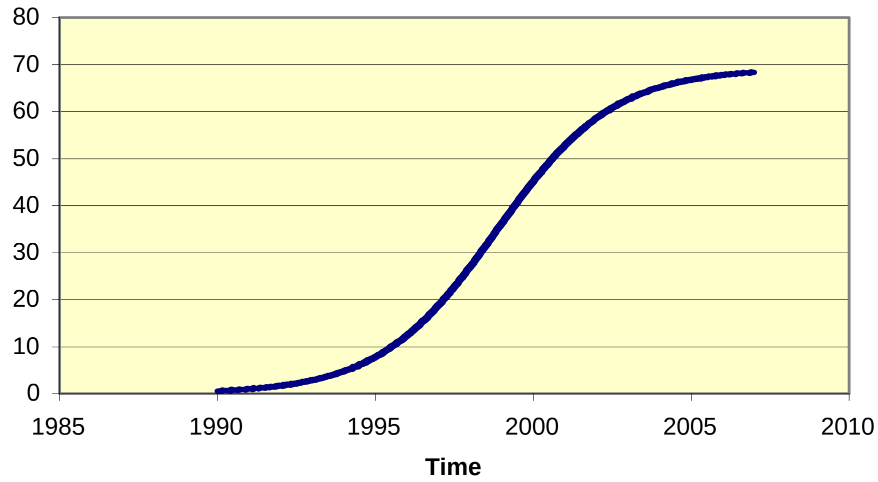
Data are from Surveying the Digital Future, a nationally representative telephone survey of individuals in the United States 12 years of age and older. Yearly sample sizes were in excess of two thousand respondents. Data were collected in the summer and fall of 2000 through 2006 (with the exception of 2004). An equal probability selection method (EPSEM) was used to identify the original sample in Year 1, as well as replacement respondents in subsequent years. During the first call, the interviewer spoke with an adult to create a list of all household members 12 years of age and older from which one member was randomly identified to participate. Interviews were completed in either English or Spanish and took an average of 34 min. To replace dropouts, additional phone numbers were randomly identified via EPSEM and called. The final study protocol was reviewed and approved by the Institutional Review Boards of the University of California at Los Angeles and the University of Southern California, which were also responsible for overseeing compliance with human subjects research standards.

The Digital Future Project is a comprehensive, year-to-year examination of the impact of online technology on America. The study gathers data about who is online, how long they are online, and what they do online. It also examines the implications of the use of online technology, and links this use to a broad range of values, behavior, attitudes, and perceptions. In this study we examine two main variables, Internet adoption and usage. Adoption is measured by whether or not one personally uses the Internet from anywhere. Usage is measured by how many hours per week on average one is online from anywhere.

## Results

In classical diffusion literature (e.g., Rogers, 1995) there are seven diffusion groups: innovators, early adopters, early majority, late majority, laggards, non-adopters, and discontinuers. We know from historical country-based Internet usage data (e.g., ITU, AC Nielsen, the UN) that in the United States Internet innovators likely adopted by 1992, and early adopters adopted by 1997 (Figure One). Therefore, the members of the longitudinal panel that were Internet users by 2000 were actually a mix of innovators, early adopters, and some early majority adopters.

**Figure One**
**United States Internet Diffusion Over Time**




Authors, In preparation

We segmented our panel into groups based on theoretically expected patterns (Rogers, 1995) of Internet use/non-use across our seven years of data (Table One).

Table One

Internet Diffusion Groups

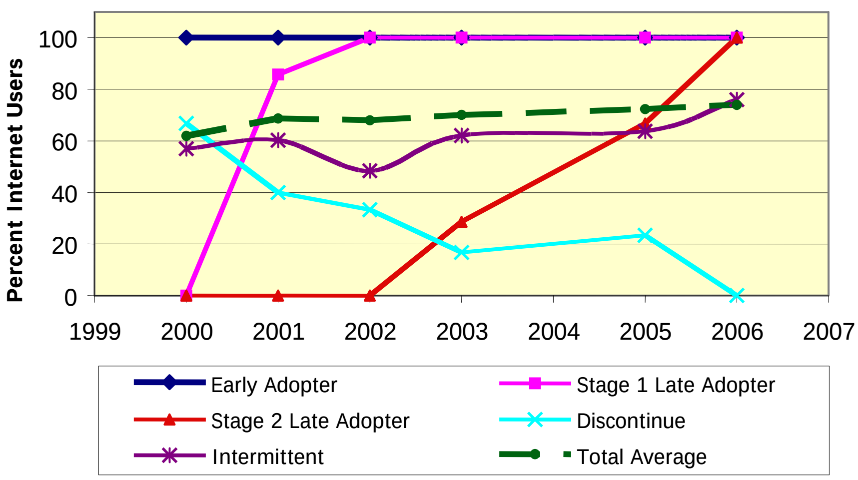
| Diffusion Groups | Frequency | Percent |
|---|---|---|
| Innovators/Early Adopters | 228 | 50.3 |
| Late and Later Adopters | 42 | 9.3 |
| Laggards | 21 | 4.6 |
| Non Adopters | 74 | 16.3 |
| Discontinuers | 30 | 6.6 |
| Intermittent | 58 | 12.8 |
| Total | 453 | 100 |

Individuals who were contiguous Internet users for all waves were classified as a combined innovator/early adopters group. Individuals who were non-Internet users in 2000, but were contiguous Internet users from 2001 on are considered as late majority adopters. Individuals who were non- Internet users from 2000 through 2003 but were contiguous Internet users from 2004 through 2006 are considered as laggards, or, as we prefer to call them, later adopters. Individuals who were non-Internet users from 2000 through 2006 are non-adopters. Individuals who were Internet users in 2000 but whose members gradually stopped using the Internet by 2006 or were not Internet users in 2000, but were Internet users for one of the waves, excluding the last wave, constitute the discontinuance group.

After completing this initial classification we found an additional 58 individuals who did not fall into a classical diffusion category. These individuals are intermittent Internet users. They actually oscillate between Internet usage and non-usage but are slowly trending towards contiguous Internet usage.

Figure Two demonstrates the use/non-use patterns excluding the non-adopter group. Figure Two emphasizes that it is difficult to form an accurate assessment of how the Internet diffused throughout the United States without taking into account the existence of classical diffusion groups. This is difficult to do in a repeated cross-sectional research design unless one depends on long-term memory data. The green dashed line in Figure Two represents average Internet usage across all groups. It is immediately evident that a single average Internet usage figure plotted over the years does not well represent the complexity of the underlying diffusion of innovation process.

**Figure Two**
**Patterns of Internet Use Diffusion by Year**



Intermittent adoption of an innovation is not discussed in the classical literature where innovations are usually adopted, rejected, or gradually disused over time. Apparently adoption of a service paid for on a monthly basis is inherently different from adoption of an innovation paid for on a one-time basis, such as a microwave oven. With a monthly service each time you pay the bill represents a decision point as to whether the service is worth the price or not. Purchasing something like a microwave oven involves only the initial decision point, and once you own it, you would be oriented towards continual usage in order to get your money's worth out of that investment. The intermittent Internet user group accounts for about 13 percent of general Internet users. Its existence might explain some of the marked variation observed in overall average Internet usage provided by different repeated measures cross-sectional research studies over time. Table Two provides a more detailed picture of six respondents selected at random from the intermittent users group. As can be seen, the pattern of usage and non-usage is somewhat chaotic. Such a detailed view showing the complex nature of Internet diffusion without dependence on long-term memory is only possible using longitudinal data.

Table Two

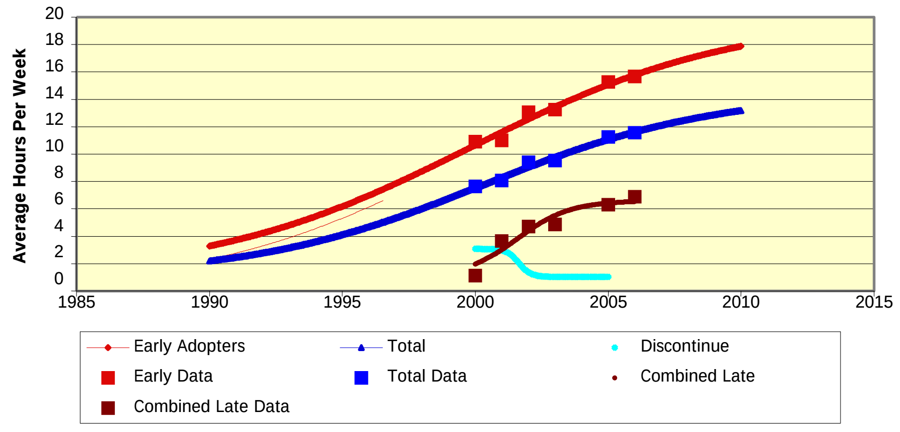
Six Randomly Selected Intermittent Internet Users Pattern of Usage

| | Wave 1 | Wave 2 | Wave 3 | Wave 4 | Wave 5 | Wave 6 |
|---|---|---|---|---|---|---|
| s1 | N | N | Y | Y | N | Y |
| s2 | N | Y | Y | Y | N | N |
| s3 | Y | N | N | N | N | Y |
| s4 | Y | Y | Y | Y | N | Y |
| s5 | N | N | Y | Y | N | N |
| s6 | N | Y | N | N | Y | Y |

**Amount of Internet Usage Follows an S-shaped curve:**

Most diffusion studies' S-shaped curves are associated with percent of the total population adopting. Figure Three demonstrates that degree of Internet usage (hours per week) also follows an S-shaped curve. Even discontinuance of Internet use follows an S-shaped curve. We have extended the form of the derived S-shaped curves beyond our actual data to illustrate their overall shape and to provide estimates on projected future growth amounts. Actual data values are signified by the points on those curves.

**Figure Three**
**Fitted S-Shaped Curves To Average Hours Per Week By Four Adopter Groups**

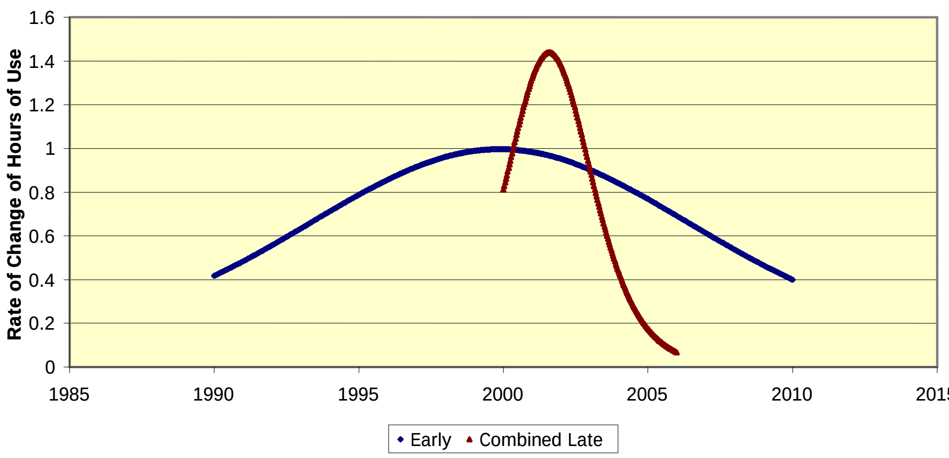



Earlier adopters' Internet usage in 2006 is 150% greater in hours per week than that of later adopters. In addition, while Internet usage of earlier adopters is projected to continue to grow another 35 to 40 percent through 2018, later adopters degree of utilization is already near its projected asymptote level of six hours per week. Clearly, later adopters are using the Internet less, which suggests they are using the Internet differently.

### Rate of Change of Internet Usage:

The first derivative of an S-shaped curve is called the Probability Density Function (PDF). It represents the rate of change of the adoption process over time. The peak value of the PDF provides the peak adoption rate, i.e., the fastest rate of adoption over the time period. Figure Four demonstrates the underlying PDF curves for our early adopters and later adopters using our longitudinal panel data.

**Figure Four**
**Rate of Change of Hours of Internet Use by Time For Two Adopter Groups**




The peak rate of change in Internet usage (increases in hours per week of Internet usage) is significantly higher for later adopters than early adopters (1.4 versus 1.0).

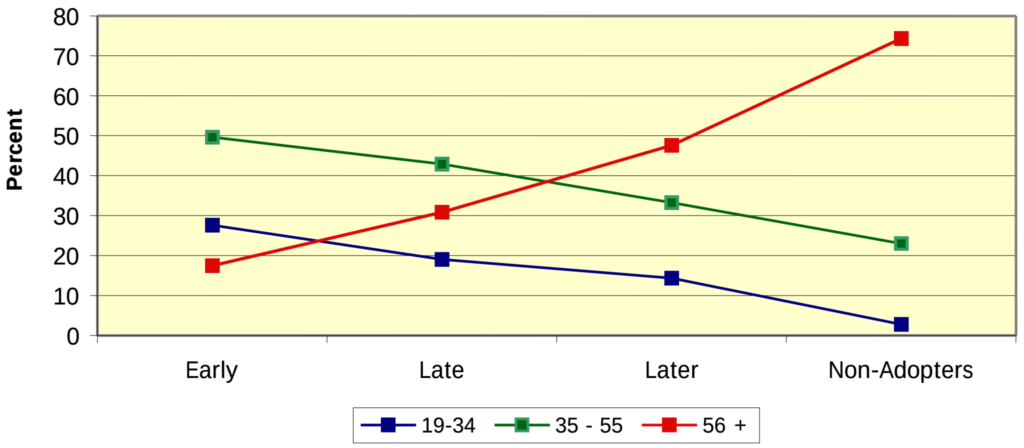
One plausible interpretation for this pattern of results relates to being on the "bleeding edge" of technology, i.e., when a technology is first developed it is relatively expensive and difficult to use. However, while later adopters increase their Internet usage more rapidly than early adopters, they do not sustain that rate of increase. So late adopters adopt later and exhibit faster increases in hours of usage, but they also reach their saturation point quicker than early adopters.

**Demographic Characteristics of Adopter Groups:**

There is a clear association between age and Internet adoption group membership. The proportion of individuals over age 55 increases exponentially as we move from early adoption, to late, later, and non-adoption. The proportion of individuals over age 55 increases from 18 percent for early adopters, to 48 percent for later adopters, to 67 percent for individuals that discontinued usage, to nearly 75 percent for non-Internet adopters. (Given the age profile for non-Internet adopters we checked their employment status. Seventy-two percent were unemployed in 2000 and the proportion of unemployment increased to seventy-seven percent by 2006.)

The majority of early adopters were not our youngest group, but were ages 35 to 55. We suspected this was due to the likelihood that older individuals needed the Internet for work. Looking at our early adopter group in wave one we found no differences between percent of home Internet usage between individuals that were 19 to 34 and 35 to 55 year olds. However, early adopters between the ages of 35 to 55 reported 49 percent greater hours of Internet work time. We can assume that a great percentage of early Internet adopters started using the Internet for work-related reasons.

**Figure Five**
**Percent Age Groups by Adoption Groups**




We confirm classical diffusion studies finding that early adopters have higher incomes and greater levels of education than later adopters (Figures Six and Seven). For example, thirty percent of the early adopters versus seventy six percent of the non-adopters reported income less then fifty thousand dollars. Fifty percent of the early adopters versus less than ten percent of the non-adopters reported four or more years of college education.

**Figure Six**
**Percent Income Less Than 50K by Adopter Groups**

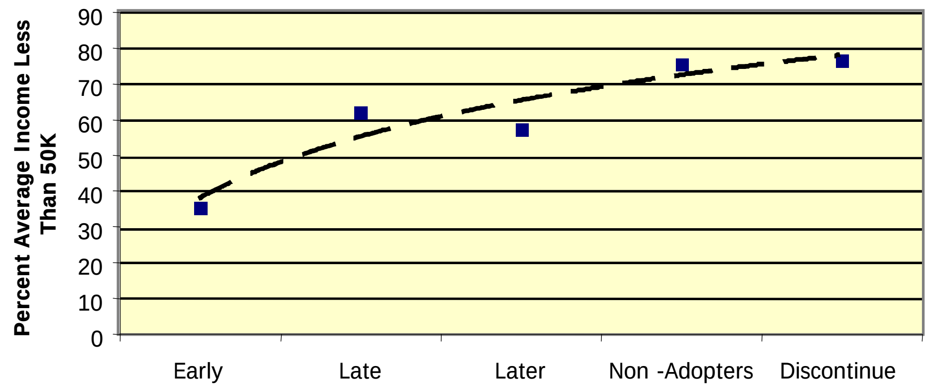
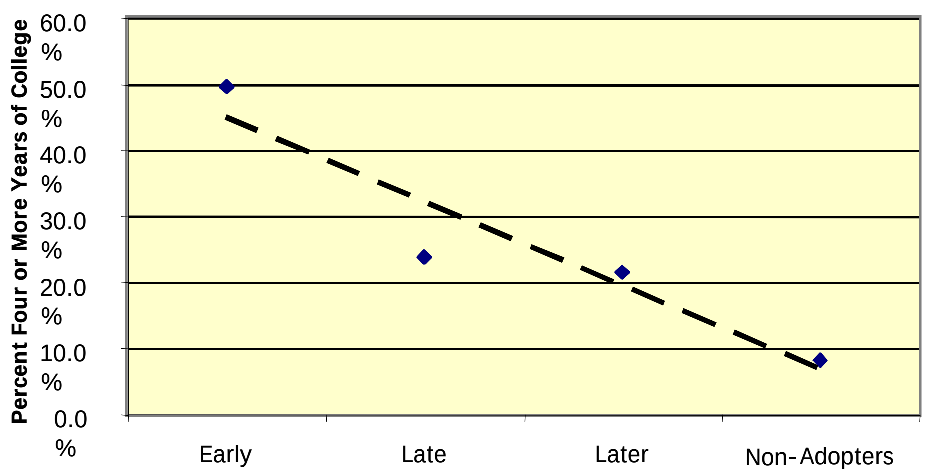



**Figure Seven**
**Percent Four or More Years of College by Adopter Groups**



**Reasons for Non-Adoption or Discontinuing Internet Usage:**

The original version of the survey questionnaire contained nine multiple-choice reasons for not using the Internet or discontinuing Internet usage. We performed a Principal Components analysis and found six factors. The bold numbers in Table Three identify the primary factor loadings. The closer the factor loading is to 1.0, the greater the correlation of the variable with the sense of the latent factor. The six-factor solution accounted for 74% of the total variation.

Table Three

Factor Analysis of Stated Reasons for Not Using the Internet

| Reasons for Discontinuing | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 |
|---|---|---|---|---|---|---|
| Computer not good enough | 0.75 | 0.28 | -0.08 | -0.12 | -0.28 | 0.12 |
| Connection too slow | 0.69 | -0.20 | 0.09 | 0.05 | 0.29 | -0.09 |
| Do not know how to use | -0.02 | 0.85 | 0.13 | 0.02 | 0.05 | 0.02 |
| Fear of / Confused by technology | -0.18 | 0.25 | 0.81 | -0.09 | 0.02 | 0.04 |
| Too difficult to get connected | 0.42 | -0.14 | 0.66 | 0.13 | 0.01 | -0.05 |
| Too Expensive | -0.04 | 0.01 | 0.02 | 0.90 | -0.08 | 0.09 |
| No computer | 0.07 | 0.47 | -0.07 | 0.47 | 0.30 | -0.21 |
| No interest | 0.02 | 0.11 | 0.02 | -0.03 | 0.89 | 0.10 |
| Privacy concerns | 0.01 | -0.02 | -0.01 | 0.05 | 0.09 | 0.96 |

Percent responses were then accumulated according to the factor structure. Data for late adopters were provided from the time period just previous to Internet adoption. Data for the Internet discontinuance group was provided just after they stopped using the Internet. Data for the intermittent group was provided just after their first discontinuance (Figure Eight).

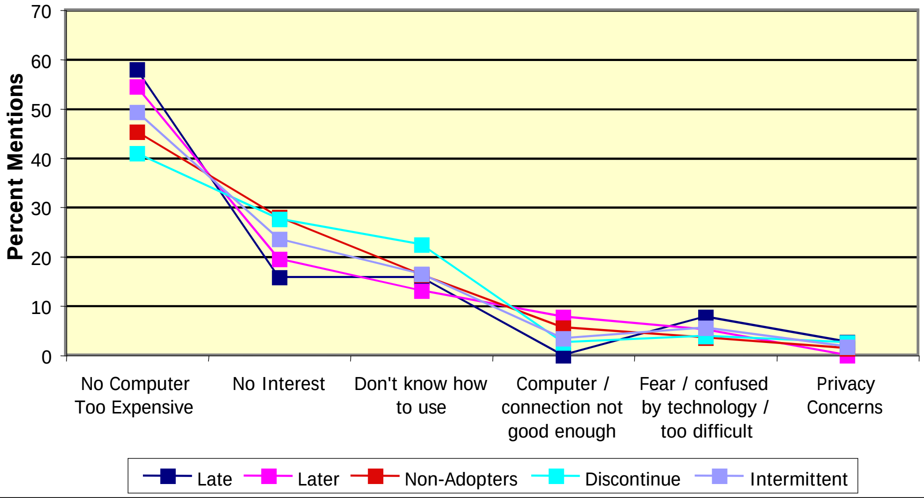



**Figure Eight**
**Stated Reasons for Not Using the Internet or For Dropping Internet Usage**

The response patterns are quite similar. The top three reasons for late adoption or discontinuance are cost, lack of interest, or lack of knowledge. The discontinuance group seems to be somewhat stronger with respect to lack of interest and lack of knowledge.

## Conclusions

Diffusion of innovations such as the Internet does not occur uniformly through a social system. There are distinct groups of individuals that adopt, do not adopt, adopt later, adopt much later, or even intermittently adopt. An overall population S-shaped diffusion curve provides an aggregate look at how the adoption process proceeds over time. However, the actual underlying population is heterogeneous with respect to adoption intentions and the actual pattern of adoptions is far more complex than implied by looking at a total population's S-shaped diffusion curve (see for example Figure One).

Confirming classical literature, we find that earlier adopters are individually younger, more educated, and exhibit higher income levels. Individuals who do not adopt or adopt later are predominantly older. The stated reasons for not adopting the Internet or dropping Internet usage are nearly identical regardless of when adoption occurred. The three primary reasons are no computer/too expensive, no interest, or don't know how to use it. Over three-fourths of non-adopters were unemployed in 2006 pointing out that Internet usage has a strong economic and active work force requisite. One needs money to pay for monthly access, and one needs training to both appreciate the Internets' value and to be able to use it. Provision of low cost computers is a start, but if society decides it wants non-adopters to have Internet access then poorer individuals will require financial aid. They might also require technical training so they can appreciate the significant advantages of being connected to the World Wide Web. Simply providing inexpensive computers to older or non-trained individuals might prove insufficient.

It is difficult to calculate accurate long-term growth rates using a repeated cross-sectional research design because cohorts exhibit experiential drift (Singer & Willett, 2003). This is confirmed in this study where we found average growth rate in Internet hours of use for 19 to 24 year olds to be 100 percent greater for a repeated cross-sectional research approach as opposed to a longitudinal panel approach. Given that the predominance of research on diffusion of the Internet in the United States uses a cross-sectional research design approach, this finding has important ramifications with respect to planning for future infrastructure needs.

Most innovation diffusion studies focus on use or non-use. This study expands on that information by examining the change trajectories for amount of Internet usage. Degree of utilization change trajectories also follow S-shaped curves. As with use and non-use, change trajectories for amount of utilization differ depending on when the Internet was adopted. Earlier adopters' Internet usage in 2006 is 150% greater in hours per week than later adopters'. In addition, while Internet usage of earlier adopters is projected to continue to grow another 35 to 40 percent through 2018 (Figure Three), later adopters degree of utilization is already near its projected asymptote level of six hours per week. We also found that the rate of increase for later adopters is faster than the rate of increase for the earlier adopters. We suggest this pattern of results relates to being on the "bleeding edge" of technology, referring to technology that is so new that it is difficult to use, expensive, and entails a greater financial risk, especially if the innovation is not subsequently broadly accepted. We also found that the projected Internet utilization growth for later adopters is relatively flat. This implies that later adopters are using the Internet differently than early adopters.

We would like to point out that cross-sectional research designs are not totally flawed with respect to many of their findings. However, the addition of longitudinal data will very likely support and augment many of the conclusions based on cross-sectional research designs. We do anticipate substantial increases in the precision of analytical findings and a great deal of improvement with respect to causal implications.

### Future Research

In the near future we will begin an examination of the longitudinal panel data in a more individualistic manner. For example, the current aggregate analysis of same respondents data demonstrates a clear association between income levels and when adoption occurs. This needs to be explored further by looking at how changes in individual income levels affect Internet adoption and discountenance, providing a stronger causal connection between (1) wealth and (2) Internet adoption and degree of utilization.

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