

Universal Service in a Wireless World

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December 8, 2015

Abstract

In 2005, the FCC expanded Lifeline: the primary telephone subsidy program, to include discounts for prepaid wireless service as well as for traditional landline service. This study provides insights into the effects of the subsidy, including its expansion, on household adoption of basic telephone service and conducts cost-benefit analysis using data taken from the National Health Interview Survey over 2003-2010. Results indicate that the Lifeline program increases a household's propensity to subscribe to phone service; however, the effects are quite small. Findings reveal that subsidy, as it has evolved, suffers from a great deal of infra-marginal subscribers and would benefit from restructuring.

JEL classification: L96, L98

I am grateful to John Mayo, John Rust, Marius Schwartz, Alexei Alexadrov, Nate Miller, Greg Rosston, and Scott Wallsten for their comments. I am grateful to Amanda Delp and Marcia Mintz for their editorial suggestions. And I am also grateful to the Georgetown Center for Business and Public Policy for sponsoring the access of the proprietary data for this project.

1 Introduction

Universal service has been a central goal of telecommunications policy for over 100 years.¹ Over that period, policymakers have focused on a variety of metrics for judging the “universality” of service, but the most common has been the so-called “penetration rate” of landline telephone service among American households.² Universal service policies have been implemented to ensure that all Americans have the opportunities and security that telephone service provides.

Against this backdrop, in 1984 the Federal Communications Commission (FCC) implemented the Lifeline program. Lifeline is a means-tested program that provides low-income households with a discount on their monthly telephone bill. Between 1988 and 2014 the number of Lifeline beneficiaries grew from roughly 1.8 million to more than 13.7 million. The corresponding expenditures of the program grew from approximately 32 million dollars in 1988 to 1.7 billion dollars in 2014.³

The growth of the subsidy was significantly affected by the policy change that the FCC introduced in 2005. Initially the Lifeline subsidy was available only to subscribers of wireline services. Due to low enrollment rates and the spread of new wireless technology, the FCC allowed companies offering prepaid wireless services the opportunity to offer Lifeline service to eligible households.

In the wake of this new policy, Lifeline subscriptions and the costs of Lifeline grew rapidly from roughly \$800 million in 2008 to \$1.7 billion in 2014 peaking at \$2.1 billion in 2012. These ballooning costs of the subsidy provoked considerable criticism of the program, calls for program reform, and even proposed legislation to end the Lifeline program altogether or at least eliminate its wireless element.⁴

The merits of this policy change, hereinafter referred to as the *wireless Lifeline initiative*, to

¹This effort first began through private-sector calls for “universal service” (see Parsons and Bixby (2010)) but later became an explicit public policy objective. See 47 U.S.C. § 151, stating that “communication by wire and radio so as to make available, so far as possible, to all the people of the United States, without discrimination...with adequate facilities at reasonable charges.” Subsequently in Section 254 (b)(3) of the Telecommunications Act of 1996, the goal was made even more explicit, stating that “consumers in all regions, including low-income consumers...should have access to telecommunications and information services.”

²The Communications Act of 1996 expanded the notion of universal service to include advanced telecommunications services as they evolve. In particular, in 2005, the universal services policies were extended to include wireless service; in 2010 the FCC released the National Broadband Plan that started to shape policies toward promotion of the high-speed Internet access.

³See FCC (2014).

⁴See, e.g., Spencer E. Ante “Millions Improperly Claimed U.S. Phone Subsidies,” *Washington Post*, February 11, 2013, p. A1. Also see, the bill “Stop Taxpayer Funded Cell Phones Act of 2011” introduced by Rep. Tim Griffin; and “Ending Mobile Phone Welfare Act of 2013” introduced by Rep. David Vitter.

include not only wireline but also wireless telephony in the Lifeline program, has not undergone a systematic economic analysis. Specifically, while some observers have defended the Lifeline subsidy noting that under the program the telephone penetration rate among low-income households increased from 80 percent in 1984 to 92.6 percent by 2013,⁵ this growth in subscribership may have been driven by factors other than the Lifeline program. Neither the posturing of critics or supporters of Lifeline provide specific insights on several key economic questions surrounding the program. Principal among these is whether the program as it has evolved has acted to promote connectivity of American households and at what cost.

This paper has two goals. First, I seek to provide further insights into the effects of the Lifeline program on household adoption of telephone service. In particular, I focus on two aspects: the impact of the amount of the subsidy, and the impact of the recent evolution of the subsidy from being a wireline-only program to supporting both wireline and wireless services. Second, based on my estimation, I conduct a cost-benefit analysis of the subsidy. These questions are important in light of recent proposed rulemaking issued by the FCC, where the Commission proposes steps to extend the Lifeline program to broadband service.⁶

To study the impact of the Lifeline subsidy, I utilize a unique database that combines both public and proprietary (location) household-level data taken from the National Health Interview Survey (NHIS) for the 2003-2010 period.⁷ The theoretical framework is a utility-based model of consumer behavior that incorporates characteristics suggested by the data and controls for the levels of subsidy benefits and regulatory changes. These data are not ideal – there is no information on whether a household participates in the Lifeline program or not. In fact, there is no nationwide database that captures participation of households in Lifeline. To mitigate this problem, the empirical estimation is conducted under two scenarios: first, only households that are eligible for Lifeline receive the subsidy (perfect enforcement); second, the Lifeline rules are not enforced and all households receive the subsidy (inefficient enforcement). The second scenario is considered because of the evidence that a substantial number of non-eligible households received

⁵See, FCC (2013).

⁶See FCC (2015).

⁷Public NHIS data are available for the later period of time, but proprietary data that I use for my estimation are available only for the 2003-2010 period.

the subsidy – this phenomenon was especially aggravated after implementation of the *wireless Lifeline initiative*.⁸ In the post-estimation, I conduct two counterfactual experiments to analyze how subscription choices of households change if the *wireless Lifeline initiative* is eliminated (i.e., the subsidy is not available for wireless service), and if the subsidy is eliminated altogether. Based on the results of these counterfactual experiments, I calculate the cost of adding a marginal subscriber.

In the perfect enforcement scenario, the results indicate that larger subsidies increase the propensity of households to subscribe to telephone service. Adoption of the new policy – *wireless Lifeline initiative* – also increased telephone penetration rates among households. However, the estimates show that adding a marginal subscriber to the telephone network is quite costly. Given that the Lifeline benefit payments in 2010 amounted to approximately \$1.2 billion, the estimated cost of adding a marginal wireline or wireless subscriber is \$1,151 per year. Given that the actual cost of the subsidy is only \$138 per year, the estimates indicate that only one of eight households enrolled in Lifeline subscribes to telephone service because of the subsidy; the other seven are infra-marginal subscribers (i.e., households that would subscribe to telephone service even in the absence of the subsidy). Based on the results of a counterfactual experiment specific to the *wireless Lifeline initiative*, the estimated cost of adding a marginal subscriber to a wireless network is \$2,835 per year. That means that only one out of twenty households that receive subsidies for wireless prepaid service subscribes to telephone service because of the subsidy; the other nineteen are infra-marginal subscribers. I also find that if the Lifeline program were eliminated altogether, over one million households would have cancelled telephone service in 2010, which would have decreased the telephone penetration rate among US households from 95.8 percent to 94.9 percent.

In the inefficient enforcement scenario, the level of the Lifeline benefit and the extension of the subsidy to wireless service also increase the propensity of households to subscribe to telephone service. However these effects, while significant, are much smaller than in the first scenario. Thus, the estimated cost of adding a marginal subscriber to the telephone network, wireline or wireless, is higher than in the first scenario – approximately \$3,093 per year, while the cost of adding a marginal subscriber to a wireless network is \$5,486 per year. In this scenario the consumer behavior is quite different than in the perfect enforcement case. The results from the counterfactual experiment

⁸See FCC (2012).

indicate that if the subsidy were cancelled for both wireline and wireless services, the majority of consumers would switch from the “wireless-only” category to either “both” or “landline-only” categories. Only about 400,000 households would have disconnected telephone service in 2010, which would have decreased the overall telephone subscription rates from 95.8 percent to 95.5 percent.

This study complements the literature in several ways. First, I estimate my model in the framework where consumers have a choice of wireless, wireline or both services,⁹ while existing empirical studies of the Lifeline program focus primarily on traditional *landline* service [Garbacz and Thompson(1997, 2002, and 2003), Eriksson, Kaserman and Mayo (1998), and Ackerberg et al. (2014)]. Second, I analyze how the extension of Lifeline to include wireless service affected a household’s propensity to adopt a phone. To my knowledge, there has been no empirical study of this regulatory change. Finally, I provide a cost-benefit analysis of the subsidy as a whole and of its wireless element.

My results are similar to the existing findings. Most of the economic research on the Lifeline program has indicated that it has promoted telephone subscriptions, but the gains have been costly. Erickson, Kaserman and Mayo (1998) estimate that the cost per new subscriber was between \$133 and \$556 depending on the poverty level for the 1985-1993 period. Garbacz and Thompson (2002) show that the cost per added household was \$191 in 1990, and it increased to \$1581 in 1998. The most recent study by Ackerberg et al. (2013) estimates that the cost of adding a new subscriber was \$519 in 2000.

The next section provides background of the Lifeline program.

2 Evolution of the Lifeline Program

The Lifeline program was established in 1984 after the divestiture of AT&T in response to the concerns that potential rate increases could harm low-income consumers and decrease their

⁹This paper builds on the literature that studies telecommunications demand, e.g., Perl (1983), Taylor and Kridel (1990), Bell Canada (Bodnar et al. 1988), Train, McFadden and Ben-Akiva (1987), Taylor (1994), Schement (1995), Riordan (2002), Rodini, Ward and Woroch (2003), Gideon and Gabel (2011), and Macher et al. (2015).

telephone subscription rates.¹⁰ Initially Lifeline was available to low-income subscribers of wireline service, the only telephone option widely available to the public at the time.

The Lifeline program promotes telephone subscribership by providing low-income households with monthly discounts on the cost of telephone service. To qualify for Lifeline, the household income must be at or below 135 percent of the Federal Poverty Guidelines, or one of the household members must participate in one of the welfare programs specified by the FCC.¹¹ Each eligible household can subsidize at most one phone, regardless of the number of telephone subscriptions in a household. Currently, the level of Lifeline benefits is standardized in all states at \$9.25 per month. Before 2012, the subsidy amount varied across states. My estimation strategy leverages this variation to evaluate the importance of the size of the benefit. Table 1 shows the amounts of Lifeline benefits across US states in 2010.¹²

Historically, the program was not very popular among eligible households. Figure 1 compares Lifeline program participation with household participation in the Supplemental Nutrition Assistance Program (SNAP), a welfare program that is used by the FCC to establish the eligibility criteria for participation in Lifeline, over 1996-2014. This comparison suggests that many eligible households do not take advantage of Lifeline benefits.¹³ The Commission undertook several measures to increase participation rates in the program.

First, in 2000 the FCC enhanced the program benefits for residents living on or near federally-recognized tribal lands and reservations.¹⁴ Second, in 2004, the Commission expanded the federal

¹⁰Together with Lifeline in 1987 the FCC established another low-income subsidy program Link Up. Link Up is a one time subsidy that reduces the initial subscription fee for the public switched network or the activation fee for wireless service. Link Up has been a much smaller program than Lifeline, it accounted for less than 10 percent of total low-income subsidy payments. It was eliminated except for recipients on Tribal lands in February 2012 as a result of FCC reforms (see FCC (2012)) and it is not addressed in the current study.

¹¹These federal programs include: Medicaid, Supplemental Nutrition Assistance Program (Food Stamps or SNAP), Supplemental Security Income (SSI), Federal Public House Assistance (Section 8), Low-Income Home Energy Assistance Program (LIHEAP), Temporary Assistance to Needy Families (TANF), National School Lunch Program's Free Lunch Program, Bureau of Indian Affairs General Assistance, Tribally-Administered Temporary Assistance for Needy Families (TTANF), Food Distribution Program on Indian Reservations (FDPIR), Head Start (if income eligibility criteria are met), or State assistance programs (if applicable).

¹²The statistics are provided for 2010, because the sample used in the empirical estimation is for the 2003-2010 period.

¹³Studies by Burton, Macher and Mayo (2007) and Hauge, Jamison and Jewell (2008) examine Lifeline participation rate and characteristics of the program that might influence enrollment in the subsidy.

¹⁴Federal-State Joint Board on Universal Service; Promoting Deployment and Subscribership in Unserved and Underserved Areas, Including Tribal and Insular Areas, Twelfth Report and Order, and Further Notice

default eligibility to include an income-based criterion of 135 percent of the federal poverty guidelines and additional means tested programs.¹⁵ Finally, in 2005, the FCC decided to forego a “facilities requirement” for approving telephone companies as Eligible Telecommunications Carriers (ETCs) for Lifeline support only. This change in regulation, which from now on is referred to in this paper as *wireless Lifeline initiative*, provoked rapid growth of Lifeline subscribers and consequently costs of the subsidy.

Since the 1996 Telecommunications Act, the FCC had maintained a requirement that only facilities-based telephone companies could serve as ETCs for the purpose of providing the Lifeline subsidy. However, based on the petition of TracFone, a non-facilities-based, commercial mobile radio service provider (reseller) offering prepaid service, the FCC decided to eliminate the facilities requirement.

Although TracFone was granted a forbearance from the facilities requirement in 2005, its designation as an ETC was conditional on implementation of several FCC requirements¹⁶ and the first Lifeline offerings by TracFone finally appeared in 2008 in Florida, Tennessee, and Virginia.

In fact, facilities-based carriers had provided Lifeline support for wireless service before 2008; however, the Lifeline wireless payments were negligible. The elimination of the “facilities requirement” opened a way for many resellers that previously had not qualified as ETCs, to apply for provision of Lifeline support – by 2014 prepaid wireless carriers were offering Lifeline subsidy in 49 states. For this reason, the *wireless Lifeline initiative* is often considered the beginning of subsidized wireless phones, popularly called “Obama phones.”¹⁷

of Proposed Rulemaking, CC Docket No. 96-45, FCC 00-208, 15 FCC Rcd 12,208 (2000).

¹⁵See *Lifeline* and *Link Up*, Report and Order and Further Notice of Proposed Rulemaking, 19 FCC Rcd 8302 (2004).

¹⁶The grant of the ETC status was conditional on TracFone (a) providing its Lifeline customers with 911 and enhanced 911 (E911) access regardless of activation status and availability of prepaid minutes; (b) providing its Lifeline customers with E911-compliant handsets and replacing, at no additional charge to the customer, non-compliant handsets of existing customers who obtain Lifeline-supported service; (c) complying with conditions (a) and (b) as of the date it provides it provides Lifeline service; (d) obtaining a certification from each Public Safety Answering Point (PSAP) where TracFone provides Lifeline service confirming that TracFone complies with condition (a); (e) requiring its customers to self-certify at time of service activation and annually thereafter that they are the head of household and receive Lifeline-supported service only from TracFone; and (f) establishing safeguards to prevent its customers from receiving multiple TracFone Lifeline subsidies at the same address.

¹⁷This moniker is however inapt. The change in the regulation was approved in 2005, during the Bush Administration.

Since implementation of the *wireless Lifeline initiative*, the number of Lifeline participants has grown significantly. Figure 2 shows that the number of program participants grew from 6.7 million in 2008 to almost 14 million in 2014. As a result the payouts under the Lifeline program have increased as well; Figure 3 shows that the costs of the program more than doubled from \$785 million in 2008 to \$1.7 billion in 2014.

The increasing costs of the Lifeline program have resulted in higher fees passed along to consumers. All universal service support mechanisms, including Lifeline, are funded by the Universal Service Fund (USF). Companies pay a percentage (or contribution factor) of their interstate and international end-user revenues that appear on consumers' monthly wireline and wireless service bills. Figure 10 displays the growth of Lifeline quarterly spending requirements and USF contribution factor. In 2008 the average Lifeline spending per quarter was around \$200 million, in 2012 quarterly spending rose three times to \$600 million, and it fell to \$400 million quarterly in 2014. At the same time the USF contribution factor grew from 10 percent to 16 percent. According to the FCC 2014 Monitoring report, each household faces an approximately \$3 monthly charge that goes to USF, which amounts to approximately \$36 out of pocket expenditures per household per year.

To better understand the nature of this increase in participation rates and program costs, I segmented Lifeline beneficiaries into subscriber groups of wireline, wireless excluding prepaid, and prepaid wireless services. Figures 4 and 5 show that most of the growth since 2009 in the number of program subscribers and payments can be attributed to the growth of Lifeline subscribers to prepaid wireless service. From 2008 to 2014 the percentage of Lifeline reimbursements to resellers increased from 1 to 76; while the percentage of Lifeline reimbursements to wireline carriers decreased from 90 to 16.

The extension of the subsidy to prepaid wireless service may have benefited low-income consumers, the majority of whom have been relying solely on wireless service in the recent years.¹⁸ Figure 6 shows subscription rates to telephone service among low-income and all US households over the 1984-2014 period. The telephone subscription rates among low-income households have increased from 89.7 percent in 2008 to 93.1 percent in 2014. Also, the difference in subscription

¹⁸Blumberg, Stephen J., and Julian V. Luke (2015).

rates between low-income and all US households has significantly narrowed over time.

Alternatively, even though the growth of the Lifeline program coincided with the growth of telephone subscriptions (this tendency is shown in Figure 3), there might be other factors that prompted households to subscribe to telephone service such as improved quality of wireless service or a decrease in prices of telephone service. Potentially, the growth of Lifeline may have been caused by the worsened economic conditions and decreases in income. Note that concurrent with the effective implementation of the *wireless Lifeline initiative* in 2008, the US entered a period of significant financial turmoil and recession. During this time other social welfare programs also experienced significant increases in program participation and in program costs.

Besides worsened economic conditions, there are several other possible causes of growth of the Lifeline program related to the introduction of *wireless Lifeline initiative* that would not necessarily result in increased subscription rates. First, the *wireless Lifeline initiative* might have attracted eligible customers who had not been enrolled in Lifeline before the subsidy expansion. These could be either customers who had not subscribed to telephone service before Lifeline expansion (marginal consumers), in which case subscription rates would increase, or customers who would have subscribed to telephone service anyway but who now find it more attractive to take Lifeline (infra-marginal subscribers), in which case subscription rates would stay the same.

A second source of change that might be caused by the *wireless Lifeline initiative* is that the filter by which households are deemed to be eligible became less binding. The program enrollment process, initially designed for traditional wireline service, was not adjusted for extension to wireless service which is quite different in nature. This led to fraud and waste of federal funds.¹⁹ In particular, the rule of one phone service per household became harder to sustain once the subsidy was available to cell phone service subscribers in the absence of a unified database of all Lifeline customers.

Finally, the verification procedures during initial enrollment in the program have also proved inefficient in some states. Lifeline subscribership data reflects troubling evidence suggesting that non-eligible households may be enrolling in the program at a particularly rapid rate in states that

¹⁹Julie A. Veach (2013).

do not require documentation of program-based eligibility at sign-up.²⁰

This research seeks to explore the role of Lifeline in the growth of telephone subscribership among US households. If in fact Lifeline increased telephone penetration rates, how much does it cost to add a marginal subscriber to the telephone network under the program?

3 Data

Data for this research are taken from the National Health Interview Survey (NHIS) conducted by the National Center for Health Statistics (NCHS). The NHIS is a household survey that collects data on roughly 35,000 - 40,000 households and 75,000 - 100,000 individuals annually. The survey does not follow the same individuals through the course of interviews, hence my sample is a pooled sample of cross-sections. The NHIS includes questions on demographics, the health status of the population, and telephone coverage. Specifically, the survey includes questions about the status of household subscription to telephone services: either wireline or wireless, both or none. The NHIS conducts the survey in person and covers the civilian and non-institutionalized population residing in the United States at the time of the interview.²¹

While most of the NHIS data are publicly available, specific household location is confidential. With the approval of the Centers for Disease Control and Prevention (CDC), I obtained the restricted portion of the data and could therefore link the NHIS sample to data from the Federal Communications Commission, the United States Census Bureau, the United States Bureau of Labor Statistics, and the United States Department of Agriculture.

3.1 Data Overview and Descriptive Statistics

The initial NHIS data set contains 190,072 household-level observations. I eliminate observations for which essential information is missing. The sample used in the estimation contains

²⁰For example, the number of Lifeline subscribers in Louisiana, which does not require documentation of program participation at enrollment, increased by 1,565 percent from 2008 to 2011. Over the same period, the number of Lifeline subscribers in Kansas, which does require documentation, increased only by 105 percent from 2008 to 2011 (See FCC (2012)). Based on the ETCs' surveys conducted in 2011, 9 percent of the respondents surveyed responded that they were no longer eligible for Lifeline, and 27 percent of subscribers failed to respond to the carriers' verification surveys.

²¹For further details, see http://www.cdc.gov/nchs/nhis/about_nhis.htm.

approximately 20,000 observations in each year for the 2003-2010 period, or 167,397 household-level observations in total. Table 2 shows the annual percent of households without phone service in the sample. It stays around 1.5 percent every year with small variation.²²

Figures 7, 8, and 9 show annual telephone subscription choices for the whole sample, low-income households, and households that I identify as eligible for Lifeline, respectively, for the period of 2003-2014. The telephone choices include no phone, landline only, wireless phone only, or both services. Low-income households are households with income below poverty level, and they are a subset of eligible households. As shown in these figures, low-income households experience the lowest subscription rates, followed by eligible households.

Both eligible and low-income households are more likely to choose subscription to only one service, and there has been a dramatic shift in preferences toward wireless service among all groups of households. In the period 2003-2008, both eligible and low-income households exhibit heavy reliance on landline. In 2009, across the entire sample for the first time the percentage of households that subscribe to cell phone only service exceeded the percentage with landline service. The same shift occurred among eligible and low-income households. In 2014, almost 57 percent of eligible households were wireless-only, and more than 62 percent of low-income households subscribed only to cell phone service. In contrast, the US average was around 47 percent in 2014.

Table 4 provides summary statistics based on the sample used in the estimation.

3.2 Variables

To determine the main factors that influence demand for telephone service, and in particular the effect of subsidies and regulation, I employ several groups of explanatory variables. Variables of primary interest are levels of subsidy and measures of changes in regulation. Second, I incorporate price measures along with household income. Third, I include demographic characteristics that have been historically shown to affect the demand for telephone service. Finally, I control for

²²As shown in Table 2, the full NHIS sample contains larger percentage of households without telephone service; however for some households in the sample essential information is missing. In most cases, it is the information about income level that is not provided. However, as shown in Appendix A, demographic characteristics of the NHIS data set closely resemble those of the U.S. population. For this reason, I believe that the estimates based on restricted sample of households for which all information is represented are correct.

quality characteristics of wireline and wireless services. Below I provide a general overview of the variables. Appendix B includes the notation, definitions and sources of all variables.

Low-Income Program Variables To account for the effect of the subsidies, I include combined federal and state monthly Lifeline support per beneficiary by state (*Lifeline Benefit*) for the 2003-2010 period. These data are available within the FCC “Universal Service Monitoring Report.” I expect that higher program benefits will result in an increased propensity of telephone subscriptions.

To control for the availability of the *wireless Lifeline initiative* in a particular state, I use total prepaid wireless Lifeline payments within the state for each year (*Wireless Lifeline Initiative*). Zero or very small payment amounts under the *wireless Lifeline initiative* mean that there is no ETC in the state that offers Lifeline for wireless prepaid service, or that eligible customers are unaware of the subsidies. The greater the amount of payments under the *wireless Lifeline initiative*, the more likely that the subsidy for prepaid wireless service is easily available to eligible households in that particular state.²³

Finally, from the NHIS data, I identify households eligible for low-income benefits according to the federal eligibility criteria (*Eligible Household*).

Price and Income Variables In order to estimate consumer demand empirically, I include measures of wireline and wireless prices. I use 2002 data on the basic flat monthly charges by wire centers throughout the U.S.²⁴ The areas served by wire centers typically comprise parts of several counties. I use population weights within individual wire centers to construct a weighted price by county for residential landline service throughout the U.S. To update these data for the 2003-

²³For robustness check, I used other controls for the *wireless Lifeline initiative*, such as an indicator that subsidies for wireless prepaid service are offered in a particular state, and wireless Lifeline prepaid payments per capita. The regression results with either of these measures are very similar to the ones with the total prepaid wireless payments.

²⁴These data were graciously provided by Greg Rosston, Scott Savage and Bradley Wimmer. See Rosston, Savage and Wimmer (2008) for their research using these data. While many local telephone companies offer local measured service in which customers pay a smaller monthly subscription charge and (after a call or minute allowance) pay a marginal charge per minute or call, industry sources report that the percentage of customers who avail themselves of this option is *de minimus*. Accordingly, I focus on consumers’ choices based on variations in flat monthly rates. For a detailed study of the economics of such optional calling plans, see Miravete (2002).

2010 period, I utilize the Federal Communication Commission’s “Reference Book of Rates, Price Indices, and Household Expenditures for Telephone Service” (Reference Book). The Reference Book reports the results of an annual survey of local monthly fixed telephone rates for 95 cities located throughout the U.S. The year-to-year Pearson correlations between the prices are very high, averaging .96 during the relevant time period, indicating that the major source of wireline price variation is captured by the spatial disaggregation of prices at the beginning of the sample period. The prices are updated by the values of the Consumer Price Index (CPI) for local exchange service during the 2003-2010 sample period.

Finding a measure of wireless price is quite a challenge. Mobile carriers offer numerous subscription plans to consumers. A plan usually includes a “bucket” of minutes for a flat rate charge. For consumers whose usage levels remain within the purchased bucket, the price can be taken as an average monthly expenditure for the service. Data on average expenditure per user (including roaming charges and long-distance toll calling) were taken from the Cellular Telephone and Internet Association (CTIA). CTIA conducts a semi-annual survey of its member companies called *Wireless Industry Indices*. The survey includes data from companies representing over 95 percent of all U.S. wireless subscribers between 2003-2010. To account for spatial variation in the measure of wireless prices, I incorporate local and state taxes paid by consumers in different locales. Data on state and local taxes are provided by the Committee on State Taxation (COST). The tax data are collected every three years starting in 1998 (i.e. 2001, 2004, 2007 and 2010).²⁵ COST reports the prevailing state sales tax inclusive of general sales taxes. Local tax rates for each state were calculated as the average of those imposed in the largest city and those imposed in the capital city. The first two reports include the single measure of local and state taxes applied to wireline local and long distance service as well as mobile service. In later reports, taxes levied specifically on wireless service were reported separately. I used linear interpolation to calculate tax rates for the years between reports.

Drawing on the NHIS survey data, I also include measures of household income. Household income is categorized relative to an annual poverty threshold using four dichotomous variables. Household income below the poverty threshold (*Income1*), between one and two times the poverty

²⁵See COST (2002, 2005) and Mackey (2008, 2011).

threshold (*Income2*), between two and four times the poverty threshold (*Income3*), and more than four times the poverty threshold (*Income4*) are relevant categories.

Endogenous Variables and Exclusion Restrictions I consider the potential endogeneity of prices and the amount of the Lifeline subsidy. The endogeneity of prices may rise for several reasons: for example, where there is an unobserved attribute of the service, such as quality or advertising, that is correlated with price. Without correcting for endogeneity, the aggregated demand is estimated to be upward-sloping, suggesting that omitted attributes are positively correlated with demand.

The endogeneity concern regarding the amount of the Lifeline subsidy arises from the presumption that states with lower telephone subscription rates might provide higher low-income support in order to increase penetration rates. This assumption is supported by the statistics from the FCC Monitoring Report, 2010. Table 3 shows that in 1997 the penetration rates among low-income households in the states with high assistance is lower than in the states with intermediate or low assistance. The same holds for the sample of all households; however, the difference in penetration rates among states with different levels of assistance is smaller. By 2009, the difference in telephone subscription rates diminished for states with different support levels.

As always with endogeneity, the selection of exclusion restrictions is an issue. Exclusion restrictions should be correlated with the endogenous variables, but should not affect the dependent variable. The exclusion restriction I use in the equation (2) for estimation of the wireline price is the *Hausman-Type Instrument*.²⁶ The price instrument for county i is calculated as the average price in other counties in the same state. This instrument seems to be appropriate, because carriers face the same regulations and fees within the same state, so the prices of the same carrier in other counties should reflect common costs within the state.

To estimate the wireless price, I use *Mobile Penetration*. It is plausible that economies of scale exist in the wireless industry. Economies of scale imply cost reductions with increased penetration. Thus, mobile penetration might impact the price as a cost-shifter. Regression analysis shows that the mobile penetration rate does not influence telecommunications demand.²⁷ Hence, it seems to

²⁶See Hausman (1996), Petrin and Train (2010).

²⁷See Barnett and Kaserman (1998).

be a reasonable choice of instrument.

I use the percent of families at or below 135 percent of the poverty level (*Families Below 135*) as the exclusion restriction for the subsidy payments. This variable does not directly affect the telecommunications demand, but states with higher poverty levels may be more prone to provide higher social benefits. To check for robustness, I also use the party affiliation of the governor (*Democrat Governor*) as an exclusion restriction for the amount of the subsidy. In the majority of the states, a public utility commissioner is appointed by the governor. The Public Utility Commission plays a major role in determining the size of the Lifeline subsidy. Democrats might be inclined to provide more generous subsidies than Republicans.

Demographic Variables I include demographic variables that are conventionally regarded as important determinants of telephone demand. I control for age (*Age of Head of Household*), education (*Educated Household*), household size (*Household Size*), home ownership (*Own Home*), ratio of employed members in a household (*Ratio Working*), number of children (*Children*), the presence of a student in a household (*Student*), the presence of members with health limitations (*Limited Youth* and *Limited Adult*) in a household, the presence of a retiree in a household (*Retired Household*); racial composition (*White, Black, Hispanic* and *Native American Households*), and gender composition (*Female Household* and *Male Household*).

Quality Variables/Geographic Variables I include population density (*Population Density*) to account for potential network effects, or in contrast, the potential extra value of connection to a resident of a rural area.²⁸ To capture the increase in demand due to inter-temporal variation in the wireless service quality, I control for a number of cell sites deployed by the wireless industry in each year between 2003-2010 (*Cell Sites*).²⁹

²⁸See, Macher et al. (2015).

²⁹The annual data are available in the CTIA report. It includes repeaters and other cell-extending devices but excludes microwave hops. The location of the specific cell site is confidential, thus I am unable to account for their geographic distribution. My measure of cell sites might also underestimate inter-temporal wireless service quality improvement due to technological differences of towers deployed in the different periods.

4 Econometric Specification

For empirical estimation I utilize a mixed logit model. This model allows to account for heterogeneity in consumers' preferences, does not restrict substitution patterns, and allows for correlation in unobserved factors over time. The price coefficient varies across consumers, while other coefficients are fixed. The price coefficient is independently normally distributed. I also account for potential endogeneity of the prices and levels of subsidy benefits.

Consider a consumer who faces four alternatives for a telephone: (1) no phone, (2) landline only, (3) cell phone only, or (4) both landline and cell phone, and chooses the alternative with the highest level of utility. The utility of option j ($j = 0, N, W, NW$), which accordingly corresponds to the choice of no phone (0), wireline only (N), wireless only (W), or both phones (NW) can be written as:

$$U_{njt} = V(\text{Price}_{njt}, LL_{nt}, WLI_{njt}, \mathbf{X}_{nt}, \beta_n) + \epsilon_{njt}, \quad (1)$$

where Price_{njt} is the price of service j ($j = N, W, NW$) faced by household n at time t , and price of outside option (no phone) is zero; LL_{nt} denotes the amount of Lifeline benefits that household n faces at time t ; WLI_{njt} represents the *wireless Lifeline initiative* (it is approximated by the total amount of subsidy payments to wireless prepaid ETCs in the state of household n 's residence at time t); \mathbf{X}_{nt} is a $k \times 1$ vector that includes all other controls, such as income and demographic characteristics of household n at time t and some alternative-specific characteristics in the area where household n resides; β_n is a random price coefficient that represents taste of consumer n ; ϵ_{njt} is the unobserved portion of utility.

To address the issue of potential endogeneity of prices and low-income benefits, I follow Petrin and Train (2010) by implementing a control function approach. The idea behind the control function approach is to derive proxy variables that condition on the parts of endogenous variables that are correlated with the unobserved utility ϵ_{njt} . This can be done, if endogenous variables are regressed on all the exogenous variables that enter utility and some exclusion restrictions Z_n that do not directly enter utility, but impact endogenous variables. In the first stage I estimate the following system of equations:

$$\begin{cases} Price_{njt} = f(\mathbf{X}_{nt}, Z_{nt}) + v_{njt}, \\ LL_{nt} = f(\mathbf{X}_{it}, Z_{nt}) + v_{nt}. \end{cases} \quad (2)$$

System of equations (2) is estimated by simple OLS regression of prices and subsidy benefits on exogenous variables \mathbf{X}_{nt} and exclusion restrictions Z_{nt} . Then I recover the estimated residuals to use them as control functions in the estimation of mixed logit:

$$\epsilon_{njt} = CF(v_{njt}, v_{nt}; \lambda_P, \lambda_B) + \tilde{\epsilon}_{njt}, \quad (3)$$

where $CF(v_{njt}, v_{nt}; \lambda_P, \lambda_B)$ denotes the control function with corresponding parameters λ_P and λ_B . I specify the control function as linear in v_{njt} and v_{nt} ; $\tilde{\epsilon}_{njt}$ are i.i.d. extreme value and independent of other regressors.

The utility function with the control function that generates the mixed logit model is specified as:

$$U_{njt} = V(Price_{njt}, LL_{nt}, WLI_{njt}, \mathbf{X}_{nt}, \beta_n) + \lambda_P v_{njt} + \lambda_B v_{nt} + \sigma \eta_{nj} + \tilde{\epsilon}_{njt}, \quad (4)$$

where η_{nj} is i.i.d. standard normal, and σ is standard deviation of η_{nj} .

Conditional on the CF, the probability that consumer n chooses alternative i is equal to

$$P_{ni} = \int \mathbb{1}(U_{nit} > U_{njt} \forall j \neq i) f(\beta_n, \tilde{\epsilon}_n) \phi(\eta_n) d\beta_n d\tilde{\epsilon}_n d\eta_n, \quad (5)$$

where $\mathbb{1}$ is an indicator function.

Given that the error terms follow extreme value distribution, the mixed logit probability based

on this utility is specified as:

$$P_{ni} = \int \left(\frac{e^{V_{ni}(v_n, \nu_n, \eta_n)}}{\sum_{j=1}^4 e^{V_{nj}(v_n, \nu_n, \eta_n)}} \right) \phi(v_n) \phi(\nu_n) \phi(\eta_n) dv_n d\nu_n d\eta_n. \quad (6)$$

In the framework of perfect enforcement, the subsidy levels as well as the expansion of Lifeline are relevant only to eligible households. To account for that, the amounts of the Lifeline benefits, and control for the *wireless Lifeline initiative* enter utility function intersected with the dummy variable indicating that a household is eligible to enroll in the program. In the framework of ineffective enforcement, I assume that any household is a potential beneficiary of Lifeline. In this case, subsidy levels and Lifeline expansion are relevant for every household and these variables enter utility without any intersection.³⁰

5 Results

First, consider mixed logit model in a perfect enforcement framework, where it is assumed that only eligible households are able to enroll in the subsidy program. In each regression the unit of observation is a household and the dependent variable is telephone choice of the household.

The independent variable of interest is the amount of subsidy benefits (*Lifeline Benefit*), and the total amount of Lifeline payments for wireless prepaid service in a state (*Lifeline Wireless Initiative*). All subsidy-related variables enter the model interacted with an indicator of eligible household (*Eligible Household*).

Other independent variables are the prices of all telephone options (wireline, wireless, or both services); the price of the outside option (no phone) is zero. I include controls for household income and demographic characteristics (*Retired Household, Age of Head of Household, Own Home, Black Household, Hispanic Household, Native American Household, Population Density, Household Size, Male Household, Educated Household, Ratio Working, Children, Student, Limited Youth, Eligible Household*),³¹ a number of cell sites (*Cell Sites*) to control for inter-temporal changes in the quality

³⁰This approach is used in the majority of existing studies of Lifeline (see, Garbacz and Thompson (1997, 2002, 2003)), except for the study by Ackerberg et al. (2014) who conduct analysis on the sample of low-income households.

³¹See Macher et al., (2015).

of wireless service, and year dummies to account for time fixed effects and the potential impact of recession. Following the methodology of control function approach, I include estimated residuals from the equation (2).

Table 5 reports the estimation results for this model. The reference category is the outside option (no phone). The retained price residuals from the first step are not significant indicating that the hypothesis of price exogeneity cannot be rejected. The retained residual of *Lifeline Benefit* is negative and significant, which means that the hypothesis of the endogeneity of amount of subsidy cannot be rejected.

Determinants of Telephone Subscription The estimates confirm findings in the existing literature; the major drivers of telephone demand are found to be price, income, age, home ownership, and quality of mobile service.³² Lower prices increase the propensity of households to adopt a phone. The results, not surprisingly, indicate that the most price-sensitive groups of consumers are households below the poverty level, and with the ratio of income to the poverty level between one and two. The price-sensitivity does not vary significantly among consumers in the two highest income categories.

Wealthier and elderly households have a higher propensity to subscribe to the telephone network. Wealthier households tend to subscribe to both services, and are less likely to be wireless-only. The greater age of the head of the households and home ownership are both associated with an increased propensity of subscription to wireline service only, or to both wireline and wireless services, and a decreased propensity of subscription to wireless service only.

The results also indicate that improved quality of wireless service, measured by the number of cell sites, considerably increases the propensity of households to subscribe to wireless service only, and decreases the propensity of households to subscribe to only a landline.

Effects of Lifeline. Perfect Enforcement Turning to the principal variables of interest, the results reveal that higher levels of Lifeline benefits increase the likelihood of subscription to telephone services among eligible households. The results also indicate that the FCC's *wireless Lifeline initiative* has had a positive and significant impact on the propensity to subscribe to landline only and to wireless only services. As expected the implementation of subsidies for wireless

³²See, for example, Riordan (2002), Macher et al. (2012).

prepaid service increases the propensity to subscribe to wireless service. It is quite surprising that the *wireless Lifeline initiative* increases the household propensity to subscribe to landline service. A possible explanation is that the extension of Lifeline made the subsidy program more popular among eligible households, perhaps due to advertising. More eligible households started enrolling not only in wireless Lifeline, but also in Lifeline for wireline service.

To summarize, the results indicate that the subsidy, in fact, has increased telephone penetration rates among eligible households, and the subsidization of prepaid wireless service has encouraged even more low-income households to subscribe to telephone network.

To test the goodness of fit of the mixed logit model, I estimate the predicted frequencies of alternatives. Table 6 shows that the estimated probabilities closely match the shares of customers choosing each alternative.

Counterfactual Policy Experiment. Perfect Enforcement Using the estimates from the mixed logit model reported in Table 5, I conducted a policy experiment to see how elimination of Lifeline altogether, or its prepaid wireless part, would impact penetration rates and telephone choices of households in general. Table 7 provides the results of this exercise. The estimates show that if the prepaid mobile service were not subsidized, households would switch from being wireless only to “both” and “landline only” categories. Households would switch to the “both” category, because the two services are substitutes; hence, a household can partly substitute the more expensive wireless service for the less expensive landline service, and still enjoy the convenience of wireless service (mobility). In addition, 147,034 households give up the telephone service altogether.

If the program were to be eliminated entirely, then over one million households would cancel telephone services (that is a 23.6 percent in the number of households that currently do not have telephone service); 60 percent of disconnected households are coming from the “wireless only” category, 30 percent from the “landline only” category, and 10 percent from the “both” category. The elimination of the subsidy would have decreased telephone penetration rate from 95.8 percent to 94.9 percent in 2010.

Based on the results of the counterfactual experiment conducted above, I estimate the cost of adding a marginal subscriber (in this context, a household) to telephone network, wireless or wireline, in 2010. I divide Lifeline expenditures in 2010 – approximately \$1.24 billion dollars – by

the number of households that would disconnect telephone service if subsidy was not available. My calculations show that it costs \$1,151 per year to add a new subscriber to the telephone network, while the actual average cost of the subsidy is \$138 per household per year. This result indicates that out of eight households that receive the subsidy only one household subscribes to telephone service because of the subsidy, and the other seven would have telephone service even if the subsidy were not available.

Similarly, I calculate the cost of adding a marginal subscriber to the wireless network. I find that the *wireless Lifeline initiative* has attracted new subscribers at an even higher expense of \$2,835 per additional subscriber per year. That means that only one out of twenty households is a marginal subscriber; and the remaining nineteen are infra-marginal subscribers.

Inefficient Enforcement of Eligibility The FCC reported cases when non-eligible consumers enrolled in the low-income support programs due to self-certification of eligibility.³³ With this evidence, I consider a scenario with ineffective enforcement of subsidy rules, that is when non-eligible households are also able to receive the subsidy.

To estimate a mixed logit model in this setting, I include controls from the previous model, except now the program benefits and control for the *wireless Lifeline initiative* enter the model without interaction with eligibility.

Table 8 reports estimation results for this model. The results closely mimic estimates under the perfect enforcement scenario. The level of the Lifeline subsidy has a positive and statistically significant impact on the propensity of households to adopt a phone. The introduction of subsidies for prepaid wireless service also enhances the subscription to all three telephone options. However, both coefficients are smaller than in the case of perfect enforcement of Lifeline rules.

Table 9 presents the goodness of fit test for this mixed logit model. The predicted frequencies of alternatives closely match the actual shares of consumers choosing each alternative.

Counterfactual Policy Experiment. Inefficient Enforcement Table 10 provides the results of the policy experiments. The elimination of the *wireless Lifeline initiative* results in a massive switch of wireless-only subscribers to landline and both services, where the majority would subscribe to a landline in addition to a cell phone. Furthermore, 76,001 households would

³³See FCC (2012).

cancel a phone service altogether. If the Lifeline program is eliminated entirely, then the majority of switching households would migrate to “wireless-only” category (2.2 million), while 401,911 households would give up the telephone service (8.8 percent of the total number of households that currently do not have telephone service). In this scenario, the elimination of the Lifeline program would have decreased telephone penetration rates only by 0.3 percent - from 95.8 to 95.5 percent in 2010.

The bottom line is, if non-eligible consumers are also able to receive a subsidy for telephone service, the penetration rates would slightly increase, but to a greater extent it would influence the telephone choices of households, not the subscription decision. Under this scenario, the overall cost of adding a marginal subscriber to telephone network (wireline or wireless) in 2010 is \$3,093 per year, while the cost of adding a marginal subscriber to the wireless network is \$5,486 per year.

6 Conclusion

An extensive body of literature has evaluated universal service and the policies implemented to achieve ubiquity of access to the historical wireline network. Over the years, the Lifeline program has undergone significant changes that include changes in benefit levels, eligibility criteria, and services supported by this program. The existing literature does not provide sufficient research on universal service policies as they have evolved. This paper seeks to fill that gap and investigates if the low-income program has acted to promote connectivity of American households and at what cost.

The results reveal that when the rules of the program are strictly enforced and only eligible households are able to enroll in Lifeline, higher amounts of the subsidy increase the propensity of households to subscribe to telephone service. The policy experiment based on the estimates from the mixed logit model showed that if the wireless prepaid part of Lifeline were to be eliminated, 147,034 households would cancel telephone services. If the Lifeline program were to be terminated altogether, then over one million households would give up telephone services, which would have increased the rate of households without telephone service from 3.9 percent to 4.8 percent in 2010. The overall estimated cost of adding a new subscriber to the telephone network in 2010 is \$1,151

per year; while the cost of adding a new subscriber under the prepaid wireless part of Lifeline is much higher: \$2,835 per year.

Under the assumption that any household is able to enroll in the subsidy program, the results indicate that the higher Lifeline benefits encourage subscription to the telephone network. Introduction of subsidies to prepaid wireless service also has a positive impact on the likelihood of subscription to all three telephone options. However, in this setting, the subsidy to a greater extent influences the choice of telephone options, not the subscription decision. In this setting the estimated cost of adding a marginal subscriber to the telephone network in 2010 is \$3,093 per year, while the cost of adding a marginal subscriber under the *wireless Lifeline initiative* is \$5,486 per year.

The lesson here is that prior to the extension of the subsidy to additional services, the policy-makers should thoroughly consider the changes in the program that need to take place in order to make the program efficient in fulfilling its purpose (help marginal consumers to subscribe to telephone network). Also, given how many infra-marginal subscribers currently receive the subsidy, more research is needed to identify the eligibility filters that would efficiently target consumers that need subsidy assistance.

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APPENDIX A

COMPARISON OF NHIS AND THE US CENSUS BUREAU DEMOGRAPHICS

	<i>General Demographic Characteristics: July 2007</i>	<i>NHIS Sample 2007</i>	<i>General Demographic Characteristics: July 2008</i>	<i>NHIS Sample 2008</i>	<i>General Demographic Characteristics: July 2009</i>	<i>NHIS Sample 2009</i>	<i>General Demographic Characteristics: July 2010</i>
SEX AND AGE							
Male	49.29%	48.35%	49.31%	48.35%	49.33%	48.19%	49.20%
Female	50.71%	51.65%	50.69%	51.65%	50.67%	51.81%	50.80%
Under 5 years	6.87%	7.71%	6.91%	7.50%	6.94%	7.37%	6.50%
5 to 9 years	6.58%	7.79%	6.60%	7.70%	6.71%	7.90%	6.60%
10 to 14 years	6.74%	7.81%	6.60%	7.50%	6.51%	7.65%	6.70%
15 to 19 years	7.12%	7.54%	7.08%	7.38%	7.02%	7.50%	7.10%
20 to 24 years	6.97%	6.49%	6.93%	6.50%	7.02%	6.19%	7.00%
25 to 34 years	13.46%	13.31%	13.46%	13.47%	13.54%	13.15%	13.20%
35 to 44 years	14.31%	14.44%	13.98%	14.01%	13.53%	13.89%	13.30%
45 to 54 years	14.55%	14.14%	14.59%	14.22%	14.52%	14.28%	14.50%
55 to 59 years	6.05%	5.54%	6.11%	5.95%	6.18%	5.91%	6.40%
60 to 64 years	4.80%	4.34%	4.97%	4.63%	5.15%	5.05%	5.50%
65 to 74 years	6.42%	6.04%	6.62%	6.10%	6.77%	6.26%	7.10%
75 to 84 years	4.32%	3.72%	4.28%	3.84%	4.28%	3.67%	4.20%
85 years and over	1.83%	1.13%	1.88%	1.21%	1.83%	1.18%	1.80%
Median age	36.6	34	36.8	34	36.8	35	37.2
18 years and over	75.50%	71.85%	75.68%	72.68%	75.72%	72.36%	76.00%
21 years and over	71.31%	67.86%	71.43%	68.61%	71.41%	68.34%	71.50%
62 years and over	15.24%	13.25%	15.41%	13.57%	15.79%	14.00%	16.30%
65 years and over	12.56%	10.89%	12.78%	11.15%	12.89%	11.11%	13.10%
18 years and over	75.50%	71.85%	75.68%	72.68%	75.72%	72.36%	76.00%
Male	36.75%	33.89%	36.86%	34.33%	36.91%	34.04%	38.91%
Female	38.75%	37.96%	38.82%	38.35%	38.81%	38.32%	37.09%
65 years and over	12.56%	10.89%	12.78%	11.15%	12.89%	11.11%	13.10%
Male	5.30%	4.73%	5.41%	4.77%	5.48%	4.90%	5.65%
Female	7.26%	6.16%	7.37%	6.38%	7.41%	6.20%	7.45%
RACE							
White	79.96%	67.29%	79.80%	66.62%	79.57%	66.15%	74.20%
Black or African	12.85%	15.51%	12.85%	15.59%	12.91%	15.75%	12.60%
American Indian	0.97%	1.16%	1.01%	1.10%	1.03%	0.81%	0.80%
Asian	4.43%	5.88%	4.46%	6.30%	4.56%	6.41%	4.80%
HISPANIC OR							
Hispanic or Latino	15.09%	24.64%	15.44%	23.85%	15.77%	25.34%	16.40%
Not Hispanic or	84.91%	75.36%	84.56%	76.15%	84.23%	74.66%	83.60%

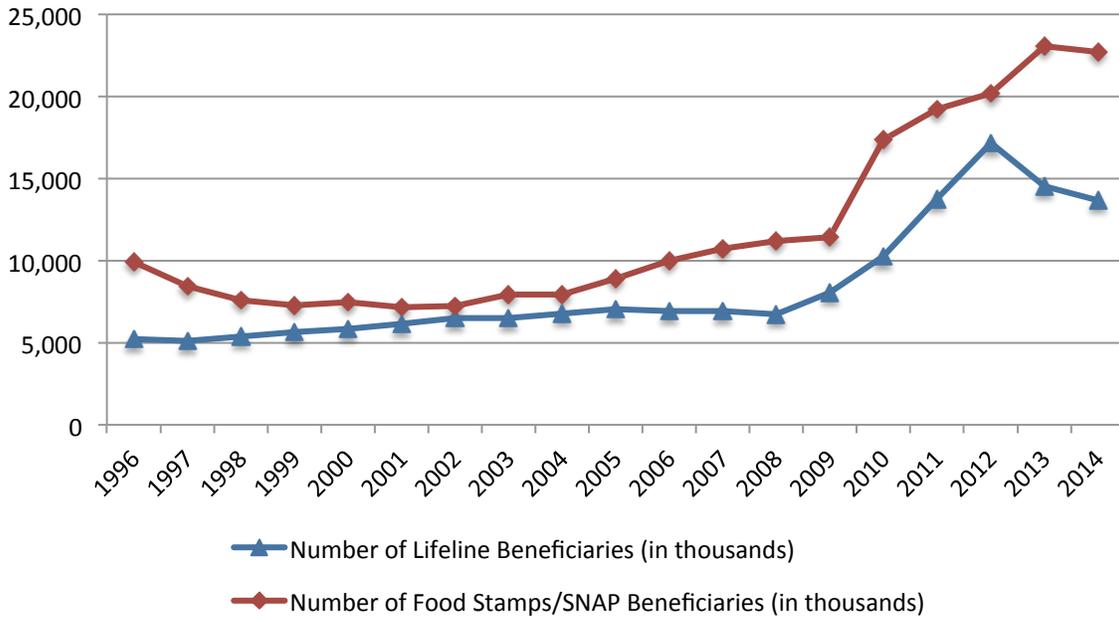
APPENDIX B

VARIABLES DESCRIPTION AND SOURCE

<i>Dependent variables</i>	<i>Description and source</i>
<i>Phone</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household subscribed to any telephone service, wireline or wireless, at the time of the survey, and is zero otherwise.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Demographic variables</i>	<i>Description and source</i>
<i>Age of Reference person</i>	Age of reference person in the surveyed household.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Retired Household</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household includes retired person.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Ratio Working</i>	Ratio of people in the surveyed household who work.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Children</i>	Number of household members under age 18.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Student</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household includes students.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Limited Youth</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household includes member under 31 years old who has health limitations.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Limited Adult</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household includes member older than 30 years old who has health limitations.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Own Home</i>	This variable is dichotomous, taking on a value of 1 if someone in the surveyed household owns the home.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Educated Household</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household includes at least one member with college degree or higher.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Male Household</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household includes only males, and is zero otherwise.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Black Household</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household consists of Black/African American people only, and is zero otherwise.
<i>Hispanic Household</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household consists of Hispanic people only, and is zero otherwise.
<i>Native American Household</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household consists of Indian people only, and is zero otherwise.
<i>Household size</i>	Number of members in the surveyed household.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Population Density</i>	Population density, county level.
	Source: U.S. Census Bureau, annual 2003-2010.
<i>Eligible Household</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household is eligible to receive Lifeline benefits.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Price and income variables</i>	<i>Description and source</i>
<i>Wireline Price</i>	Source: data was supplied by Greg Rosston, Scott Savage and Bradley Wimmer, who collected it for the purposes of the research in Rosston, Savage and Wimmer (2008), adjusted for years 2003-2010.
<i>Wireless Price</i>	Source: CTIA's Wireless Industry Report Indices, 2008.
<i>CPI for Wireless Telephone Services</i>	Source: FCC "Reference Book of Rates, Price Indices, and Household Expenditures for Telephone Service", annual 2002-2010.

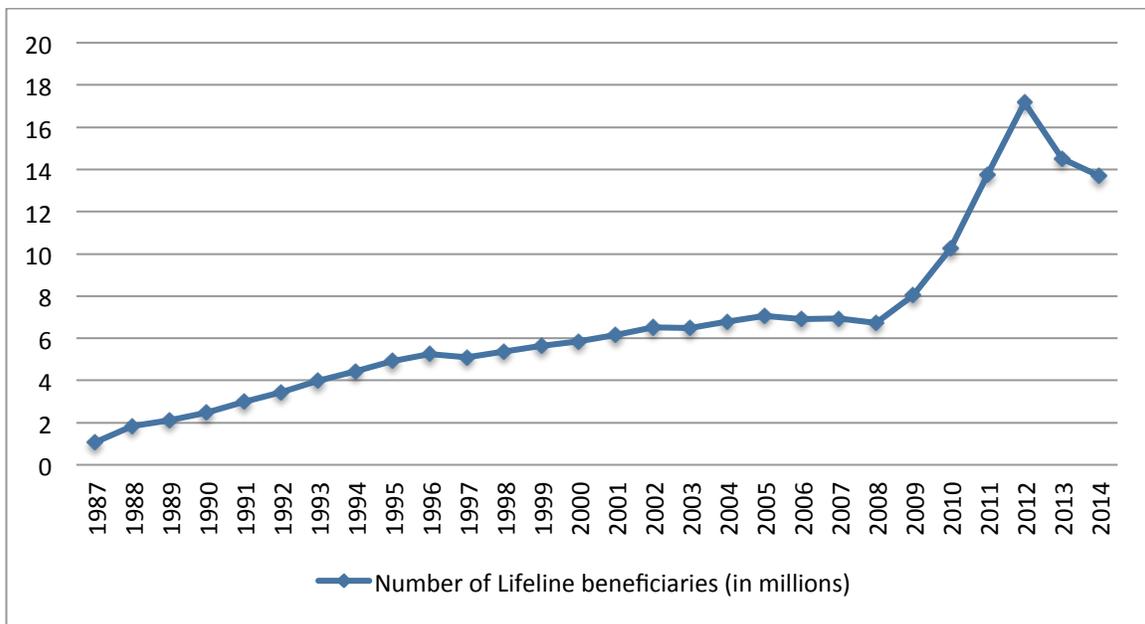
<i>CPI for Wireline Telephone Services</i>	Source: FCC "Reference Book of Rates, Price Indices, and Household Expenditures for Telephone Service", annual 2002-2010.
<i>State and Local Taxes on Wireless Telephony</i>	Source: The Council on State Taxation (COST), years 2001, 2004, 2007, 2010.
<i>Income1</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household has family income below poverty threshold.
<i>Income2</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household has ratio of family income to poverty threshold between 1 and 2.
<i>Income3</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household has ratio of family income to poverty threshold between 2 and 4.
<i>Income4</i>	This variable is dichotomous, taking on a value of 1 if the surveyed household has ratio of family income to poverty threshold above 4.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Quality/Geographic variables</i>	<i>Description and source</i>
<i>Cell Sites</i>	Number of registered cell sites.
	Source: CTIA's Wireless Industry Report Indices, 2008.
<i>Low-income program benefits</i>	<i>Description and source</i>
<i>Lifeline Benefit</i>	Monthly federal and state Lifeline support.
	Source: FCC "Universal Service Monitoring Report", annual, 2003-2011.
<i>Wireless Lifeline Initiative</i>	Total amount of prepaid wireless Lifeline payments in a state.
	Source: FCC "Universal Service Monitoring Report", annual, 2003-2011.
<i>Exclusion restrictions</i>	<i>Description and source</i>
<i>Mobile Penetration</i>	Proportion of households subscribed to wireless services in an economic area, or county.
	Source: National Health Interview Survey, annual, 2003-2010.
<i>Hausman-Type Instrument</i>	Hausman-type instrument for wireline price.
	Source: data was supplied by Greg Rosston, Scott Savage and Bradley Wimmer, who collected it for the purposes of the research in Rosston, Savage and Wimmer (2008), adjusted for years 2003-2010.
<i>Families Below 135</i>	Percent of Families at or below 135 percent of the poverty level.
	Source: Current Population Survey, 2003-2010.
<i>Democrat Governor</i>	This variable is dichotomous, taking value of 1 if the surveyed household is located in a state where governor is affiliated with Democratic party.
	Source: National Governors Association, 2003-2010.

FIGURE 1
NUMBER LIFELINE VS FOODS STAMPS/SNAP BENEFICIARIES



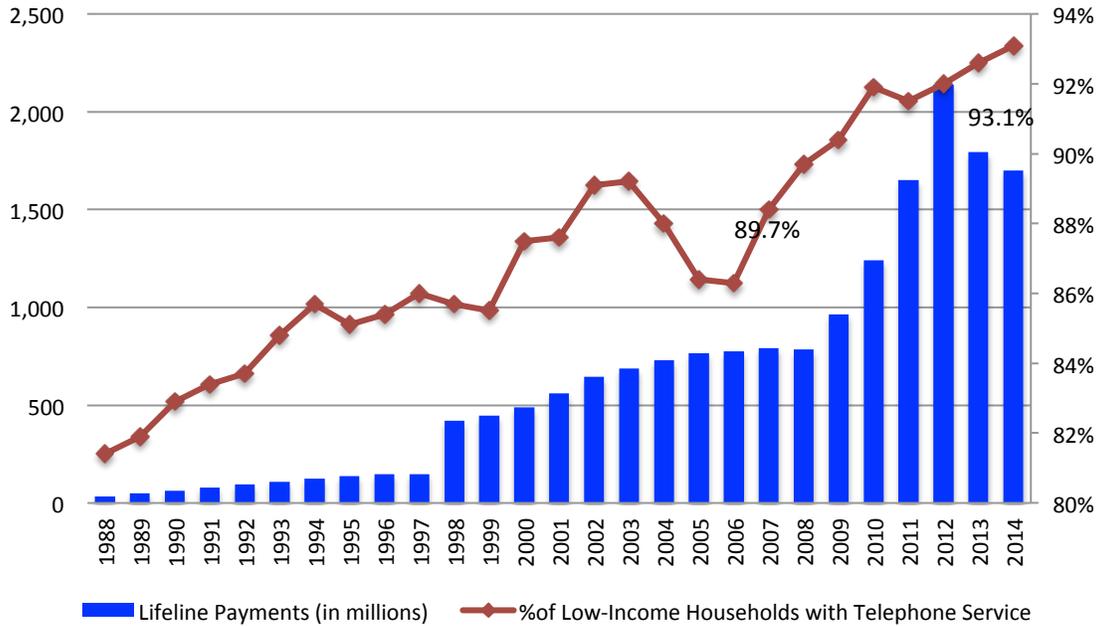
Source: FCC 2014 Universal Service Monitoring Report, Table 2.1 and Table 2.7; USDA Trends in Supplemental Nutrition Assistance Program Participation Rates: Fiscal Year 2010 to Fiscal Year 2012 (July 2014); USDA SNAP Monthly Report (July 5 2015).

FIGURE 2
NUMBER OF BENEFICIARIES IN THE FCC LIFELINE PROGRAM, 1987-2014



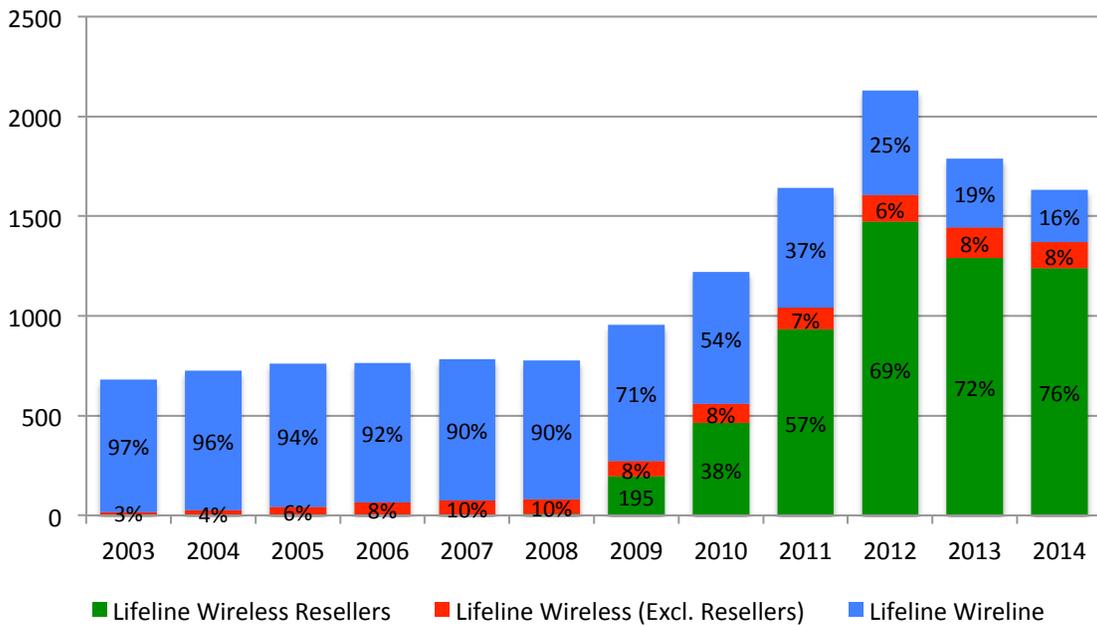
Source: FCC 2014 Universal Service Monitoring Report, Table 2.1 and Table 2.7.

FIGURE 3
LIFELINE PAYMENTS AND PERCENT OF LOW-INCOME HOUSEHOLDS
WITH TELEPHONE SERVICE, 1988-2014



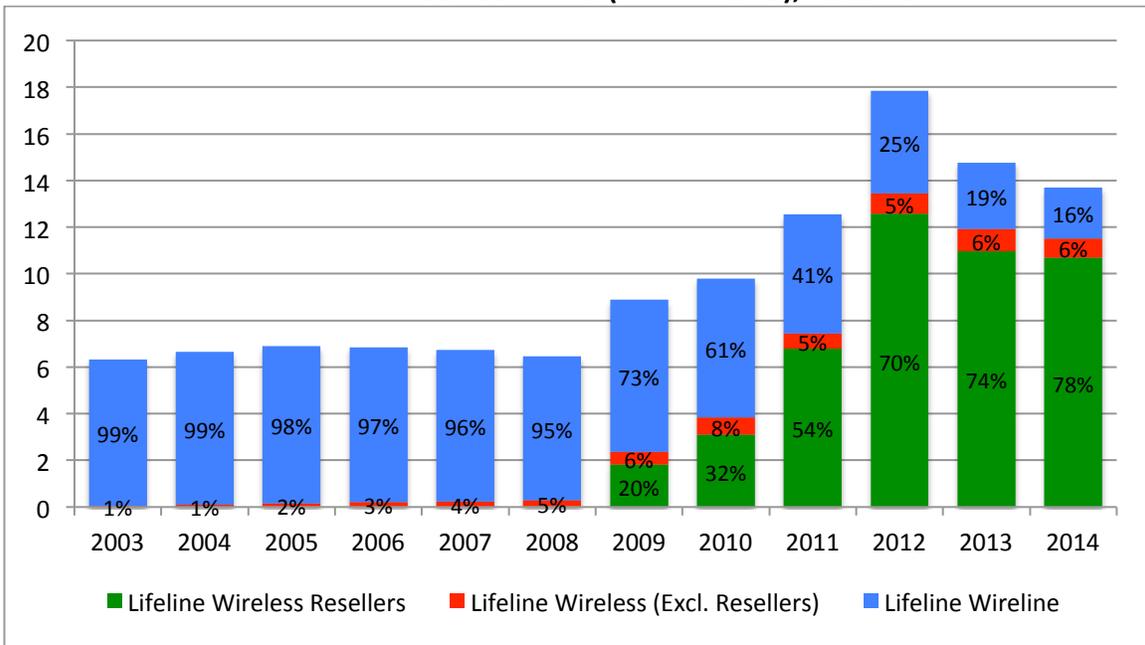
Source: FCC 2014 Universal Service Monitoring Report, Table 2.2, Table 2.7, and Table 3.2; FCC 2010 Universal Service Monitoring Report, Table 6.14.

FIGURE 4
LIFELINE PAYMENTS (IN MILLIONS), 2003-2014



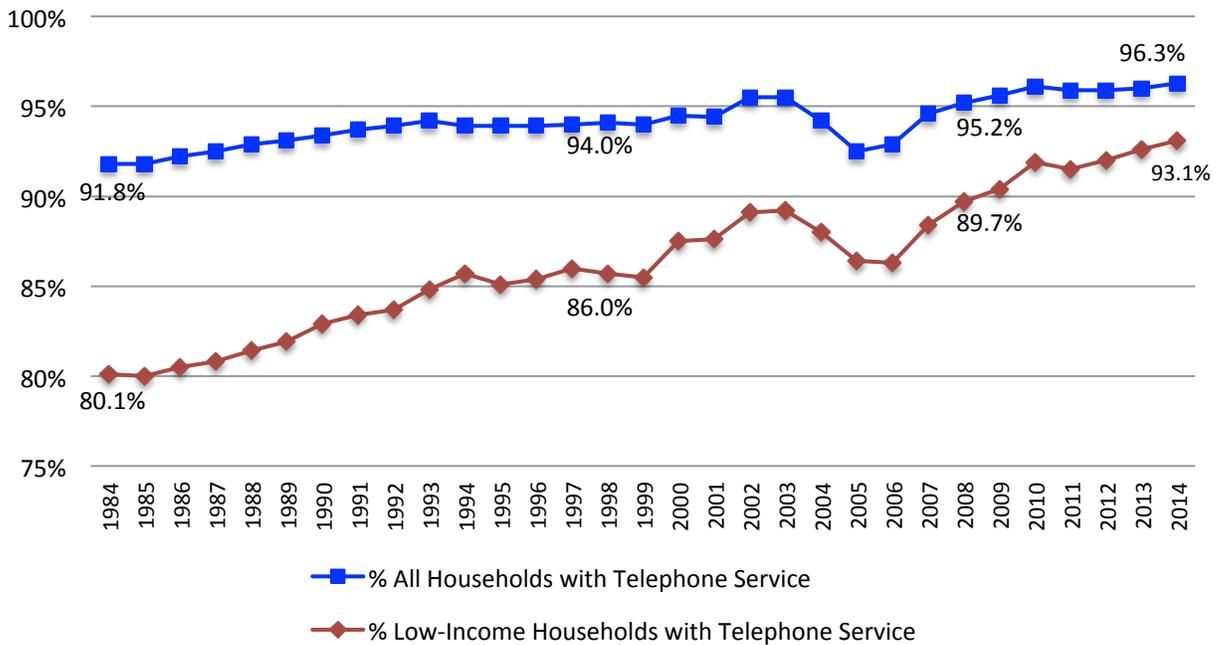
Source: FCC 2013 Universal Service Monitoring Report, "Supplementary Report Material, LI Support - by Study Area.

FIGURE 5
LIFELINE SUBSCRIBERS (IN MILLIONS), 2003-2014



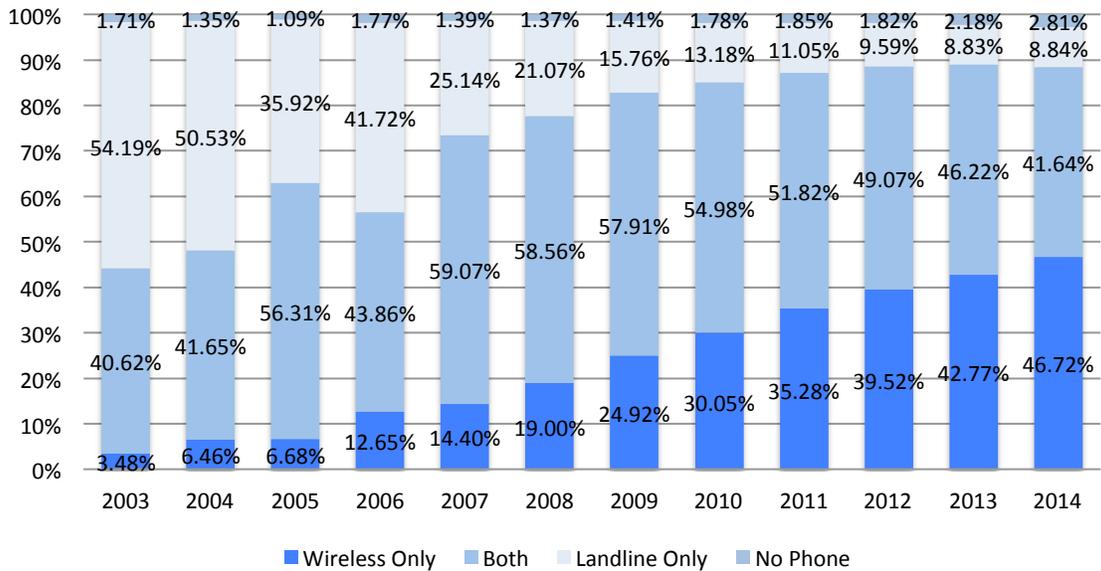
Source: FCC 2013 Universal Service Monitoring Report, "Supplementary Report Material, LI Support - by Study Area."

FIGURE 6
HOUSEHOLDS WITH TELEPHONE SERVICE, 1984-2014



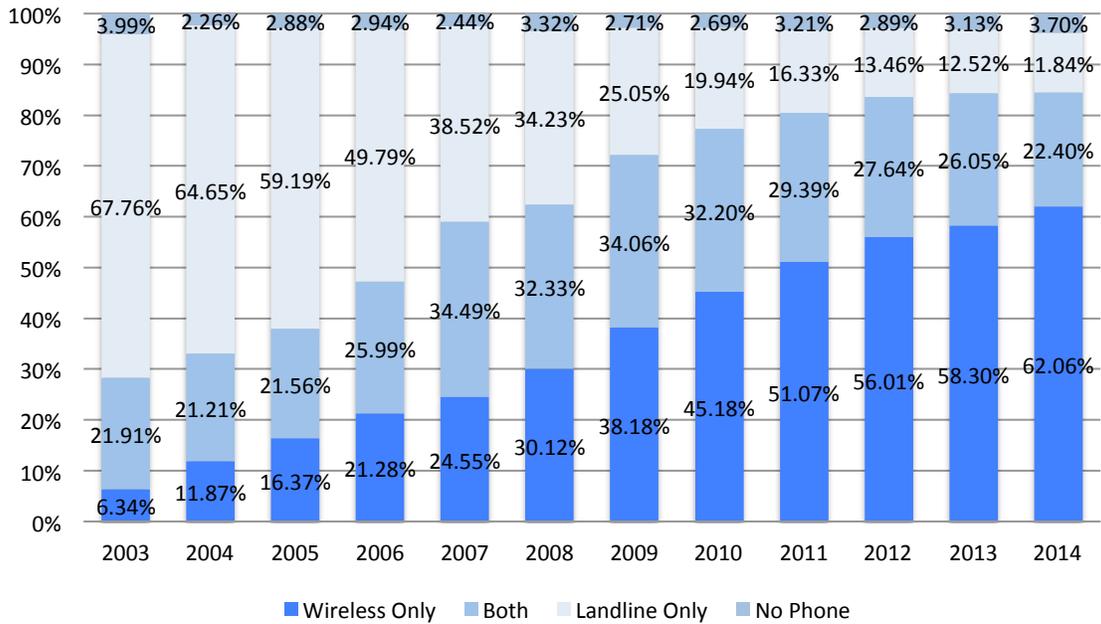
Source: FCC 2014 Universal Service Monitoring Report, Table 3.2; FCC 2010 Universal Service Monitoring Report, Table 6.14.

FIGURE 7
HOUSEHOLDS TELEPHONE SUBSCRIPTION CHOICES,
2003-2014



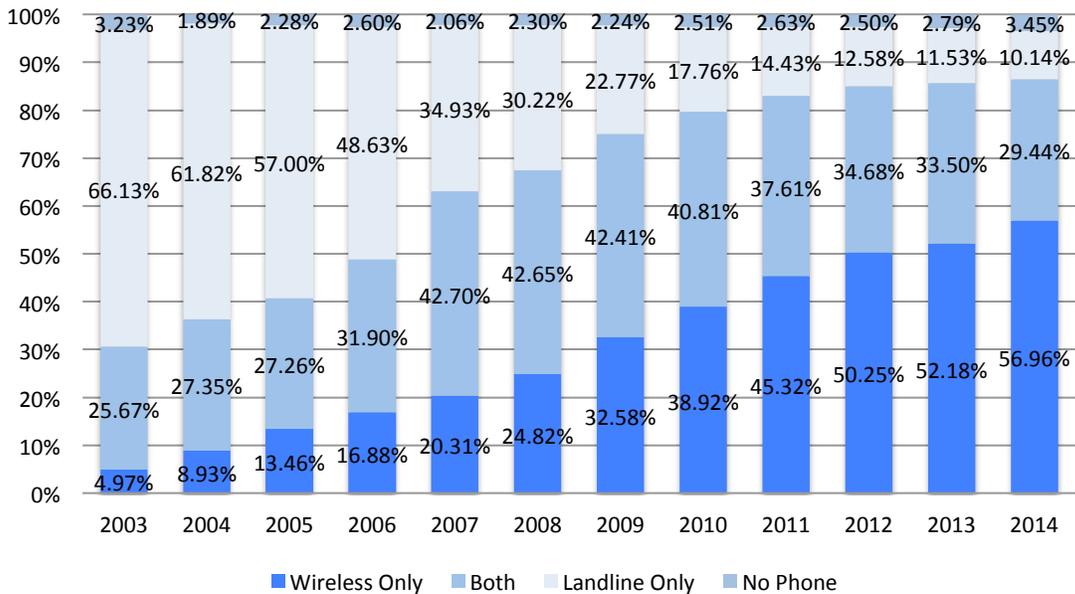
Source: National Health Interview Survey, 2003-2014.

FIGURE 8
LOW-INCOME HOUSEHOLDS TELEPHONE SUBSCRIPTION CHOICES,
2003-2014



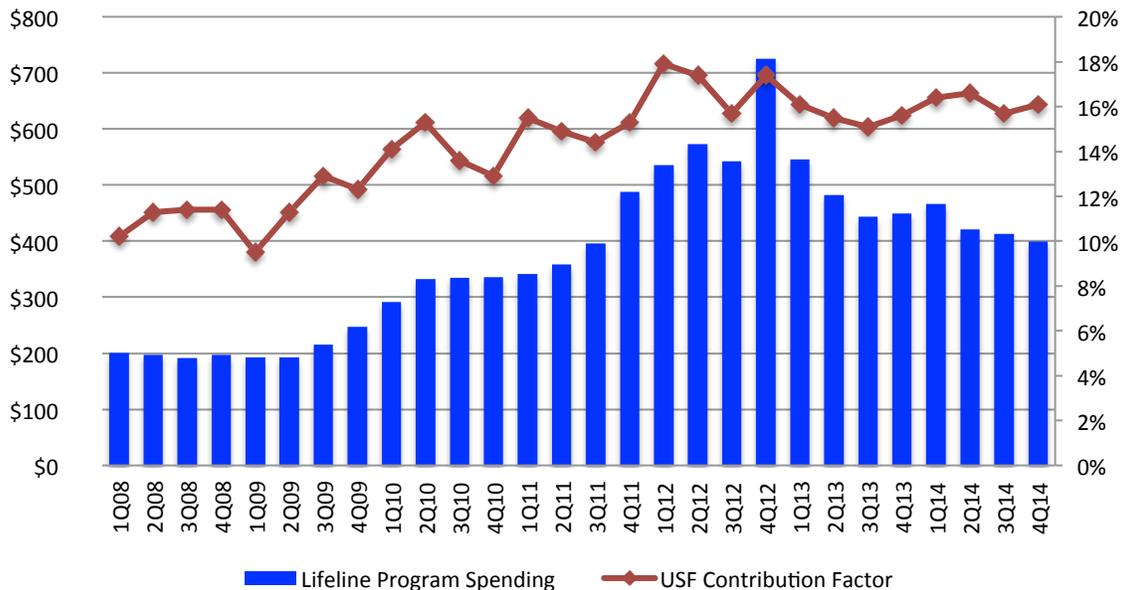
Source: National Health Interview Survey, 2003-2014.

FIGURE 9
ELIGIBLE HOUSEHOLDS TELEPHONE SUBSCRIPTION CHOICES,
2003-2014



Source: National Health Interview Survey, 2003-2014.

FIGURE 10
LIFELINE PROGRAM SPENDING AND USE CONTRIBUTION FACTOR,
1Q 2009-4Q 2014



Source: FCC 2014 Universal Service Monitoring Report, Table 1.6 and Table 1.11; FCC 2013 Universal Service Monitoring Report, Table 1.9 and Table 1.11; FCC 2012 Universal Service Monitoring Report, Table 1.9; FCC 2010-2011 Universal Service Monitoring Reports, Table 1.10. This figure is also available in the IIA White Paper (November 6, 2014).

**TABLE 1
STATE LIFELINE SUPPORT PER LINE, 2010**

<i>State</i>	<i>Total Lifeline Support</i>	<i>State</i>	<i>Total Lifeline Support</i>
Alabama	\$13.56	Nebraska	12.06
Alaska	13.45	Nevada	10.98
Arizona	11.76	New Hampshire	11.83
Arkansas	12.03	New Jersey	13.23
California	11.75	New Mexico	13.20
Colorado	13.46	New York	13.23
Connecticut	11.31	North Carolina	13.26
Delaware	12.97	North Dakota	11.23
District of Columbia	10.80	Ohio	12.58
Florida	13.44	Oklahoma	8.43
Georgia	13.45	Oregon	13.46
Hawaii	8.25	Pennsylvania	11.22
Idaho	13.30	Puerto Rico	13.50
Illinois	8.74	Rhode Island	13.37
Indiana	7.94	South Carolina	13.63
Iowa	7.09	South Dakota	8.42
Kansas	11.55	Tennessee	13.30
Kentucky	13.53	Texas	12.62
Louisiana	11.54	Utah	13.32
Maine	13.25	Vermont	13.23
Maryland	12.64	Virgin Islands	13.50
Massachusetts	13.35	Virginia	12.99
Michigan	11.56	Washington	11.24
Minnesota	9.76	West Virginia	13.16
Mississippi	13.39	Wisconsin	10.99
Missouri	11.93	Wyoming	13.50
Montana	12.35	Average	\$12.07

Source: FCC 2011 Universal Service Monitoring Report, Table 2.3.

**TABLE 2
PERCENT OF HOUSEHOLDS WITHOUT TELEPHONE SERVICE,
2003-2010**

<i>Year</i>	<i>Full NHIS sample</i>	<i>Sample used for estimation</i>
2003	3.59%	1.71%
2004	3.48%	1.35%
2005	3.52%	1.09%
2006	3.82%	1.77%
2007	2.90%	1.39%
2008	2.87%	1.37%
2009	2.52%	1.41%
2010	2.64%	1.78%

**TABLE 3
COMPARISON OF PENETRATION RATES BY LEVEL OF LIFELINE ASSISTANCE**

<i>Lifeline Category</i>	<i>Low-Income Households</i>		<i>All Households</i>	
	Penetration Mar-97	Penetration Mar-09	Penetration Mar-97	Penetration Mar-09
<i>Full or High Assistance</i>	85.60%	90.20%	93.70%	95.30%
<i>Intermediate</i>	87.20%	91.80%	95.00%	96.60%
<i>Basic or Low</i>	86.20%	89.10%	93.90%	95.20%

Source: FCC 2010 Universal Service Monitoring Report, Table 6.7.

**TABLE 4
DESCRIPTIVE STATISTICS, 2003-2010**

<i>Demographic Variables and Attributes</i>	<i>Percent</i>
<i>Income Groups</i>	
<i>Income1</i>	14.93%
<i>Income2</i>	19.27%
<i>Income3</i>	29.62%
<i>Income4</i>	39.19%
<i>Own Home</i>	62.50%
<i>Household Size</i>	
<i>1 person</i>	25.56%
<i>2 people</i>	31.47%
<i>3 people</i>	16.61%
<i>4 people</i>	14.88%
<i>5 or more people</i>	11.48%
<i>Mean Number of Children</i>	0.74
<i>Chosen Phone Option</i>	
<i>No Phone</i>	1.17%
<i>Landline Only</i>	28.82%
<i>Wireless Only</i>	16.46%
<i>Both</i>	53.54%
<i>Eligible Households</i>	24.24%
<i>Black</i>	14.67%
<i>Hispanic</i>	16.46%
<i>Native American</i>	0.67%
<i>Wireline Price</i>	\$16.81
<i>Wireless Price</i>	\$58.55
<i>Lifeline benefit</i>	\$11.48

TABLE 5
PARAMETER ESTIMATES FOR MIXED LOGIT MODEL
(PERFECT ENFORCEMENT)

VARIABLES	Both	Landline	Wireless
<i>Price</i>	-0.007***	-0.007***	-0.007***
	(0.002)	(0.002)	(0.002)
<i>Price*Income2</i>	-0.011***	-0.011***	-0.011***
	(0.003)	(0.003)	(0.003)
<i>Price*Income3</i>	-0.004	-0.004	-0.004
	(0.002)	(0.002)	(0.002)
<i>Price*Income4</i>	-0.003	-0.003	-0.003
	(0.003)	(0.003)	(0.003)
<i>Price St. Error</i>	0.003	0.003	0.003
	(0.004)	(0.004)	(0.004)
Income			
<i>Income2</i>	1.319***	0.428***	-0.135
	(0.246)	(0.088)	(0.193)
<i>Income3</i>	1.336***	0.388***	-0.836***
	(0.242)	(0.105)	(0.195)
<i>Income4</i>	1.745***	0.266**	-0.904***
	(0.254)	(0.120)	(0.207)
Demographic characteristics			
<i>Retired Household</i>	0.450***	0.649***	-0.243**
	(0.101)	(0.101)	(0.107)
<i>Age of Reference Person</i>	0.010***	0.022***	-0.018***
	(0.001)	(0.001)	(0.001)
<i>Own House</i>	1.026***	0.698***	-0.175***
	(0.057)	(0.057)	(0.058)
<i>Black Household</i>	-0.126*	-0.069	-0.348***
	(0.065)	(0.065)	(0.067)
<i>Hispanic Household</i>	-0.570***	-0.212***	-0.427***
	(0.060)	(0.060)	(0.062)
<i>Native American Household</i>	-0.727***	-0.645***	-0.584***
	(0.172)	(0.173)	(0.178)
<i>Household Size</i>	0.246***	0.054	-0.036
	(0.035)	(0.035)	(0.036)
<i>Male Household</i>	-0.799**	-0.504***	-0.022
	(0.060)	(0.060)	(0.061)
<i>Educated Household</i>	0.436***	0.134*	0.167**
	(0.069)	(0.069)	(0.070)
<i>Ratio Working</i>	0.174**	-0.219***	0.683***
	(0.079)	(0.079)	(0.082)
<i>Limited Youth</i>	0.330***	0.112	0.280***
	(0.092)	(0.093)	(0.095)
<i>Student</i>	0.480***	0.178	0.582***
	(0.108)	(0.109)	(0.110)
<i>Children</i>	0.072	0.150***	0.051
	(0.046)	(0.047)	(0.047)
<i>Eligible</i>	-1.330**	-1.052*	-3.776***
	(0.594)	(0.593)	(0.595)
<i>Population Density</i>	0.065***	0.032**	-0.036**
	(0.015)	(0.014)	(0.014)
Low Income Program			
<i>Lifeline Benefit x Eligible</i>	0.086*	0.086*	0.086*
	(0.050)	(0.050)	(0.050)
<i>Prepaid Wireless Lifeline Payments x Eligible</i>	0.004	0.005*	0.033***
	(0.003)	(0.003)	(0.003)

Quality Control			
<i>Cellsite</i>	0.321	-1.029***	4.297***
	(0.344)	(0.340)	(0.370)
Control Functions			
<i>Lifeline Benefit Residual</i>	-0.118**	-0.118**	-0.118**
	(0.054)	(0.054)	(0.054)
<i>Price Residual</i>	0.0002	0.0002	0.0002
	(0.004)	(0.004)	(0.004)
Constant	-2.436	14.444***	-47.536***
	(4.154)	(4.087)	(4.470)
Year Dummies	yes		
State Dummies	no		
Observations	167,397		
Log-Likelihood	-134,190		
McFadden R²	0.231		

Note: The reference category is "No Phone." The exclusion restrictions used in the first stage are: Hausman-Type Instrument, Mobile Penetration, and Democrat Governor. Variables that have the same coefficient across all alternatives are alternative-specific (e.g., Price).

Standard errors in parentheses; significant at: * = 0.10, ** = 0.05, *** = 0.01

**TABLE 6
ACTUAL AND PREDICTED FREQUENCES OF ALTERNATIVES (PERCENT)**

	<i>No Phone</i>	<i>Both</i>	<i>Landline Only</i>	<i>Wireless Only</i>
<i>Actual Shares</i>	1.174%	53.544%	28.821%	16.460%
<i>Predicted Shares</i>	1.175%	53.544%	28.822%	16.460%

**TABLE 7
EFFECTS OF PRICE/POLICY CHANGES (NUMBER OF HOUSEHOLDS)**

<i>Policy Change</i>	<i>No Phone</i>	<i>Both</i>	<i>Landline Only</i>	<i>Wireless Only</i>
<i>Turn Off Wireless Lifeline Initiative</i>	147,034	988,944	616,658	-1,752,635
<i>Turn Off Lifeline and Wireless Lifeline Initiative</i>	1,080,055	-117,325	-334,431	-628,297

TABLE 8
PARAMETER ESTIMATES FOR MIXED LOGIT MODEL
(INEFFECTIVE ENFORCEMENT)

VARIABLES	Both	Landline	Wireless
<i>Price</i>	-0.015*** (0.003)	-0.015*** (0.003)	-0.015*** (0.003)
<i>Price*Income2</i>	-0.007** (0.003)	-0.007** (0.003)	-0.007** (0.003)
<i>Price*Income3</i>	0.001 (0.003)	0.001 (0.003)	0.001 (0.003)
<i>Price*Income4</i>	0.003 (0.003)	0.003 (0.003)	0.003 (0.003)
<i>Price St. Error</i>	-0.001 (0.005)	-0.001 (0.005)	-0.001 (0.005)
Income			
<i>Income2</i>	1.058*** (0.260)	0.362*** (0.090)	-0.850*** (0.204)
<i>Income3</i>	0.914*** (0.255)	0.283*** (0.106)	-1.731*** (0.204)
<i>Income4</i>	1.249*** (0.266)	0.145 (0.121)	-1.867*** (0.216)
Demographic characteristics			
<i>Retired Household</i>	0.428*** (0.101)	0.631*** (0.100)	-0.322*** (0.108)
<i>Age of Reference Person</i>	0.010*** (0.001)	0.022*** (0.001)	-0.018*** (0.001)
<i>Own House</i>	1.027*** (0.056)	0.699*** (0.057)	-0.194*** (0.058)
<i>Black Household</i>	-0.113* (0.064)	-0.055 (0.065)	-0.311*** (0.067)
<i>Hispanic Household</i>	-0.573*** (0.060)	-0.218*** (0.060)	-0.454*** (0.062)
<i>Native American Household</i>	-0.733*** (0.171)	-0.650*** (0.173)	-0.624*** (0.182)
<i>Household Size</i>	0.248*** (0.035)	0.057 (0.036)	-0.033 (0.036)
<i>Male Household</i>	-0.800** (0.060)	-0.505*** (0.060)	-0.027 (0.061)
<i>Educated Household</i>	0.432*** (0.069)	0.132* (0.070)	0.144** (0.070)
<i>Ratio Working</i>	0.153** (0.078)	-0.235*** (0.079)	0.587*** (0.082)
<i>Limited Youth</i>	0.332*** (0.092)	0.113 (0.093)	0.313*** (0.096)
<i>Student</i>	0.457*** (0.107)	0.164 (0.109)	0.518*** (0.111)
<i>Children</i>	-0.07 (0.047)	0.147*** (0.047)	0.027 (0.048)
<i>Eligible</i>	-0.318*** (0.076)	-0.048 (0.076)	-3.766*** (0.081)
<i>Population Density</i>	0.081*** (0.015)	0.046*** (0.015)	-0.007 (0.015)
Low Income Program			
<i>Lifeline Benefit</i>	0.024*** (0.002)	0.024*** (0.002)	0.024*** (0.002)
<i>Prepaid Wireless Lifeline</i>	0.010*** (0.002)	0.008*** (0.002)	0.010*** (0.002)

Quality Control			
<i>Cellsite</i>	0.229	-1.079***	4.220***
	(0.337)	(0.335)	(0.367)
Control Fintions			
<i>Lifeline Benefit Residual</i>	-0.062***	-0.062***	-0.062***
	(0.005)	(0.005)	(0.005)
<i>Price Residual</i>	0.007***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)
Constant	-1.182	14.777***	-45.764***
	(4.070)	(4.030)	(4.433)
Year Dummies	<i>yes</i>		
State Dummies	<i>no</i>		
Observations	167,397		
Log-Likelihood	-131,420		
Mcfadden R²	0.247		

Note: The reference category is “no phone.” The exclusion restrictions used in the first stage are: Hausman-Type Instrument, Mobile Penetration, and Families Below 135. . Variables that have the same coefficient across all alternatives are alternative-specific (e.g., Price).

Standard errors in parentheses; significant at: * = 0.10, ** = 0.05, *** = 0.01

**TABLE 9
ACTUAL AND PREDICTED FREQUENCES OF ALTERNATIVES (PERCENT)**

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**TABLE 10
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<i>Policy Change</i>	<i>No Phone</i>	<i>Both</i>	<i>Landline Only</i>	<i>Wireless Only</i>
<i>Turn Off Wireless Lifeline Initiative</i>	76,001	409,361	146,434	-631,796
<i>Turn Off Lifeline and Wireless Lifeline Initiative</i>	401,911	-1,820,017	-778,514	2,196,622