Consumer Usage of Broadband Internet Services: an analysis of the case of Portugal

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ABSTRACT

We analyze the intensity and patterns of use of fixed and mobile broadband consumers in Portugal. If usage across types of consumers is similar after controlling for individual characteristics identified to be important drivers of adoption, then it is more likely that consumers view mobile and fixed broadband as somewhat substitutable. Such a result is important for studies of broadband impacts; specifically, for discerning whether mobile broadband service will have a similar level of impact upon social and economic development as fixed broadband services have had.

Results indicate that broadband uses are similar across fixed and mobile users, suggesting that the technologies are somewhat substitutable from customers' perspectives and raising the possibility of limited differential effects on innovation and other social goals. Results of interest include the characteristics of Internet users by technology, and differences of usage patterns reflected by individual characteristics.

INTRODUCTION

The issues of substitutability across broadband technologies and the context in which broadband penetration occurs are important for a variety of reasons. First, if the frequency and intensity of Internet use across types of consumers is similar after controlling for individual characteristics identified to be important drivers of adoption, then it is more likely that consumers view mobile and fixed broadband Internet access as somewhat substitutable. This is important for discerning whether mobile broadband service will have a similar level of impact upon social and economic development as fixed broadband services have had.

Several empirical studies have linked the use and adoption of broadband technology to various measurements of both economic and job growth; however, such analyses have not been undertaken specifically with regard to mobile broadband diffusion. In part, this is due to data limitations that exist due to the relatively recent emergence of mobile broadband technology.

Additionally, as the goal of ubiquitous broadband adoption increasingly is proposed, policy-makers will find it necessary to determine which demographic or socio-economic groups are least likely to be included in the achievement of this goal. To that end, a clear understanding of characteristics of individuals who access the Internet through various means, and such individuals' patterns of use can help to determine appropriate policies for reaching such individuals and for providing information on benefits of Internet applications likely to be important to them.

To add to studies focusing primarily on fixed broadband adoption, we include analyses of mobile and nomadic broadband adoption and consumer usage patterns. Specifically, we consider characteristics of broadband users by access type and relevant socio-economic and demographic variables, and we analyze usage patterns by access type, also including relevant explanatory variables.

BACKGROUND

The economic importance of broadband is well accepted, but there is much that we do not know about how various technologies of broadband delivery differ in their commercial viability, effectiveness, and value. In some countries, such as the United States, customers often can choose between fixed technologies (such as DSL, fiber to the home (FTTH), and cable), and can access wireless broadband through WiFi and third generation mobile (3G). In other countries, where cable television is less well developed, customers generally do not have the option of choosing cable for broadband access. Japan is emphasizing FTTH in its broadband policies, and also relies on DSL. There also are countries, such as Portugal, where wireless broadband is expanding rapidly. Whether customers view these various technologies as providing equivalent broadband access is important for public policy reasons: a country that is predominant in one broadband technology may be so because regulatory policies include technology biases. Such a country could be at a competitive disadvantage if its populace would find a different mix of technologies to be more productive economically and socially. On the

other hand, if alternative broadband technologies are close substitutes, then a country could waste resources promoting a change in technology mix.

Another important consideration for understanding the roles of various broadband technologies is the context within which broadband penetration occurs. According to Schwab and Porter (2007), the most competitive economies in the future will be those that are innovation-driven. Broadband is instrumental in creating opportunities for innovation in a modern economy. A study by Van Ark and Inklaar (2005) supports this assertion, finding that the economies that have experienced the greatest economic impacts from information technologies are those that have leveraged those technologies to create entirely new products and ways of doing business. Still, broadband alone does not promote innovation; the Global Competitiveness Index includes numerous economic and legal features of a country that should be present if broadband is to reach its potential impact.[i]

Studies of fixed broadband adoption and deployment are numerous. Holt and Jamison (2008) provide an overview of various economic impact studies, but such studies of broadband's effects suffer from the problem of endogeneity (i.e., information that comes from the model cannot be used to explain the model). For example, if it is observed that economic development and broadband adoption are positively correlated, how does one know whether economic development results from broadband adoption, leads to broadband adoption, or both? The accepted wisdom is that broadband is both a cause and an effect of economic development.

In order to understand the benefits of broadband both for individual consumers and for achievement of social goals, it is critical to understand consumers' usage of broadband. This includes the degree to which consumers make choices based on technology preferences, and consumers' usage patterns and intensity. In other words, determining consumers' broadband applications and the amount of time spent using broadband enables policymakers to adopt the most appropriate methods of achieving social and economic goals.

Demand studies for broadband generally have found that demand is positively correlated with income, education, and greater use of other information technologies. For example, Crandall *et al*. (2002), Kridel *et al*. (2001), Garcia-Murillo (2005), and Prieger and Hu (2008) find that lower-income groups are less likely to subscribe to broadband than higher-income groups. Goldfarb and Prince (2008) concur in this finding and add that more highly educated consumers are more likely than less-educated consumers to purchase broadband.

With respect to race and ethnicity, Fairlie (2004) uses US Current Population Survey data to show that blacks and Hispanics are less likely to have a computer in the home than are members of other racial or ethnic groups; this of course means these households do not have broadband access in their homes. Other studies address race and ethnicity more directly. Prieger (2003) and Hu and Prieger (2008) find that race has no impact on suppliers' willingness to deploy DSL, once variations in income and other economic factors are considered. Leigh (2003) finds similar results. However, Flamm and Chaudhuri (2007), GAO (2006), and Prieger and Hu (2008) find that race impacts

broadband adoption, perhaps because of differences in computer skills (Krueger, 2003) or network effects (Goolsbee and Klenow, 2002). These race impacts may result from factors that are correlated with race, but that are unobserved in the researchers' data or not fully captured in the statistical analysis even if the data are there. For example, Prieger and Hu (2008) discuss whether some blacks and Hispanics lack spare time to be online or find online content less valuable than do other racial groups.

In contrast to other studies, Goldfarb and Prince (2008) survey 18,439 Americans and find that, conditional on adoption, low-income, less-educated consumers spend more time online than their higher income, more educated counterparts, a result that is best explained by differences in the opportunity cost of leisure time according to the study.[ii]

With respect to the impact of broadband, Holt and Jamison (2008) provide an overview of various studies, but such studies of broadband's effects suffer from the problem of endogeneity (i.e., information that comes from the model cannot be used to explain the model). For example, if it is observed that economic development and broadband adoption are positively correlated, it is impossible to know whether economic development results from broadband adoption, leads to broadband adoption, or both. The accepted wisdom is that broadband is both a cause and an effect of economic development. Clearly research has proven that advanced communications technologies have a significant economic impact across countries and increasingly so, as such advanced technologies are more rapidly deployed. Unfortunately, rarely does this research include usage or adoption patterns, and deployment clearly is an imperfect proxy for actual broadband use. For this reason, we focus on consumer usage patterns and intensity of broadband use in an effort to expand the existing literature to include choices based on broadband access technology.

BROADBAND USAGE IN PORTUGAL

Broadband access to the Internet was offered in Portugal through cable modem technology beginning in 1999. In 2000, the telecommunications industry was fully liberalized, and local loop unbundling was mandated in 2001. Subsequently, the telecommunications incumbent Portugal Telecom (PT) began offering broadband Internet access through ADSL, and currently offers broadband Internet access both through DSL and cable.[iii]

Among EU Member States, Portugal has the highest ratio of fixed broadband subscribers using a provider other than the incumbent. However, Portugal also has one of the lowest growth rates in fixed broadband. In fact, by the broadband performance index developed, Portugal ranks poorly - in the fourth of five clusters. The 2008 ITIF Broadband Rankings listed Portugal as 18th, with a composite score only slightly higher than average (10.15 compared to an average of 10.00).[iv] Currently Portugal residents increasingly use mobile broadband. Portugal makes intensive use of mobile communications services with 58 percent of voice traffic originating from mobile networks. The mobile market also is credited with exhibiting low churn and high customer loyalty.

Data[v]

For our analyses we draw upon data largely obtained from three surveys conducted in Portugal in 2006 and 2008.[vi] The surveys were stratified by geographic regions of the country that correspond generally with the Nomenclature of Territorial Units for Statistics (NUTS II) geographical coding used by the European Union to indicate divisions of countries for statistical purposes. These regions include: Açores, Algarve, Centro Litoral, Grande Lisboa, Grande Porto, Interior, Madeira, and Norte Litoral.

Education levels vary across the regions, with the highest education levels being in the most urban and highest income areas (Grande Lisboa and Grande Porto), and the lowest education levels (i.e., illiterate) being in some of the lowest income regions (for example Madeira and Alentejo). The vast majority owns a television; however few have more than one car. On average, in 2006 about 40 percent of Portugal households accessed the Internet from their homes. Of those with home Internet access, 61 percent used dial-up Internet access but that proportion is shrinking. Norte Litoral, Grande Lisboa and Centro Litoral had greater home Internet access via cable than by phone.

A primary focus is to understand usage patterns and intensity of use among fixed, mobile, and nomadic consumers.[vii] As prior literature has found education to be a significant determinant of broadband usage, we illustrate fixed, mobile, and nomadic usage by education level from 2008 survey data. This and other such delineations serve to frame the empirical models used in the analyses.

Analyses and Results[viii]

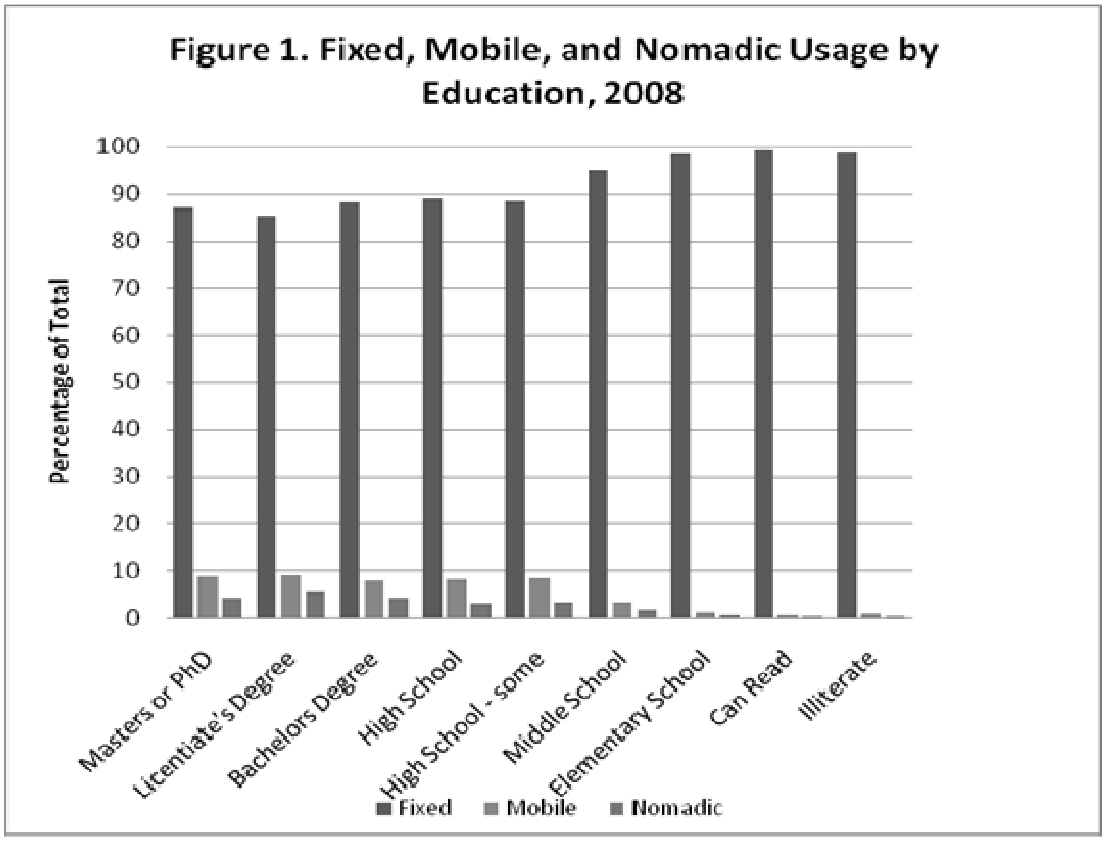
Characteristics of Broadband Consumers

Prior research focuses on characteristics primarily of fixed broadband users. Including characteristics of fixed, mobile, and nomadic broadband users in Portugal provides evidence that across technologies, there is some variation in characteristics among users. We begin by describing the empirical models used in the analysis.

Empirical models for analyses of user characteristics employ utility models in which the utility of individuals from alternative modes of Internet access depends on characteristics of the individual or household, and on characteristics of the respective mode of Internet access.[ix] Specifically, the multinomial logit model,[x] which is an extension of the logit regression model used to represent the choice between mutually exclusive options, is appropriate to use.[xi]

The dependent variable for the model focusing on characteristics of broadband users by technology is a binary (dummy) variable representing households' broadband choices. Explanatory variables include the age, education level, and employment status of the main income contributor, the number of people in the household, the number of children in the household, the occupation of the primary respondent, wealth, region, and habitat. Results of the multinomial logit estimations used to compare individuals' characteristics

by the manner in which they access the Internet for the years 2006 and 2008 are reported in relative risk ratios (rather than coefficients); these represent the probability that respondents choose an alternative, such as mobile broadband, relative to the omitted (reference) alternative, which in this case is fixed broadband.



The results indicate that older persons and persons with lower education levels, lower incomes, and smaller households are the least likely to have Internet access of any form. Madeira is the region where people are least likely to have no Internet access. The relative probability of a wealthier respondent not having Internet access in the home is 0.36, meaning most people of higher income do have Internet access in their home.

The choice of narrowband versus fixed broadband follows a similar pattern, with older persons being more likely to have narrowband than fixed broadband. High school graduates were 2.7 times more likely to have no Internet access than to have fixed broadband compared to university graduates; compared to respondents with a university degree, those who graduated from high school were approximately half as likely to have mobile instead of fixed broadband (relative probability 0.55). Households with at least two cars were 1.73 times more likely to get mobile broadband instead of fixed broadband than households with a single car or without a car.

In general, having at least one child appears to make it more likely that a household will not have home Internet access. Similarly, larger households are less likely to have Internet access at home, but household size does not affect significantly the choice between different types of Internet access.[xii] Initially the probability of not having Internet

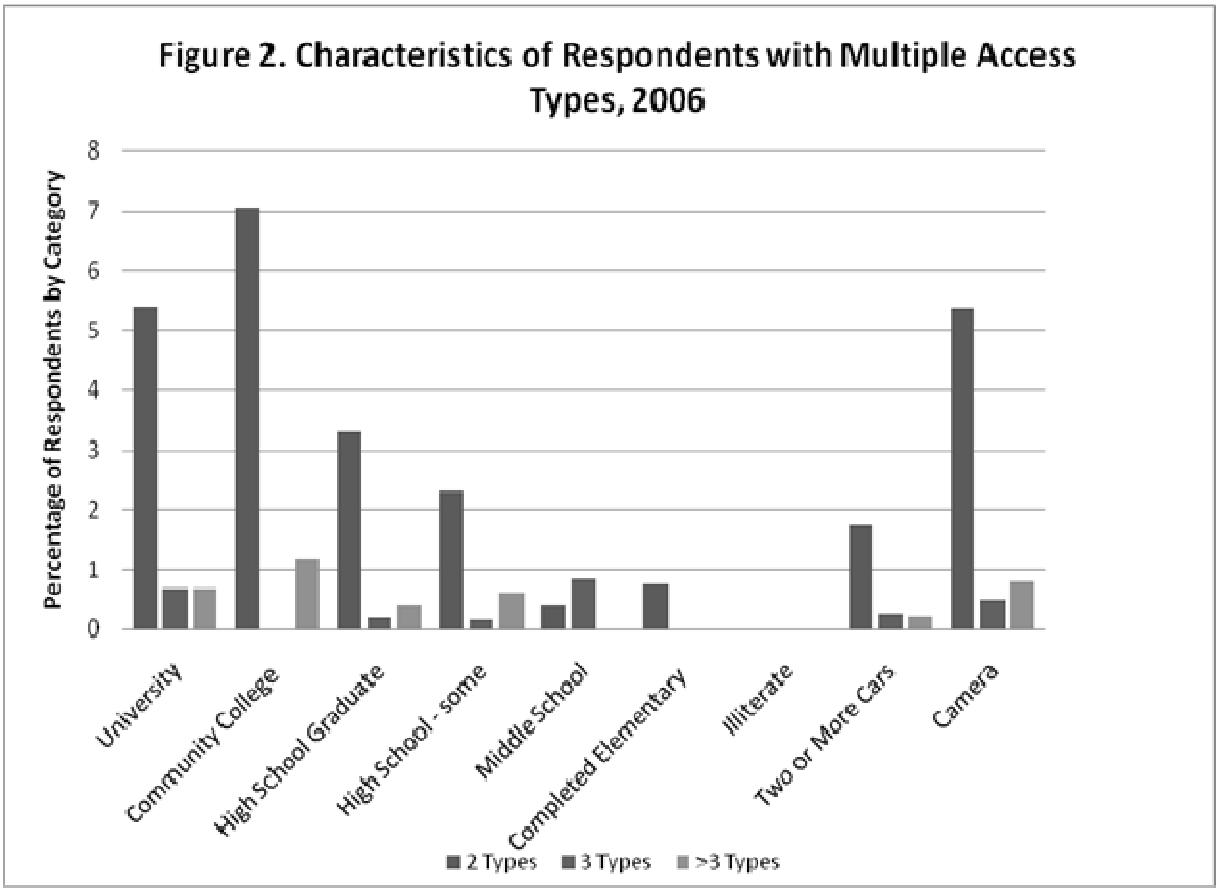
at home relative to that of having fixed broadband decreases with family size, but that probability increases for families with at least five individuals;[xiii] the minimum probability of not having home Internet access instead of having fixed broadband Internet access is for a household size between four and five members[xiv].

The results also indicate that income (using a proxy by a dummy variable for two or more cars and owning a dishwasher) and education are the primary factors related to the choice between fixed and mobile broadband.

Finding differences across end-users who choose multiple types of access is a valuable goal to help determine the degree to which such access types are substitutes. In this respect there exists limited support for the notion that multiple access types are indeed substitutes: of approximately 8,600 respondents in the 2006 BCS survey, only 151 (1.76 percent) report having more than one type of home Internet access, and 80 percent of those had only two types. Still, it is useful to attempt to ascertain reasons for multiple modes of access to better understand substitutability across such modes, as these respondents indicate that various access types are not perfect substitutes. It is possible that fixed broadband might be deemed more valuable for those with a fixed location who want higher bandwidth, while mobile may be more useful for those who also are more mobile.

Nomadic users often are also fixed broadband subscribers or mobile broadband subscribers. This results from the growth of home WiFi networks and the converged device market, which in Europe has grown from about 11 million units sold in 2005 to more than 15 million in 2006. Furthermore, the converged device customer profile has been changing in Europe. As recently as 2005, most high-end smartphones were used primarily for business. Now consumers are using these convergence devices, such as the BlackBerry Pearl or Palm Treo 750, for web browsing, checking personal e-mail, managing family schedules, and the like. This has happened in part because of a decrease in prices: T-Mobile UK has given the BlackBerry Pearl away for free with some wireless calling plans and, in 2008, T-Mobile Germany launched the iPhone in packages priced for the residential user.[xv]

Figure 2 illustrates the education and income level (by proxy) of those respondents reporting two or more types of Internet access in their homes in 2006. Those reporting multiple access types generally have a higher level of education, and also greater income. While income is expected to be a significant predictor of multiple modes of access, the link between multiple modes of access and education is not as predictable. Results indicate that age falls steadily with an increase in the number of types of access (from an average age of 36.23 years to 31.29).[xvi] Regional variations exist as well; noticeably, Madeira has about the same number of homes with two, three, or more types of access and Algarve has only one type. Being island regions, the Açores and Madeira might be expected to be similar; however, they do not appear to have the same options available. It remains to be determined why individuals need more than one access type; in other words, for a small subset of our sample database it is clear that types of access are not perfect substitutes; there must be value in different forms of access.

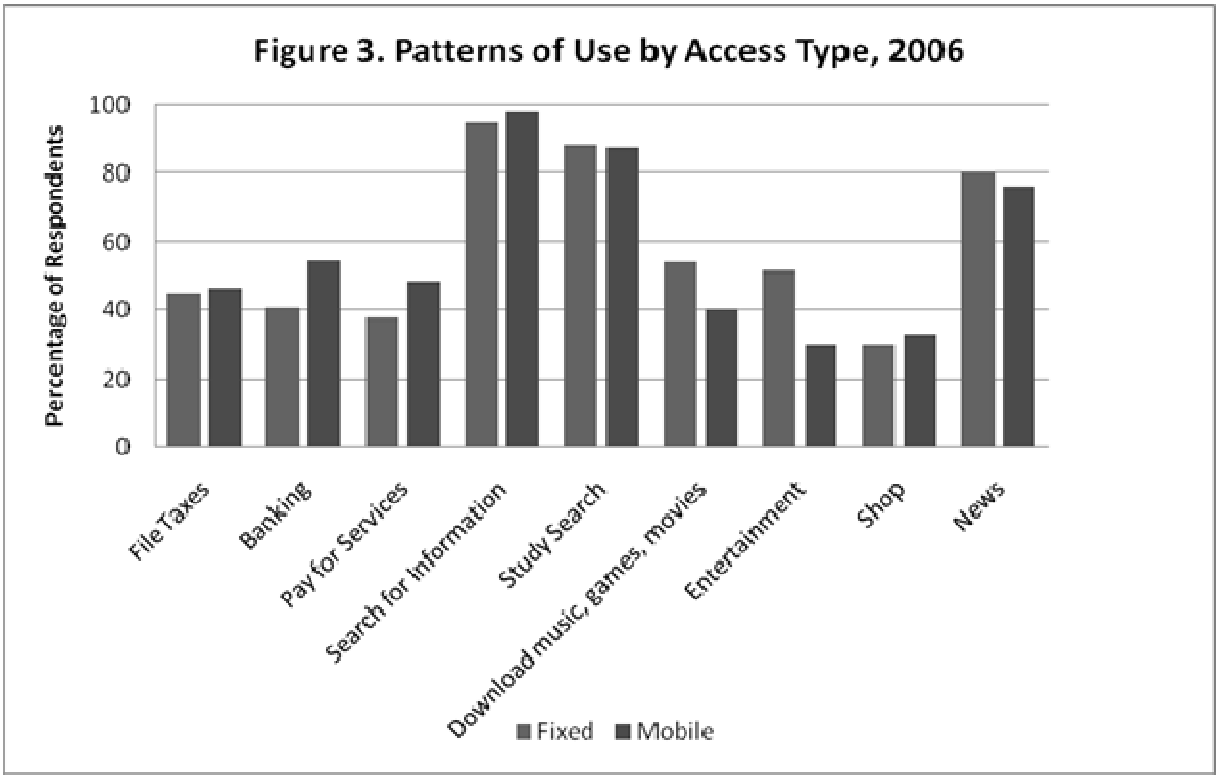


Analysis of Usage Patterns

The value of understanding usage patterns lies in finding potential differences among consumers for various broadband technologies. Usage is an indirect indicator of the value consumers place on their Internet access; that value is expected to vary across types of consumers (i.e., across ages and education levels) as well as across types of applications (i.e., filing taxes versus downloading music). In aggregate, hours of use are approximately 18 hours per week for fixed broadband and 21 hours per week for mobile broadband. The most frequently reported number of hours of use for fixed users was 10 hours per week (18 percent of respondents) followed by 20 hours per week (17 percent of respondents). 20 hours per week was the most frequently reported response of mobile users (22 percent) followed by 5 hours and 10 hours per week (18 percent and 16 percent, respectively).

There are different ways of measuring usage. We focus primarily on hours and types of usage; however, access bandwidth also is important. For example, respondents were asked which package offered by their provider they had chosen. In some instances the package information obtained in the survey included bandwidth (e.g., Sapo offers a 2MB, 4MB, and 8MB package, among others; TvTel offers 256 1GB, 256 3GB, 256 SL and 512 SL; Via Networks offers 512K, 768K, and 1024K, among others), but in other instances only the name of the plan was given, not the features.

Surveys show that hours of use and types of usage are fairly consistent across age groups and regions in Portugal, even though variations are statistically significant in econometric models (details of which are below). Similarly, types of usage are similar across access types. Mobile access is slightly greater for financial applications than fixed access is, and fixed acces is slightly greater for entertainmet, news, and downloading of music, games, and movies. This might occur because mobile broadband is associated with higher-income users than is fixed broadband. Figure 3 illustrates these results.



Empirical models analyzing the difference in usage between narrowband and broadband users consider both the impact of fixed versus mobile access on hours of use and the purpose of use (making purchases, bank transfers, filing taxes), after controlling for individual/household characteristics. This suggests the extent to which narrowband and broadband are substitutes, and similarly the extent to which fixed and mobile broadband are used for similar purposes.

The empirical results indicate that older respondents tend to have lower hours of use; those age 25 to 44 have the highest usage among various age groups.[xvii] Wealthier respondents have higher hours of use. More densely populated and urban areas have higher usage as well. The more densely populated areas of Portugal also have higher per capita GDP and the marginal cost of providing broadband should be lower in more densely populated areas than in less densely populated areas. Finally, there exists a negative relationship between satisfaction with speed and hours of use.

Logistic regressions suggest that mobile subscribers are not different from other broadband subscribers with respect to financial applications; only narrowband proved to

be significant in terms of access mode. Education remains a primary indicator of Internet usage. There are variations across regions once other socio-economic characteristics are controlled for, for example, almost all regions, Madeira being the exception, have lower propensity to use Internet financial services than Grande Lisboa (the reference region).

With respect to non-financial uses, in general a few trends stand out. First, age is significant for entertainment uses (those reporting downloading music, games, and videos, as well as entertainment); younger users consistently access the Internet for non-financial uses at a greater level than older users. Also, education is significant for news-related uses; users with more years of education access the Internet for news at a greater level than less-educated users. As might be expected, the length of time the respondent has had home Internet access is significantly correlated with online shopping, perhaps indicating that those more familiar with Internet use become more trusting of Internet shopping opportunities. Mobile broadband users are less likely than DSL broadband users to use broadband for most of the non-financial uses.

Surveys indicated that fixed service customers are more likely to be frequent broadband users than other access customers, but nomadic customers may be different than fixed or mobile customers. Both fixed and mobile show similar usage profiles: between 40 and 50 percent of the customers of each access type use broadband several times each day, a little more than 25 percent use it at least once each day, and less than 10 percent use it less than once per week. The nomadic customers have a flatter distribution: less than 40 percent use it several times a day, more than 30 percent use it once per day, and over 20 percent use it twice per week. This is consistent with what we might expect of nomadic users: at least some of them would have to physically go to a hotspot to access the Internet and this inconvenience would lower the number of times they use broadband relative to users that have it available at home (i.e., fixed and mobile subscribers) or with them as they move about (i.e., mobile subscribers).[xviii]

Portions of our analyses considered differences between users of fixed, mobile, and nomadic broadband. While information on nomadic broadband users is limited, there appear to be few differences between fixed, mobile, and nomadic broadband customers in terms of hours of use, implying that at least fixed and mobile broadband are viewed as substitutes by many customers. The differences shown using both 2006 BCS and 2008 ICSCE datasets include the following statistically significant findings:

- Mobile broadband users are slightly less satisfied than fixed and nomadic with their service, but fixed and nomadic broadband customers have about the same degree of satisfaction.
- Customers of the three types of access – fixed, mobile, and nomadic – are similar in their satisfaction with their service speeds.
- Most customers do not switch providers.
- Mobile broadband customers are heavier users in terms of hours of use than are customers of fixed broadband.
- Mobile broadband subscription is higher relative to fixed in older age groups.

- Most regions are similar in their use of fixed and mobile broadband, but Açores and Madeira, both island regions, show relatively more mobile broadband usage than the other regions.
- Most respondents who are accessing the Internet from home multiple times per day are doing so via fixed communications.

FUTURE RESEARCH DIRECTIONS

The surveys in Portugal serve to provide important information on customers and usage. Additional data on prices for narrowband and broadband (both fixed and mobile), as well as nomadic, would allow the determination of the elasticity between technologies. Speed information and volume of traffic both would improve the strength of the models employed. Actual expenses per month for service bundles including broadband, television, fixed telephony, mobile telephony, as well as actual usage of each service for fixed and mobile (number of hours, not just number of occurrences) are needed. It is difficult to analyze bundles without detailed knowledge about the package, but since this is how customers are purchasing the services, these details are important to gather.

Several important research questions could drive future directions, including those relating to nomadic use, market competition, and resolving cause and effect questions. Regarding nomadic usage, the analyses indicate that nomadic subscriptions in Portugal follow a different pattern than does the development of hotspots. This implies that hotspots are a broader market than nomadic Portuguese customers. The location choices and technology impacts of hotspots should be explored, as should the types of customers who find nomadic use to be a substitute for fixed or mobile broadband descriptions. Such analyses could inform important public policy questions about regulatory oversight (if any) that might be appropriate for nomadic subscriptions and hotspots. This could be particularly important in countries that are growing rapidly and have large geographic space.

Market performance is an important question. Further work on price elasticities and cross elasticities would be valuable in the study of a country's markets and the development of appropriate regulatory policies.

As a matter of important developments for research techniques, the choice of broadband plan and usage are endogenous, and the hours of use of different services are likely correlated. Future work should examine carefully the cause and effect relationships, paying particular attention to the interdependencies.

Finally, it is understood that broadband has economic impacts. Less well understood are the societal impacts, more specifically, the impacts of citizen participation in government, educational achievement, and other societal engagements. For example, in Brazil children in low-income areas are given computer training, after which the training facility sets them up with their first job. As another example, in some African countries, mobile communications are used to monitor elections.[xix]

CONCLUSION

In the literature to date there remains a great deal that is unknown with respect to how various technologies of broadband delivery differ in their commercial viability, effectiveness, and value. Currently available data have enabled us to provide a wealth of information not previously available on the characteristics of customers and their associated usage patterns and the degree to which customers view different types of Internet access to be substitutes.

The analysis of usage objectives and patterns of use determined that fixed and mobile customers are remarkably similar. Results also are in agreement with other studies that have found that more educated, wealthier, and younger customers tend to have greater usage hours. There also exists evidence that customers use the Internet (whether it is via fixed, mobile, or nomadic access) in similar ways. Slight differences were found in usage patterns by customer characteristics and also across geographical regions; however, these differences are as expected. For example, in the autonomous regions of Açores and Madeira, one might expect mobile Internet access to be more prevalent relative to other regions due simply to the terrain and cost of providing fixed versus mobile broadband.

While this analysis is specific to Portugal, there is no reason to assume that findings for Portugal are not illustrative of a general trend across other similarly developed countries. This makes the conclusions of these analyses of the deployment, adoption and use of fixed and mobile broadband access useful in a much broader context.

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KEY TERMS & DEFINITIONS

Fixed Broadband: Method of accessing the Internet via modem or ISDN, ADSL or other XDSL access, or cable.

Internet Access Substitutability: the degree to which consumers are willing to trade one form of Internet access for another form, i.e., fixed broadband Internet for mobile broadband Internet.

Internet Usage Patterns: Internet consumers' typical uses of various applications, including financial uses, entertainment uses, and research, among others.

Mobile Broadband: Method of accessing the Internet via mobile phone or PDA with broadband Internet connection, or data transmission card.

Multinomial Logit Model: Empirical model that requires the distribution of the random error terms to be independent and identical over the alternatives.

Nomadic Broadband: Wireless access whereby the end-user can move among different access locations, such as hot spots, using a method other than one classified as mobile broadband.

Relative Risk Ratio: Empirical result that is reported rather than a standard coefficient. The ratio represents the probability that respondents choose an alternative relative to the omitted (reference) alternative, i.e., choosing mobile broadband relative to fixed broadband.

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[i] The Global Competitiveness Report is published annually by the World Economic Forum. The rankings are calculated from publicly available data and from an annual survey conducted by the World Economic Forum. The number of countries ranked varies based on available survey data within countries. The report is available at http://www.weforum.org/en/initiatives/gcp/Global%20Competitiveness%20Report/index.htm. According to the most recent report, the main purpose of the ranking and report is to improve the understanding of the key factors that determine economic growth, and to explain "why some countries are much more successful than others in raising income levels and opportunities for their respective populations, offering policymakers and business leaders an important tool in the formulation of improved economic policies and institutional reforms."(page xi).

[ii] Our findings indicate that broadband usage is increasing in income and education. This contrasts with the Goldfarb and Prince study, but does not contradict it. Their finding relates to all Internet usage and shows that time is less valuable for lower income and less educated households. This time preference could lead lower income, less educated customers to use more dialup Internet than broadband, leaving open the possibility that once a customer has adopted broadband, the customer's usage might be positively correlated with income and education.

[iii] Pereira and Ribeiro (2006).

[iv] ITIF 2008.

[v] For detailed information on data used, analyses, and results, please see the full paper, available at www.purc.ufl.edu.

[vi] Specifically, data are from the following surveys: 2006 Consumo de Banda Larga survey (broadband consumption survey, abbreviated as BCS), 2008 Inquérito ao Consumo das Comunicações Electrónicas survey (survey of consumption of electronic communication services, abbreviated as ICSCE), and 2008 Índice Europeu da Satisfação de Consumidor (European consumer satisfaction index, abbreviated as ECSI). The surveys differ and therefore cannot be combined for empirical analysis (i.e., data is cross-sectional). Information on the manner in which the surveys were given and the households selected is available from the authors upon request.

[vii] Nomadic users are characterized based on their responses to 2008 ICSCE survey question Q.93, "What type of Internet connection do you use at home?" Responses were as follows: modem or ISDN (1), ADSL or other XDSL access (2), cable (3), mobile phone or PDA with broadband Internet connection (4), phone connected to Internet through narrowband (5), broadband wireless connections other than mobile phone and PDA (6), data transmission cards (7), and other or do not know, which also were coded responses. By these categories, respondents answering (6) were considered nomadic users (those answering 4 and 7 were considered mobile). The frequency of responses is available upon request.

[viii] We note at the outset of our analysis that some of the data represents subjective opinions and impressions of the respondents, including statements about what they intend to do. For example, in the next section we examine respondents' statements about their intent to change service providers. Survey respondents' answers to such questions can be imprecise. Cummings et al. (1995) find that when survey respondents are asked whether a product is worth a particular price, more respondents will say "yes" if they are told they have no obligation to buy the product at the stated price than if there is an obligation to purchase at the price. In the case of the survey data we use, respondents' statements concerning their

satisfaction, usage and uses, and intent to switch providers might be imprecise. If the errors in their answers are random, then the effect on our research is to decrease the confidence we can place in our statistical results leading us to understate the validity of our findings. If the errors are systematic, in other words, if respondents consistently understate usage, then the effect on our research is to bias our results either up or down, depending on the direction of error. Since we cannot know whether respondents made errors in their answers and, if they did, the direction of those errors, we cannot do better than report our results with this caveat.

[ix] Utility also depends on a random disturbance that has extreme value distribution of type I, which gives rise to logit models of choice between alternatives.

[x] A multinomial logit is appropriate for any binary dependent variable y_i and a continuous independent variable x_i, $Pr(y_i=1)=F(x_i' b)$ where, as before, b is a vector of parameters to be estimated and F is the logistic cumulative distribution function.

[xi] The multinomial logit requires the distribution of the random error terms to be independent and identical over the alternatives. This can produce biased estimates if the cross-elasticities between all pairs of alternatives are identical. The major weakness of the multinomial logit is that the choice between alternatives (i.e., DSL versus cable) depends solely on the characteristics of those alternatives being compared, excluding the characteristics of any other alternatives possible.

[xii] It is unclear from the data why the presence of children and larger household size decreases the probability of having Internet access given the common understanding that Internet access is useful for education and entertainment. We note that while "study search", which would appear to be an educational use, is a prominent use of the Internet in Portugal, general information searching and obtaining news are comparable and might not be related to children or household size. This issue would appear to require further study to find an answer in which we could place more confidence.

[xiii] The actual coefficients are -0.7594721*dc_3+0.0799416*dc_3^2.

[xiv] The minimum is 0.7594721/(2*0.0799416)=4.75 household members.

[xv] IDC, as cited by Standard and Poor's (2009).

[xvi] Result is not shown in the figure.

[xvii] Results are provided in the Appendix, section 1b. In the 2008 ICSCE survey we do not have a question asking hours of use; Q92 asks "How often do you usually use Internet in your home?" with possible responses of: several times a day, once a day, two to three times a week, and less than once a week. The 2008 estimation is therefore an ordered logit instead of a negative binomial model as used for the 2006 analysis.

[xviii] Respondents are asked what type of home Internet access they use, and those responding "nomadic" may therefore interpret this question as asking what type of Internet access they use either most frequently for personal reasons, or access other than at and for work.

[xix] For more on these and other examples of societal impacts, see Jamison (2007).