Chapter 9
Residential Demand for Wireless Telephony

Donald J. Kridel

9.1 Introduction

Headlined by Verizon Communications agreement to pay $130 billion to buy Vodafone Group out of its U.S. cellular business, and the earlier attempted purchase of T-Mobile by AT&T (itself a merged SBC, Bell South and "old" AT&T Wireless), the wireless telephone industry continues to attract media attention and to grow at significant rates.

However, despite this impressive presence and growth, empirical evidence regarding the demand for wireless services is still relatively uncommon. In this chapter, we provide estimates of the price (and other) elasticity of residential demand for wireless telephony (using individual household observations). Using a large data set with over 20,000 observations, we estimate a discrete-choice model for the demand for wireless telephony. Preliminary elasticity estimates indicate that residential wireless demand is price-inelastic.

9.2 Data Analysis

The discrete-choice model was estimated using data from a proprietary survey of telecommunications services conducted by CopperKey Technologies late in the second quarter of 2001. The data set analyzed includes approximately 20,000

Portions of this chapter were presented at the 2002 International Forecasting Conference, San Francisco, CA, June 2002. Originally the paper was intended to be part of the Taylor-Rapport-Kridel series (1997, 1999a, 1999b, 2001, 2002a, 2002b, 2003, 2004) on telecom demand. For a variety of legal reasons related to the demise of CopperKey, access to the data was delayed significantly.

D. J. Kridel (✉)
1 University Blvd, St. Louis, MO 63121, USA
e-mail: kridel@umsl.edu

J. Alleman et al. (eds.), *Demand for Communications Services - Insights and Perspectives*, The Economics of Information, Communication, and Entertainment,
DOI: 10.1007/978-1-4614-7993-2_9,

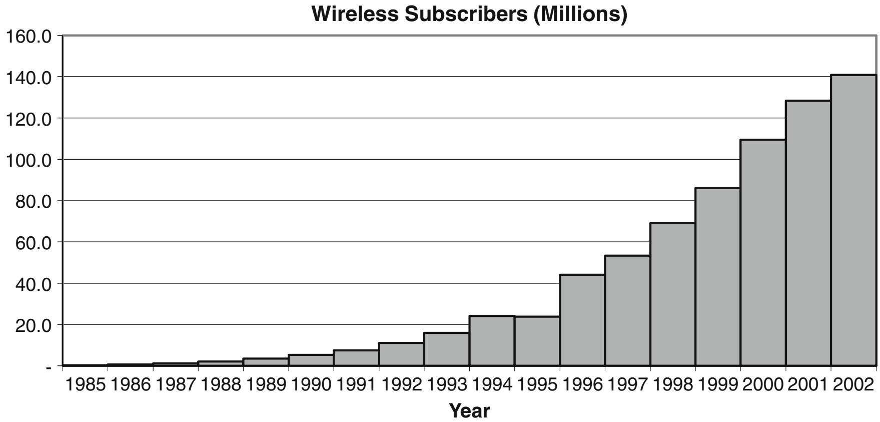

Fig. 9.1 Wireless subscribers (Milions)

responders from the superset of 34,000 panel members that were mailed the survey instrument. Demographic data are available for the entire 34,000 households, while the detailed telephony questions (on which this analysis is based) are available only for the responders.

In addition to the survey response data, pricing and demographic data have been matched to the survey respondents. In particular, poverty rates and income distribution information (from US Census data updated by CACI) were matched to the households (via Zip Code or Zip+4, depending on the variable in question). In addition, price information was collected from various web-based providers and resellers. For each geographical area involved, wireless access prices, usage prices, free minutes and wire-line access prices were collected.[1]

As is evident in Fig. 9.1, since its emergence in 1985, the wireless communications sector has experienced incredibly strong year-over-year growth (Fig. 9.1 shows growth through the year after the survey was collected; for more recent data see final section of the chapter).

Figures 9.2, 9.3, 9.4, 9.5 (using data from the survey) relate wireless penetration rates to various demographic factors of interest. In addition, penetration rates for other "access" type services like paging, local-phone, internet, and cable are provided as a basis of comparison. Figure 9.2 details penetration rates by income category. While all services follow the same basic pattern, it is interesting to note that wireless- and internet-penetration appears to be more income-sensitive.

Penetration by age group is displayed in Fig. 9.3. While both local- and cable-services do not exhibit diminishing trends with age, wireless, paging, and internet

[1] For each geography, carrier information for at least three (up to five) carriers were selected. For each carrier, the lowest-price (or entry level) plan and a mid-level plan (a plan that included 200–300 free minutes) were summarized. For wire-line rates, tariff information for the local exchange companies (LECs) were utilized.

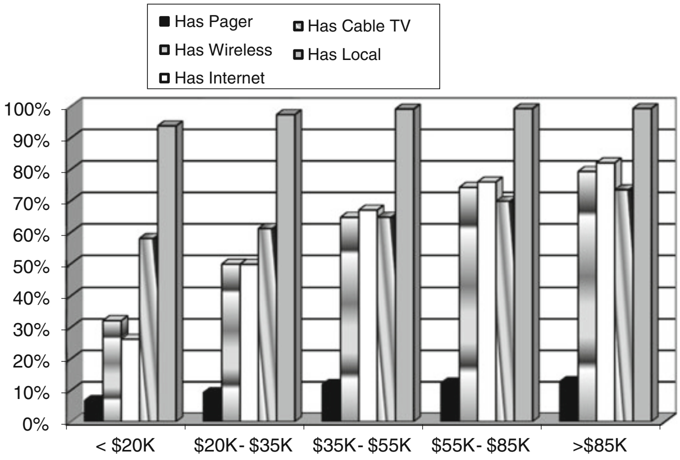

Fig. 9.2 Telecom services by income

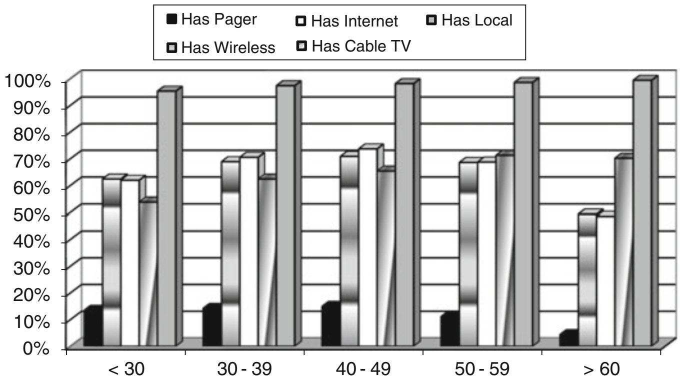

Fig. 9.3 Telecom services by age

services appear to have a "slimmer" right tail, indicating relatively lower penetration rates for the older (over 50) respondents.

Figure 9.4 illustrates penetration by occupation for male members of a household. (Occupation for female members looks similar, although with lower wireless rates among the Crafts and Farming occupations.)

Market-size differences in penetration are highlighted in Fig. 9.5. Wireless, paging, cable, and internet services have higher penetration rates in more urbanized markets, while local service does not seem to be influenced by market size. The differences are relatively small reflecting improved geographic availability (coverage) for those services.

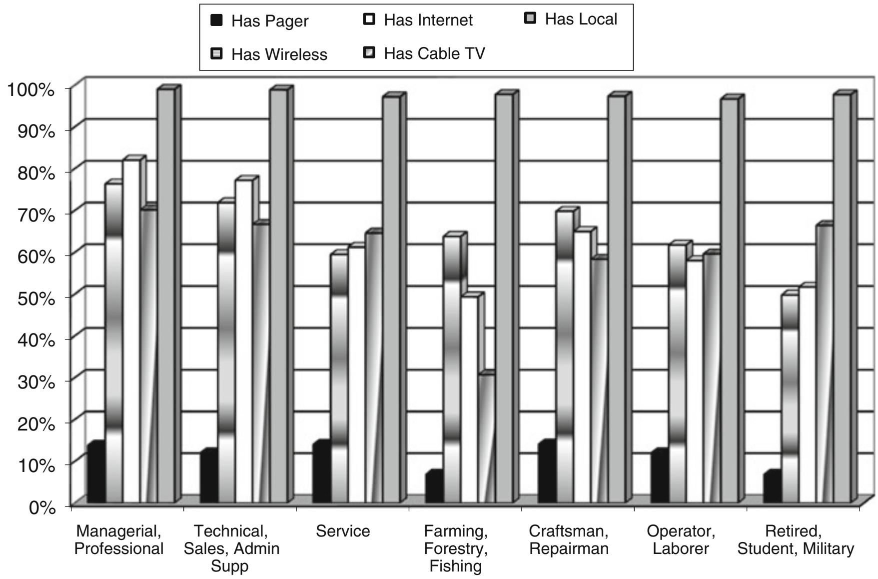

Fig. 9.4 Telecom services by occupation, male

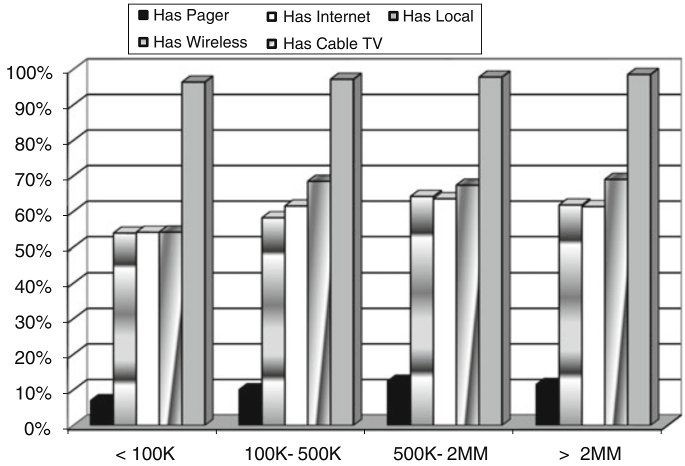

Fig. 9.5 Telecom services by market size

Figure 9.6 displays the means and standard deviations for the communications services summarized above. Local telephony has the lowest variance (indicating little difference in penetration rates across geographies), while the other services have comparable variances.

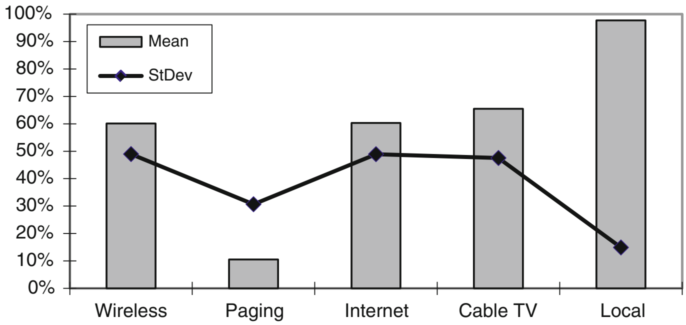

Fig. 9.6 Mean and standard deviation by service

9.3 A Logit Model of Wireless Demand

We now turn to an econometric analysis of the demand for wireless service. The model employed takes its cue from the modeling framework that has been widely used in various choice situations.[2] Wireless service, as it will be used in this chapter, will refer to the demand for wireless phone service by a household.

Beginning with the usual utility maximization assumptions, the model is given by:

$$\text{Prob (wireless access} \mid x) = P\,(\varepsilon_N - \varepsilon_Y > V_Y - V_N), \tag{9.1}$$

Where P (wireless access | x) is the probability, conditional on x, that a household subscribes to wireless service. The V_i's denote the observable utilities for having wireless service (Y) or not (N). These utilities depend on the vector x which contains attributes of the choice (price and free minutes) and attributes of the decision-maker (income and socio-demographic variables). Specifying the V_i's (as linear functions of the variables in x) and the ε_i's as independent and identically distributed (IID) Type-I extreme-value random variables yields a standard logit model. With these assumptions, the model can accordingly be written as:

$$\text{Prob (wireless access} \mid \text{x}) = 1/(1 + \exp(-\,\text{x}\beta)) \tag{9.2}$$

[2] Had usage data been available, the standard (at least in telecom demand analysis) method of employing the 2-step consumer surplus approach could have been utilized (Taylor 1994). Here, since no usage information is available, the standard indirect utility maximization approach is used. See for example, Train (1986) and Amemiaya (1985).

9.4 Data Sources and Definitions of Variables

9.4.1 Data Sources

As previously noted, the model was estimated using data from the proprietary survey of telecommunications services conducted by CopperKey Technologies in the second quarter of 2001. The data set contained over 20,000 responders from the superset of 34,000 surveyed households. As noted above, the cross-market pricing and call-plan information were collected and cleansed. Further, some variables (from the US Census, e.g., poverty rates) were matched to the survey data.

The availability of demographic data for both responders (20,000) and nonresponders (14,000) provided a basis to assess the representativeness of the final sample. The following figures provide a comparison of the demographic attributes of responding and nonresponding households. Figure 9.7 compares the income distribution. As can be seen, the poor (<$15,000 and $15,000-$25,000) respond more frequently (possibly as a result of the incentive to participate in the panel). There is a slight under-response in the middle incomes (between $35,000 and $125,000). All in all, the sample seems relatively representative with respect to income.

Larger differences in response can be seen in Fig. 9.8. The young generally under-respond, while older households are more likely to respond (especially households over 60). The importance of these differing response rates will be captured formally by modeling response and adding an additional independent

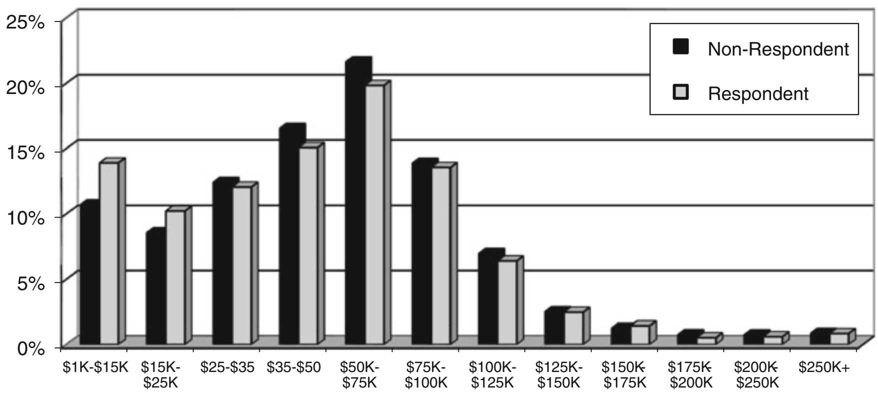

Fig. 9.7 Income distribution, respondent versus nonrespondent

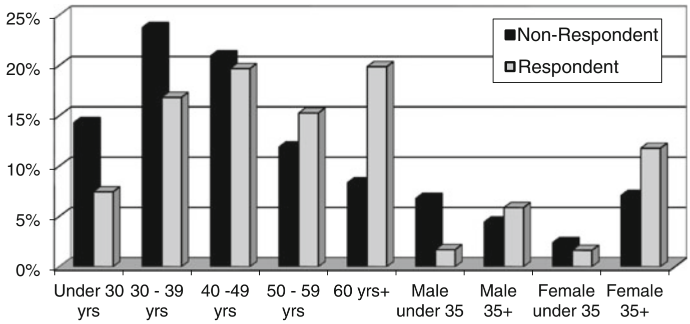

Fig. 9.8 Age respondent versus nonrespondent

variable to the final wireless model, namely the hazard rate from the familiar 2-step Heckman procedure.[3]

The wireless service variable is a binary variable coded to be equal to 1 if the respondent indicated that they had a wireless phone and 0 otherwise. Wireless price variables used in the analysis were derived from the pricing plans reported by the major wireless service providers in various US markets; wire-line prices were collected from LEC tariffs.

The following household economic and socio-demographic variables are also included in the analysis as predictors:

- Income
- Age
- Whether household head is self-employed
- Whether household head runs business from home
- Whether household owns their own home
- Whether household head attended college
- Occupation
- Ethnic origin
- Household size.

Some of the attributes of Communities and Wireless Services used in the model include:

- Size of a community
- Price of basic wireless plan available in the community.

No modeled specifications yielded statistically significant estimates (many specifications yielded estimates with the incorrect sign) of the wire-line price

[3] See Heckman (1976). Since demographic variables were available for the entire "mailed-to" population, we first built a logit model for response/non-response. From this model of 34,000 observations, an inverse Mill's ratio or hazard rate variable was calculated and added to the model for wireless.

indicating that as of mid-2001, there was no evidence of the substitution of wireless access for wire-line access.

9.5 Estimation Results

The results from estimating the logistic regression model in expression (9.2) are presented in Table 9.1. The columns in this table give the estimated coefficient, estimated standard error, and t-statistic for each of the independent variables.

Likelihood ratio tests indicated that ethnic parameters differ by market size and as such had to be estimated separately.

Table 9.1 Estimation results: wireless access

Variable definition	Coefficient	T-statistic	Mean
Constant	−0.607	−1.03	1.00
Price of a basic wireless package	−0.033	−2.60	25.35
Price of a basic wireless package—Large metro area	−0.019	−1.87	11.22
# of free minutes included in the basic wireless package	0.002	1.74	111.90
Log of income	0.671	24.91	3.72
Log of age	−0.546	−4.56	3.89
Household size	0.032	1.74	2.66
Home ownership indicator	0.257	5.55	0.78
Marital status married	0.138	2.81	0.68
Home business indicator	0.332	5.37	0.12
Self-employed indicator	0.259	5.26	0.20
Telecommute indicator	0.497	6.90	0.08
Education: high school graduate	−0.044	−0.97	0.20
Education: college graduate	0.067	1.53	0.22
Household composition: male alone	−0.503	−6.18	0.06
Household composition: female alone	−0.037	−0.51	0.10
Ethnic origin: African-American living in large metro area	0.557	5.82	0.04
Ethnic origin: African-American living in medium-size metro area	0.466	3.79	0.02
Ethnic origin: African-American living in small metro area	0.427	2.71	0.01
Ethnic origin: African-American living in rural area	0.482	3.18	0.01
Ethnic origin: Hispanic	−0.020	−0.23	0.05
Occupation: managerial, executive	0.300	6.71	0.29
Occupation: sales	0.297	4.96	0.10
Occupation: crafts	0.257	3.50	0.06
Large metro area indicator	0.745	2.88	0.44
Medium size metro area indicator	0.293	5.15	0.20
Small metro area indicator	0.087	1.47	0.15
% in poverty indicator	−0.652	−2.72	0.11
Selectivity adjustment parameter	−0.500	−3.82	−1.06

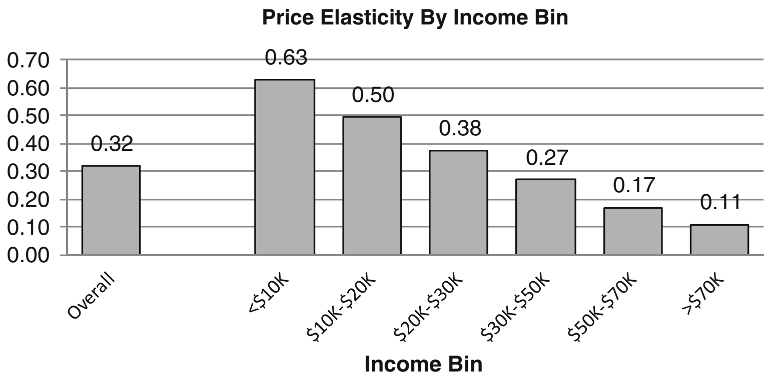

Fig. 9.9 Estimated price elasticity by income bin

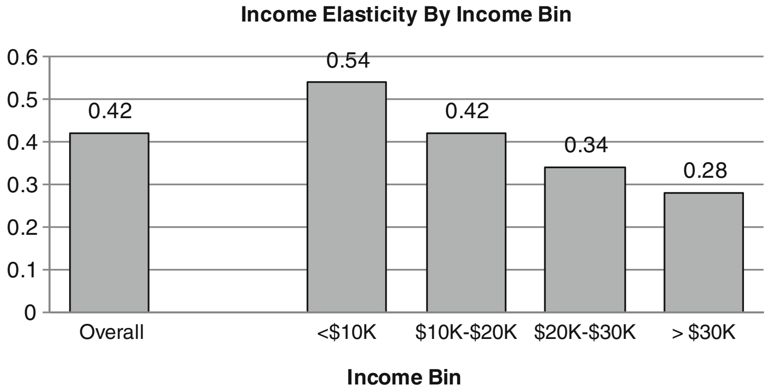

Fig. 9.10 Income elasticity by income bin

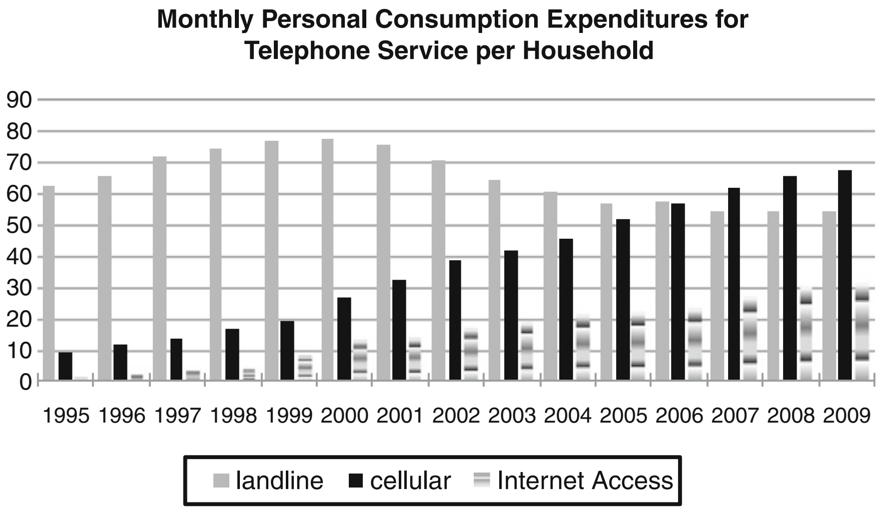

Fig. 9.11 Monthly personal consumption

Table 9.2 Recent measures of wireless industry performance

Metric	June 1996	June 2001	June 2006	June 2011
Wireless subscribers (M)	38.2	118.4	219.6	322.8
Wireless penetration (%)	14.0	40.9	72.5	102.4
Wireless-only households	N/A	N/A	10.5 %	31.6 %
Wireless total $B	21.5	58.7	118.3	164.6
Wireless data $B	N/A	0.3	11.3	55.4
Annualized minutes of use (B)	44.4	344.9	1,680.0	2,250.0
Annualized text messages (B)	N/A	N/A	113.5	2,120.0
Cell sites	24,802	114,059	197,576	256,920

The price response parameter with respect to the price of a basic wireless package (available in the community) was differentiated by size of market. The overall price elasticity of subscription (i.e., access) to wireless service was found to be about −0.33 which is considerably more elastic than the −0.04 that is estimated for local wire-line telephony.[4] This suggests that even taking into account factors such as convenience, mobility and the relative insecurity of wireless service, wireless subscribers are still more responsive to price than are wire-line subscribers. Finally, as is to be expected, wireless-subscription demand is more price-elastic for households with lower income (Fig. 9.9).

The overall income elasticity of demand for wireless subscription was found to be around 0.42. As shown in Fig. 9.10, the income elasticity falls as income rises and ranges from about 0.55 for low-income households (<10 K) to about 0.30 for relatively high-income households (>30 K).

9.6 Conclusions

The price-elasticity of demand for wireless access is inelastic, with an estimated value of about −0.33. Further, a relatively low-income elasticity of demand was found. Perhaps most surprisingly, no empirical evidence of wireless for wire-line substitution was found. This finding is almost certainly a result of the study period.

In Fig. 9.11 (recreated from the Federal Communications Commission (FCC)), consumption expenditures per household for wireless, wire-line, and internet access are displayed. As clearly demonstrated, the relative importance of wireless and wire-line has shifted dramatically from the period when this survey utilized in this study was undertaken. In 2001 (the year of the survey), we observed the first (modest) decline in wire-line expenditures; the decline has continued over the rest of the decade. At the same time, wireless has continued to grow at a dramatic pace. Indeed, in 2007, wire-line expenditures are smaller than were wireless expenditures.

[4] See Taylor and Kridel (1990).

Table 9.2 (from CTIA, 2009) further demonstrates the shifts in the telecommunications industry. It is now estimated that there are more wireless subscribers than the number of living people in the United States. (At the time of the survey, wireless penetration was approximately 40 %.) Minutes of use have grown dramatically. The shifts in usage toward texting and data and away from voice are even more dramatic: texting is now as large as is voice while data have grown to account for about 1/3 of total wireless revenues.

These data suggest two important next steps in a comprehensive wireless research agenda. These studies will require additional data (and/or alternative data sources).

- Models that account for substitution, for example, using wireless services to substitute for wire-line services. Figure 9.11 (along with Table 9.2) indicates that this phenomenon is becoming relatively commonplace. Ward and Woroch (2009) provide estimate of usage substitution.
- The demand for usage needs to be carefully considered. This will likely require collection of actual bills, which unfortunately is a nontrivial undertaking. (Bill Harvesting once performed by PNR is generally no longer available.) In principle, the component should include voice, data, and text.

References

Amemiya T (1985) Advanced econometrics. Harvard University Press, Harvard

CTIA (2009) The wireless association, Washington, DC, USA www.ctia.org

Heckman JJ (1976) The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. Ann Econ Soc Measur 5:475–492

Kridel DJ, Rappoport PR, Taylor LD (1999a) An econometric analysis of internet access. In: Loomis DG, Taylor LD (eds) The future of the telecommunications industry: forecasting and demand analysis, Kluwer Academic Press, New York, pp 21–42

Kridel DJ, Rappoport PR, Taylor LD (1999b) IntraLATA long-distance demand: carrier choice, usage demand and price elasticities. Int J Forecast 18(2002):545–559

Kridel DJ, Rappoport PR, Taylor LD (2001) Competition in IntraLATA long-distance: carrier choice models estimated from residential telephone bills. Inf Econ Policy 13:267–282

Kridel DJ, Potapov V, Crowell D (2002a) Small geography projections, presented at the 20th Annual ICFC conference, San Francisco, CA, June 25–28 2002

Kridel DJ, Rappoport PR, Taylor LD (2002b) The demand for high-speed access to the internet: the case of cable modems. In: Loomis D Taylor L (eds) Forecasting the internet: understanding the explosive growth of data communications, Kluwer, New York, pp 11–22

Rappoport PR, Taylor LD, Kridel DJ, Serad W (1997) The demand for internet and on-line access. In: Bohlin E, Levin SL (eds) Telecommunications transformation: technology, strategy, and policy, IOS Press, Amsterdam

Rappoport PR, Kridel DJ, Taylor LD, Alleman JH, Duffy-Deno KT (2003) Residential demand for access to the internet. In: Madden G (ed) Emerging telecommunications networks: the international handbook of telecommunications economics, vol II, Edward Elgar, USA pp 55–72

Rappoport PN, Kridel DJ, Taylor LD (2004) The demand for broadband: access, content and the value of time. In: Crandall R, Alleman J (eds) Broadband: should we regulate high speed internet access?, AEI-Brookings, pp 62–87

Taylor LD (1994) Telecommunications demand in theory and practice. Kluwer Academic Publishers, New York

Taylor LD, Kridel DJ (1990) Residential demand for access to the telephone network. In: de Fontenay A, Sibley D, Shugard M (eds) Telecommunications demand modeling: an integrated view, North-Holland, pp 105–118

Train KE (1986) Qualitative choice analysis. MIT Press, Cambridge MA

Ward M, Woroch G (2009) The effect of prices on fixed and mobile telephone penetration: using price subsidies as natural experiments, http://businessinnovation.berkeley.edu/Mobile_Impact/Ward_Woroch_Fixed_Mobile_Penetration.pdf