Residential Demand for Access to the Internet[1]

Paul Rappoport, Temple University
Donald J. Kridel, University of Missouri at St. Louis
Lester D. Taylor, University of Arizona
James Alleman, University of Colorado and Columbia University

1.0 Introduction

The focus in this paper is on the residential demand for access to the Internet, and represents an extension of earlier work on Internet access demand by Rappoport, Taylor, Kridel, and Serad (1998), Kridel, Rappoport, and Taylor (1999), Kridel, Rappoport, and Taylor (2000), and Duffy-Deno (2000). The analysis of broadband demand has been studied by Eisner and Waldon (1999), Madden, Savage, and Coble-Neal (1999) and Madden and Simpspn (1997). With the aggressive marketing of cable modems and ADSL service, a growing number of residential households in the U.S. now have a choice regarding how they access the Internet. The choice set available, however, is not uniform. In some areas, the only form of access is through dial-up modem, while in other areas various forms of high-speed access (cable modems or ADSL) are available as well. This paper reports the results from a set of models of Internet access where the models are differentiated by the availability of Internet access options. The models are based on the analysis of surveys submitted by over 20,000 households during the period January – March, 2000.[2] Among other things, we are able to report broadband penetration rates and compare those to Internet access estimates presented in the NTIA Report, Falling Through the Net: Toward Digital Inclusion.[3] In addition, we present a more complete set of estimated price elasticities for both basic and high-speed access to the Internet.

The organization of the paper is as follows. We begin in the next section with a brief summary of the demographics of Internet and broadband access. We compare the information obtained in the Omnibus Survey with results presented in the NTIA report.

---

[1] The authors wish to thank Dr. Don Michels and Dr. Dale Kulp for their assistance.
[2] Centris® Omnibus Survey, Marketing Science Corporation, January – March, 2000.
[3] NTIA, Falling through the Net: Toward Digital Inclusion, US Department of Commerce, National Telecommunications and Information Administration, , October, 2000.
http://www.ntia.doc.gov/ntiahome/digitaldivide/

Section 3 then presents the underlying models for estimating access elasticities. In section 4 we discuss the data. In Section 5 we present the results from the estimation. Finally, in Section 6 we discuss these results and their implications.

Section 2: Demographic Profiles of Access to the Internet

Consumer interest in the Internet is well documented. The NTIA study reports overall Internet penetration rates of 42.1%.[4] The survey data used in this study suggest household penetration rates of 46.5%. These numbers represent a significant increase in the proportion of households with access to the Internet. As recently as 1998, national studies indicated that only 26% of households had access to the Internet.[5] Even in 2000, the vast majority of these households accessed the Internet through dial-up modems. However, the rate of broadband access is increasing. Recent estimates have 4.5% of all households accessing the Internet through broadband connections. Or, over 10% of those connected to the Internet access the Internet via broadband.[6] Estimates obtained from the omnibus survey indicate that 9.7% of households that access the Internet have broadband or high-speed connections. This translates into 4.9% of all households with broadband access. The reasons for the increasing popularity of broadband access are: the availability and marketing of cable modems (CM) and ADSL services; the perceived need by users for more speed and bandwidth, and the decreasing price of broadband access.

The following figures display Internet penetration rates according to household size, level of education, and income. As noted, these charts are based on data from an omnibus survey.[7] Where appropriate, NTIA results are presented for comparison.

Figure 1 demonstrates that overall Internet penetration rates increase with household size. While the NTIA report does not provide Internet penetration rates by size of household, the report provides Internet penetration rates by household type. The NTIA report

---

[4] op cit NTIA, pp. 1-3
[5] ibid NTIA, p1
[6] ibid, pp. 23
[7] Centris® Market Systems Group, Ft. Washington, PA

indicates that households with children have a penetration rates well over the average—a finding consistent with Figure 1.

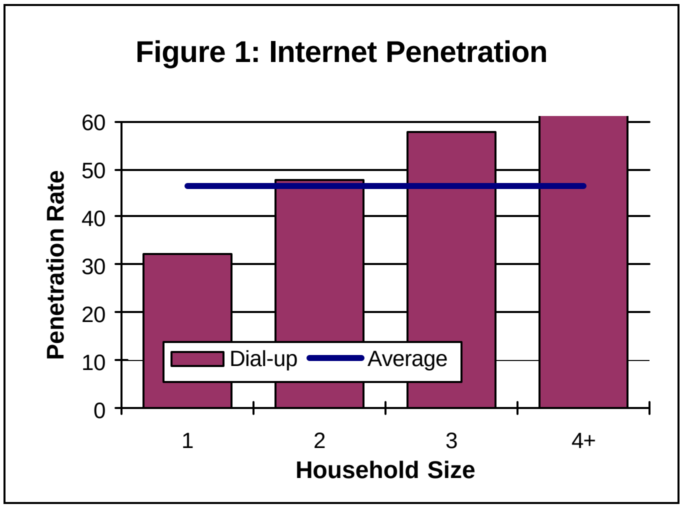


Figure 2 presents broadband penetration rates by household size. The distribution shows an increased likelihood of broadband access as household size increases.

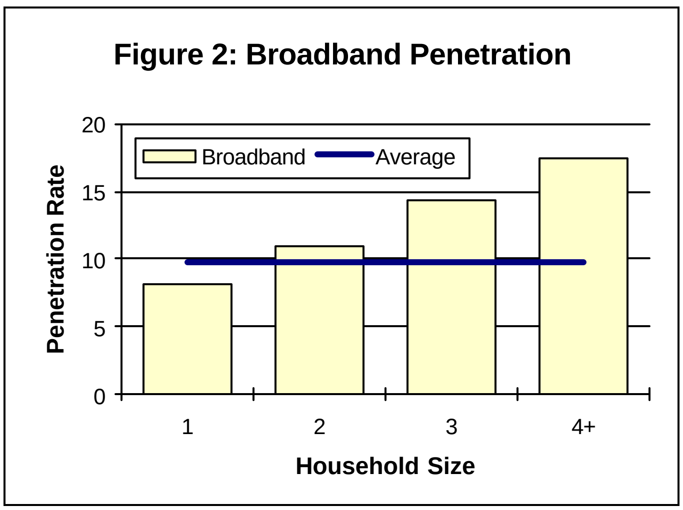
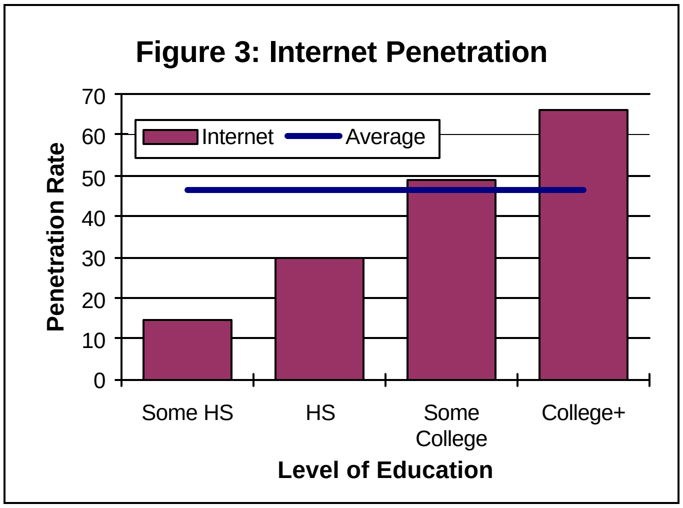
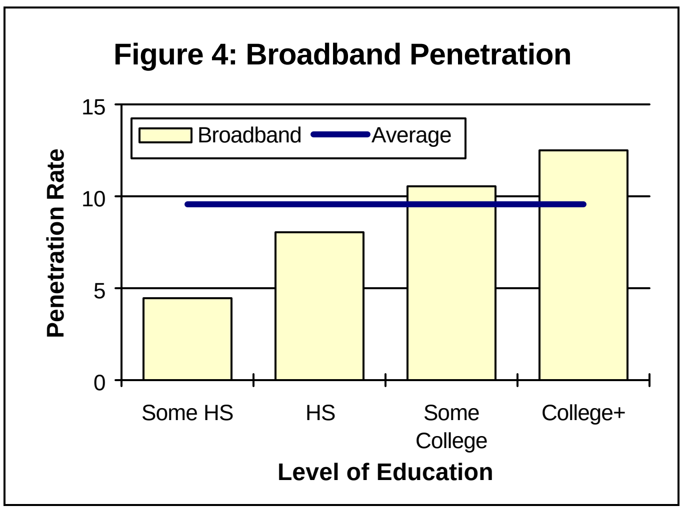


Figure 3 demonstrates that there is a positive correlation between level of education and Internet penetration. Having some college is associated with above average penetration rates. Similar distributions were reported in the NTIA report.[8]

[8] op. cit. p 99



The relationship between high-speed access and education is similar (Figure 4). Again households with some college have above average penetration rates.



Previous studies have shown that income is correlated with Internet access and use of broadband services.[9] Figure 5, which relates Internet penetration to income category, is consistent with his finding. Note that the richest households are almost 4 times as likely to have Internet access as the poorest households.

---

[9] Cf., Rappoport, Taylor, Kridel, and Serad (1998) and Kridel, Rappoport, and Taylor (1999) and Kridel, D.J., Rappoport, P.N., and Taylor, L.D. (2001),

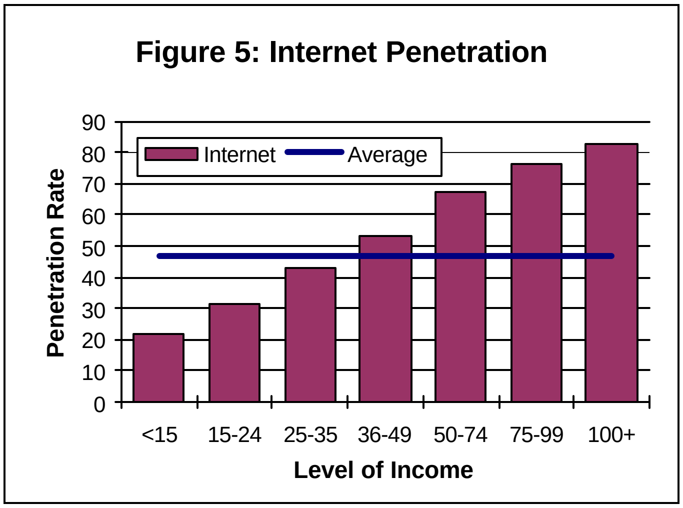
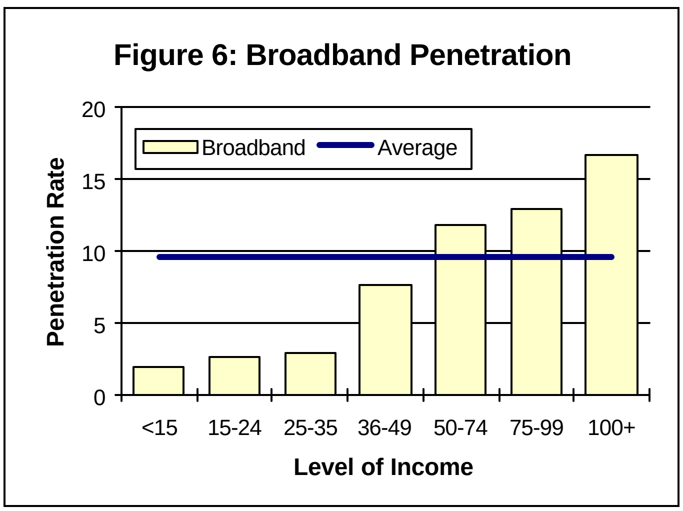
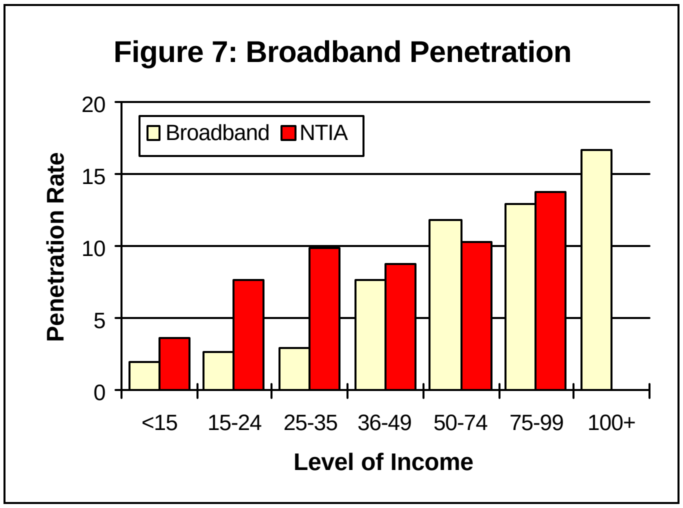


Figure 6 provides the same information for broadband households. Income has an even stronger effect on broadband than on Internet access in general. Indeed, the richest households are 5.5 times as likely to have broadband as the poorest households.



The NTIA report indicates a much higher broadband penetration rate at lower levels of income than was found in the omnibus survey responses. Figure 7 provides the comparison by income category. These results should be interpreted with care since the sample sizes for broadband are small.



Section 3 Models of Internet access

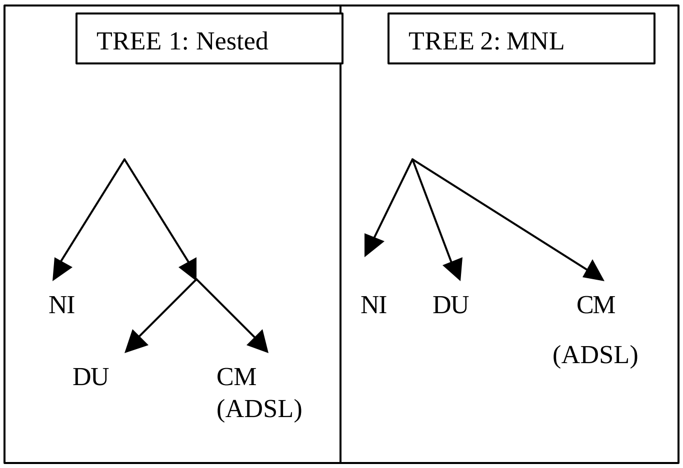
Models of residential access to the Internet were developed in previous papers.[10] The following extensions are considered in this paper. First, the choice of access depends on the availability of the service. For broadband, this requires that either cable modem or ADSL service was available. Not all choices are available to all households. Thus, for some regions of the country, models were estimated reflecting the entire range of choices. For other areas, the number and type of choice was limited.

Table 1 displays the differing areas for Internet access. Each area is defined by the availability of Internet options.

	Choices
Area 1	Dial-up ONLY
Area 2	Dial-up AND Cable Modem OR ADSL
Area 3	Dial-up Cable Modem ADSL

[10] ibid Rappoport, Taylor, Kridel, and Serad (1998) and Kridel, Rappoport, and Taylor (1999) and Kridel, D.J., Rappoport, P.N., and Taylor, L.D. (2001),

Note that for Areas 2 and 3, there are differing choice structures that could be utilized in the estimation framework. For example, in Area 2, possible decision (or tree) structures could be as follows:



(Note that NI refers to no Internet. DU refers to dialup access. CM refers to cable modem access and ADSL refers to ADSL access.)

For some households, the choice is Internet access via dial-up access or no Internet access. A simple binary choice model is appropriate for modeling that choice. In Area 2, the choice expands. In this situation, one broadband service is also available to the household. In Area 3, the choice expands further. Now both cable modem access and ADSL service are available to the household. We note the number of choices increases as we move from Area 1 to Area 3.

Models for Area 2 can be estimated with either Tree 1 or Tree 2 structures; a nested logit specification (Tree 1) or a multinomial logit specification (Tree 2). The nested structure assumes the choice is between dial-up access or one type of broadband access, given the households has internet service. The multinomial structure is based on three choices confronting the household at the same time – choice of no internet access, dial-up access or one type of broadband access. The complexity of structures changes for models associated with Area 3.

For models of Area 3, two specifications can be specified and estimated. The first is a the nested logit structure as represented in Tree 3. Here there are two branches to consider. The first branch looks at internet service provided by either dial-up service or broadband service. For models in Area 3, both types of broadband service are available. The second branch looks at the type of broadband service chosen, assuming the household has broadband service. The first branch can also be specified as a multinomial logit.

Area 1 Only option for Internet access is dial-up access

For this situation, the following model is utilized:

$$(1)\ \Pr(Y=1) = \frac{e^{b'x}}{1+e^{b'x}}$$

where Y=1 is the choice of Internet service using dial-up access and Y=0 represents no Internet access. The choice of explanatory variables x includes income, household size, education, age, gender and price.

Area 2: Choice is dial-up and one high-speed alternative

For this situation the multinomial logit model is utilized (Tree 2 above). The general form of the model is:

$$(2)\ \Pr(\text{choice}_{\mathrm{j}}) = \frac{e^{b_j' x}}{\sum_j e^{b_j' x}}\ .$$

The choices considered are no Internet, dialup Internet, and either cable modem or ADSL access. Two models were estimated. The first includes those observations where both dialup access and cable modem service (but not ADSL service) were available. The second considers observations where both dialup access and ADSL (but not cable modem service) were available.

Tree 3 All choices available

Either the multinomial specification given above or the nested logit specification could be estimated for this choice situation. In the nested logit specification, the decision tree assumes individuals choose a branch (dial-up or broadband) and then an alternative, given the branch (for the branch broadband, the alternatives are ADSL or cable modem). The probability of choosing an alternative k from branch j and and limb I is given by[11]:

(3) $\Pr(k|l,i) = \dfrac{e^{b'x_{k|j,i}}}{\sum_{n|j,i} e^{b'x_{n|j,i}}} = \dfrac{e^{b'x_{k|j,i}}}{e^{J_{j|i}}}$ where $J_{j|i}$ is the inclusive value for branch j in limb i.

(4) $P(j|i) = \dfrac{e^{a'y_{j|i} + t_{j|i} J_{j|i}}}{\sum_{m|i} e^{a'y_{m|i} + t_{m|i} J_{m|i}}}$

(5) $P(i) = \dfrac{e^{g'z_i + s_i I_i}}{\sum e^{g'z_1 + s_1 I_1}}$

such that

(6) P(k,j,i)=p(k|j,i)*P(j|i)*P(i)

For the model of Internet access, these probabilities translate to: P(Cable modem access, broadband service, Internet service) = P(cable modem|broadband and Internet) * P(Broadband|Internet) *P(Internet). Similar expression exist for ADSL and dial-up service. The nested logit model makes use of two limbs: Internet access or non Internet access; two branches: dial-up service or broadband service; and two alternatives along the branch of broadband (cable modem or ADSL). The difference between the nest logit using the explicit tree structure and the multinomial logit specification is the specification of the tree structure. The nested logit assumes choices are based on perceived groups on the part of consumers.

---

[11] See Greene (2000), pp. 865-872.

Section 4 Data

As noted above, the information used in the analysis was obtained from the Centris® Omnibus Survey administered by the Marketing Science Corporation of Ft. Washington, PA. The time period for the survey covered the period of January, 2000 to March 31, 2000. During that time period, 20,755 households were surveyed. Respondents were selected randomly. The Centris® Survey contained questions on households use of the Internet, their form of access, and its cost. Information was also obtained on household use of computers and other electronic equipment, as well as on household demographics.

In addition to the survey data, additional data on cable-modem availability and price and ADSL availability and price were used. These data were developed by Duffy-Deno (2000). Price data were obtained partly from a national on-line survey of Internet households conducted in March 2000 by TNS Telecoms. The TNS survey targeted responses from each of three groups of Internet households across the US: those that use dial-up, ADSL, or cable-modem (CM) to access the Internet. Only households whose primary computer that accesses the Internet is at home were solicited for the survey.

The on-line survey price data were augmented by data on prices for the Internet access types that are currently not used by the household. For example, the price for ADSL access and the price for CM access (both inclusive of any ISP charge) that a given dial-up access household would likely have to pay for high-speed access (HSA), were the latter available. ADSL prices, for those households who do not have ADSL access, are assumed to be those of the household's serving Local Exchange Carrier (LEC) (e.g., Pacific Bell).[12] CM prices, for those households who do not have CM access, are assumed to be those of the household's serving CATV provider (e.g., Time Warner).[13] Finally, dial-up prices, for those households who do not have dial-up access, are assumed

[12] The price of the serving LEC's entry residential ADSL offering is used. The LECs were the primary source of ADSL service to the residential sector during the time period covered by the survey. These prices were obtained from the LECs web sites.

[13] The CM access prices are those for current CATV subscribers, obtained from the CATV provider web sites.

to be the average ISP price (paid by survey households) in the Census region in which the household resides.

The on-line survey data were also augmented by data on the availability of HSA in each household's area. Clearly, one reason why a household does not have HSA is because neither ADSL nor CM access is available. Using the zip code and phone number provided by the on-line survey respondents, an indication of whether ADSL and/or CM access is being marketed in the household's immediate area can be obtained.

Five-digit zip codes were used to determine if CM service was available in the household's zip code. This was accomplished through CM availability through checks of the CM providers' web sites. While cable-modem service may not be available throughout a zip code, knowledge that cable-modem service is available in at least some portion of a zip code suggests that cable operators are actively marketing the service in the household's immediate geographic region. Likewise, the household's area code and prefix were used to determine if the LEC (e.g., Pacific Bell) is providing ADSL service from the central office servicing that area code and prefix. This again was accomplished through an availability check on the LECs' web sites, as well as through the use of data provided by some LECs as to which central offices were currently provisioned for ADSL. Distance limits and line requirements can preclude ADSL service to a household even if a serving central office has been enabled to provide ADSL. However, as with cable-modems, an indication can be obtained as to the geographic extent to which ADSL currently is being marketed. Consequently "availability" of HSA is defined in terms of whether ADSL and/or CM access is being marketed somewhere in a household's immediate geographic area (i.e., serving wire center or 5-digit zip code).[14] Price and availability data were then matched to the Centris® household records at the zip-code level.

---

[14] To determine whether ADSL or CM access is available to a specific household premise would require the input of the household's address into the service providers' availability checks, offered on their web sites. The on-line survey did not ask for a premise address.

Variables and delimiters used in this study:

The following explanatory variables were used in the model of simple binary choice (Model 1):

- HHSIZEi: Household size (measured as a categorical relative to household size 8, with values 1, 2, 3, 4, 5,6,and 7)
- INCOMEi Income (measured as a categorical variable relative to $100 K+, with <15, 15-24, 25-34,36-49,50-74,75-99)
- EDUCi Education (measured as a categorical variable relative to college+, with <HS, HS, some college, college graduate)
- Age
- Gender
- DUPRICE Average price for dial-up Internet service
- PR_cable Average price of cable modem service
- PR_ADSL Average price of ADSL service
- CM_AV Indicator of cable modem availability
- DSL_AV Indicator of ADSL availability
- BB_price Average price of broadband service

Section 4 Empirical Results

Area 1

The first model is specified in terms of a simple logistic model, in which choice is between having Internet access via dial-up modem (Y = 1) or choosing to not to have Internet access at all (Y = 0). The probability of choosing Internet is therefore according given by:

For this estimation, a sub-sample of respondents was used. The sub-sample consisted of all records where either cable modem access or ADSL service was not available. The sub-sample consisted of 15,387 observations. The results from this estimation are displayed in Table 2.

Table 2 Output for Model 1
(Choice: no Internet or dialup access)

Variable	Coefficient	St. Error	T Statistic	P-value
Constant	2.891	0.515	5.641	
DUPRICE	-0.0358	0.020	-1.79	0.035
HHSIZE (1)	-0.370	0.198	-1.86	0.630
HHSIZE (2)	0.221	0.195	1.113	0.911
HHSIZE (3)	0.279	0.196	1.420	0.155
HHSIZE (4)	0.378	0.197	1.919	0.055
HHSIZE (5)	0.394	0.201	1.960	0.495
INCOME (<15k)	-1.699	0.093	18.26	0.000
INCOME (15-25)	-1.395	0.082	17.01	0.000
INCOME (25-35)	-1.019	0.078	13.06	0.000
INCOME (35-50)	-0.729	0.073	9.986	0.000
INCOME (50-74)	-0.325	0.074	4.391	0.000
INCOME (75-100)	-0.100	0.084	1.194	0.233
EDUC (< HS)	-1.572	0.100	-12.57	0.000
EDUC (HS)	-0.938	0.071	-13.15	0.000
EDUC (S College)	0.379	0.072	5.264	0.000
EDUC (College)	0.530	0.072	7.361	0.000
GENDER (M)	0.831	0.358	2.320	0.020
AGE	1.955	0.127	15.39	0.000

As suggested by the demographic profiles, age, income, education level and household size are all highly significant in this model. The categorical variables are all relative to the value for the category that was not included. For income, the bin 100,000 + was not included. For Household size, 6+ was omitted. For education, post college was omitted. The elasticity with respect to the dial-up price, calculated from the coefficient for DUPRICE is -0.372.[15] This compares quite closely with –0.38 elasticity reported in Kridel, Rappoport, and Taylor (1999).

Area 2 Dialup service vs cable modem service

In this model, the dataset was restricted to include only those observations for which cable service was and ADSL service was not available. There were 3705 observations

[15] The formula used $\hat{b} * DUPRICE * (1 - share_{\text{internet}})$ where the mean DUPRICE is $20.38

that met this criterion. The average price for cable service was $40.57, while the average price for dialup service in this sample was $20.11.

The output from this estimation is displayed below in Table 3. Estimated own and cross price elasticities were computed.[16] These elasticities are given in Table 3.

Table 3 Output for Model 2a
(Choice: dialup or cable modem)
P(Y=Dialup)

Variable	Coefficient	St. Error	T Statistic	P-value
Constant	0.643	0.904	0.711	
DUPRICE	-0.023	0.010	-2.310	0.027
PR_CABLE	0.259	0.018	14.714	0.000
INCOME (<15k)	-0.049	0.010	-0.491	0.623
INCOME (15-25)	-0.079	0.078	-1.001	0.340
INCOME (25-35)	-0.030	0.042	-0.710	0.453
INCOME (35-50)	0.043	0.025	1.720	0.068
INCOME (50-74)	0.057	0.026	2.192	0.051
INCOME (75-100)	0.074	0.027	2.740	0.005
GENDER (M)	0.328	0.177	1.850	0.064
AGE	-0.028	.0075	-3.014	0.003

P(Y=Cable modem)

Variable	Coefficient	St. Error	T Statistic	P-value
Constant	-1.894	1.780	-1.059	
DUPRICE	0.004	0.029	0.013	0.986
PR_CABLE	-0.0235	0.009	-2.622	0.008
INCOME (<15k)	-1.358	0.507	-2.677	0.007
INCOME (15-25)	-1.151	0.396	-2.905	0.004
INCOME (25-35)	-1.227	0.352	-3.486	0.000
INCOME (35-50)	-1.125	0.290	-3.882	0.000
INCOME (50-74)	-0.641	0.243	-2.640	0.008
INCOME (75-100)	-0.736	0.286	-2.574	0.010
GENDER (M)	0.652	0.177	3.684	0.000
AGE	0.049	0.021	2.333	0.024

We note that for the choice of dialup service, cable modem service is a significant substitute. For those customers with cable modem service, however, dialup service is

[16] Own price elasticity is $\hat{b}_j * (1 - share_j) * price_j$;cross price elasticity is given by $\hat{b}_i * (share_i) * price_i$

insignificant. We also note a more significant impact of income in the choice of service for cable modem. Bold numbers represent own price elasticities.

Table 4

Estimated Elasticities

	Dialup	Cable Modem
Dialup	**-0.230**	0.518
Cable Modem	0.001	**-0.895**

There were 4041 observations for the model where dial up access and ADSL (but not cable modem access) service were available.

Table 5 Output for Model 2b
(Choice: dialup or ADSL)
P(Y=Dialup)

Variable	Coefficient	St. Error	T Statistic	P-value
Constant	1.575	0.161	9.749	
DUPRICE	-0.016	0.002	-7.490	0.000
PR_ADSL	0.961	0.250	3.844	0.000
INCOME (<15k)	-0.409	0.046	-8.545	0.000
INCOME (15-25)	-0.288	0.042	-6.927	0.000
INCOME (25-35)	-0.219	0.036	-6.027	0.000
INCOME (35-50)	-0.111	0.033	-3.444	0.000
INCOME (50-74)	-0.051	0.031	-1.761	0.078
INCOME (75-100)	0.031	0.032	0.912	0.362
GENDER (M)	0.031	0.018	1.701	0.089
AGE	-0.004	0.0007	-5.312	0.000
EDUC (<HS)	-0.219	0.055	-3.987	0.001
EDUC (HS)	-0.078	0.035	-2.223	0.026
EDUC (S College)	0.013	0.033	0.390	0.697
EDUC (College)	0.046	0.021	2.190	0.032

P(Y=ADSL)

Variable	Coefficient	St. Error	T Statistic	P-value
Constant	6.927	1.117	6.204	
DUPRICE	0.005	0.012	0.368	0.712
PR_ADSL	-0.031	0.007	-4.428	0.000
INCOME (<15k)	-2.402	0.346	-6.939	0.000
INCOME (15-25)	-1.898	0.321	-5.906	0.000

INCOME (25-35)	-1.582	0.299	-5.286	0.000
INCOME (35-50)	-0.996	0.288	-3.464	0.000
INCOME (50-74)	-0.588	0.293	-2.002	0.043
INCOME (75-100)	0.571	0.399	1.432	0.152
GENDER (M)	0.212	0.132	1.541	0.000
AGE	-0.021	0.005	-4.602	0.000
EDUC (<HS)	-1.067	0.361	-2.892	0.038
EDUC (HS)	-0.433	0.264	-1.637	0.101
EDUC (S College)	0.129	0.272	0.488	0.625
EDUC (College)	0.502	0.272	1.841	0.066

Table 6

Estimated Elasticities

	Dialup	ADSL
Dialup	**-0.168**	0.423
ADSL	0.040	**-1.364**

Area 3 All broadband services available

In this area, consumers face the complete choice set: no access, dial-up, cable model and ADSL. A sub-sample of 5255 observations was used in the estimation of this model.

For Area 3, a multinomial logit function was specified to estimate the choice between dial-up access and broadband access (Tree 1). The second branch in Tree 3, was estimated as a nested logit, utilizing LIMDEP's NLOGIT routine.[17] The specification of the branches is dependent on the significance of the inclusive values, which link branch to limb. NLOGIT provides for the complete specification and estimation of these inclusive values.[18]

The following table reports the estimation of the first branch in the structure – choice between dial-up access and broadband access.

[17] Greene, LIMDEP Version 7.0.

[18] The last branch, ADSL vs Cable modem is specified as a function of price only, there being no other choice specific attributes available. The second branch in Area 3 is viewed in terms of a nested logit.

Table 7

P(Y=Dialup)

Variable	Coefficient	St. Error	T Statistic	P-value
Constant	0.474	0.448	1.058	
DUPRICE	-.0285	0.021	-1.337	0.183
BB_PRICE	0.017	0.008	2.125	0.024
INCOME (<15k)	-0.854	0.071	-12.03	0.000
INCOME (15-25)	-0.557	0.058	-9.667	0.000
INCOME (25-35)	-0.191	0.052	-3.667	0.000
INCOME (35-50)	0.066	0.047	1.409	0.159
INCOME (50-74)	0.316	0.049	6.445	0.000
INCOME (75-100)	0.507	0.048	10.40	0.000
GENDER (M)	0.246	0.031	7.845	0.000
AGE	-0.012	0.001	-12.00	0.000
EDUC (<HS)	-1.687	0.083	-20.44	0.000
EDUC (HS)	-0.955	0.057	-16.86	0.000
EDUC (S College)	-0.311	0.058	-5.30	0.000
EDUC (College)	0.137	0.059	2.307	0.021

P(Y=Broadband)

Variable	Coefficient	St. Error	T Statistic	P-value
Constant	6.927	1.117	6.204	
DUPRICE	0.002	0.061	0.037	0.982
BB_PRICE	-0.039	0.010	-3.90	0.000
INCOME (<15k)	-1.202	0.284	-4.243	0.000
INCOME (15-25)	-0.972	0.220	-4.411	0.000
INCOME (25-35)	-0.715	0.189	-3.787	0.000
INCOME (35-50)	-0.535	0.158	-3.375	0.000
INCOME (50-74)	0.244	0.132	1.856	0.064
INCOME (75-100)	0.751	0.152	4.917	0.000
GENDER (M)	0.896	0.097	9.177	0.000
AGE	-0.018	0.002	-9.000	0.000
EDUC (<HS)	-2.291	0.316	-7.229	0.000
EDUC (HS)	-1.437	0.159	-9.010	0.000
EDUC (S College)	0.316	0.142	2.222	0.056
EDUC (College)	0.499	0.142	3.511	0.000
IV	0.445	0.227	1.960	0.025

The multinomial model confirms that income and education level are major determinants of choice. The increased importance of higher levels of income and college and post college education in the choice of broadband service are also evident. IV represents the inclusive value as computed from the lower branch. The derived elasticities at this stage are given in Table 8.

Table 8

Estimated Elasticities

	Dialup	Broadband
Dialup	**-0.277**	0.725
Broadband	0.021	**-1.491**

Focusing on the second branch in Tree 3 unobservable differences in the utility functions for CM and ADSL are unlikely to be related to any of the observed demographic variables. Hence, only choice-specific variables are included (prices) to model broadband choice.

The following output pertains to the estimation of the choice between cable modem access or ADSL access. Price is the difference between the prices facing the subscriber.

Table 9

Variable	**Coefficient**	**St. Error**	**T Statistic**	**P-value**
Price_diff	-0.0414	0.009	-4.487	0.000

The LIMDEP direct (in bold) and cross price elasticities are given below:

Table 10

	Cable Modem	ADSL
Choice: Cable Modem	**-0.587**	0.766
Choice: ADSL	0.618	**-1.462**

Section 6. Conclusions

Using recent data from an omnibus survey, we have estimated models of consumer access to the Internet. These include models of where the choice is only dial-up access and models the choice is dial-up access, or broadband access; where the broadband choice is cable modem or ADSL.

The generic dial-up elasticity consistently falls in the -.2 to -.4 range, a number in line with previous estimations. The availability of choice matters. First, when the only alternative is ADSL, we note a significant cross price effect suggesting ADSL is a strong substitute for dial-up access. The ADSL elasticity is greater than one. However, as the penetration rates of ADSL service increase, we expect that price elasticity to become inelastic. A similar result is found in the model where cable modems are the only other alternative to dial-up access. The cable modem elasticity is smaller than the elasticity estimated for ADSL, reflecting more the increased penetration rate of cable modems in the residential market.

For the model where all types of access are available to the household, we note that both ADSL service and cable model service are strong substitutes to dial-up access. We also observe, not surprisingly, that ADSL and cable modems are substitutes for one another.

There are other factors at work in the decision to adopt broadband service. These are summarized in the type, duration and reach of the household's usage. The logical extension of the choice modeling requires the collection and use of Internet activity information. This information is being collected and will be incorporated into future broadband models.

The broadband penetration data suggest that the market for broadband services will continue to growth. As the demand for bandwidth and service quality increases, the market should witness the increasing migration of dial-up customers to customers with broadband services. This migration will accelerate as broadband prices (relative to dial-up prices) fall, as availability of broadband services increases, and as the applications that use broadband services increase.

References

Duffy-Deno, Kevin T., "Demand for High-Speed Access to the Internet Among Internet Households," TNS Telecoms, November 2000.

Eisner, J. and Waldon, T. (1999), "The Demand for Bandwidth: Second Telephone Lines and On-Line Services," Federal Communications Commission, Washington, D.C.; forthcoming in *Information Economics and Policy*.

Greene, W.H. (2000), ECONOMETRIC ANALYSIS, 4th ed., Prentice-Hall.

Kridel, D.J., Rappoport, P.N., and Taylor, L.D. (1999), "An Econometric Model of the Demand for Access to the Internet," in *The Future of the Telecommunications Industry: Forecasting and Demand Analysis*, ed. by D.G. Loomis and L.D. Taylor, Kluwer Academic Publishers.

Kridel, D.J., Rappoport, P.N., and Taylor, L.D. (2001), "An Econometric Model of the Demand for Access to the Internet by Cable Modem," *Forecasting the Internet: Understanding the Explosive Growth of Data Communications*, ed. by D.G. Loomis and L.D. Taylor, Kluwer Academic Publishers.

Madden, G., Savage, S.J., and Coble-Neal, G. (1999), "Subscriber Churn in the Australian ISP Market," *Information Economics and Policy*, Vol. 11, No. 2, July 1999, 195-208.

Madden, G. and Simpson, M. (1997), "Residential Broadband Subscription Demand: An Econometric Analysis of Australian Choice Experiment Data," *Applied Economics*, Vol. 29, pp. 1073-1078.

NTIA (2000), "Falling through the Net: Toward Digital Inclusion", US Department of Commerce, National Telecommunications and Information Administration, October, 2000.

Rappoport, P.N., Taylor, L.D., Kridel, D.J., and Serad, W. (1998), "The Demand for Internet and On-Line Access," in *Telecommunications Transformation: Technology, Strategy and Policy*, ed. by E. Bohlin and S.L. Levin, IOS Press, pp. 205-218.