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An Examination of Home Internet and Mobile Device Use in the U.S.

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Abstract

It is important to understand the determinants of the extent and types of activities performed by home Internet users and by mobile device users, as well as the interactions between these modes of usage. Few studies have looked at the interactions between these two channels of digital communication. While most prior research has been based upon surveys of attitudes toward and intentions to use a technology (and lack a final link to actual usage), in this study, the extent of actual home Internet use, mobile device use, and the simultaneity between these modes of usage are examined. We find that, overall, mobile device use is enhanced by home Internet use, while the two act as substitutes in the case of advanced and sensitive applications.

Keywords: internet use, mobile device use, mobile devices, home internet

Introduction

Expansion in the extent of home Internet use and the types of activities performed online is a very important social and economic phenomenon. More recently, mobile devices capable of accommodating many of these same activities have become widely available. Trends in the use of these devices and the interaction between their use and the use of home PCs and laptops are likely to have crucial social and economic implications for decades to come.

Internet use has moved from the very basic activities of email and web surfing to advanced uses such as buying and selling online, dealing with government agencies for filing tax returns and other documents, making invoice payments, transferring funds and carrying out other banking activities which were hitherto done by regular mail or manually; other enhanced uses are looking up locations and obtaining driving directions, social networking, streaming audio and video, chatting with the help of specific applications (MSN Messenger, Skype) meant for this purpose, and telecommuting.

Mobile devices (such as smartphones and tablets) have progressed beyond their initial uses for phone calls and text messages to include many of the same uses as desktop machines described above. Research firm IDC predicts that there is a transition to mobile device and wireless Internet access from traditional home Internet access and that this will continue at a more rapid pace in the foreseeable future (Hachman, 2011).

Editor: Eli Cohen

The technology acceptance model (TAM), which has traditionally been used to study the adoption of new technologies, views technology as a tool and not as a consumer good. In contrast, recent studies (Abad, Diaz, & Vigo, 2010; Hong & Tam, 2006; Lauren & Lin, 2005) of mobile device use have measured user perceptions of hedonic characteristics (enjoyment of use).

Motivation for this Study

The interplay between home Internet use (HIU) and mobile device use (MDU) may yield interesting research results if both these approaches are used. Mobile devices can be viewed as an alternative channel that will compete with and perhaps displace HIU for certain types of activities, or these two alternatives may tend to complement each other as they contribute to greater levels of usefulness and comfort in conducting online (including sensitive) activities. For the purposes of this study, HIU and MDU are viewed as technologies having utilitarian and hedonic characteristics and treated as jointly determined endogenous variables allowing examination of their mutual impact.

The remainder of this article is organized as follows. First a review of literature relating to adoption of technology in general is presented, followed by research more specifically focused on Internet and mobile device usage. We finish this part with research focused on the relationship between Internet and mobile device usage. Next, the model and hypotheses of this study and their relationship to the prior modeling constructs is presented. Lastly, empirical results along with the study summary and conclusions are presented.

Modeling Adoption of Technology

Research on Technology Adoption

The most prevalent model for analyzing technology adoption is the technology acceptance model or TAM (Davis, 1989, Davis, Bagozzi, & Warshaw, 1989), which has its antecedents in the theory of reasoned action (Fishbein & Ajzen, 1975). This model postulates that usage of a new technology (U) is driven by an individual's intention to use the technology (IU) which is, in turn, dependent upon the technology's perceived usefulness (PU) and its perceived ease of use (PEU), where PU and PEU are determined by appropriate sets of exogenous variables. Legris, Ingham, and Collerette (2003) analyzed 22 studies based upon the TAM model and found that the results were mostly consistent with the predictions of the model although they noted that the explanatory power of many of the studies was rather weak. These studies almost always looked at adoption of new technology in the context of the workplace and have included extensions that may not be relevant outside the work environment. For example, Venkatesh and Davis (2000) included factors such as whether the use of the application was mandatory or optional and job relevance in their TAM2 model.

Research on Internet and Mobile Device Adoption

Most studies of adoption of home Internet and/or mobile device applications have taken the basic TAM model as their starting point. However, a number of extensions to that model have been introduced to capture hedonic elements in the decision to purchase and use these products and services, and a number of recent studies of mobile device adoption have included extensions of the TAM model constructs focusing on key elements of the nature and uses of these types of devices.

One clear limitation of the traditional TAM model is the fact that it views a technological product or service entirely as a tool whose value will be determined by how "useful" it is in relation to the effort required to learn to use it. This view may be adequate when assessing work related hardware and software; however, home computers, Internet services, and certainly mobile devices are purchased at least in part for the enjoyment they bring. Webster and Martocchio (1992) suggested that a trait described as "microcomputer playfulness" had a positive influence on the user's engagement and rate of learning to use computer software. A number of recent studies relating to mobile device acceptance have modified the TAM model to include an additional measure described as perceived enjoyment (Abad et al., 2010; Hong & Tam, 2006), perceived playfulness (Fang, Chan, Brzezinski, & Xu, 2006), or simply fun (Bruner & Kumar, 2005; Chtourou & Souiden, 2010). Each of these studies found this additional perceived enjoyment (PE) factor to have a significant positive impact on intention to use or actual use of the mobile device or service being evaluated.

A 'consumer good' view implies that the consumer must purchase the good or service and thus its price or affordability becomes an important factor. Lauren and Lin (2005) found that perceived financial cost had a significant negative effect on the intention to use a mobile banking service. Wang, Lin, and Luarn (2006) used an instrument described as perceived financial resource and found that this instrument positively influenced both perceived usefulness and the intention to use a mobile financial service. Both of these studies used pooled Likert scale measures with questions related to the degree of financial burden – cost relative to the users perceived ability to pay. Both of these studies also included a measure of computer self-efficacy and found that perceived self-efficacy impacted intention to use a mobile service both directly and indirectly (by increasing the perceived ease of use). Kiovumaki, Ristola, and Kesti (2008) found that user skill and familiarity with mobile devices had a significant positive impact on the intention to use a set of local government online directory services. The need to expand the TAM model in these areas was also recognized by Venkatesh, Thong, and Xu (2012) in their unified theory of acceptance and use of technology (UTAUT2) model which expanded their previous model to include factors of hedonic motivation and price value.

Since both home Internet and mobile device applications often involve online completion of activities that were previously performed offline, factors such as the user's perception of the reliability of the service provider and the degree of satisfaction with offline channels for completing an activity can be important factors affecting adoption of the online alternatives. The Lauren and Lin (2005) and Wang et al. (2006) studies cited above also found that the perceived credibility (read reliability and viability) of the service provider had a significant positive influence on the intention to use the service, while a study of offline investment banking customers (Falk, Schepers, Hammerschmidt, & Bauer, 2007) found that customers who were more satisfied with their offline services tended to report lower perceived usefulness and perceived ease of use of online (home Internet or mobile) services.

Early studies of usability and adoption of mobile devices identified interface features and network capabilities as key technology characteristics affecting adoption (Sarker & Wells, 2003) and found information relevance, ease of use, and made for the medium applications to be more important for mobile devices versus web applications (Venkatesh, Ramesh, & Massey, 2003). Constantiou, Damsgaard, and Knoutson (2007) identified what they described as four incremental steps to adoption of advanced mobile device use: first, using the mobile device only for talking, then sending texts, then using the device for photography, and finally using the mobile device for web-surfing and other Internet based applications. A qualitative study (Laukkanen, 2007) comparing perceptions of home Internet versus mobile device banking found efficiency, convenience, and safety to be the most salient features distinguishing the two media with convenience favoring MDU while efficiency and safety were generally perceived to be better on the home or wired Internet.

Research on Interplays between Wired and Wireless Internet Devices

HIU and MDU can be viewed as alternative channels for consuming a service. A study of Portuguese bank customers (Patricio, Fisk, & Falcão e Cunha, 2003) looked at the use of Internet banking integrated in a multi-channel offering that included telephone banking. They found that customers used the alternative online channels in a complementary manner and that the type of transaction also influenced the channel choice. Jung and Lee (2011) examined the tradeoffs between Internet and mobile device usage to access banking services and argued that use of these two channels might be either complements or substitutes. Their study indicated that (1) when online services are adopted as a substitute for traditional (non-online) services, HIU and MDU are deployed by users in a complementary manner, especially so as the users are acquiring familiarity with online services, but (2) MDU could ultimately supplant and become a substitute for HIU due to their greater convenience. They found HIU and MDU to be either complements or unrelated in their study.

It should be noted that the extent of mobile device use is rapidly changing. A Pew study (Crossman, 2013) found that the percentage of U.S cell phone owners using their cell phones for on-line banking increased from 18% to 35% between 2011 and 2013. This rapid expansion is likely to change the relationships between wired and wireless technologies. Interestingly, the relationship between these technologies shows high variance internationally. For instance a recent report indicates that "there are ten times as many mobile phones as landlines in sub-Saharan Africa" (Aker & Mbiti, 2010); Stork, Calandro, and Gamage (2014) suggest that mobile devices are rapidly overtaking wired devices even for basic Internet services in much of Africa even where fixed internet is available; and Hall (2012) notes that mobile phone applications are being used in Kenya to extend banking services to rural areas without the necessity of establishing bank branches there. Throughout the developing world, wireless communications are being extended to populations lacking wired telecommunications access and clearly the relationship between wired and wireless communications will be very different in those regions.

Impact of Security and Privacy Concerns

Perceived risk in communicating sensitive information has been seen as a factor limiting Internet use. Milne, Rohm, and Bahl (2004) found that the level of privacy concern had a significant positive relationship to the number of privacy measures taken by Internet users, while Malhotra, Kim and Agarwal (2004) found that "Internet user information privacy concerns" significantly reduced trusting beliefs and increased risk beliefs and, in turn, reduced the intention to use e-commerce sites. Similarly, Paine, Reips, Stiegerc, Joinsona, and Buchanand (2007) cited fears of loss of privacy, viruses, and identity theft as factors limiting acceptance of Internet applications, and these risks may be viewed as still greater for mobile devices. Jung and Lee (2011), also note that perceived risk is greater for mobile devices than for HIU and this limits the substitution of MDU for HIU – that is, as long as MDU is perceived as having higher risk, users will prefer using the Internet from a home PC for more sensitive services instead of using of mobile devices for these services.

Impact of other Control Factors

Demographic characteristics, such as age, gender, and household composition, can also be expected to affect use of online devices and the types of applications used. A recent Pew study indicates that the rate of ownership of cell phones and laptop computers among U.S adults declines steadily with age and that ownership of desktop computers is highest among those aged 35-46 and is least frequent among 18 to 34 year olds and those over 65 (Mulvihill, 2011). Not surprisingly, Hwang and Park (2013) have found that age has a significant negative impact on the extent of use of social networking sites, and Thayer and Ray, (2006) found that use of the Internet for communication with friends and unknown individuals (versus relatives) declined significantly with age. Dholakia (2006) noted gender differences in Internet use internationally based on 2004 data, with males using the Internet in greater number and for longer amounts of time. He noted similar differences in U.S. use, but found that these differences had shrunk over time and perhaps were beginning to reverse, although females over 50 were still more than 5% less likely to use the Internet than their male counterparts. Joiner et. al. (2012) found that male students used the Internet for a broader set of activities than did female students, but they also found that females used the Internet for communication more than did males. Similarly, Jackson et al. (2008) found in a study of children's IT use that males were more likely to use video games than females while females were more extensive in their cell phone use. Use of cell phones and the Internet by children is an important household issue for families. Cell phones with GPS have been marketed as a tool to allow parents to keep track of their children's location (Segan, 2006) and parents whose children have cell phones overwhelmingly rejected the idea of cell phone bans in schools because they want to be able to contact their children in case of emergency (99%) or if there are changes in schedules (84%) (Mullen, 2006). At the same time, Gibbs (2009) notes concerns about sexting, cyber-bullying, and other dangerous online activities which may cause parents to limit their children's online presence and perhaps their own. Taken together, these studies suggest that the extent and composition of Internet and mobile devices usage is likely to be affected by age and may also be affected by gender and the presence of children in a household.

A Reduced Form Consumer Good Technology Adoption Model

Basis for Model Development

The background described above suggests that a model of the adoption of a Technological Consumer Good or Service (TCGS) involves factors far beyond those hypothesized by early versions of the TAM model. Therefore, enjoyment of the use of the service, cost of the service, risk associated with the use of the service, and tradeoffs among complementary or substitute types of services are factors considered in this study. Figure 1 presents a summary reduced form view of the factors expected to affect TCGS adoption and use. This model suggests that, adoption of a TCGS will be positively influenced by its Perceived usefulness and Perceived ease of use, the utilitarian elements taken directly from the TAM model. In addition, User self-efficacy in the use of the technology or use of computing technology in general is expected to positively impact use of the TCGS, and perceived risk in using the TCGS is expected to negatively impact use of the TCGS. While both of these factors have appeared in more conventional TAM models, the perceived risk factor is substantially expanded in the case of a TCGS due to issues of personal privacy and security.

The factors of Perceived Enjoyment, Perceived Affordability, and Use of Alternative TCGSs are added to the model to reflect the hedonic consumption effect, and the economic impacts of cost and the availability of substitute or complementary products. Greater enjoyment and greater affordability (or lower perceived cost) are expected to positively impact TCGS use, while Use of Alternative TCGSs is expected to increase use of the target TCGS if the Alternative is a complement to its use and to reduce use of the target TCGS if the alternative is a substitute for the target TCGS.

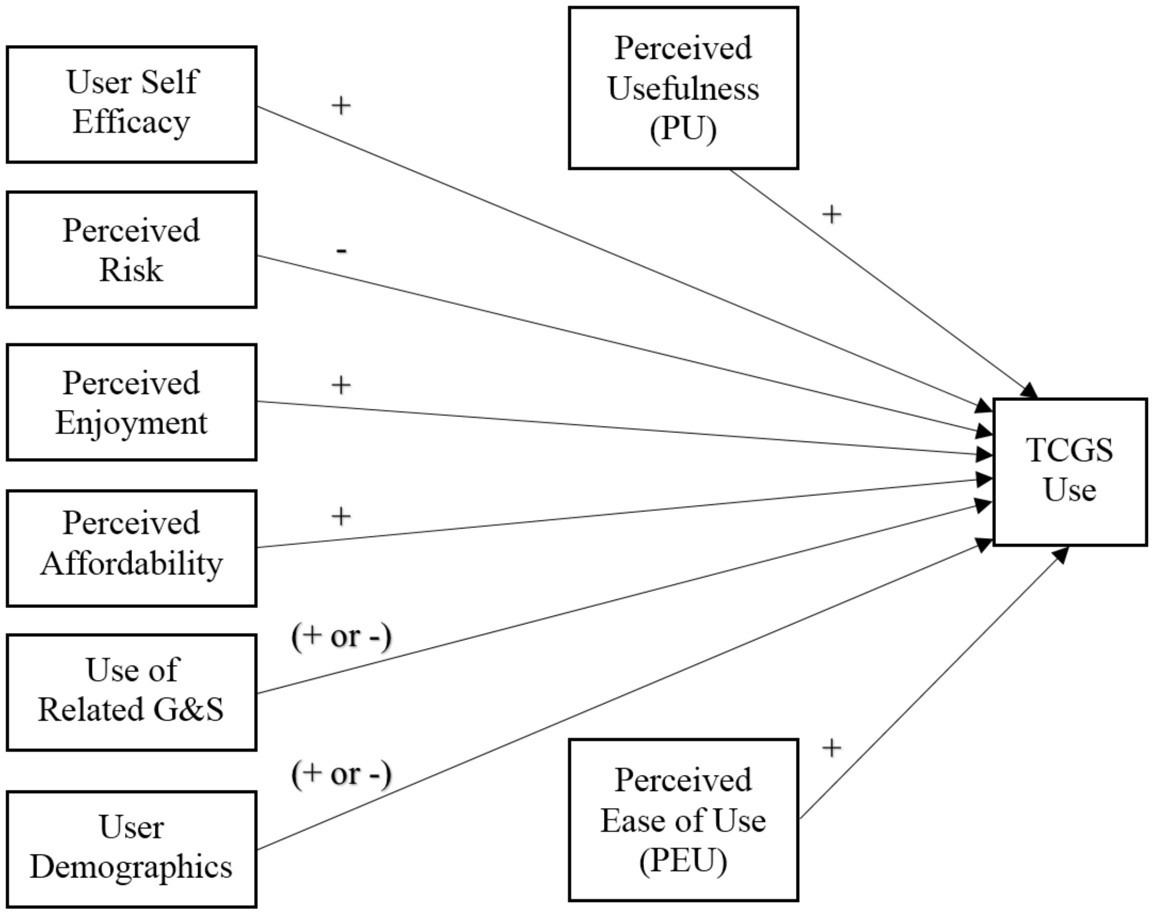

FIGURE 1: A Reduced Form Technology Consumer Product Adoption Model

Finally, a variety of User Demographic Characteristics may impact TCGS use. Demographic characteristics have rarely been considered in the studies discussed above because the respondents tended to be demographically homogeneous, or because the sample size was too small to allow this type of breakdown, or because user demographics were simply not collected. The data set used in this study was systematically sampled to reflect the demographic diversity of the population of the United States and, thus, provides the capability to examine the effect of demographic characteristics such as age, gender, education level, and family income on the adoption of the TCGSs studied here.

Empirical Model and Hypotheses

Survey Data and Model Variables

This study utilizes data from a July 2011 survey of Internet and mobile device use conducted by the U.S. Census Bureau as an addendum to the Current Population Survey. A list of the variables used and their definitions is presented in Table 1 below. The survey data focus on actual use of Internet and mobile device applications and not just the intent to use them and provides data about various forms of HIU and MDU. This allows evaluation of the interactions between home (wired or wireless) Internet and mobile device usage and allows examination of counts of the total number of types of usage (MDU and HIU) as well as counts of selected types of use of home

Internet and mobile device applications and services. In the case of HIU a subset of activities involving the transfer of potentially sensitive information (SHIU) is identified. In the case of mobile devices a subset of more advanced types of uses (AMDU) – other than phone calls and text messages – is identified. These usage counts form the endogenous variables of the study.

Table 1: Study Variables and Their Definitions

Demographic and other Control Variables

Gender (G)-> Male or Female

Age (A) -> In years

Residence (R) ->Urban area (2) or Other (1)

Education Level (EL) -> Number of years of education, recoded from categories, using midpoint of range

Family Income (FI) -> In $ '000s per annum

Exogenous Internet Use Related Variables

Internet Use (IU) -> Count of the number of hours per week spent on the Internet

Computer Occupation (CO) -> Employed in non-computer field (1), Employed in computer field (2)

Work Internet Use (WIU) -> Do not use Internet at work (1), Use Internet at work (2)

Internet Trust (IT) -> Belief in the use of the Internet for online transactions - less risky than traditional means e.g., telephone (3), about the same (2) or more risky (1)

Internet Controls (IC) -> Count of # of types of controls used on Internet surfing

Children in different age groups (CU5, CU13, CO14, TC) -> respectively, Children 5 and under, 6 to 13 and 14 & over (all Y/N), total # children in all age groups

Type of Internet connection (B) -> Broadband or Narrowband

Endogenous Variables:

Home Internet Use (HIU) -> Count of # of types of online actions involving wired home Internet use

Mobile Device Use (MDU) -> Count of # types of mobile device (wireless) use including phone calls, texts, web browsing, email, maps/GPS, games, social networks, apps, audio/video

Sensitive Home Internet Use (SHIU) -> Count of # of types of online actions involving transmission of sensitive information over the wired Internet from a home machine

Advanced Mobile Device Use (AMDU) -> Count of # types of advanced mobile device (wireless) use excluding phone calls/texts, but including web browsing, email, maps/GPS, games, social networks, apps, audio/video

A major advantage of the survey used here is that provides a large and diverse set of data that is representative of the U.S. population across age (A), gender (G), residence – urban versus rural – (R), Family Income (FI) and education level (EL) and allows control/investigation of the impact of these demographic factors.

Simultaneous Equation Regression Model

As reflected in the equations below, the first model (1a and 1b) examines the determinants of total home Internet and total mobile device usage and the interactions between them, while the next (2a and 2b) uses parallel sets of variables to examine the determinants of AMDU and SHIU and their mutual influences. Figure 2 below presents the simultaneous equations model for the equations in our system in visual form.

1a. $\mathbf{MDU = \alpha_1 + \beta_{1\text{-}1}HIU + \beta_{1\text{-}2}R + \beta_{1\text{-}3}G + \beta_{1\text{-}4}IT + \beta_{1\text{-}5}A + \beta_{1\text{-}6}FI + \beta_{1\text{-}7}CU5 + \beta_{1\text{-}8}CU13 + \beta_{1\text{-}9}CO14 + \beta_{1\text{-}10}TC + \varepsilon_1}$

$$\textbf{1b. } HIU = \alpha_2 + \beta_{2\text{-}1}MDU + \beta_{2\text{-}2}IU + \beta_{2\text{-}3}IC + \beta_{2\text{-}4}R + \beta_{2\text{-}5}G + \beta_{2\text{-}6}IT + \beta_{2\text{-}7}A + \beta_{2\text{-}8}FI + \beta_{2\text{-}9}CO + \beta_{2\text{-}10}WIU + \beta_{2\text{-}11}B + \varepsilon_2$$

$$\textbf{2a. } AMDU = \alpha_1 + \beta_{1\text{-}1}SHIU + \beta_{1\text{-}2}R + \beta_{1\text{-}3}G + \beta_{1\text{-}4}IT + \beta_{1\text{-}5}A + \beta_{1\text{-}6}FI + \beta_{1\text{-}7}CU5 + \beta_{1\text{-}8}CU13 + \beta_{1\text{-}9}CO14 + \beta_{1\text{-}10}TC + \varepsilon_1$$

$$\textbf{2b. } SHIU = \alpha_2 + \alpha_2 + \beta_{2\text{-}1}AMDU + \beta_{2\text{-}2}IU + \beta_{2\text{-}3}IC + \beta_{2\text{-}4}R + \beta_{2\text{-}5}G + \beta_{2\text{-}6}IT + \beta_{2\text{-}7}A + \beta_{2\text{-}8}EL + \beta_{2\text{-}9}CO + \beta_{2\text{-}10}WIU + \beta_{2\text{-}11}B + \varepsilon_2$$

Because this study uses secondary data, attitudinal/perceptual variables like those described in many of the studies cited above are not relied upon. Instead this source provides a set of data including attributes that are proxies for several of the variables described in these studies. The number of Internet controls (IC) and the level of trust in using the Internet (IT) are proxies for perceived risk, where greater Internet trust is seen as reducing perceived risk and thus increasing the likelihood of TCGS use; Internet Controls impact wired Internet Use since they are usually applied to this mode of use. Correspondingly:

> Hypothesis 1a: The greater the number of Internet Controls (IC), the higher the Usage Counts HIU and SHIU
>
> Hypothesis 1b: The higher the level of Internet trust (IT), the higher the Usage Counts HIU, MDU, SHIU and AMDU

Use of the Internet at work (WIU) and working in a computer related occupation (CO) can both be thought of as proxies for self-efficacy which, in turn has been shown to increase TCGS use; these effects are applicable to wired Internet use since mobile devices are universally used.

> Hypothesis 2a: Internet Use at Work (WIU) leads to higher Usage Counts HIU and SHIU
>
> Hypothesis 2b: Computer Related Occupation (CO) leads to higher Usage Counts HIU and SHIU

A higher education level (EL) can be viewed as enhancing self-efficacy but having more to do with increasing perceived usefulness and is thus expected to increase TCGS. Family income (FI) serves as a proxy for perceived affordability of Internet and mobile device services. Since dollar costs of these services are nearly constant nationwide, it is the available family income that determines affordability. Education Level (EL) and Family Income are correlated as might be expected. Using both variables in the same regression model will confound the results. We believe that FI will impact mobile device uses as higher income individuals can choose plans with higher data rates, minutes of talk time and messages. Higher education, on the other hand, will lead to more wired Internet use, as these users will have more activities they plan to carry out online. Thus:

> Hypothesis 3: Education Level (EL) increases Sensitive Home Internet use (SHIU) and Home Internet use (HIU)
>
> Hypothesis 4: Family Income (FI) increases MDU and AMDU

The weekly number of hours of home Internet use (HIU) can be thought of as a proxy for perceived usefulness, or perceived enjoyment, or some combination of these factors. There are additional factors that can be viewed as enhancing the perceived usefulness of the target services. The presence of broadband Internet service (B) in a household is expected to positively impact HIU and SHIU by enhancing the usefulness of home Internet applications and services. Living in an urban versus a rural area (R) is expected to differentiate the usefulness of mobile devices via greater access to sites equipped for mobile device e-commerce, thus positively impacting MDU and AMDU from rural areas. Therefore:

> Hypothesis 5: Broadband Internet service leads to higher HIU and SHIU

> Hypothesis 6: Residence in non-urban areas will lead to higher MDU and AMDU

Few studies have analyzed the effects of age on use of these types of services. However, it has often been suggested that younger individuals, who have grown up with these technologies, are apt to be more comfortable in using them and more complex in their usage patterns.

> Hypothesis 7: Younger individuals will have higher usage counts, namely, HIU, MDU, SHIU and AMDU

With respect to gender, there is no clear rationale to expect either males or females to be more prevalent users of these services.

> Hypothesis 8: There will not be significant differences in the impact of gender G on usage counts, HIU, MDU, SHIU and AMDU

Further, the presence of children at various ages in a household (CU5, CU13, CU14, and TC) can be viewed as enhancing the usefulness of mobile devices (as they are used to coordinate the activities of the children).

> Hypothesis 9: Mobile Device Use counts (MDU and AMDU) will be higher in households with children in the different age groups (CU5, CU13, CU14) and total number of children (TC)

Of particular interest is the interaction between the dependent variables HIU and MDU in equations 1A and 1B, and SHIU and AMDU in Equations 2A and 2B. The expected effect will be negative if these channels for consuming services are viewed as substitutes and positive if they are viewed as complements which jointly substitute for non-online channels providing these services. We hypothesize that these channels will be complements at this stage of the development of the use of digital services.

> Hypothesis 10a: HIU and MDU are complementary in their mutual effects on each other

> Hypothesis 10b: SHIU and AMDU have mutually positive impacts

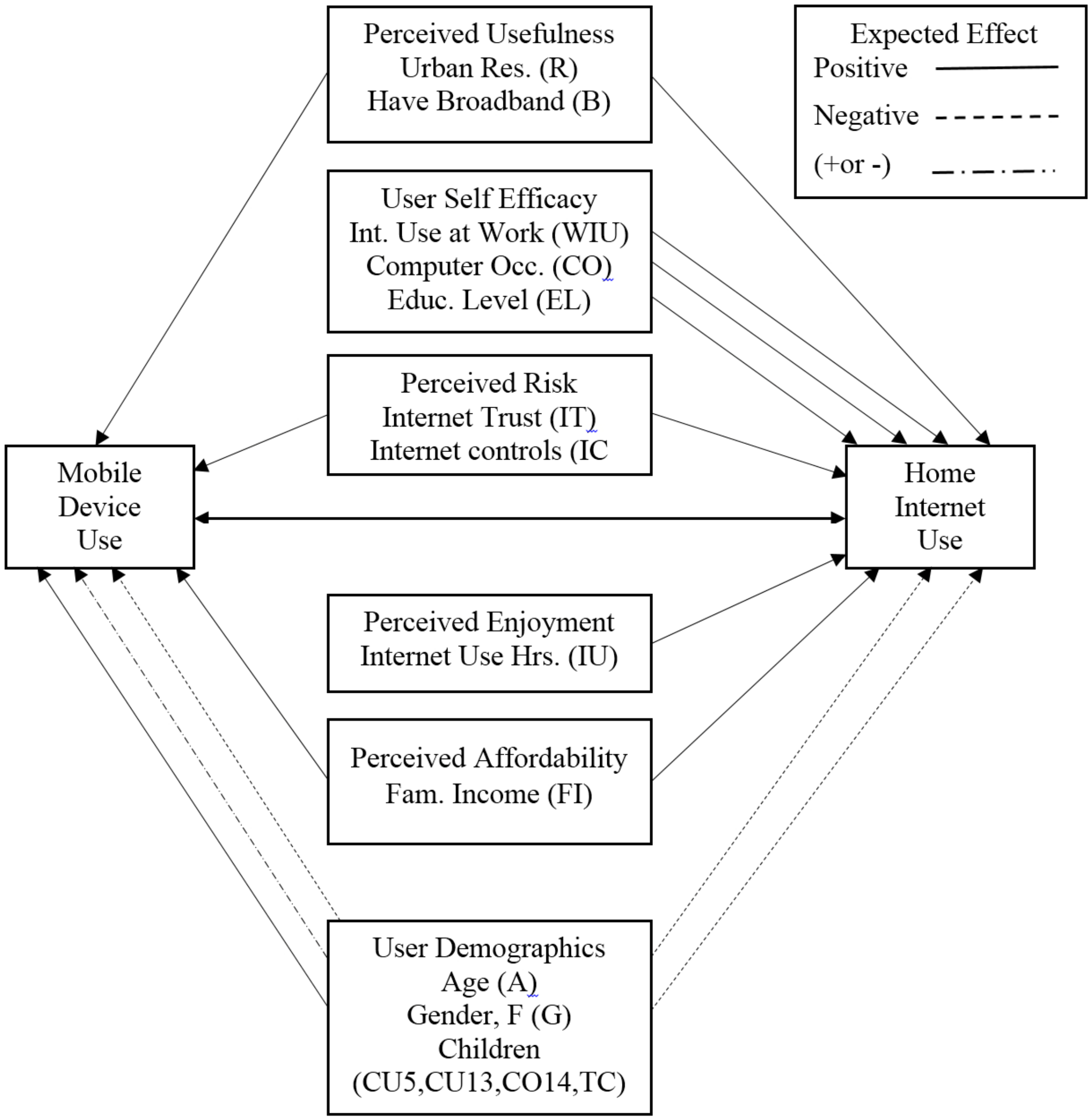

FIGURE 2: Model of Determinants of Home Internet and Mobile Device Use

Discussion of Results

Data Transformation

Data from the July, 2011, U.S. current population survey was converted to provide the variables described above. Respondents included adults with children under 18 in their household. In addition, individuals who fell into any one of the following categories, (1) reported their work situation as unemployed (2) had no Internet connection or (3) had no mobile device, were eliminated from the processed dataset, leaving a total of 8,130 observations. The data was split almost evenly between male and female respondents. Gender, Residence, Occupation, Broadband connectivity (vs. Dial-up), Work Internet Use, and Internet Trust were converted to dummy variables in the empirical model.

Data Analysis

Table 2 below shows descriptive statistics for the variables. As can be observed there is sufficient variance in the data; also note that the dummy variables referred above are shown as 1 and 2 or 1, 2 and 3 in Table 2 but in the actual regression model, these were converted to 0/1 intercept dummies. We also tested the correlations between the continuous exogenous variables to justify their use in our empirical model. The Pearson correlation coefficients among the exogenous variables shows only one correlation greater than 0.25, that correlation (0.45) is between family income and education level (years), and these are not used as exogenous variables in the same regression equation.

Table 2: Descriptive Statistics

Item	Mean	Std. Dev.	Min	Max
Age	40.13	9.05	15	80
Residence (Urban or Other)	1.80	0.40	1	2
Education (Years)	14.32	2.49	0	20
Family Income ($ ’000s)	86.84	60.7	2.50	225.00
Occupation (Computer/Other)	1.04	0.19	1	2
Internet Use at Work (No/Yes)	1.34	0.47	1	2
Gender (Male/Female)	1.45	0.52	1	2
Total # Children	1.74	1.01	0	9
Home Internet Uses (Count)	5.11	2.81	0	11
Sensitive Home Internet Uses (Count)	3.45	1.69	0	6
Internet Controls (Count)	5.13	1.28	0	6
Internet Use (Hours)	20.97	22.39	0	105
Internet Trust (Less, Same, More)	2.09	0.95	1	3
Mobile Device Uses (Count)	5.38	2.82	1	10
Advanced Mobile Device Uses (Count)	3.58	2.64	1	8

Because of the joint endogeneity in the model, we use a 3 stage least squares regression method to test the hypotheses. Each equation has at least 1 independent variable not included in the other, thus satisfying the identification criteria needed for the estimation.

The results for the total number of home internet uses and total number of mobile device uses (equations 1a and 1b) are presented in Table 3. The results of the simultaneous equation model contained in equations 2a and 2b focusing attention on the advanced forms of mobile device use and joint determination of sensitive home internet use are presented in Table 4.

Interpretation of Results

Some of the expected effects from the overall usage model (shown in Table 3) are validated while others are not. For example, Home Internet Use reinforces Mobile Device Use (as hypothesized) but not vice versa. Possible explanations: using home computers allows discovery of applications that are helpful when out of the home and lead to using smartphones to a greater extent; in addition, it could be that any user (or household) has a flexible number of hours that is spent online and more use of the home device (with wired or wireless Internet connectivity) induces higher use of the other device, which in this case is the smartphone (mobile device). Therefore, a wired home computer user, completing multiple online activities, will use their mobile device for more online activities that may or may not be similar. The reverse is not supported, implying that mobile device users use their home computers more for things that they might not need (or do not wish) to carry out on mobile devices (e.g., tax returns, invoice payments).

Table 3: Three stage least squares results (equations 1a and 1b) - (System Weighted R-Squared: 0.1894)

Model		(Count of) Mobile Device Uses			
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	4.533893	0.212402	21.35	<.0001
Home Internet Uses	1	0.583504	0.025240	23.12	<.0001
Residence	1	0.297233	0.074393	4.00	<.0001
Gender	1	-0.00924	0.058897	-0.16	0.8753
Internet Trust (Less)	1	-0.21398	0.060872	-3.52	0.0004
Internet Trust (More)	1	0.242064	0.102294	2.37	0.0180
Age	1	-0.06225	0.003673	-16.95	<.0001
Family Income	1	0.001786	0.005391	3.31	0.0009
Children Under 5	1	0.056522	0.067534	0.84	0.4027
Children Under 13	1	0.094277	0.077310	1.22	0.2227
Children Over 14	1	0.096605	0.068976	1.40	0.1614
Total # Children	1	-0.07499	0.035626	-2.10	0.0353

(Adj R-Sq 0.1328)

Model		(Count of) Mobile Device Uses			
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	6.906749	3.785800	1.82	0.0681
Mobile Device Uses	1	0.023856	0.434150	0.05	0.9562
Internet Use (Hours)	1	0.025338	0.006800	3.73	0.0002
Internet Controls	1	-0.40744	0.115082	-3.54	0.0004
Residence	1	0.199483	0.197067	1.01	0.3114
Gender	1	0.020230	0.055853	0.36	0.7172
Internet Trust (Less)	1	-0.17577	0.152141	-1.16	0.2480
Internet Trust (More)	1	0.067396	0.156861	0.43	0.6675
Age	1	-0.02448	0.032498	-0.75	0.4512
Education (Yrs)	1	0.004823	0.002082	2.32	0.0206
Occupation	1	0.494425	0.171367	2.89	0.0039
Internet Use at Work	1	-1.32269	0.319047	-4.15	<.0001
Broadband	1	0.647664	0.236307	2.74	0.0061

(Adj R-Sq 0.2162)

Living in an urban area significantly increases the number of mobile device actions, but not the number of wired Internet activities. This is perhaps because all areas have adequate wired Internet access, while the presence of some types of wireless services remains more limited in rural areas. Next, there is no gender difference when it comes to either of the two endogenous variables. Also, somewhat surprising is the result that Internet use at work significantly reduces the number of online activities in households. This could be the result of "Internet fatigue" combined with finding most of what one needs during periods of such use at work.

On the matter of users regarding Internet transactions to be inherently risky, thereby resulting in reduced use of the Internet, our findings are the following. 1. Users of wired devices do not show significant restraint in their use stemming from perceived risk. 2. Those viewing on line transactions as more risky do use their mobile devices for fewer actions while those viewing online transactions as less risky do the opposite. The difference in these results may suggest that availability of, and knowledge about security and privacy measures for mobile devices is not as widespread as it is for Internet connections from home. The additional measure of perceived risk from Internet use, as captured in the number of Internet controls, did lead to a reduction in the number of home device online uses/activities in the household as hypothesized.

The results also indicate that the presence (or absence) of children in different age groups does not significantly impact the number of uses to which a mobile device is put. It may be that these dummy variables impact the number of hours spent using mobile devices instead of the number of actions involving the said devices. Equally surprising is that the total number of children in a household marginally (but statistically significantly) reduces the number of mobile device uses. We explain this result by observing that the more children, the more focus on using mobile devices (such as smartphones) for basics, namely phone calls and text messages, and not so much on the advanced uses.

Findings that consistently support the hypothesized relationships include the following. Those in a computer related occupation do carry out more activities online, as hypothesized, perhaps because of higher levels of familiarity and ease with technology. In line with intuition, broadband Internet connectivity (as opposed to dial-up) leads to more home Internet use. As expected, family income increases mobile device use as well as home Internet use. This, we believe, is a question of affordability. Higher family income levels allow those households to go in for plans with higher data uploads and downloads. While older Mobile Device users (as expected) use their instruments for fewer activities, the same is not true for Internet use at homes; age is not significant here, possibly because the use of the Internet at home has become so ubiquitous that it has become a part of everyday life, regardless of age.

Table 4 presents results for the model where the endogenous variables are the number of advanced mobile device uses and the number of sensitive home internet activities (equations 2a and 2b). As before, some of the expected effects are validated while others are new and different. As before, living in an urban area does significantly increase the count of advanced mobile device actions, but not the count of wired Internet activities involving the transfer of confidential data. This carries the same explanation as before, namely, non-urban areas have adequate wired Internet access (but not necessarily wireless coverage) which makes it possible to look for information as well as make payments and place orders online just as easily as for those in urban areas. Also as before, there is no gender difference when it comes to either of the two endogenous variables. This can also be considered intuitive in today's society where females and males both work and need to keep in touch with each other as well as carry out transactions such as bank deposits, online purchases and the like.

As expected, Internet use at work (statistically) significantly increases the number of sensitive online activities in households. This differs from the effect of this variable on total home internet use in the earlier model (equations 1a and 1b). What seems to be the case here is that Internet use at work leads to better understanding of security/privacy/confidentiality issues involved in conducting sensitive online actions even at home.

Older Mobile Device users (as expected) use their instruments for fewer activities; the same is true for wired Internet use at homes; age is significant even here. Thus, unlike the earlier case (equations 1a and 1b), the wired Internet computer at home is not so ubiquitous that it has become a part of everyday life, regardless of age, when it comes to conducting online transactions that need sensitive personal data to be transferred. Older users still feel a higher need to protect themselves from issues such as identity theft.

Table 4: Three stage least squares results (equations 2a and 2b) - (System Weighted R-Squared: 0.2299)

Model		(Count of) Mobile Device Uses			
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	8.928775	0.224351	39.80	<.0001
Sensitive Home Internet Uses	1	-0.80914	0.037926	-21.33	<.0001
Residence	1	0.299763	0.071374	4.20	<.0001
Gender	1	-0.03907	0.056264	-0.69	0.4875
Internet Trust (Less)	1	-0.21187	0.058374	-3.63	0.0003
Internet Trust (More)	1	0.167326	0.098416	1.70	0.0891
Age	1	-0.07026	0.003269	-21.49	<.0001
Family Income	1	0.001166	0.005262	2.22	0.0267
Children Under 5	1	0.004622	0.026532	0.17	0.8617
Children Under 13	1	-0.03093	0.030071	-1.03	0.3038
Children Over 14	1	-0.03735	0.026915	-1.39	0.1652
Total # Children	1	0.016169	0.014956	1.08	0.2797

(Adj R-Sq 0.1206)

Model		(Count of) Mobile Device Uses			
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	8.735702	0.578158	15.11	<.0001
Advanced Mobile Device Uses	1	-0.76886	0.090600	-8.49	<.0001
Internet Use (Hours)	1	-0.00471	0.001520	-3.10	0.0020
Internet Controls	1	0.063890	0.024126	2.65	0.0081
Residence	1	0.194275	0.066502	2.92	0.0035
Gender	1	-0.03100	0.041832	-0.74	0.4586
Internet Trust (Less)	1	-0.13244	0.050513	-2.62	0.0088
Internet Trust (More)	1	0.066103	0.076603	0.86	0.3882
Age	1	-0.05474	0.006265	-8.74	<.0001
Education (Yrs)	1	-0.04387	0.005804	-7.56	<.0001
Occupation	1	-0.13192	0.049039	-2.69	0.0072
Internet Use at Work	1	0.329222	0.068117	4.83	<.0001
Broadband	1	-0.15832	0.066646	-2.38	0.0175

(Adj R-Sq 0.1786)

Here are some results which are different. Those in a computer related occupation carry out fewer sensitive activities online, which is surprising. This can be explained by considering the higher level of exposure of such workers to instances of identity theft, releases of new viruses/malware and cases of online businesses with less than secure websites. Thus, higher levels of familiarity and ease with technology actually limit what these employees do.

Broadband (home) Internet connectivity significantly reduces the count of sensitive online actions from home, leading us to offer the explanation that high speed connections favor more actions involving large data downloads such as videos and music, perhaps even VoIP calls.

Another finding contrary to that hypothesized is that education levels marginally decrease the number of sensitive online actions at home. We expected that education would raise the awareness of Internet users on how to protect their online data transmission and thereby result in more such activity. However, education likely also increases awareness of online risks which appears to have led more educated users to limit the types of sensitive online activities they carry out. On the other hand, family income positively affects advanced mobile device use as hypothesized – this is again the issue of affordability – users with higher income levels can afford more expensive data plans with correspondingly higher monthly quotas.

Belief that the Internet is more risky than traditional channels of business transactions does significantly reduce the use of the (home) Internet, for sensitive activities, while the effect of believing that the Internet is less risky than traditional channels has the expected sign, but is not statistically significant. This same pattern also holds with regard to advanced mobile device usage. Those viewing online transactions as having enhanced risk are less likely to use either wired or wireless online devices for sensitive activities.

As expected, the analysis shows that the use of more Internet Controls results in higher count of home internet activities requiring the transfer of confidential data. Such controls seem to provide a sense of security that they are protected from potentially unsafe web-sites.

A noteworthy finding is that Advanced Mobile Device Use count and Sensitive Online Actions count do not mutually reinforce each other, but have a substitution effect. The data show that the more sensitive online actions on a user's part from home, the fewer the number of advanced uses they carry out on their smart-phones and vice versa. This seems to suggest that once users have come to embrace the advanced capabilities of mobile devices, their convenience will cause them to be substituted for performing similar activities on their wired home internet devices. This result suggests that users potentially see wired and wireless devices as useful for different sets of activities. This presents implications for sellers of such services looking to match their online offerings to the appropriate online platform.

Another significant result from this analysis is that the presence (or absence) of children in any age group (even the total number of children) has no effect on the number of advanced uses to which a mobile device is put. It could be argued that in most households, parents might limit the use of their mobile devices to the basic actions of text messages and phone calls in order to guard against potentially huge bills from their carriers.

This survey data is for US residents and hence the interpretation of the results must necessarily apply to them. However, we conjecture that in Europe, Australia, and New Zealand, where the diffusion of mobile device technology has been shown to be higher, some of the same results could be valid, e.g., the substitution effect between wired and wireless devices. The same may apply even to developing nations in Asia where the demand for mobile technology is outstripping the older (wired) access method.

Conclusion and Planned Extensions

Since this study is exploratory in nature, its conclusions thus far are necessarily limited. However, a number of interesting elements have already been uncovered. With regard to demographics, gender does not appear to impact Internet or mobile device use; younger users and urban users were seen to engage in more mobile device use (both MDU and AMDU) and more SHIU, while overall Internet use (HIU) appears to be ubiquitous across all ages and types of residence; the presence of children in a household appears to have little effect on mobile device use, while family income, reflecting ability to pay, does appear to impact the extent of mobile device use and overall HIU. Perceptions of riskiness of online activity do impact use and users appear to be more concerned with these risks when using mobile devices or when doing sensitive activities on the Internet, while familiarity with the Internet through using it at work or working in a computer occupation appears to have mixed effects on home Internet usage. Finally, while HIU appears to have a complementary effect on MDU, MDU does not have a significant impact on HIU. In addition, AMDU and SHIU are found to substitute for each other. This may reflect increased maturity in mobile device platforms and service offerings which are making them stronger substitutes for HIU.

There are a number of ways in which the work presented here can be extended. As a next step, the authors intend to look at usage of individual types of home Internet and mobile device applications and services using logistic regression techniques in order to get a more detailed look at factors impacting these more specific types of use; specifically whether these are conducted using wireless access. We also wish to extend the system of equations to include determinants of Internet controls and number of hours of Internet use and hope to shed more light on this topic. For instance, we may be able to uncover more support for activities like VoIP or video downloads being carried out on wired devices and buy/sell/GPS activities on mobile devices.

It seems fair to state that there is room for more interesting findings that might have significant implications for providers of such services, and the authors hope to uncover these results.

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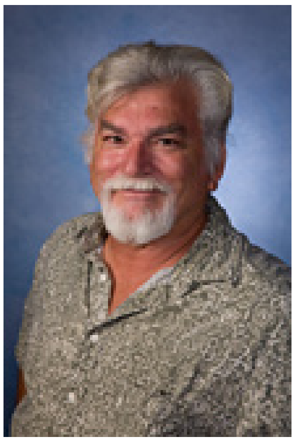
Biographies



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