U.S. Consumer Preferences for Telephone and Internet Services

Evidence from the RAND American Life Panel

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Published by the RAND Corporation, Santa Monica, Calif.

Preface

The United States is currently undergoing a transformation in telecommunications technology. In the past, home-based landline telephone systems were the primary means of peer-to-peer communication. However, the introduction of mobile telephone service and fixed and mobile Internet services has changed the manner in which Americans communicate with each other. Because telecommunications services use large network infrastructures that create barriers to entry and are associated with public goods, including safety, they have traditionally been subject to regulation by state utility commissions and the Federal Communications Commission (FCC). As new technologies develop and traditional copper-wire networks are eliminated in favor of relatively new Internet protocol packet networks using a range of facilities, including wireless, copper, and fiber, these regulatory agencies face challenges in determining the appropriate role of regulation, including ensuring universal access and protecting the public. Furthermore, as telephone services are increasingly bundled with additional services with augmented features, questions arise about the nature of trade-offs between service bundles on the demand side. For example, some consumers may favor the enhanced functionality of new services provided by mobile telephones, even if, in some instances, voice quality may not be as high as with traditional landline fixed voice service.

As a first step in understanding the preferences of consumers, this report examines the joint revealed and stated preferences of American consumers toward four major categories of services: landline telephone—i.e., fixed voice service; mobile telephone—i.e., mobile voice service; fixed Internet; and mobile Internet. We present data on the incidence of participation in free and reduced-price telephone service programs, the services consumed in respondents' homes, the explanatory factors related to landline incidence, and the self-reported relative importance of each service. We also split the sample into a small number of preference classes on the basis of the data to understand consumer priorities.

This information can be useful to regulators, such as the FCC, and public utility commissions that seek to understand the likely effects and incidence of alternative policy regimes as technologies evolve. It should also be of interest to researchers and the general public concerned with the current technology transition and of methodological interest to researchers interested in estimating underlying preferences when a discrete number of classes of individuals is assumed.

This research was sponsored by the FCC. The lead author of the report was Craig A. Bond of the RAND Corporation, and the co–principal investigators for the broader project were Howard J. Shatz and Edward Balkovich. This document does not express the views of the FCC or any commissioner or employee of the FCC.

RAND Science, Technology, and Policy

The research reported here was conducted in the RAND Science, Technology, and Policy Program, which focuses primarily on the role of scientific development and technological innovation in human behavior, global and regional decisionmaking as it relates to science and technology, and the concurrent effects that science and technology have on policy analysis and policy choices. The program covers such topics as space exploration, information and telecommunication technologies, and nano- and biotechnologies. Program research is supported by government agencies, foundations, and the private sector.

This program is part of RAND Justice, Infrastructure, and Environment, a division of the RAND Corporation dedicated to improving policy- and decisionmaking in a wide range of policy domains, including civil and criminal justice, infrastructure protection and homeland security, transportation and energy policy, and environmental and natural resource policy.

Questions or comments about this report should be sent to the lead author, Craig A. Bond (Craig_Bond@rand.org). For more information about RAND Science, Technology, and Policy, see www.rand.org/jie/stp or contact the director at stp@rand.org.

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Summary

The United States is currently undergoing a transformation in telecommunications technology. Twisted copper wire to the home coupled with circuit-switched transmission—the system colloquially known as "plain old telephone service" (POTS)—is no longer the only option. Additional products, such as mobile telephony and Internet services (both fixed and mobile), are developed, bundled, and sold to consumers as alternatives to their traditional landlines.

Promoting the public good through telecommunications regulation requires knowledge of consumer preferences. Newer services offer many attributes that some consumers may prefer to the incumbent technology, but other attributes of the traditional system may be degraded or missing in a new consumption bundle. Design of new regulatory strategies to promote the public good depends on understanding the preferences of consumers with regard to these trade-offs, as do the potential welfare effects of any policy change. Indeed, the Federal Communications Commission (FCC) is considering the standards by which it will evaluate the adequacy of a modern replacement for a legacy service.

This report analyzed data from a three-question survey on the use of and preferences related to landline telephone (or fixed voice service), mobile telephone (or mobile voice service), fixed high-speed Internet, and mobile Internet services. The questions were developed to help understand the size and sociodemographic characteristics of groups of consumers who consume different telecommunications services and to help understand consumers' underlying preferences toward each service. These questions were part of larger pilot study using the RAND American Life Panel, which provides an Internet-based sample of the population of the United States. Unlike much of the data on telecommunications use previously appearing in the literature, we used the household as the unit of measure, included both telephone and Internet services, and have provided an analysis of both stated and revealed preferences.

The self-reported data show that approximately 90 percent of households have at least one mobile telephone, 75 percent have fixed high-speed Internet, 58 percent have mobile Internet, and 49 percent have landline telephones. Approximately 8 percent of Americans participate in a reduced-price telephone program, such as that overseen by the FCC called the Lifeline program. Only 2 percent have none of the four services, while 93 percent have some form of telephone service, and 85 percent have some form of Internet services. Among those who have telephones, about 48 percent are mobile only, 48 percent have both mobile and landline telephone services, and the remainder (4 percent) have landline telephones only. Mobile telephones thus appear to substitute for landlines for about half of the population, in that telephone services that have been historically provided by legacy fixed voice have been given up in favor of mobile technologies. It is more likely for a household to have a fixed landline for respondents

who are older, female, wealthier, and more highly educated and who identify as Black/African American, all else equal.

Stated preference analysis showed that mobile telephone service is most important to the average respondent, followed by fixed Internet, mobile Internet, and landline telephone. This corresponds with the self-reported data on telecommunications use, which can be considered revealed preferences (as opposed to stated preferences). Using a method known as *best-worst analysis*, we estimate that on an underlying rating scale used to describe the probability of choosing a service as "best," mobile voice service is approximately 3.5 times more important than fixed voice service for the average consumer, and about 2 times more important than fixed or mobile Internet service. This scale is based on the overall probability of choosing a service as most important.

There is, however, considerable variation in preferences across the population. Using more-advanced statistical techniques (mixed logit and latent-class logit models), we found that the variation can be characterized by four classes of preferences. Two of the four classes (comprising 66 percent of the population) view mobile voice service as most important and fixed voice (landlines) as least important, while a third class (14 percent of the population) prioritizes Internet and mobile telephone over landline telephone service. The remaining class, approximately 20 percent of the population, views landline telephone as the most important service (with mobile voice service second). Nevertheless, this group (which tends to be older, is less likely to be employed, and has lower incomes) still has a mobile telephone adoption rate similar to the classes that prioritize mobile telephones. One interpretation of this result is that this group views fixed voice and mobile voice services as complements, rather than substitutes, although we have not formally estimated these relationships for the sample.

These results suggest that the welfare effects of changing communication technologies, and those of any accompanying regulatory response, are likely to differ across different sets of consumers. We have established that the evolution of technology away from POTS as a standard has resulted in a significant shift toward mobile telephones for many customers, with both revealed and stated preference analysis suggesting no major losses in welfare as a result for the set of consumers who have shifted. On the other hand, the estimated 20 percent of the population that prioritizes landline telephones is more likely to (1) include later adopters of relatively new technologies and (2) suffer welfare losses as a result of the elimination of legacy services. To the extent that regulatory agencies require additional information about consumer preferences and behavior to develop rules and regulations regarding the technology transition to protect consumers, this report provides a helpful step.

Acknowledgments

The authors thank Jay Schwarz, Pam Megna, Octavian Carare, Daniel Kahn, Randy Clarke, Steve Rosenberg, Eric Ralph, Trent Harkrader, Madeleine Findley, and Matthew DelNero at the Federal Communications Commission (FCC) for encouraging this analysis and providing scoping and feedback. We also thank the nonauthor members of the FCC Technology Transition team at RAND, including Edward Balkovich, John S. Davis II, Liisa Ecola, Bonnie Ghosh-Dastidar, Zev Winkelman, Chuck Stelzner, Salar Jahedi, Cole Sutera, and Ingo Vogelsang, for helpful feedback. Finally, we thank our reviewers, Jeff Prince and Jill Luoto, for thoughtful and helpful comments that greatly improved the report. All errors and omissions remain the responsibility of the authors. This document does not express the views of the FCC or any commissioner or employee of the FCC.

Abbreviations

ALP	American Life Panel
CDC	Centers for Disease Control and Prevention
CPS	Current Population Survey
DCE	discrete choice experiment
FCC	Federal Communications Commission
FI	fixed Internet
LT	landline telephone
MI	mobile Internet
MT	mobile telephone
POTS	plain old telephone service
VOIP	voice over Internet protocol

CHAPTER ONE

Introduction

The United States is currently undergoing a transformation in telecommunications technology. Prior to the mass adoption of mobile and Internet communication technologies, real-time voice communication over the telephone was transmitted via copper pair wiring and circuit switching. The introduction and widespread adoption of mobile wireless technologies and the ability for voice calls to be carried over the Internet (known as voice over Internet protocol [VOIP]) is one aspect of this transformation. Another is that telecommunications service providers, such as AT&T and Verizon, are investing in fiber optic networks to serve homes and businesses. This combination of developments has resulted in a shift away from traditional "plain old telephone service" (POTS) to other types of communication services (including telephone, broadband Internet, and television services) or mobile-only telephone solutions for many households that no longer rely on twisted copper pairs.

From a technological standpoint, voice services delivered over a number of transmission media (e.g., twisted-pair copper, fiber, wireless spectrum) using a variety of protocols provide similar services, with differences in quality, availability during power outages, compatibility with existing complementary services (such as alarm systems and medical alert devices), and other factors. However, to certain segments of the population, these variations may be of significant importance. In addition, certain types of telephone services (such as mobile) may be easily bundled with other services (such as mobile Internet). That is, even if the fixed voice and mobile voice solutions are *technologically* similar, different consumers may prioritize different aspects of what is being provided and so may choose to purchase only one of the services, both services, or neither service. As a result, the elimination of a given technology (such as POTS) may have differential welfare effects across populations.

Similarly, the introduction of VOIP solutions that do not specifically require a telephone (such as Skype and related programs that use personal computers as hardware and the Internet as the network) has created the possibility of instantaneous voice communication without a specific piece of hardware designed solely for that purpose, and thus another possible substitute for fixed voice service. For some consumers, this means that they can obtain voice communication services through the Internet, and so what was traditionally considered "telephone service" through either a landline or a mobile telephone is no longer strictly needed. These households have substituted the Internet for the legacy public switched telephone network.

Because of the natural barriers to entry involved in providing services through a large, capital-intensive network infrastructure (and thus a view that telephony was best conceived as a "natural monopoly"), telephone service providers are subject to federal oversight and regulated as utilities by state public utility commissions and the Federal Communications Commission (FCC). With the development of new substitute technologies that blur the lines between

telephone and other types of services, however, the regulatory challenges have increased. For example, in a recently released rulemaking proposal, the FCC is seeking comment on the standards by which it will evaluate the adequacy of a modern replacement for a legacy service.[1]

To help the FCC navigate the regulatory challenges associated with the development of new substitute telecommunications technologies, the FCC asked the RAND Corporation to assess aspects of the substitutability of VOIP and other technologies for services related to traditional copper-line POTS services. This RAND research report is related to that effort.

Objective of the Current Study

This report presents an analysis of data from a three-question survey on the use of and preferences related to different forms of telephone and Internet services.[2] The questions were developed to help understand the size and sociodemographic characteristics of groups of consumers who consume different telecommunications bundles and the underlying preferences toward each service. Of particular interest is the relative importance ranking of four potentially substitutable or complementary services between different consumer groups: landline telephone (or fixed voice services), mobile telephone (or mobile voice services), fixed Internet in the home, and mobile Internet.

This research can be used by the FCC and public utility commissions to help understand the current underlying distribution of different telecommunications services to residential customers, how these consumers view the importance of various services, and how these preferences vary across the population. In turn, this information could be used as part of the general rulemaking process related to the transition. In addition, unlike much of the technical data available, which uses a line or subscription as the unit of measure, the unit of analysis here is the individual or household (depending on the question), which is the behavioral unit over which telecommunications consumption decisions are made.

This research should also be of interest to researchers and the general public concerned with the current technology transition and should be of methodological interest to researchers interested in estimating underlying preferences when a discrete number of classes of individuals is assumed.

Study Methods

The RAND research team was provided the opportunity to ask three questions to the RAND American Life Panel (ALP), which is "a nationally representative, probability-based panel of over 6,000 members age 18 and older who are regularly interviewed over the Internet for

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[1] FCC, *Report and Order, Order on Reconsideration, and Further Notice of Proposed Rulemaking*, Washington, D.C., FCC 15-97, August 6, 2015c.

[2] Although we focus on the three questions designed by the research team, the full survey presented to respondents was on a number of topics from various projects and included many questions, including sociodemographic information.

research purposes."[3] These questions, developed in consultation with the FCC's Wireline Competition Bureau, addressed the following:

- the prevalence of free or reduced-price telephone service through a government program (such as the FCC's Lifeline program)
- the prevalence of landline telephone, mobile telephone, mobile Internet, and fixed high-speed Internet services that can only be used at home (henceforth "fixed Internet")
- each individual's ranking of the four services in terms of importance in their life.[4]

Weighted estimates from the ALP can be used to make inferences about the prevalence of each technology across the population and the sociodemographic characteristics associated with users of a given bundle. In addition to the standard sociodemographic characteristics collected from each panel member, other ALP surveys can be linked to individuals to bring in additional information.[5]

In addition to providing baseline statistics about the respondents who answered each question, we used regression techniques (namely, limited dependent variable logit models) to determine the significant determinants of participation in government programs and the continued use of landline telephone (fixed voice) service. To analyze the rankings data, we used mixture models that can account for differences in preferences across the sample (termed *unobserved heterogeneity* in the economics literature). In particular, we utilized the implied choices from the ranks to estimate a latent-class discrete choice model, with classes that are defined probabilistically within the model on the basis of the observed rankings. We then used the most likely class for each individual to segment the sample and estimate the descriptive statistics within each class.

Relationship to Other Data Sources and Studies

We are aware of several other publicly available sources of data regarding the prevalence of different telecommunications products across residential households.

First, the FCC collects a considerable amount of data on the state of the industry. Until 2010, the commission published an annual report titled *Trends in Telephone Service,* although no such report is publicly available thereafter.[6] More-recent relevant data about telephone and Internet service come from two series: *Local Telephone Competition* and *Internet Access Services*, which are published biannually.[7] Both of these sources utilize data from FCC Form 477, which collects subscriber information for providers of local telephone service (including incumbent

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[3] For more information on the ALP, see RAND Labor and Population, "RAND American Life Panel," 2016. An expanded discussion of the ALP is provided in the next chapter.

[4] See Chapter Two for specific question wording. Given the pilot nature of the ALP survey used to collect the information, we were unable to pretest the questions. However, RAND worked with the FCC to ensure that the questions were understandable to the lay population.

[5] Only standard socioeconomic data were considered in this report; however, linking to other studies is a possible extension for future research. A complete list of past studies is available at RAND American Life Panel, "All Papers," 2015b.

[6] FCC, "Trends in Telephone Service," undated.

[7] FCC, "IATD Data and Statistical Reports," 2015a.

local exchange carriers, competitive local exchange carriers, mobile telephone providers, and interconnected VOIP) and Internet access connections over 200 kilobits per second in at least one direction (including fixed and mobile Internet by geography, technology, and speed). Most of these data are at the subscriber or connection level, especially for telephone service, although the FCC does report subscribership ratios and percentages subscribed for Internet service and also breaks down this information by select sociodemographic statistics, such as income, age, race, and household density. The most recent data publicly available as of the writing of this report (August 2016) were through calendar year 2013.

The Centers for Disease Control and Prevention's (CDC's) National Center for Health Statistics administers the National Health Interview Survey, which includes information on telephone coverage for the civilian noninstitutionalized population of the United States.[8] The survey covers both landline (fixed voice) and mobile telephone (mobile voice) service, with data collected at the family level and reported biannually.[9] Data are stratified by race and ethnicity, age, sex, education, employment status, household structure, poverty status, geography, housing density, and home ownership status. The most current data as of the writing of this report (August 2016) are for December 2014 (preliminary estimates) and do not include Internet service.

The Pew Research Center has conducted 97 surveys since 2000 that document American Internet usage over time.[10] In a summary report, Internet usage is stratified by age, educational attainment, income, race and ethnicity, housing density, and gender. Data are at the individual level and focused on use, and the summary report included data from 2000 through 2015. The data are for Internet service only.

The U.S. Census Bureau's American Community Survey collects data about telephone service availability, computer ownership, and Internet subscriptions, including dial-up and fixed and mobile broadband Internet. Data for Internet subscriptions are at the "population in households" level, meaning that they are a count of persons living in households with a particular service. Data for telephone services available are in terms of occupied housing units. In addition, the Census Bureau's Statistical Abstract of the United States reports average annual telephone expenditures broken out by residential/pay telephone, mobile telephone, and other services, as well as household Internet usage and access in and outside the home.

In July 2015, the Current Population Survey (CPS), co-sponsored by the Bureau of Labor Statistics and the U.S. Census Bureau, collected data on computer and Internet use via the Computer and Internet Use Supplement, including devices, location of Internet use, service provider, importance of certain characteristics of Internet usage, how the Internet is accessed, whether the service is combined with other telephony services, the use of the Internet at home and away from home, and, if not used, why. In addition, the CPS has been tracking consumer expenditures on fixed voice and mobile voice services on an annual basis and has data on pricing for both services as well.

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8 Stephen J. Blumberg and Julian V. Luke, *Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July–December 2014*, Hyattsville, Md.: National Center for Health Statistics, June 2015.

9 CDC defines *family* as an individual or group of two or more related persons living together in the same housing unit (or *household*). More than one family can live in a household (Blumberg and Luke, 2015).

10 A. Perrin and M. Duggan, *Americans' Internet Access: 2000–2015*, Washington, D.C.: Pew Research Center, June 26, 2015.

All of these sources measure revealed behavior; that is, they measure the subscriptions, use, and status of households' consumption in the market. Comparing the utilization estimates of this study to these other estimates provides a measure of convergent validity across the samples. One difference of our data compared with the CDC and Pew information is that our data include both telephone and Internet services split according to fixed and mobile technologies. Compared with the FCC data, our survey contains information at the household level, rather than the subscription level or telephone line level. In addition, our stated preference data are unique across the three sources, allowing for a fuller analysis of preferences across telephony technologies.

We are not aware of any other studies that have attempted to describe the importance of rankings across the four services addressed in this study. However, stated preference methods are well established, especially in the environmental and health economics literatures.[11] One example of the use of such methods in the telecommunications context is a discrete-choice experiment to estimate the willingness to pay for mobile telephone services.[12] Another uses a choice experiment to estimate the value of attributes related to broadband Internet.[13] Furthermore, best-worst analysis, in which consumers choose the most important ("best") and least important ("worst") element from an experimentally designed list, is gaining in popularity in marketing, food, and health care research.[14] This method, more thoroughly described in Chapter Four, can provide a consistent means of comparison of values across individuals that may be an improvement over more-traditional rating scales.[15]

Organization of This Report

This report is organized as follows. Chapter Two details the data collected for this report, including the sociodemographics of the weighted sample that is representative of the population. Chapter Three reports results relating to the revealed preferences of the population, including their participation in government programs for free and reduced-price telephone service and the services that are used in their households. Chapter Four presents a series of results from the stated preference rankings using a series of statistical modeling techniques. Chapter Five concludes with a summary of the results and brief suggestions for future research. Appendix A provides the results for the logit regression models of Chapter Three but without coefficient restrictions imposed, as they are in the main body of the report. Appendix B provides a technical discussion of the methods used in the report.

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[11] See, e.g., P. A. Champ, K. J. Boyle, and T. C. Brown, eds., *A Primer on Non-Market Valuation*, New York: Kluwer Academic Publishers, 2003.

[12] Hui Lu, Charlene Rohr, Peter Burge, and Alison Grant, *Estimating the Value of Mobile Telephony in Mobile Network Not-Spots*, Santa Monica, Calif.: RAND Corporation, RR-641-DEFRA, 2014.

[13] G. Rosston, S. Savage, and D. Waldman, "Household Demand for Broadband Internet Service," *Communications of the ACM*, Vol. 54, No. 2, February 2011, pp. 29–31.

[14] J. L. Lusk and B. C. Briggeman, "Food Values," *American Journal of Agricultural Economics*, Vol. 91, No. 1, 2009, pp. 184–196.

[15] J. A. Lee, G. N. Soutar, and J. Louviere, "Measuring Values Using Best-Worst Scaling: The LOV Example," *Psychology and Marketing*, Vol. 24, 2007, pp. 1043–1058.

CHAPTER TWO

Data and Summary Statistics

This chapter describes the methods and data collected from the ALP and provides summary statistics for the sample used in this report.

Data and Collection Methods

The RAND American Life Panel

The ALP originated as a partnership between RAND and the University of Michigan Health and Retirement Study in 2003, funded by a five-year grant from the National Institute on Aging. The panel has evolved to include a sample of more than 6,000 American individuals age 18 and older from several sources of participants over 11 recruitment methods. Surveys are generally distributed through the Internet, access to which in some cases (depending on recruitment method) is provided to panel members in the event that they lack such access.[1] Panel members who do not have a computer or Internet access at home typically use a computer at work; a computer belonging to friends and family; or public-use computers, such as at a local library. Note that the ALP is representative of adult *individuals* and is not a probability sample of *households*. As such, household-level results are best interpreted as the household information associated with these individuals. Researchers and other users registered with the ALP can field their own surveys and gain access to data, with more than 430 surveys fielded to date by approximately 35 research groups.[2]

For more information about ALP, the interested reader is referred to the ALP data pages: https://alpdata.rand.org.

Telecommunications Questions

The data used in this study were collected from the ALP *Pilot Survey 2015* (also named *Well Being 432*). In partnership with the FCC, RAND developed two questions about services currently consumed by the household of the respondent (Questions 1 and 2 below, which we name the "revealed preference" questions) and one question about the importance of the four services to the individual (Question 3 below, which we name the "stated preference" question).

[1] The survey we administered asked about Internet service. Specifically, the question referred to "high-speed Internet service . . . provided by a cable, telephone, satellite, or other company." This wording was chosen to limit respondents' self-reporting of ALP-provided Internet services in this category. However, it is possible that some respondents may have reported ALP-provided Internet in this question, which would inflate the results.

[2] RAND American Life Panel, home page, 2015a.

1. Does your household currently have free or reduced-price telephone service through a government program (such as the Lifeline program)? Include both landline and cell phones.
   1. Yes
   2. No
   3. Don't know or don't remember.

2. At your home, do you or any members of your household have any of the following services? Please check all that apply.
   1. Landline telephone calling at your home
   2. Mobile wireless telephone calling, also known as cell phones, that you can use away from your home
   3. Mobile wireless Internet that you can use generally anywhere away from your home with a smartphone, tablet, or other mobile device
   4. High-speed Internet service that you can use only at home, provided by a cable, telephone, satellite, or other company
   5. None of the above.

3. Based on your household's current situation, how would you prioritize the importance of the following services in your life? Please rank from 1 = highest priority to 4 = lowest priority.
   - Landline telephone calling at your home
   - Mobile wireless telephone calling that you can use away from your home
   - Mobile wireless Internet that you can use generally anywhere away from your home with a smartphone, tablet, or other mobile device
   - High-speed Internet service that you can use only at home, purchased from a cable, telephone, satellite, or other company.

The data were collected through an Internet survey administered by the ALP over the period from June 4, 2015, through August 6, 2015. In addition to the maintained sociodemographic information, the survey also asked questions from other researchers about influenza vaccination, sexual orientation, the perceived importance of learning a foreign language, and the willingness to pay for a more efficient court system, among others. The overall response rate for the survey as of August 24, 2015, was 80.0 percent, with *response rate* defined as the number of completed interviews divided by the selected sample size. Response rates for each ALP survey will vary. Interested readers can register with the ALP and view the data used in this report at RAND American Life Panel, "ALP Data and Metadata," 2015c.

Population Weights

Sampling weights are constructed by RAND on a survey-by-survey basis to correct for sampling error in each ALP survey and allow for making proper inferences about the population. Weights are developed by employing a "raking" procedure that uses the Current Population Survey as a benchmark.[3] Observations are weighted for the collected sample to match select distributions of variables in the overall population. The set of variables on which the distributions are matched includes gender-specific age, race and ethnicity, and education distributions,

[3] Raking is a reweighting process for a sample in which the weighted marginal totals for the sample are made to agree with the corresponding totals of the population.

plus household income by number of household members.[4] In the next section, we report both the unweighted and weighted summary statistics. Unless otherwise noted, in the following chapters, we use only the weighted data, although the broad results are largely invariant to either weighting scheme.

Summary Statistics

Table 2.1 provides weighted and unweighted selected summary statistics for the sample data. Weighted data may be interpreted as representative of the national population as represented by the Current Population Survey. Geographical divisions are as defined by the U.S. Census Bureau.[5]

As seen in Table 2.1, the raw sample is slightly skewed toward older, female, well-educated, and nonemployed respondents. The probability weights used correct for these differences.

Table 2.1
Select Sociodemographic and Geographic Summary Statistics

Variable	Number of Observations	Unweighted Mean	Weighted Mean
Age	5,049	51.61	47.17
		(0.22)	(0.34)
Gender (=1 if female)	5,049	0.59	0.52
		(0.01)	(0.01)
Income class	5,034	10.44	10.43
		(0.05)	(0.08)
Highest education class	5,049	11.38	10.54
		(0.03)	(0.05)
Married (=1 if yes)	5,049	0.60	0.62
		(0.01)	(0.01)
Foreign-born (=1 if yes)	5,049	0.10	0.10
		(0.00)	(0.01)
Race			
White/Caucasian (=1 if yes)	5,047	0.78	0.76
		(0.01)	(0.01)
Black/African American (=1 if yes)	5,047	0.11	0.12
		(0.00)	(0.01)
American Indian or Alaskan Native (=1 if yes)	5,047	0.01	0.01
		(0.00)	(0.00)

[4] RAND American Life Panel, "Panel Weighting," 2015d.

[5] U.S. Census Bureau, "Census Regions and Divisions of the United States," undated.

Table 2.1—continued

Variable	Number of Observations	Unweighted Mean	Weighted Mean
Asian or Pacific Islander (=1 if yes)	5,047	0.02	0.02
		(0.00)	(0.00)
Other (=1 if yes)	5,047	0.08	0.09
		(0.00)	(0.01)
Employed (=1 if yes)	5,049	0.57	0.59
		(0.01)	(0.01)
Geography (proportion in each division)			
New England	5,049	0.04	0.04
		(0.00)	(0.00)
Mid-Atlantic	5,049	0.12	0.13
		(0.00)	(0.01)
East North Central	5,049	0.15	0.16
		(0.01)	(0.01)
West North Central	5,049	0.05	0.05
		(0.00)	(0.00)
South Atlantic	5,049	0.16	0.16
		(0.01)	(0.01)
East South Central	5,049	0.04	0.05
		(0.00)	(0.00)
West South Central	5,049	0.15	0.15
		(0.01)	(0.01)
Mountain	5,049	0.10	0.10
		(0.00)	(0.01)
Pacific	5,049	0.18	0.17
		(0.01)	(0.01)

SOURCE: Authors' calculations from the ALP.

NOTES: Standard errors are in parentheses. Household income classes are defined as 1 = less than $5,000, 2 = $5,000 to $7,499, 3 = $7,500 to $9,999, 4 = $10,000 to $12,499, 5 = $12,500 to $14,999, 6 = $15,000 to $19,999, 7 = $20,000 to $24,999, 8 = $25,000 to $29,999, 9 = $30,000 to $34,999, 10 = $35,000 to $39,999, 11 = $40,000 to $49,999, 12 = $50,000 to $59,999, 13 = $60,000 to $74,999, and 14 = $75,000 or more. Highest education classes are defined as 1 = less than 1st grade; 2 = 1st, 2nd, 3rd, or 4th grade; 3 = 5th or 6th grade; 4 = 7th or 8th grade; 5 = 9th grade; 6 = 10th grade; 7 = 11th grade; 8 = 12th grade but no diploma; 9 = high school graduate with diploma or the equivalent (e.g., GED); 10 = some college but no degree; 11 = associate degree in college occupational/vocational program; 12 = associate degree in college academic program; 13 = bachelor's degree (e.g., B.A., A.B., B.S.); 14 = master's degree (e.g., M.A., M.S., M.Eng., M.Ed., M.S.W., M.B.A.); 15 = professional school degree (e.g., M.D., D.D.S., D.V.M., L.L.B., J.D.); and 16 = doctoral degree (e.g., Ph.D., Ed.D.). Geographic divisions are defined according to the U.S. Census Bureau.

CHAPTER THREE

Revealed Preferences for Telecommunications Services

This chapter analyzes the data related to the two revealed preference questions asked in the ALP survey. The responses to these questions provide information about the services actually consumed by American households in the summer of 2015. Because these services are, for the most part, purchased in the marketplace, this information provides a snapshot of consumers' choices given their budget constraints at current prices. Despite this report's use of the term *revealed preferences* to distinguish services consumed in the marketplace (as opposed to the stated preferences described in Chapter Four), it should be noted that this is self-reported consumption and has not been verified by the authors.

First, we provide information on participation in government programs that provide free or reduced-price telephone service (such as the Lifeline program). We then report the self-reported services consumed by households.

Prevalence of Reduced-Fee Telephone Service

The FCC administers a reduced-fee landline or mobile telephone service program for low-income households supported by the Federal Universal Service Fund called Lifeline. The program was designed to "ensure that qualifying low-income consumers could afford phone service and the opportunities and security it provides."[1]

Eligibility is determined by income at or below 135 percent of federal poverty guidelines or participation in various federal or state-level assistance programs.[2] Discounts apply to only one telephone service (i.e., either landline or mobile). According to Section 54.405 of the FCC's rules, carriers are required to "[p]ublicize the availability of Lifeline service in a manner reasonably designed to reach those likely to qualify for the service."[3]

Participation in Reduced-Fee Telephone Programs

The first telecommunications question included in the ALP asked about participation in free or reduced-price telephone programs:

[1] FCC, "Lifeline Support for Affordable Communications," last updated August 17, 2016.

[2] FCC, 2016.

[3] 47 CFR 54.405, 2010.

> Does your household currently have free or reduced-price telephone service through a government program (such as the Lifeline program)? Include both landline and cell phones.
>
> 1. Yes
> 2. No
> 3. Don't know or don't remember.

Table 3.1 provides responses to this question as weighted and unweighted proportions. Approximately 8 percent of the surveyed population reported participation in free or reduced-price telephone service provided through a government program.

Table 3.2 compares information about the estimated sociodemographic and regional characteristics of participants in free or reduced-price telephone service and nonparticipants. As anticipated, participants in Lifeline and similar programs tend to have lower household incomes ($12,500 to $19,999) than nonparticipants ($40,000 to $49,000). Correspondingly, they are less likely to be employed and tend to have less formal education. They are also more likely to be unmarried and to have been born outside of the United States. Those who self-identified as belonging to the Black/African American or Other race categories are also more likely to participate in the programs. Regionally, participants are more likely to be located in the Mid-Atlantic and Pacific divisions and less likely to be located in the North Central and South Atlantic divisions. These results are simple, unconditional means; the next subsection describes the results of several regressions that provide conditional results in a probabilistic sense.

Explaining Program Participation

Table 3.3 shows the results of a restricted weighted logistic regression that explains participation in a free or reduced-price telephone program as a function of demographic and geographic

Table 3.1
Proportion of Respondents Receiving Free or Reduced-Price Telephone Service Through Government Program

	Unweighted Proportion	Weighted Proportion
Yes	0.08	0.08
	(0.00)	(0.01)
No	0.90	0.90
	(0.00)	(0.01)
Unknown	0.01	0.02
	(0.00)	(0.00)

SOURCE: Authors' calculations from ALP.

NOTES: Number of observations = 5,013. Standard errors are in parentheses. Proportions may not sum to 1 because of rounding.

Table 3.2
Sociodemographic Characteristics of Participants in Government Programs That Provide Free or Reduced-Price Telephone Service and Nonparticipants

Characteristic	Participants	Nonparticipants
Age	45.89	47.47
	(1.15)	(0.36)
Gender (=1 if female)	0.57	0.52
	(0.03)	(0.01)
Income class	5.20***	11.01***
	(0.23)	(0.07)
Highest education class	9.00***	10.73***
	(0.12)	(0.05)
Married (=1 if yes)	0.36***	0.65***
	(0.03)	(0.01)
Foreign-born (=1 if yes)	0.17***	0.09***
	(0.03)	(0.01)
Race (proportion in each class)		
White/Caucasian (=1 if yes)	0.54***	0.79***
	(0.03)	(0.01)
Black/African American (=1 if yes)	0.24***	0.11***
	(0.03)	(0.01)
American Indian or Alaskan Native (=1 if yes)	0.02	0.01
	(0.01)	(0.00)
Asian or Pacific Islander (=1 if yes)	0.02	0.02
	(0.01)	(0.00)
Other (=1 if yes)	0.19***	0.07***
	(0.03)	(0.01)
Employed (=1 if yes)	0.31***	0.62***
	(0.03)	(0.01)
Geography (proportion in each division)		
New England	0.06	0.04
	(0.02)	(0.00)
Mid-Atlantic	0.18**	0.13**
	(0.03)	(0.01)

Table 3.2—continued

Characteristic	Participants	Nonparticipants
East North Central	0.06***	0.17***
	(0.01)	(0.01)
West North Central	0.01***	0.05***
	(0.01)	(0.00)
South Atlantic	0.09***	0.16***
	(0.02)	(0.01)
East South Central	0.04	0.04
	(0.01)	(0.00)
West South Central	0.17	0.15
	(0.02)	(0.01)
Mountain	0.08	0.10
	(0.02)	(0.01)
Pacific	0.29***	0.16***
	(0.03)	(0.01)
Number of observations	417	4,514

SOURCE: Authors' calculations from the ALP.

NOTES: These results are weighted. *** = significant differences between participants and nonparticipants at the 1 percent level. ** = significant differences between participants and nonparticipants at the 5 percent level. These results do not include respondents who marked "Don't know or don't remember." Standard errors are in parentheses. Household income classes are defined as 1 = less than $5,000, 2 = $5,000 to $7,499, 3 = $7,500 to $9,999, 4 = $10,000 to $12,499, 5 = $12,500 to $14,999, 6 = $15,000 to $19,999, 7 = $20,000 to $24,999, 8 = $25,000 to $29,999, 9 = $30,000 to $34,999, 10 = $35,000 to $39,999, 11 = $40,000 to $49,999, 12 = $50,000 to $59,999, 13 = $60,000 to $74,999, and 14 = $75,000 or more. Highest education classes are defined as 1 = less than 1st grade; 2 = 1st, 2nd, 3rd, or 4th grade; 3 = 5th or 6th grade; 4 = 7th or 8th grade; 5 = 9th grade; 6 = 10th grade; 7 = 11th grade; 8 = 12th grade but no diploma; 9 = high school graduate with diploma or the equivalent (e.g., GED); 10 = some college but no degree; 11 = associate degree in college occupational/vocational program; 12 = associate degree in college academic program; 13 = bachelor's degree (e.g., B.A., A.B., B.S.); 14 = master's degree (e.g., M.A., M.S., M.Eng., M.Ed., M.S.W., M.B.A.); 15 = professional school degree (e.g., M.D., D.D.S., D.V.M., L.L.B., J.D.); and 16 = doctoral degree (e.g., Ph.D., Ed.D.). Geographic divisions are defined according to the U.S. Census Bureau.

Table 3.3
Restricted Logit Regressions of Participation in a Free or Reduced-Price Telephone Service Program as a Function of Demographics and Location

Characteristic	Restricted Coefficients	Marginal Effects
Income class ($60,000–$74,999 = baseline)		
<$5,000	4.30***	0.25***
	(0.36)	(0.02)
$5,000–$7,499	3.84***	0.22***
	(0.41)	(0.03)
$7,500–$9,999	4.57***	0.27***
	(0.37)	(0.02)
$10,000–$12,499	4.23***	0.25***
	(0.35)	(0.02)
$12,500–$14,999	4.04***	0.24***
	(0.40)	(0.02)
$15,000–$19,999	3.14***	0.18***
	(0.35)	(0.02)
$20,000–$24,999	3.16***	0.18***
	(0.36)	(0.02)
$25,000–$29,999	2.48***	0.14***
	(0.42)	(0.03)
$30,000–$34,999	2.08***	0.12***
	(0.44)	(0.03)
$35,000–$39,999	2.29***	0.13***
	(0.39)	(0.02)
$40,000–$49,999	1.66***	0.10***
	(0.59)	(0.04)
$50,000–$59,999	0.96**	0.06**
	(0.46)	(0.03)
Education (high school graduate with diploma or the equivalent = baseline)		
Master's degree	–1.20**	–0.07**
	(0.48)	(0.03)
Foreign-born (=1 if yes)	0.61**	0.04**
	(0.26)	(0.02)

Table 3.3—continued

Characteristic	Restricted Coefficients	Marginal Effects
Race (white/Caucasian = baseline)		
Asian or Pacific Islander (=1 if yes)	–1.16**	–0.07**
	(0.53)	(0.03)
Employed (=1 if yes)	–0.43***	–0.03***
	(0.16)	(0.01)
Geography (New England = baseline)		
Mid-Atlantic	–0.53**	–0.03**
	(0.23)	(0.01)
East North Central	–1.16***	–0.07***
	(0.28)	(0.02)
West North Central	–1.57***	–0.09***
	(0.45)	(0.03)
South Atlantic	–0.92***	–0.05***
	(0.34)	(0.02)
East South Central	–0.72*	–0.04*
	(0.40)	(0.02)
West South Central	–0.45**	–0.03**
	(0.22)	(0.01)
Mountain	–0.87***	–0.05***
	(0.30)	(0.02)
Intercept	–4.72	
	(0.47)	
Log-likelihood	–964.37	

SOURCE: Authors' calculations from the ALP.

NOTES: These results are weighted. Sample size = 4,931. *** = statistically significant at the 1 percent level. ** = statistically significant at the 5 percent level. * = statistically significant at the 10 percent level. These results do not include respondents who marked "Don't know or don't remember." Standard errors are in parentheses. *Intercept* refers to the constant term in the logit model. Marginal effects were calculated at means. Income and education categories were entered as dummy variables with the baseline income category of $60,000–$74,999 and the baseline education category of high school graduate with diploma or the equivalent. There were no program participants with incomes greater than $75,000. Zero restrictions were imposed from the unrestricted model, according to Wald/likelihood ratio tests. Geographic divisions are defined according to the U.S. Census Bureau.

variables.[4] The difference between Table 3.3 and Table 3.2 is that Table 3.3 shows how each characteristic is related to program participation, *holding all other characteristics constant*. For example, it shows for any given education level how being foreign-born would change the likelihood of program participation. In contrast, the data in Table 3.2 are unconditional. For example, they show the proportion of foreign-born people participating in the program without adjusting for income or other characteristics. In Table 3.3, the restricted model excludes all coefficients that are not jointly statistically significant, while the Marginal Effects column shows the change in predicted probability as a result of a one-unit change in the explanatory variable for the restricted model.[5] Appendix A presents the unrestricted results.

All else equal, the probability of participation in a free or reduced-price government telephone program increases by four percentage points if the respondent was not born in the United States and decreases by three percentage points if the respondent is employed. Furthermore, household income is a significant predictor of program participation up to levels of $60,000, with probabilities generally decreasing with income levels. Geographically, those respondents living in New England and the Pacific region are more likely to participate. Note that unlike the results in Table 3.2, differences in program participation by marital status and racial category are not significant (except for those identifying as Asian or Pacific Islander) when controlling for other variables. This suggests that causes other than marital status or racial category are mostly driving program participation.

The results above are for the entire (weighted) sample. However, the Lifeline program is means-tested, with eligibility determined by the federal poverty level, which depends on household size (and, in the case of Alaska and Hawaii, geography). To limit the analysis to a sample that is more representative of eligible participants, we classified a subset of respondents as eligible for participation if their income class as reported in the ALP was less than or equal to 135 percent of the federal poverty level.[6] Because we observe only self-reported income classes and household size, this procedure will likely classify a relatively small proportion of respondents as eligible for the program, when in reality they may not be.

Approximately 25 percent of the overall weighted sample (23 percent of the unweighted sample) was classified as eligible. Of these, just less than 29 percent (25 percent of the unweighted sample) reported participation in the free or reduced-price program.

Table 3.4 presents the results of a restricted model of participation in free or reduced-price telephone programs for those households that are categorized as eligible according to this methodology (see Appendix A for the unrestricted results). Qualitatively, the results are similar to those of Table 3.3, although age is significant in the restricted sample, foreign-born status is no longer significant, and there are slight differences in the racial and geographical coefficients. Quantitatively, the marginal effects on propensity to participate at lower income classes relative

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[4] A logit regression parameterizes the probabilities of a discrete dependent variable (i.e., one that takes on only two values) as a function of independent variables using the logistic function and assuming a Type I extreme value error term. See Appendix B for more details.

[5] The p-value of the test of the excluded variables was 0.2434, meaning that there is about a 24-percent chance that in repeated samples, we would observe a test statistic greater than the one calculated if the null hypothesis is true. Typical threshold p-values used in this type of statistical analyses are 0.05. As such, we have good statistical evidence that the coefficients are jointly equal to zero.

[6] HealthCare.gov, "Federal Poverty Level (FPL)," undated.

Table 3.4
Restricted Logit Regressions of Participation in a Free or Reduced-Price Telephone Service Program as a Function of Demographics and Location for Lifeline-Eligible Households

Characteristic	Restricted Coefficients	Marginal Effects
Age	0.02***	0.00***
	(0.01)	(0.00)
Income class		
<$5,000	1.25***	0.22***
	(0.29)	(0.05)
$5,000–$7,499	0.82**	0.15**
	(0.36)	(0.06)
$7,500–$9,999	1.35***	0.24***
	(0.29)	(0.05)
$10,000–$12,499	1.10***	0.20***
	(0.28)	(0.05)
$12,500–$14,999	1.01***	0.18***
	(0.32)	(0.06)
$15,000–$19,999	—	—
$20,000–$24,999	0.55*	0.10*
	(0.33)	(0.06)
Highest education class		
Master's degree	–1.54**	–0.28**
	(0.60)	(0.11)
Race (white/Caucasian = baseline)		
Other (=1 if yes)	0.64***	–0.28***
	(0.24)	(0.11)
Employed (=1 if yes)	–0.52**	–0.09**
	(0.21)	(0.04)
Geography (New England = baseline)		
East North Central	–0.66**	–0.12**
	(0.32)	(0.06)
West North Central	–1.16**	–0.21**
	(0.50)	(0.09)
South Atlantic	–1.13***	–0.20***

Table 3.4—continued

Characteristic	Restricted Coefficients	Marginal Effects
	(0.33)	(0.06)
Mountain	–0.63*	–0.11**
	(0.32)	(0.06)
Intercept	–2.00***	
	(0.39)	
Pseudo log-likelihood	–620.19	

SOURCE: Authors' calculations from the ALP.

NOTES: These results are weighted. Sample size = 1,118. *** = statistically significant at the 1 percent level. ** = statistically significant at the 5 percent level. * = statistically significant at the 10 percent level. Data include only respondents classified as eligible. These results do not include respondents who marked "Don't know or don't remember." Standard errors are in parentheses. Marginal effects were calculated at means. Income and education categories were entered as dummy variables with the baseline income category of $15,000–$19,999 and the baseline education category of high school graduate with diploma or the equivalent (e.g., GED). All income levels equal to or greater than $25,000 were dropped because of a lack of eligibility, perfect predictions, or statistical insignificance. Geographic divisions are defined according to the U.S. Census Bureau.

to the baseline income category of $15,000 to $19,999 per year are statistically equivalent to each other, although this may be to lower statistical power due to a restricted sample size.

Prevalence of Telecommunications Services

Services Consumed

The second telecommunications question included in the ALP asked about the services currently consumed in the respondent's household:

> At your home, do you or any members of your household have any of the following services? Please check all that apply.
>
> 1. Landline telephone calling at your home
> 2. Mobile wireless telephone calling, also known as cell phones, that you can use away from your home
> 3. Mobile wireless Internet that you can use generally anywhere away from your home with a smartphone, tablet, or other mobile device
> 4. High-speed Internet service that you can use only at home, provided by a cable, telephone, satellite, or other company
> 5. None of the above.

Table 3.5 reports the unweighted and weighted proportions of respondents with specific services. With the exception of "None," categories are not mutually exclusive.[7]

These estimates suggest that of the four services, mobile telephone service is most prominent, with 90 percent (plus or minus approximately 2 percent) of households reporting mobile telephone service. Approximately three-quarters of households have fixed Internet services, and 58 percent report mobile Internet service. Approximately half of households still use landline telephone (fixed voice) services. Approximately 2 percent of respondents reported not having any of the four services.

Table 3.6 reports the proportion of households with a particular bundle of services, sorted from most to least frequent.[8]

We estimate that more than 93 percent of American households have some form of telephone service, and 85 percent of American households have either fixed or mobile Internet service. Of those with telephone service, approximately 48 percent can be classified as mobile-only

Table 3.5
Proportion of Households with Select Telephone and Internet Services

	Unweighted Proportion	Weighted Proportion
Landline telephone (LT)	0.54	0.49
	(0.01)	(0.01)
Mobile telephone (MT)	0.91	0.90
	(0.00)	(0.01)
High-speed fixed Internet (FI)	0.77	0.75
	(0.01)	(0.01)
Mobile Internet (MI)	0.59	0.58
	(0.01)	(0.01)
None	0.02	0.02
	(0.00)	(0.00)
Number of observations	5,011	5,011

SOURCE: Authors' calculations from the ALP.

NOTES: These results are weighted. Categories are not mutually exclusive.

[7] Because some recruitment methods provide Internet access to users, it is possible that data related to fixed Internet are biased. However, this bias should be attenuated through the weighting scheme.

[8] We allowed respondents to self-identify the presence or absence of each service in their home, without restriction. As such, categories with small numbers of respondents (such as mobile Internet only) should be interpreted with caution. For example, it is possible that a subset of this 1.5 percent of the population actually does have mobile Internet with no mobile telephone service, or it may be that some respondents misunderstood the question (e.g., counting mobile Internet–enabled devices that are not associated with a carriers' data network plan, such as some iPads, as "mobile Internet") and/or responded in error.

Table 3.6
Proportion of Households with Particular Telephone and Internet Service Bundles

Rank	Description	Share/ Standard Error
1	All services (LT, MT, FI, and MI)	0.264
		(0.008)
2	MT, MI, and FI only	0.206
		(0.008)
3	LT, MT, and FI only	0.136
		(0.006)
4	MT and FI only	0.096
		(0.006)
5	MT only	0.085
		(0.006)
6	MT and MI only	0.058
		(0.005)
7	LT and MT only	0.028
		(0.003)
8	No services	0.023
		(0.003)
9	LT, MT, and MI only	0.022
		(0.003)
10	FI only	0.018
		(0.003)
11	LT and FI only	0.017
		(0.002)
12	MI only	0.015
		(0.002)
13	LT only	0.014
		(0.002)
14	MI and FI only	0.011
		(0.003)
15	LT, MI, and FI only	0.004
		(0.001)
16	LT and MI only	0.003
		(0.001)

SOURCE: Authors' calculations from the ALP.

NOTES: These results are weighted. Sample size = 5,011. Categories are mutually exclusive.

customers, while an equal 48 percent have both mobile and landline service.[9] The remaining 4 percent are landline-only customers. Based on raw percentages within the class of telephone consumers, then, it appears that there is an almost equal split between those who consume both mobile and landline services and those who consume only one service, with a large majority of the latter choosing mobile voice service over landline telephone service.[10]

When comparing the telephone and Internet categories, 13 percent of the sample are telephone-only (landline or mobile telephone without Internet) households, while 4 percent are Internet-only households. Eighty-seven percent of households have both Internet access and telephone service (either landline or mobile) in their homes. Thus, only a small portion of the sample appears to view Internet access as a substitute for telephone service.

In terms of individual bundles, just over a quarter of the population is estimated to have all four services in the household, with another fifth (about 21 percent) having all services except landline telephone. The third-most-frequent category includes households with landline telephone, mobile telephone, and fixed Internet, at nearly 14 percent of the population. An additional 10 percent of households have only mobile telephone and fixed Internet, with another 14 percent choosing only mobile telephones with or without Internet. These top six categories account for 85 percent of the population. Only 1.4 percent of the population has only a landline telephone, which is a smaller percentage than those having no services at all.

Explaining Landline Incidence

As carriers continue the transition away from POTS telephone service, an examination of those who have not yet opted to eliminate landline services from their households can provide information about those who are more likely to consume landline (regardless of technology) and other telephony services together rather than only one type of service. Table 3.7 provides the results of a restricted weighted logit regression that estimates the probability of a household having a landline telephone (fixed voice) service as a function of sociodemographic and geographic characteristics. The unrestricted model is reported in Appendix A.

Positive coefficients in the regression imply a greater likelihood of having a landline in the home. There is good evidence that respondents who are older, who are female, and who have higher incomes and educations are more likely to have landlines in the home. Similarly, relative to those who identify as white/Caucasian, there is relatively weak evidence (statistically speaking) that those identifying as American Indian or Alaskan Native and Asian or Pacific Islander are less likely to have landlines.[11] Individuals living along the East Coast are more likely to maintain a landline than those in the West (including the West North Central, West South Central, and Pacific regions). The technological and behavioral mechanisms that are driving these results (e.g., exposure to a competitive market with multiple bundled services and low prices, working from home, length of time in the home) are not explored in this report but are a subject for future research.

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[9] We believe that the majority of our respondents who used Internet-based telephone services through a computer (such as Skype) would not have reported having a landline telephone.

[10] Although one explanation for this result is that some consumers view the services as substitutes and some as complements, an alternative explanation is that the levels of satisfaction, or utility, from both services are positively correlated (see, e.g., M. Gentzkow, "Valuing New Goods in a Model with Complementarity: Online Newspapers," *American Economic Review*, Vol. 97, 2007, pp. 713–744). We thank a reviewer for this insight and note that this is a fruitful area for future research.

[11] The *p*-value associated with the omitted variables in the restricted regression is 0.3722.

Table 3.7
Restricted Logit Regressions of Landline Incidence as a Function of Demographics and Geography

Characteristic	Restricted Coefficients	Marginal Effects
Age	0.06***	0.01***
	(0.00)	(0.00)
Gender (=1 if female)	0.22***	0.04***
	(0.08)	(0.02)
Income class ($60,000–$74,999 = baseline)		
$12,500–$14,999	–0.91***	–0.18***
	(0.25)	(0.05)
$25,000–$29,999	–0.47**	–0.09**
	(0.20)	(0.04)
$60,000–$74,999	—	—
$75,000–$99,999	0.27**	0.05**
	(0.14)	(0.03)
$100,000–$124,999	0.63***	0.12***
	(0.14)	(0.03)
$125,000–$199,999	0.88***	0.17***
	(0.16)	(0.03)
$200,000 or more	0.75***	0.15***
	(0.22)	(0.04)
Highest education class (high school graduate with diploma or the equivalent = baseline)		
5th or 6th grade	–1.80***	–0.35***
	(0.59)	(0.12)
7th or 8th grade	–0.93**	–0.18**
	(0.41)	(0.08)
12th grade but no diploma	–0.88***	–0.17***
	(0.28)	(0.06)
High school graduate with diploma or the equivalent	—	—

Table 3.7—continued

Characteristic	Restricted Coefficients	Marginal Effects
Race (white/Caucasian = baseline)		
American Indian or Alaskan Native (=1 if yes)	–0.63*	–0.12*
	(0.34)	(0.07)
Geography (New England = baseline)		
Mid-Atlantic	0.39***	0.08***
	(0.13)	(0.02)
West North Central	–0.36**	–0.07***
	(0.18)	(0.04)
West South Central	–0.53***	–0.10***
	(0.13)	(0.02)
Pacific	–0.22*	–0.04*
	(0.12)	(0.02)
Intercept	–3.07***	
	(0.23)	
Pseudo log-likelihood	–2,868.09	

SOURCE: Authors' calculations from the ALP.

NOTES: These results are weighted. Sample size = 4,994. *** = statistically significant at the 1 percent level. ** = statistically significant at the 5 percent level. * = statistically significant at the 10 percent level. These results do not include respondents who marked "Don't know or don't remember." Standard errors are in parentheses. Income and education categories were entered as dummy variables with the baseline income category of $60,000–$74,999 and the baseline education category of high school graduate with diploma or the equivalent (e.g., GED). Geographic divisions are defined according to the U.S. Census Bureau.

CHAPTER FOUR

Stated Preferences for Telecommunications Services

This chapter analyzes the data related to the stated preference question asked in the ALP survey. The responses to this question provided information about the preferences of the respondents with respect to telecommunications services—namely, how important each service is in the respondent's life. This question falls into a class of preference information known in the economics literature as *stated preferences*. Stated preferences are distinguished from revealed behavior (as analyzed in Chapter Three) because stated preferences do not involve a market transaction (such as the purchase of a service). Although economists generally consider revealed behavior to be a more desirable source of data because it is based on actual actions, stated preference data can be useful for estimating preferences that might otherwise be impossible to uncover, given what is observed in the market. That said, stated preference methods are based on self-reported choices outside of a market environment and, thus, may not be accurate reflections of real-world market behavior. This may induce hypothetical bias.

By asking individuals to rank each of the four telecommunications services, we were able to place each service on an underlying scale of relative importance based on the probability of an individual choosing a service as most important. This provides information on consumers' preferences of the various technologies, including the importance of landline telephone, in the presence of potential substitutes. In addition, we were able to uncover differences in the rankings by different groups of consumers, thus helping to identify classes of consumers who are likely to react differently as modern telephony evolves. To our knowledge, this is the first such analysis of preferences of these telephone and Internet services.

This chapter first describes the subsample of data used to analyze the rankings and provides summary statistics. We then statistically analyze the rankings using a best-worst scaling exercise, incorporating such methods as mixed logit and latent-class logit to account for differences in preferences among different subsets of respondents.

Preference-Ranking Data

The third telecommunications question included in the ALP asked about preferences for the four services under investigation in this report:

> Based on your household's current situation, how would you prioritize the importance of the following services in your life? Please rank from 1 = highest priority to 4 = lowest priority.
>
> - Landline telephone calling at your home

- Mobile wireless telephone calling that you can use away from your home
- Mobile wireless Internet that you can use generally anywhere away from your home with a smartphone, tablet, or other mobile device
- High-speed Internet service that you can use only at home, purchased from a cable, telephone, satellite, or other company.

Despite being explicitly prompted to only use rankings of 1 through 4, a number of respondents did not comply with these instructions. Because we could not be certain that those who offered a complete 1–4 ranking are a random subsample of the full sample, new weights were required to ensure that the subsample was representative of the population. As such, we used a logistic regression to model the probability of a completed ranking exercise as a function of the demographic variables used in this report. The predictions from this exercise were then computed, and new weights were formed by multiplying the population weights provided by the ALP by the inverse of the predicted probabilities. In addition, because of a coding error associated with the initial survey deployment, not all respondents were provided an opportunity to answer this question.[1]

To show the effect of this reweighting and associated sample sizes, Table 4.1 provides summary proportions for the self-reported services that households consume.

Given the close match, the remainder of this chapter uses data from the reweighted complete ranking subsample.

Ranking Statistics

Figure 4.1 provides the weighted proportions of the complete ranking subsample that ranked each service in a particular position, sorted from most to least important on average.

As seen in the figure, the top-ranked service in terms of importance on average is mobile voice, followed by fixed and mobile Internet. Landline telephone is ranked as the least important overall, although approximately 17 percent of the sample ranked it as first. In fact, nearly the same proportion of respondents that ranked fixed Internet first ranked landline telephone first, with the lowest proportion ranking mobile Internet first. The results imply that for those consumers who use only one form of telephone service, mobile voice service is preferred over landline telephone service. We note, however, that this is not the case for all respondents, and we have not formally established a substitutability/complementary relationship between the services. In addition, because the data are ordinal, we cannot identify the strengths of these preferences without additional methods.

As a validity check, we should observe a relatively high proportion of respondents who rank a particular service as first in importance consuming that service; that is, the revealed preference information should correlate with the stated preference data. Table 4.2 provides the weighted proportion of the subsample consuming each service stratified by service that is ranked first by each respondent.

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[1] The initial design of the questions asked a random 50 percent of the sample to provide a full 1–4 ranking, while the other half was asked only to rank the most and least important service. The goal of this design was to investigate the effect of elicitation differences on the parameter estimates. However, we discovered during survey administration that the latter question was not correctly structured, and, thus, the data were not usable. Following this discovery, all subsequent respondents were asked for a full ranking.

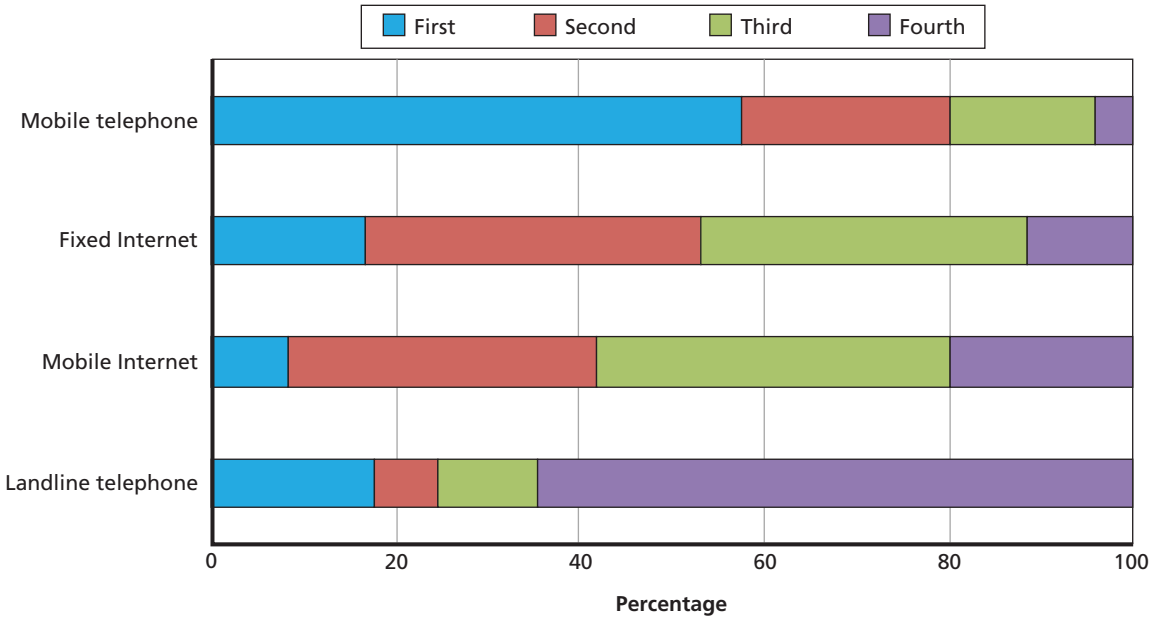
Table 4.1
Proportion of Households with Select Telephone and Internet Services for Complete Ranking Subsample

	Weighted Proportion	Complete Ranking Proportion
Landline telephone (LT)	0.49	0.49
	(0.01)	(0.01)
Mobile telephone (MT)	0.90	0.89
	(0.01)	(0.01)
Fixed Internet (FI)	0.75	0.76
	(0.01)	(0.01)
Mobile Internet (MI)	0.58	0.58
	(0.01)	(0.01)
None	0.02	0.02
	(0.00)	(0.00)
Number of observations	5,011	2,745

SOURCE: Authors' calculations from the ALP.

NOTES: Categories are not mutually exclusive. Weighted proportions are identical to those in Table 3.5. The complete ranking subsample consists of reweighted respondents who completed the 1–4 ranking exercise in accordance with the survey instructions. Standard errors are in parentheses.

Figure 4.1
Rankings of Telephone and Internet Services by Complete Ranking Subsample



SOURCE: Authors' calculations from the ALP.
NOTE: All mean ranks are statistically different from each other.

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Table 4.2
Proportion of Households with Select Telephone and Internet Services by First-Ranked Service

Service Present in Household	LT Ranked First	MT Ranked First	MI Ranked First	FI Ranked First
Number of observations	443	1,594	224	484
Percentage of subsample ranking this service as most important	16.1	58.1	8.2	17.6
Landline telephone (LT)	**0.87**	0.37	0.43	0.51
	(0.03)	(0.02)	(0.05)	(0.04)
Mobile telephone (MT)	0.74	**0.95**	0.81	0.85
	(0.04)	**(0.01)**	(0.04)	(0.03)
Mobile Internet (MI)	0.28	0.63	**0.84**	0.61
	(0.03)	(0.02)	**(0.04)**	(0.03)
Fixed Internet (FI)	0.73	0.74	0.69	**0.89**
	(0.03)	(0.02)	(0.05)	**(0.03)**
None	0.03	0.01	0.05	0.00
	(0.02)	(0.01)	(0.03)	—

SOURCE: Authors' calculations from the ALP.
NOTES: How to interpret this table: 58.1 percent of the sample ranked mobile telephone service as most important (shown in the second row). Of these respondents, 95 percent have a mobile telephone, 74 percent have fixed Internet, 63 percent have mobile Internet, and 37 percent have a landline telephone (shown in the MT Ranked First column). Bold indicates that the service ranked first in importance overall is associated with the highest proportion of consumption across each first-ranked category. Standard errors are in parentheses.

As indicated in bold, the service ranked first in importance overall is associated with the highest proportion of consumption across each first-ranked category, implying reasonable consistency between revealed and stated preferences. Respondents who ranked landline telephone as most important are also likely to have mobile telephone and fixed Internet in their households. Those who ranked mobile telephone first are likely to also have fixed and mobile Internet (but not a landline telephone). Those who ranked mobile Internet as most important are also likely to have mobile telephone and fixed Internet, and those who ranked fixed Internet first have shares above 50 percent for every service. This stratification suggests that those who prioritize landline telephone service and fixed Internet service (about a third of the sample) view mobile telephones and landline telephones as complements (more so for the fixed voice group), in the sense that both telephone services tend to be in the home. On the other hand, those who prioritize mobile telephone or mobile Internet service (about two-thirds of the sample) view fixed voice service and mobile voice service as substitutes, in the sense that a majority of these households own a mobile telephone but not a landline telephone.

Relative Importance of Telecommunications Services

Best-Worst Scaling

It is possible to use the rankings data to construct an underlying scale of the importance of the four telecommunications services for one or more subsets of the sample. To do so, one uses the rankings of each service to generate informative paired comparisons. In particular, we conceptualize the ranking exercise as respondents engaging in a "best-worst" exercise over the set of services to generate a full ranking. Under best-worst analysis, it is assumed that individuals chose the best (or most important) and worst (or least important) option from a set at each choice occasion, with the choice occasions designed by the researcher. A multinomial logit (or similar) model can then be used to parameterize the probability that option *i* is chosen as best and option *j* is chosen as worst from among all the possible combinations. The probabilities of making these choices are then used to estimate an underlying "importance" function, thus placing the attributes on a common (relative) importance scale that can be used to assess relative values. See Appendix B for more information.

For our application, this procedure is implemented as follows for respondents who have ranked the services from 1 to 4:

- Choice Occasion 1: We interpret the rankings such that the most important service is assumed to be ranked first, and the least important service is assumed to be ranked fourth.
- Choice Occasion 2: Of the two remaining services that were not chosen in the first step, we interpret the service ranked second as most important from this subset, and the service ranked third as the least important from this subset.

We thus interpret the rankings as if the respondents engaged in two best-worst exercises: the first over all four services, and the second over the middle-ranked services.

As argued in Lusk and Briggeman (2009), the forecasted probability that a service is picked as most important (which the authors term the "share of preference" for a service) relative to the same probability for another service provides cardinal (as opposed to ordinal) information about relative importance. For example, if mobile telephone is three times as likely to be chosen most important than landline telephone, then it can be interpreted as three times more important. We note, however, that this interpretation relies on the predicted probabilities *across* the individuals in the sample, rather than on information provided from a given individual.[2]

Average Best-Worst Results

Table 4.3 presents the results from two best-worst models of telecommunications importance. The first is a multinomial logit model, which estimates average coefficients across the (weighted) sample (or, alternatively, that all respondents have average preferences). The second is a mixed logit (or random coefficients) model, which estimates both the mean and the variance of the

[2] In other words, the statistical identification strategy for estimating the parameters of the scale function relies on variation across the sample; however, the function itself is interpreted as the mean preference function for each individual (subject to random variation). This is consistent with other cross-sectional discrete choice applications in which sample shares are interpreted as individual-level probabilities.

Table 4.3
Multinomial Logit and Mixed Logit Best-Worst Scaling Results

	Multinomial Logit		Mixed Logit	
	Coefficient	Preference Share	Coefficient	Preference Share
Means				
Landline telephone	–0.59***	0.12***	–3.87***	0.00***
	(0.05)	(0.01)	(0.52)	(0.00)
Mobile telephone	0.67***	0.42***	2.53***	0.83***
	(0.04)	(0.01)	(0.25)	(0.03)
Fixed Internet	0.12***	0.24***	0.45***	0.10***
	(0.03)	(0.01)	(0.09)	(0.02)
Standard deviations (normal distribution)				
Landline telephone	—	—	7.25***	—
			(0.89)	
Mobile telephone	—	—	2.42***	—
			(0.25)	
Fixed Internet	—	—	1.96***	—
			(0.28)	
Pseudo log-likelihood	–7,811.44		–7,006.76	
Number of alternatives	38,430		38,430	
Number of observations	2,745		2,745	

SOURCE: Authors' calculations from the ALP.

NOTES: *** = statistically significant at the 1 percent level. Standard errors are in parentheses. The baseline service is mobile Internet, with a residual share of 0.22 in the multinomial model. Preference shares of the mixed logit model are unconditional and calculated based on the estimated mean coefficients.

coefficients of each of the services.[3] In other words, the mixed logit model estimates the sufficient statistics of an assumed distribution of the random parameters, rather than just the mean. In the mixed logit model, we assume that the random coefficients are normally distributed; as such, both the mean and standard deviations of each parameter are estimated. Unlike the multinomial logit specification, the mixed logit model accounts for unobserved differences between respondents, with these differences summarized by the estimated mean and standard deviations of the distributions assumed for the random coefficients.

This specification has the advantage of allowing for deviations from the average, conditional on an assumed distribution of the random coefficients. A finding that one or more of

[3] The mixed logit model is estimated via simulated maximum likelihood estimation, in which random draws are used in the estimation process (K. E. Train, *Discrete Choice Methods with Simulation*, Cambridge, UK: Cambridge University Press, 2003). We used 200 Halton draws in the estimation process.

the estimated standard deviations is significantly different from zero implies that there is heterogeneity (i.e., variation) in preferences across the sample.[4] We also report preference shares (or the probability that a service is selected first). For the mixed logit specification, the reported probability shares are unconditional (i.e., calculated from the overall mean coefficients).[5] In each case, model identification requires that one of the coefficients be fixed; we arbitrarily set the mobile Internet coefficient equal to zero.

Because the coefficients of the model have no natural interpretation, we focus discussion on the preference shares. When treating every respondent as equal in the multinomial logit specification, the calculated preference shares suggest that, on average, mobile telephone service is approximately twice as important as fixed and mobile Internet and approximately 3.5 times more important than landline (fixed voice) service. These results are rank-order consistent with the mean rankings in Figure 4.1, but the results use the probabilistic information and the overall pattern of ranking across the sample to imply intensity of preferences across the sample.

When the specification is relaxed to allow for differences in preferences via the positive standard errors, the unconditional (or mean) preference share for mobile telephone goes up considerably, while the shares for the other three services go down. This implies that at the means of the parameter distributions, the probability of choosing mobile telephone as most important is higher than implied by the multinomial logit model.[6] However, it is important to note that each respondent's preference share (as opposed to the overall mean) is best estimated by using the probabilities implied by conditioning on the respondent's observed pattern of choice.[7]

Perhaps more importantly, the estimated standard deviations for the random parameters are all significant at the 1 percent level, suggesting that there is considerable variation in preferences across respondents in the sample. Furthermore, the estimated standard deviation on the landline telephone coefficient is almost three times that of the mobile telephone coefficient, suggesting that it is the most variable of the coefficients and shares estimated. This implies a great deal of unobserved heterogeneity within the sample, meaning that different groups likely have very different preferences across the four services. The following section investigates this further.

Latent-Class Best-Worst Results

The results of the mixed logit best-worst model suggest that there is variation across preferences with regard to telecommunications services, but those results are not especially useful in describing the nature of this variation. An alternative is to assume a discrete (rather than continuous) number of classes of respondents, such that coefficients within each class are identical but can vary across classes. If we allow the class definition to be probabilistic and determined by the data, the resultant best-worst specification can be estimated via a latent-class logit

---

[4] Note that each estimated structural standard deviation parameter also has a standard error due to sampling error. As such, a test of unobserved heterogeneity for a particular standard deviation parameter involves testing the null hypothesis that this parameter estimate is equal to zero.

[5] Train, 2003, shows that conditional shares can be calculated from the unconditional distribution and the observed choices using Bayes's rule.

[6] Statistically, the mixed logit model also accounts for potential differences in the underlying "scale," or variance of the error term (Lusk and Briggeman, 2009).

[7] See Train, 2003, for more details. We do not report statistics associated with individual-specific posterior probabilities because of the latent-class model discussed in the next section, which is more policy-relevant for our application.

model.[8] The number of classes is typically chosen on the basis of the maximization of information criteria, such as the Consistent Akaike Information Criterion and the Bayesian Information Criterion, across models with increasing numbers of classes. In our application, both of these information criteria were minimized at four classes.

Conditional on the number of classes chosen by the researcher, the latent-class logit specification provides not only estimates of the underlying coefficients and preference shares within each class but also estimates of the sizes of each class. In addition, conditional on assumed class membership (usually through the most likely class to which a respondent belongs), descriptive statistics can be calculated by class to help understand the underlying sociodemographics of each.

Table 4.4 reports the estimation results of the latent-class best-worst model, with the classes defined solely on the basis of the response patterns in the data.[9] Table 4.5 presents the corresponding preference and class shares.

The results show four distinct classes of preferences. Class 1, which comprises just over 40 percent of the population, is characterized by a very high probability (approximately 95 percent) of choosing mobile telephone as the most important service. This group ranks mobile Internet ahead of fixed Internet service and very clearly views landline telephone as the least

Table 4.4
Latent-Class Logit Best-Worst Scaling Estimation Results

	Class 1	Class 2	Class 3	Class 4
Landline telephone	–4.58***	–3.88**	–0.34	2.62***
	(1.66)	(1.59)	(0.22)	(0.14)
Mobile telephone	3.54***	–0.24	1.12***	0.96***
	(0.80)	(0.18)	(0.30)	(0.15)
Fixed Internet	–0.11**	0.96***	0.24	0.82***
	(0.05)	(0.31)	(0.13)	(0.16)
Class share constant	0.70***	–0.35*	0.20	—
	(0.14)	(0.20)	(0.30)	—
Pseudo log-likelihood	–6,911.12			
Number of alternatives	38,430			
Number of observations	2,745			

SOURCE: Authors' calculations from the ALP.

NOTES: Table entries show model coefficients and associated standard errors (in parentheses). *** = statistically significant at the 1 percent level. ** = statistically significant at the 5 percent level. * = statistically significant at the 10 percent level. Standard errors were computed via the delta method.

[8] The assumption of a discrete mixing distribution (as opposed to the continuous distribution in the mixed logit model) can be considered an approximation of the true, unknown distribution (K. E. Train, "EM Algorithms for Nonparametric Estimation of Mixing Distributions," *Journal of Choice Modeling*, Vol. 1, No. 1, 2008, pp. 40–69).

[9] In other words, only ranking data are used to estimate the model. The estimation was performed using a version of lclogit.ado in the Stata statistical package.

Table 4.5
Latent-Class Logit Best-Worst Scaling Preference and Class Shares

	Class 1	Class 2	Class 3	Class 4
Preference shares				
Landline telephone	0.00	0.00	0.12***	0.70***
	(0.00)	(0.00)	(0.02)	(0.02)
Mobile telephone	0.95***	0.18***	0.51***	0.13***
	(0.04)	(0.05)	(0.06)	(0.01)
Fixed Internet	0.02	0.59***	0.21***	0.12***
	(0.02)	(0.09)	(0.03)	(0.01)
Mobile Internet	0.02	0.23***	0.17	0.05***
	(0.02)	(0.04)	(0.03)	(0.01)
Class share	0.41***	0.14***	0.25***	0.20***
	(0.05)	(0.03)	(0.06)	(0.02)
Pseudo log-likelihood	–6,911.12			
Number of alternatives	38,430			
Number of observations	2,745			

SOURCE: Authors' calculations from the ALP.
NOTES: Table entries show preference shares (probability of a class member choosing a service as ranked first) and associated standard errors. *** = statistically significant at the 1 percent level. Mobile Internet was the excluded explanatory variable. Standard errors were computed via the delta method.

important service. These respondents also have distinct preferences for the services they rank second and third, with mobile Internet preferred over fixed Internet.

Class 2, comprising approximately 14 percent of the population, also views landline telephone as least important, instead prioritizing fixed Internet service as most important. For this class, the distinction between mobile Internet and mobile telephone is less precise (as given by the statistical equivalence of the estimated coefficients for these services for this class).

Class 3 respondents, like those in Class 1, are characterized by a view that mobile voice service is most important. However, this class does not have distinct preferences among the remaining three services. Approximately 25 percent of the population falls in this category.

Class 4 respondents, who comprise about 20 percent of the population, are distinguished by their view that landline telephone service is most important, while mobile Internet service is least important. Mobile telephone and fixed Internet service are intermediately ranked and not distinguished by the estimated coefficients.

Overall, these results suggest that just over 65 percent of the population views mobile voice service as most important, 14 percent prefers fixed Internet, and 20 percent views fixed voice (landline telephone) service as most important. Landline telephones are ranked last (or tied for last) for 80 percent of the population and ranked first for the remainder (who view mobile Internet as least important). These results suggest that the vast majority of the popula-

tion does not prioritize landline telephone in the presence of an alternative, although Class 4 respondents are more likely to reverse this relationship. Furthermore, consumers tend to prefer having access to both Internet and telephone services, although Class 2 respondents prioritize both types of Internet service over telephone service, suggesting a preference for any type of Internet service over telephone services.

Although class assignments for each class are probabilistic in nature, conditional posterior probability predictions of class membership can be used to assign sample respondents to a class based on the highest predicted probability. We then computed the weighted sample sociodemographic statistics (such as age and gender) conditional on this class assignment to gain insight into the observable characteristics of class members.[10] Table 4.6 displays the results.

Members of Class 4 tend to be older on average, are less likely to be employed, and tend to have lower levels of education than the other classes. They are more likely to live in New England or the Mid-Atlantic. In accordance with the stated preference data, their revealed behavior shows that they are more likely to have a landline telephone than the other classes and less likely to have mobile Internet service. They are also more likely to participate in a free or reduced-fee government program (although not statistically different in this regard from Class 3). Interestingly, however, 77 percent of this class has a mobile telephone, and 75 percent has fixed Internet services at home, suggesting that many in this class view mobile services and fixed Internet as complements.

Class 2 (the smallest of the four) appears to be the tech-savvy group. On average, members tend to be younger and male, with relatively high incomes and high rates of both fixed and mobile Internet service subscription. They are also less likely to participate in government telephone programs. Approximately 35 percent of this group has landline telephones, suggesting a substitute relationship between these and mobile telephone and Internet services. There is no distinct geographic pattern associated with these respondents.

Class 1, the largest group, is not distinguished by any particular sociodemographic or location characteristic, but it appears to be most similar to Class 2. However, members of this group are extremely likely to possess at least one mobile telephone per household and are the least likely in the sample to have a landline telephone, which is consistent with the stated preference exercise, a substitute relationship between mobile and fixed voice service, and a complementary relationship between telephone and Internet service.

Finally, Class 3 members are essentially an intermediate group between the other classes. Members skew slightly older than Classes 1 and 2 but are more likely to be employed than Class 4. They have a high rate of mobile telephone adoption, but more than 60 percent also have a landline. They have similar fixed Internet service rates as Classes 1 and 4 but fewer mobile Internet subscriptions than Class 2. Geographically, they tend to be overrepresented in the West South Central and Mountain divisions. Although there appears to be some variation across the class, these consumers appear to view all of the services as complementary.

[10] An overall test of joint equivalence between all four classes is rejected at the less than 1 percent level of significance using the unweighted sample. Similarly, pairwise comparisons between each class reject the null of equivalence at less than 1 percent. Readers are reminded that the large number of pairwise comparisons is likely to produce several rejections simply by chance.

Table 4.6
Sociodemographic Characteristics and Revealed Preferences by Class Membership

	Class 1	Class 2	Class 3	Class 4
Sociodemographic characteristics				
Age	43.59[cd]	41.55[cd]	48.31[abd]	56.55[abc]
	(0.58)	(1.30)	(1.14)	(1.25)
Gender (=1 if female)	0.52[b]	0.36[acd]	0.56[b]	0.54[b]
	(0.02)	(0.03)	(0.03)	(0.03)
Income class	10.91[d]	11.17[cd]	10.32[b]	9.59[ab]
	(0.15)	(0.26)	(0.27)	(0.27)
Highest education class	10.81[d]	11.01[d]	10.41[d]	9.69[abc]
	(0.09)	(0.21)	(0.22)	(0.16)
Married (=1 if yes)	0.64	0.65	0.64	0.59
	(0.02)	(0.04)	(0.03)	(0.03)
Foreign-born (=1 if yes)	0.09	0.13	0.13	0.12
	(0.01)	(0.03)	(0.03)	(0.02)
Race				
White/Caucasian (=1 if yes)	0.76	0.79	0.75	0.72
	(0.02)	(0.03)	(0.03)	(0.03)
Black/African American (=1 if yes)	0.12[b]	0.06[ad]	0.12	0.16[b]
	(0.01)	(0.02)	(0.02)	(0.02)
American Indian or Alaskan Native (=1 if yes)	0.01	0.02	0.02	0.02
	(0.00)	(0.01)	(0.01)	(0.02)
Asian or Pacific Islander (=1 if yes)	0.02	0.03[d]	0.02	0.01[b]
	(0.00)	(0.01)	(0.01)	(0.00)
Other (=1 if yes)	0.09	0.10	0.10	0.08
	(0.01)	(0.02)	(0.02)	(0.02)
Employed (=1 if yes)	0.70[cd]	0.71[cd]	0.58[abd]	0.38[abc]
	(0.02)	(0.03)	(0.03)	(0.03)
Geography (proportion in each division)				
New England	0.04	0.02[d]	0.02	0.05[b]
	(0.01)	(0.01)	(0.01)	(0.01)
Mid-Atlantic	0.14	0.12	0.10[d]	0.17[c]
	(0.01)	(0.02)	(0.02)	(0.02)
East North Central	0.15	0.20	0.13	0.18
	(0.02)	(0.04)	(0.02)	(0.02)
West North Central	0.05	0.04	0.04	0.04
	(0.01)	(0.01)	(0.01)	(0.01)

Table 4.6—continued

	Class 1	Class 2	Class 3	Class 4
South Atlantic	0.15	0.16	0.14	0.20
	(0.01)	(0.03)	(0.02)	(0.03)
East South Central	0.04	0.04	0.06	0.04
	(0.01)	(0.01)	(0.02)	(0.01)
West South Central	0.16[bd]	0.10[ac]	0.18[bd]	0.08[ac]
	(0.01)	(0.02)	(0.03)	(0.02)
Mountain	0.11[d]	0.10	0.12[d]	0.06[ac]
	(0.01)	(0.02)	(0.03)	(0.01)
Pacific	0.16	0.22	0.19	0.18
	(0.01)	(0.04)	(0.03)	(0.03)
Revealed preferences				
Landline telephone (=1 if yes)	0.30[cd]	0.35[cd]	0.63[abd]	0.87[abc]
	(0.02)	(0.03)	(0.03)	(0.03)
Mobile telephone (=1 if yes)	0.96[bcd]	0.83[a]	0.89[ad]	0.77[ac]
	(0.01)	(0.04)	(0.03)	(0.03)
Fixed Internet (=1 if yes)	0.75[b]	0.87[acd]	0.68[b]	0.75[b]
	(0.02)	(0.04)	(0.03)	(0.03)
Mobile Internet (=1 if yes)	0.65[d]	0.71[cd]	0.60[bd]	0.33[abc]
	(0.02)	(0.03)	(0.03)	(0.03)
None (=1 if yes)	0.01	0.01	0.03	0.03
	(0.00)	(0.01)	(0.02)	(0.02)
Reduced-fee telephone (=1 if yes)	0.07[d]	0.05[d]	0.09	0.11[ab]
	(0.01)	(0.02)	(0.02)	(0.02)
Number of observations	1,271	397	470	598

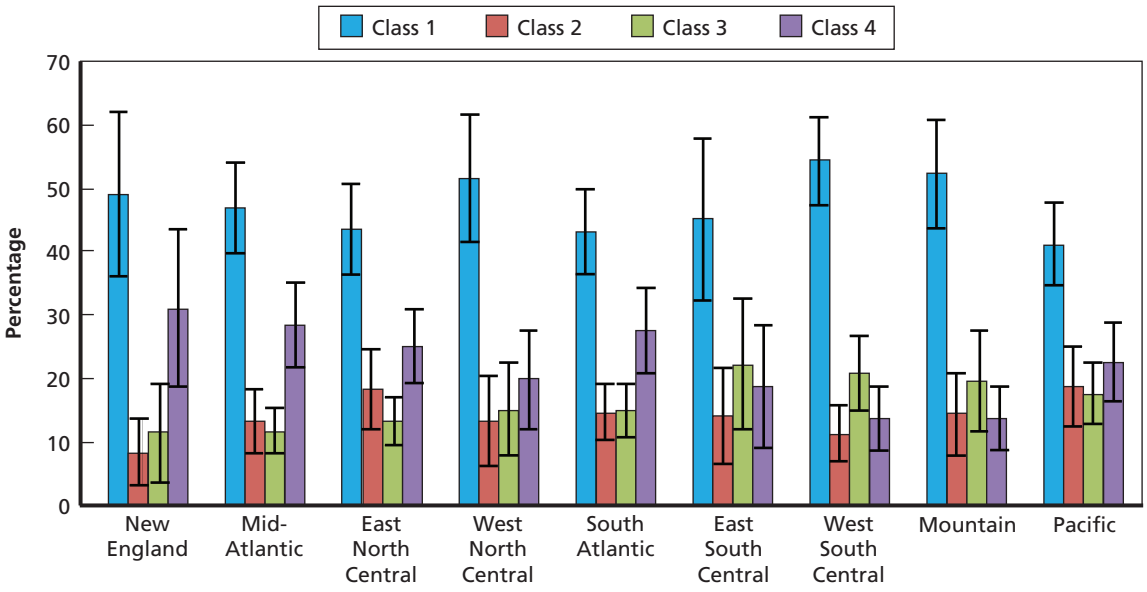
SOURCE: Authors' calculations from the ALP.

NOTES: Class 1 is characterized by a very high probability of choosing mobile telephone as the most important service and having distinct preferences among the other three services. Class 2 prioritizes fixed Internet service as most important. Class 3 views mobile telephone service as most important but does not have distinct preferences among the remaining three services. Class 4 views landline telephone service as most important. [a] = statistically different from Class 1 at 5 percent. [b] = statistically different from Class 2 at 5 percent. [c] = statistically different from Class 3 at 5 percent. [d] = statistically different from Class 4 at 5 percent. These results are weighted. Household income classes are defined as 1 = less than $5,000, 2 = $5,000 to $7,499, 3 = $7,500 to $9,999, 4 = $10,000 to $12,499, 5 = $12,500 to $14,999, 6 = $15,000 to $19,999, 7 = $20,000 to $24,999, 8 = $25,000 to $29,999, 9 = $30,000 to $34,999, 10 = $35,000 to $39,999, 11 = $40,000 to $49,999, 12 = $50,000 to $59,999, 13 = $60,000 to $74,999, and 14 = $75,000 or more. Highest education classes are defined as 1 = less than 1st grade; 2 = 1st, 2nd, 3rd, or 4th grade; 3 = 5th or 6th grade; 4 = 7th or 8th grade; 5 = 9th grade; 6 = 10th grade; 7 = 11th grade; 8 = 12th grade but no diploma; 9 = high school graduate with diploma or the equivalent (e.g., GED); 10 = some college but no degree; 11 = associate degree in college occupational/vocational program; 12 = associate degree in college academic program; 13 = bachelor's degree (e.g., B.A., A.B., B.S.); 14 = master's degree (e.g., M.A., M.S., M.Eng., M.Ed., M.S.W., M.B.A.); 15 = professional school degree (e.g., M.D., D.D.S., D.V.M., L.L.B., J.D.); and 16 = doctoral degree (e.g., Ph.D., Ed.D.). Geographic divisions are defined according to the U.S. Census Bureau.

Figure 4.2 shows the estimated share of each respondent class within each geographic division. Although there is variation in the shares for each class across locations, the estimates are not precise enough to distinguish them statistically.

The results of the latent-class best-worst model provide evidence of different segments of consumers of telecommunications technology. Four distinct classes are identified in a parsimonious manner based solely on the data. Each class has varying preferences over the four services and can be described by its sociodemographic and geographic characteristics. In addition, the relative size of each group was estimated. This information is potentially useful for future policy analysis to identify those most likely to be affected by changes in regulation and to inform related research and outreach.

Figure 4.2
Estimated Class Share by Geographic Division



SOURCE: Authors' calculations from the ALP.
NOTES: The 95 percent confidence interval of the share estimate is indicated by error bars. Class 1 is characterized by a very high probability of choosing mobile telephone as the most important service, with distinct preferences among the other three services. Class 2 prioritizes fixed Internet service as most important. Class 3 views mobile telephone service as most important but does not have distinct preferences among the remaining three services. Class 4 views landline telephone service as most important.

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CHAPTER FIVE

Conclusion

This report presented the results from three questions asked as part of a RAND American Life Panel survey to help understand the revealed and stated preferences of American households with respect to telecommunications services. In particular, we investigated participation in free and reduced-price telephone government programs, the combination of telephone (landline and mobile) and Internet (fixed and mobile) services currently chosen by households, and the preferences of respondents for these services in terms of the relative importance of the services to their lives.

Results indicate that a large proportion of the population appears to view mobile telephone service as a substitute for landline telephone service, as approximately 90 percent of households have the former but only 49 percent have the latter. That said, of the 93 percent of households with telephone service, there is an approximately equal split between mobile-only and joint mobile telephone and landline households, suggesting that some households view the services as complementary, or at least value having both. A model of stated preferences shows that the average respondent tends to view mobile voice service as the most important telephone service and landline service as the least important. Thus, while the average consumer deems telephone service a necessity, it appears that the satisfaction from mobile telephone services tends to be greater than the satisfaction from landline telephone service. This finding has important implications when considering the transition that is occurring because of the development of mobile and Internet services—namely, that some consumers may value certain attributes of new technologies more than the loss of some others.

In this particular case, however, averages do not tell the entire story. There is considerable variation across service bundles. For example, 26 percent of households subscribe to all services; 21 percent use mobile telephone and both Internet services; and 14 percent have landline, mobile telephone service, and fixed Internet only. Furthermore, the results of our stated preference analysis suggest that approximately 20 percent of the population views landline telephone service as the most important of the four telecommunications services, and there is some evidence that this subpopulation may include the more vulnerable members of society. In other words, while the average consumer may prefer new services and capabilities, this is not universal.

A fuller understanding of the preferences and values associated with the attributes of telecommunications services, including the attributes of new technologies, can contribute to the design of efficient public policy that does not hamper innovation yet maintains functionality necessary for the public good (such as current 911 emergency systems that rely on voice services). This report is a helpful step toward such an understanding. However, much more remains to be done. Future research into the technical differences between alternative tele-

phone and Internet technologies is necessary, as are estimates of the welfare effects (i.e., willingness to pay for and willingness to accept) of particular attributes and their levels. Examples of such attributes for the technology transition in telephone policy include, but are not limited to, effects on emergency services, capacity and reliability of service, quality, interoperability, access for people with disabilities, security, and coverage.[1] In addition, it would be desirable to investigate the choice environment and core drivers of these choices, such as availability, cost, and lifestyle. Stated preference methodologies are well suited to this task.

[1] These attributes of service were highlighted in FCC, "FCC Modernizes Rules to Encourage Technology Transitions, Protect Consumers and Competition," press release, August 6, 2015b.

APPENDIX A

Unrestricted Regression Results

This appendix provides the logit regression models appearing in Chapter Three without coefficient restrictions imposed.

Table A.1 reports the results from the unrestricted model associated with Table 3.3: Restricted Logit Regression of Program Participation as a Function of Demographics and Location.

Table A.2 reports the results from the unrestricted model associated with Table 3.4: Restricted Logit Regressions of Program Participation as a Function of Demographics and Location for Lifeline-Eligible Households.

Table A.3 reports the results from the unrestricted model associated with Table 3.7: Restricted Logit Regression of Landline Incidence as a Function of Demographics and Geography.

Table A.1
Unrestricted Logit Regression of Program Participation as a Function of Demographics and Location

	Unrestricted Coefficient
Age	0.00
	(0.01)
Gender (=1 if female)	–0.06
	(0.17)
Income class ($60,000–$74,999 = baseline)	
<$5,000	4.07***
	(0.54)
$5,000–$7,499	3.62***
	(0.58)
$7,500–$9,999	4.24***
	(0.55)
$10,000–$12,499	4.09***
	(0.54)
$12,500–$14,999	3.82***
	(0.56)
$15,000–$19,999	2.92***
	(0.53)
$20,000–$24,999	2.88***
	(0.53)
$25,000–$29,999	2.21***
	(0.57)
$30,000–$34,999	1.82***
	(0.58)
$35,000–$39,999	2.10***
	(0.55)
$40,000–$49,999	1.45**
	(0.71)
$50,000–$59,999	0.76
	(0.61)
$60,000–$74,999	—
$75,000–$99,999	–1.00
	(0.86)

Table A.1—continued

	Unrestricted Coefficient
$100,000–$124,999	–0.25
	(0.86)
$125,000–$199,999	0.63
	(0.68)
$200,000 or more	—
Highest education class (high school graduate with diploma or the equivalent = baseline)	
4th grade or less	–0.74
	(1.58)
5th or 6th grade	–0.39
	(0.90)
7th or 8th grade	0.53
	(0.39)
9th grade	0.70
	(0.53)
10th grade	–0.26
	(0.47)
11th grade	–0.72
	(0.52)
12th grade but no diploma	–0.15
	(0.52)
High school graduate with diploma or the equivalent	—
Some college but no degree	0.02
	(0.21)
Associate degree in college occupational/vocational program	0.18
	(0.30)
Associate degree in college academic program	0.14
	(0.32)
Bachelor's degree	–0.28
	(0.25)
Master's degree	–1.26**
	(0.50)

Table A.1—continued

	Unrestricted Coefficient
Professional school degree	-0.67
	(0.58)
Doctoral degree	–0.86
	(0.67)
Married (=1 if yes)	–0.12
	(0.19)
Foreign-born (=1 if yes)	0.57*
	(0.29)
Race (white/Caucasian = baseline)	
Black/African American (=1 if yes)	0.21
	(0.23)
American Indian or Alaskan Native (=1 if yes)	–0.52
	(0.52)
Asian or Pacific Islander (=1 if yes)	–0.94
	(0.60)
Other (=1 if yes)	0.44*
	(0.26)
Employed (=1 if yes)	–0.40**
	(0.18)
Geography (New England = baseline)	
Mid-Atlantic	–0.65*
	(0.36)
East North Central	–1.20***
	(0.38)
West North Central	–1.53***
	(0.53)
South Atlantic	–0.98**
	(0.43)
East South Central	–0.72
	(0.48)
West South Central	–0.46
	(0.34)
Mountain	–0.86**
	(0.39)
Pacific	–0.07
	(0.33)

Table A.1—continued

	Unrestricted Coefficient
Intercept	–4.54***
	(0.77)
Log-likelihood	–949.54

SOURCE: Authors' calculations from the ALP.

NOTES: These results are weighted. Sample size = 4,765. *** = statistically significant at the 1 percent level. ** = statistically significant at the 5 percent level. * = statistically significant at the 10 percent level. These results do not include respondents who marked "Don't know or don't remember." Standard errors are in parentheses. Income and education categories were entered as dummy variables with the baseline income category of $60,000–$74,999 and the baseline education category of high school graduate with diploma or the equivalent. The highest income variable was dropped because of perfect predictability of participation. Geographic divisions are defined according to the U.S. Census Bureau.

Table A.2
Unrestricted Logit Regressions of Program Participation as a Function of Demographics and Location for Lifeline-Eligible Households

	Unrestricted Coefficient
Age	0.01**
	(0.01)
Gender (=1 if female)	–0.13
	(0.20)
Income Class ($15,000–$19,999 = baseline)	
<$5,000	1.26***
	(0.33)
$5,000–$7,499	0.84**
	(0.40)
$7,500–$9,999	1.34***
	(0.33)
$10,000–$12,499	1.18***
	(0.32)
$12,500–$14,999	0.98***
	(0.35)
$15,000–$19,999	—
$20,000–$24,999	0.45
	(0.38)
$25,000–$29,999	0.05
	(0.46)
$30,000–$34,999	–0.92
	(0.64)
$35,000–$39,999	0.55
	(0.57)
$40,000–$49,999	–0.18
	(1.22)
$50,000–$59,999	—
Highest education class (high school graduate with diploma or the equivalent = baseline)	
4th grade or less	–0.69
	(1.54)
5th or 6th grade	–1.27
	(0.88)

Table A.2—continued

	Unrestricted Coefficient
7th or 8th grade	0.49
	(0.46)
9th grade	0.63
	(0.62)
10th grade	–0.38
	(0.47)
11th grade	–0.66
	(0.55)
12th grade but no diploma	–0.09
	(0.40)
High school graduate with diploma or the equivalent	—
Some college but no degree	0.06
	(0.22)
Associate degree in college occupational/vocational program	0.12
	(0.34)
Associate degree in college academic program	–0.16
	(0.39)
Bachelor's degree	–0.27
	(0.29)
Master's degree	–1.71***
	(0.62)
Professional school degree	0.24
	(0.91)
Doctoral degree	–1.18
	(0.85)
Married (=1 if yes)	0.12
	(0.20)
Foreign-born (=1 if yes)	0.47*
	(0.26)
Race (white/Caucasian = baseline)	
Black/African American (=1 if yes)	–0.06
	(0.24)
American Indian or Alaskan Native (=1 if yes)	–0.39
	(0.56)

Table A.2—continued

	Unrestricted Coefficient
Asian or Pacific Islander (=1 if yes)	–0.95
	(0.67)
Other (=1 if yes)	0.46*
	(0.27)
Employed (=1 if yes)	–0.60***
	(0.21)
Geography (New England = baseline)	
Mid-Atlantic	–0.35
	(0.46)
East North Central	–0.93*
	(0.49)
West North Central	–1.32**
	(0.66)
South Atlantic	–1.38***
	(0.50)
East South Central	–0.39
	(0.58)
West South Central	–0.28
	(0.44)
Mountain	–0.88*
	(0.49)
Pacific	–0.11
	(0.43)
Intercept	–1.87***
	(0.74)
Log-likelihood	–605.02

SOURCE: Authors' calculations from the ALP.

NOTES: These results are weighted. Sample size = 1,114. *** = statistically significant at the 1 percent level. ** = statistically significant at the 5 percent level. * = statistically significant at the 10 percent level. These results do not include respondents who marked "Don't know or don't remember." Standard errors are in parentheses. Income and education categories were entered as dummy variables with the baseline income category of $15,000–$19,999 and the baseline education category of high school graduate with diploma or the equivalent. All income levels greater than $60,000 were dropped because of no eligibility or perfect predictions. Geographic divisions are defined according to the U.S. Census Bureau.

Table A.3
Unrestricted Logit Regression of Landline Incidence as a Function of Demographics and Geography

	Unrestricted Coefficient
Age	0.06***
	(0.00)
Gender (=1 if female)	0.23***
	(0.08)
Income class ($60,000–$74,999 = baseline)	
<$5,000	–0.59*
	(0.32)
$5,000–$7,499	–0.62*
	(0.37)
$7,500–$9,999	–0.67**
	(0.31)
$10,000–$12,499	–0.28
	(0.32)
$12,500–$14,999	–1.12***
	(0.28)
$15,000–$19,999	–0.20
	(0.24)
$20,000–$24,999	–0.42*
	(0.22)
$25,000–$29,999	–0.67***
	(0.23)
$30,000–$34,999	–0.30
	(0.21)
$35,000–$39,999	–0.29
	(0.20)
$40,000–$49,999	–0.01
	(0.20)
$50,000–$59,999	–0.06
	(0.18)
$60,000–$74,999	—
$75,000–$99,999	0.09
	(0.17)
$100,000–$124,999	0.42**
	(0.18)

Table A.3—continued

	Unrestricted Coefficient
$125,000–$199,999	0.69***
	(0.19)
$200,000 or more	0.53**
	(0.25)
Highest education class (high school graduate with diploma or the equivalent = baseline)	
4th grade or less	–0.61
	(1.50)
5th or 6th grade	–1.56**
	(0.63)
7th or 8th grade	–0.65
	(0.42)
9th grade	0.15
	(0.40)
10th grade	0.44
	(0.47)
11th grade	–0.13
	(0.54)
12th grade but no diploma	–0.73**
	(0.30)
High school graduate with diploma or the equivalent	—
Some college but no degree	0.20
	(0.13)
Associate degree in college occupational/vocational program	0.01
	(0.17)
Associate degree in college academic program	0.13
	(0.18)
Bachelor's degree	0.09
	(0.13)
Master's degree	–0.02
	(0.15)

Table A.3—continued

	Unrestricted Coefficient
Professional school degree	0.23
	(0.26)
Doctoral degree	0.07
	(0.27)
Married (=1 if yes)	0.06
	(0.11)
Foreign-born (=1 if yes)	−0.18
	(0.14)
Race (white/Caucasian = baseline)	
Black/African American (=1 if yes)	0.19
	(0.14)
American Indian or Alaskan Native (=1 if yes)	−0.55*
	(0.33)
Asian or Pacific Islander (=1 if yes)	−0.30
	(0.25)
Other (=1 if yes)	0.00
	(0.18)
Employed (=1 if yes)	−0.08
	(0.10)
Geography (New England = baseline)	
Mid-Atlantic	0.21
	(0.22)
East North Central	−0.26
	(0.22)
West North Central	−0.55**
	(0.26)
South Atlantic	−0.05
	(0.21)
East South Central	−0.34
	(0.29)
West South Central	−0.72***
	(0.22)
Mountain	−0.37
	(0.23)

Table A.3—continued

	Unrestricted Coefficient
Pacific	–0.37*
	(0.21)
Intercept	–2.53***
	(0.41)
Pseudo log-likelihood	–2,842.24

SOURCE: Authors' calculations from the ALP.

NOTES: These results are weighted. Sample size = 4,994. *** = statistically significant at the 1 percent level. ** = statistically significant at the 5 percent level. * = statistically significant at the 10 percent level. These results do not include respondents who marked "Don't know or don't remember." Standard errors are in parentheses. Income and education categories were entered as dummy variables with the baseline income category of $60,000–$74,999 and the baseline education category of high school graduate with diploma or the equivalent. Geographic divisions are defined according to the U.S. Census Bureau.

APPENDIX B

Best-Worst Scaling and Related Statistical Models

Best-worst scaling is a method that uses discrete choices between alternatives to develop "strength of preference" measures over a number of objects on a common measurement scale.[1] Based on random utility theory, the method uses responses indicating the "best" (highest-utility) and "worst" (lowest-utility) object from an experimentally designed list to parameterize a utility function, assuming that the best and worst choices correspond to the pair with the maximum difference in utility from among all the objects on the list. In the example here, the objects are the four telecommunications services. With J objects on the list (here, the four services), there are a total of $J(J-1)$ possible best-worst choices per choice occasion; as such, a best-worst scaling exercise is equivalent to a discrete choice experiment (DCE).

More formally, the method posits a random utility model of the form

$$V_i = \beta_0 + \beta_1 X_{1i} + \ \ldots \ + \beta_A X_{Ai} + e_i,$$

where i denotes an individual; V_i is individual utility; X_a, $a = 1, 2, \ldots, A$, corresponds to an object in the list; the βs are the marginal utilities associated with an object; and e_i is an error term with distribution consistent with the statistical model used to estimate the function. Conceptualizing the exercise as a DCE, the Xs for each best-worst choice are defined as follows: $X_a = 1$ if attribute a is "best" for the choice, $X_a = -1$ if attribute a is "worst" for the choice, and $X_a = 0$ otherwise. Across all J choices for a particular choice occasion, the respondent is assumed to choose

$$\max_j \left\{ V_j \right\},$$

where V_j is the utility from choice j.

Because the data arising from this exercise were discrete in nature (the respondent chooses one best-worst pair per occasion), it is appropriate to use limited dependent variable methods to analyze the data. Although many such models exist, we focus on using the logistic function to model the probabilities of choice. Specifically, over J alternatives, the probability of choosing alternative k using the logistic function is

$$\Pr(\text{choosing } k) = \Pr(V_k \geq V_j \forall j) = \exp(V_k) / \sum_j \exp(V_j).$$

[1] Unless otherwise indicated, the material in this subsection draws from J. Louviere, I. Lings, T. Islam, S. Gudergan, and T. Flynn, "An Introduction to the Application of (Case 1) Best-Worst Scaling in Marketing Research," *International Journal of Research in Marketing*, Vol. 30, 2013, pp. 292–303; and Lusk and Briggeman, 2009.

In this report, Chapter Four describes the results of the best-worst preference exercise over the four telecommunications services (landline telephone, mobile telephone, fixed Internet service, and mobile Internet service) using the models described in the next sections.

Logit Model

The logistic regression model is a regression model in which the dependent variable is discrete; that is, it takes on one of two values that may be (arbitrarily) coded "yes" or "no."

Formally, the model is

$$\Pr(\text{"yes"} \mid \mathbf{x}, \boldsymbol{\beta}) = f\left(\mathbf{x}'\boldsymbol{\beta}\right),$$

where $\mathbf{x}$ is a vector of exogenous explanatory variables, $\boldsymbol{\beta}$ is a vector of coefficients to be estimated via maximum likelihood, $f(\cdot)$ is the logistic function $e^z/(1 + e^z)$, and $\mathbf{x}'\boldsymbol{\beta} = \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_K x_K$, with each x_k being an explanatory variable. The model is estimated using maximum likelihood techniques by taking logarithms of the probability statement and appending a Type I extreme value error term with cumulative distribution function $\Pr(\varepsilon < c) = \exp(-\exp(-(c + \alpha)))$, where α is a parameter of the distribution.

In this report, Chapter Three presents the results from a logit model that explains free or reduced-price telephone service program participation (the dependent variable) as a function of sociodemographic characteristics, as well as a model that explains landline incidence as a function of the same variables.

Multinomial Logit Model

The multinomial logit model (also known as the conditional logit model) uses the logistic function framework and assumes that the error term e_i is distributed as the Type I extreme value. For $k = 1, \ldots, K$ choices, the model predicts the probability of choosing choice k as

$$\Pr(k \text{ is chosen} \mid \mathbf{x}, \boldsymbol{\beta}) = \exp\{\mathbf{x}_k'\boldsymbol{\beta}\} / \sum_i \exp\{\mathbf{x}_i'\boldsymbol{\beta}\}.$$

It models the average preferences across the sample (or, functionally equivalently, assumes that all respondents have the same underlying preferences). It is thus not appropriate for investigating preference heterogeneity or variations in preferences across individuals in the sample. The model is typically estimated using maximum likelihood techniques.

In this report, Chapter Four presents the results of the best-worst preference exercise using a multinomial logit model specification.

Mixed Logit Model

The mixed logit model, also known as the random parameters logit model, relaxes some of the more restrictive assumptions of the multinomial logit model.[2] In particular, it specifically models heterogeneity in the sample using a mixture distribution to describe choice probabilities. Functionally, this implies treating the coefficients of the utility function as random parameters, and the sufficient statistics of the assumed distribution of these parameters are estimated. In this report, we assume that the parameters are normally distributed, which implies estimating both the mean and the variance of the coefficients. In addition, the mixed logit model can easily handle multiple choice occasions per respondent.

Formally, let P_k be the probability of any chosen (sequence of) alternative(s) by an individual, with $f(\beta|\theta)$ representing the joint probability distribution of the unknown coefficients of the utility function (i.e., the βs). θ are the sufficient statistics of this distribution (i.e., the means and variances to be estimated). Then the probability of choosing sequence k is

$$\Pr(\text{choosing } k) = \int P_k f(\beta \mid \theta) d\beta.$$

Because of the integrand, the model is typically estimated through simulated maximum likelihood.

In this report, Chapter Four presents the results of the best-worst preference exercise using a mixed logit model specification with coefficients specified as normally distributed.

Latent-Class Logit

The latent-class logit model (in which the sample is split into a discrete number of classes C, each of which is assumed to have a particular utility function with fixed coefficients) is the discrete analog of the mixed logit model.[3] In particular,

$$\Pr(\text{choosing } k) = \sum_c s_c P_{kc},$$

where s_c is the (estimated) share of the sample in class c, and P_{kc} is the probability of choosing k, assuming that the individual was in class c. Class membership is determined within the model. The advantage of latent-class logit for the purposes of this report is that the population can be split into discrete (homogenous) groups, and both the size and sociodemographic characteristics of each group can be estimated. Given the complexity of the likelihood function (i.e., its highly nonlinear nature), we use the expectation-maximization algorithm to estimate the model.

In this report, Chapter Four presents the results of the best-worst preference exercise using a latent-class logit model specification with four distinct classes.

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[2] See Train, 2008.

[3] See Train, 2008.

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