Low-Income Demand for Local Telephone Service: The Effects of Lifeline and Linkup

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Abstract:

We use a comprehensive data set on local telephone service prices and telephone penetration rates for low-income households to evaluate the effect of Lifeline and Linkup programs. Consistent with previous studies, we find that the elasticity of demand for telephone service is relatively low. However, by using nonlinear two-stage least squares, we find that elasticities are somewhat higher than previously estimated. In addition, we find that low-income households have very high discount rates for initial hookup charges. We run a policy experiment and find that penetration without the low-income programs would be about 5% lower among low-income households. Because of the high discount factor among low-income households, the Linkup program is a more cost effective means to subsidize low-income households.

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Introduction

"Universal service" has at least nominally been a concern of telecommunications regulators for quite a while. Usually this concern is directed at two different (but somewhat overlapping) groups: rural and low-income households. Our focus in this paper is on low-income households and the economic characteristics that affect their decisions to subscribe to telephone service. In this way, it may be possible to shed some light on the question of the effectiveness of policies that have been adopted to increase the telephone penetration of low-income households.

Overall telephone penetration in the U.S. is quite high – over 95% according to the most recent FCC "Penetration Report." (Belinfante (2003)) This same report shows that penetration rates are significantly lower for low-income households. Only 89% of households with income less than $10,000 in 1984 dollars ($17,427 in 2002) had a working telephone in their households according to the FCC Report. The FCC Report also shows that low-income penetration rates differ substantially across states, ranging from 96.5% in Maine (compared to 98.2% of all households) to under 80% in Mississippi (compared to 90.9% of all households).

The FCC has two programs designed to increase the penetration rates of low-income households. The Lifeline program, started in 1985, provides a subsidy that reduces low-income subscribers monthly access charge. The Linkup program reduces the initial hookup fee low-income households pay to establish telephone service. Both federal programs work in concert with state-level low-income programs. The FCC, in its implementation of the universal service portions of the Telecommunications Act of 1996 ("Act"), dramatically increased the size of its Lifeline subsidy. Prior to the Act, the

federal Lifeline program waived the federal subscriber line charge (SLC), which was equal to $3.50 in most jurisdictions, as long as states matched this by lowering intrastate rates. The current Lifeline program provides all low-income customers in all states a baseline support equal to the federal SLC plus $1.75, which was equal to $5.25 in all jurisdictions in 2000 with the exception of the District of Columbia where the federal SLC was less than $3.50.[1] Lifeline customers receive additional federal support equal to one half of any support provided by an intrastate program, up to $7.00 in federal support. In states that take full advantage of the matching federal program Lifeline customers receive a subsidy of $10.50.[2] The federal Linkup program reduces low-income subscribers initial connection charge by 50 percent of the customary charge, or $30, whichever is less.[3] The level of federal Linkup support was unaffected by the FCC's implementation of the 1996 Act.

Several studies have examined the effect Lifeline and Linkup programs have on penetration rates.[4] The majority of studies have used state-level data that include variables on the size of Lifeline and Linkup programs as explanatory variables in regressions that estimate the overall penetration rate in a state. For example, Garbacz and Thompson (2002, 2003) use state-level data from the 1970, 1980, 1990 and 2000 decennial censuses to estimate penetration rates. Erikson, Kaserman and Mayo (1998)

[1] The size of the baseline support has risen in recent years because the cap of the federal SLC for residential customers has increased.

[2] Again, the size of federal support has increased since 2000 with increases in residential SLCs.

[3] These programs are funded by taxes on telecommunications services. To the extent that low-income households are heavy users of the services taxed (e.g. long distance), the overall reduction in price is less. Although we recognize that marginal subscribers are not likely to be heavy users of the taxed services, telecommunications users presumably experience a price decrease). See Hausman, Tardiff and Belinfante (1993).

[4] *See* Riordan (2002) for a more complete background on the economics of universal service.

use state-level data from the current population survey ("CPS"), which is available more frequently than the census, to conduct their study. Both of these studies find that Lifeline and Linkup programs have a statistically significant impact on penetration rates, although the effects are small. Garbacz and Thompson (2003) find that the demand for local service is highly inelastic (-0.006 to –0.011 in 2000) and that Lifeline and Linkup programs have little effect on penetration, estimating that a 10 percent increase in Lifeline and Linkup expenditures would add about 20,000 households to the network in 2000. Erikson, Kaserman and Mayo (1998) find that targeted low-income subsidies positively affect state-level penetration rates, while untargeted subsidies do not have a statistically significant impact on penetration rates.

Studies that rely on statewide data use statewide-average residential prices as an independent variable. Because residential service prices can vary substantially within states, the use of statewide data masks substantial information. For example, in California, monthly rates for 100 calls a month for Lifeline customers vary from $5.01 to $6.90 and for non-Lifeline customers vary from $11.62 to $15.51.

Crandall and Waverman (2000) use location-specific price data obtained from ILECs and data from the 1990 census for 1,897 different towns or places. They use both the price of local service and the Lifeline rates as explanatory variables in different regressions, as well as a dummy variable if the state has a Lifeline or Linkup plan interacted with the poverty rate to try to measure whether poor communities in states with Lifeline and Linkup programs have higher penetration rates than poor communities in other states. They find no significant effect for Lifeline programs, which is consistent

with their finding that there is little price elasticity of demand for telephone service overall.

Crandall and Waverman find that higher first-time connection charges significantly reduce penetration rates, estimating an elasticity of penetration with respect to the charge for connecting a new subscribers ranges from -0.025 to –0.030. Surprisingly, they find that states with a Linkup program have lower penetration rates. The counterintuitive Linkup effect, they argue, may be due to the use of a dummy variable where only two states did not have a Linkup program in 1990. Perhaps more important, Crandall and Waverman note that the Linkup result may be caused by a reverse-causation problem because states that have high penetration rates may choose not to participate in federal low-income programs. Earlier works by Perl (1984) and Cain and McDonald (1991) indicate that the elasticity of demand could be higher for low-income households.

Our study differs from previous work in that we attempt to explain penetration for low-income households separately from other households. The empirics presented use data on hookup and monthly prices paid by households eligible for Lifeline and Linkup programs and characteristics of the service provided to estimate the penetration rates of households below the poverty level. Data on prices and service characteristics, obtained from Bell Operating Company (BOC) tariffs, are matched to census data for more than 9,000 places. The richness of this dataset, and our exclusive focus on poor populations, allows us to estimate the price elasticity for low-income households, which is employed to estimate of the effectiveness of low-income universal service programs. As suggested

by Crandall and Waverman, our analysis also demonstrates that it is important to control for the endogeneity of prices, which reflect the size of low-income subsidies.

Theory and Empirical Specification of Household Telephone Demand

Telephone service enables a household to place and receive calls. The value of this service depends on the location of the household and on the menu of available calling options. These calling options define the service provided to the household.

The value of telephone service to a representative household is assumed to be additively separable in the characteristics of the service. That is, a representative household is willing to pay an amount $e^t V$, where *t* describes the household, and V summarizes the nature of the service. If the price of telephone service is *R*, then the household elects service if $e^t V \geq R$, or equivalently, if $t \geq \ln R - \ln V$.

Consider a group of households. The population is described by a cumulative distribution function $F(t)$. Therefore, the share of households who demand the service (penetration rate) at price *R* is

$$S = 1 - F(\ln R - \ln V). \tag{1}$$

Now consider *M* groups, indexed $g = 1,...M$, comprising a population of households. Let X_g denote the population share of group *g*. Telephone penetration of group *g* is $S_g = 1 - F_g(\ln R - \ln V)$, and the penetration rate of the entire population is

$$S = \sum_{g=1}^{m} X_g S_g \tag{2}$$

Note that the distribution of household types within any group is exponential, with $F_g(t) = 1 - e^{-\lambda(t-\mu_g)}$ and $t \geq \mu_g$. It follows that $S_g = e^{-\lambda(\ln(R/V))+\lambda\mu_g}$ and $S = e^{-\lambda(\ln(R/V))}\sum_{g=1}^{M} X_g e^{\lambda\mu_g}$. Alternatively,

$$\ln S = -\lambda \ln R + \lambda \ln V + \ln\left(\sum_{g=1}^{M} e^{\lambda\mu_g} X_g\right). \tag{3}$$

This model of telephone demand is the basis of our empirical specification. The price elasticity of demand for service is given by the parameter λ. A noteworthy simplifying assumption is that all population groups have the same price elasticity. Group differences in demand are captured purely by the parameters $(\mu_1, \ldots \mu_M)$

A unit of observation is a population of consumers at location *l*. A vector of group shares $(X_{1l}, \ldots X_{Ml})$ describes each population, and the penetration rate at location *l* is

$$\ln S_l = -\lambda \ln R_l + \lambda \ln V_l + \ln\left(\sum_{g=1}^{M} \beta_g X_{g_l}\right) \tag{4}$$

where $\beta_g = e^{\lambda\mu_g}$. Both the price ($R_l$) and nature of service (V_l) vary across locations.

Our empirical model must deal with the fact that telephone service typically requires a monthly subscription price (P_l) and a one-time installation charge (I_l). If the household monthly "discount rate" is α, then $R_l = P_l + \alpha I_l$ and

$$\ln S_l = -\lambda \ln(P_l + \alpha I_l) + \lambda \ln V_l + \ln\left(\sum_{g=1}^{M} \beta_g X_{g_l}\right). \tag{5}$$

It remains to control for differences in the nature of service at different locations such as the number of people within the local calling area. Let Z_l denote a vector of

variables controlling for the characteristics of the service at location *l*. Then $\lambda \ln V_l = \Gamma(Z_l) + \varepsilon_l$, and

$$\ln S_l = -\lambda \ln(P_l + \alpha I_l) + \ln\left(\sum_{g=1}^{M} \beta_g X_{g_l}\right) + \Gamma(Z_l) + \varepsilon_l . \quad (6)$$

We specify a functional form for $\Gamma(\bullet)$ after we discuss the data and define Z_l. Unobservable characteristics of the service are summarized by the random variable ε_l.

Finally, we recognize that the demand for telephone service may depend on characteristics of the locations as well as on calling options. For this reason, we include location characteristics in the vector Z_l.

The parameters of interest are λ and α. The parameter λ is the elasticity of household demand with respect to the household's monthly service price, while α is the discount rate for the installation charge. Estimates of these parameters enable us to gauge the effect of Lifeline and Linkup discounts on the penetration rates of low-income populations, holding service characteristics constant.

Data

The data for the analysis come from a variety of sources: the 2000 decennial census, state-level telephone tariffs, the FCC (2000) Hybrid Cost Proxy Model, and Telcordia's (2000) Local Exchange Routing Guide (LERG). The data include information on telephone penetration rates and demographics, the price of basic local telephone service, connection charges, Lifeline and Linkup discounts, other information from state tariffs and estimates of the cost of providing local service. The data set includes 9,060 census

places located in 43 states and the District of Columbia in the original BOC regions,[5] representing approximately 50 million residential access lines. FCC ARMIS data and the HCPM indicate that the Lifeline program subsidized approximately 5 percent of the lines in our data in 2000.

The dependent variable in the empirics is the natural log of a census place's penetration rate for households below the poverty level (ln(*Telephone Penetration*)),[6] which comes from the census and is equal to the ratio of the number of low-income households where a telephone is available to the number of low-income households.[7] For our purposes, a low-income household is one below the poverty line.

Because data on local prices and other data from state tariffs are reported by wire center,[8] data from local tariffs were matched to census places using a data set obtained from Claritas, which matches census block groups with wire centers. Because local monthly prices are given by wire center and places in relatively urban areas are served by multiple wire centers, rates are not always uniform within a census place. Places with

[5] Excluded states are Alaska, Hawaii and Connecticut, which are not served by BOCs, Delaware, which is not included in the FCC HCPM, and Montana, Wyoming and Vermont, which have different prices for households served by each switch depending on the distance from the switch. Southern New England Telephone company, which provides service in Connecticut, was purchased by SBC following passage of the Telecom Act of 1996.

[6] Census places are either "incorporated areas" (like cities) or "census designated palaces" that are a separately identified concentration of population.

[7] The census defines a telephone as being available when a household has a telephone in working order and is able to make and receive calls. Households whose telephone service has been discontinued for nonpayment or any other reasons are counted as not having a telephone available (see, Census Bureau, 2000 sf3 documentation).

[8] A wire center includes all customers connected to a particular local switch. In metropolitan areas several wire centers serve a single census place, while in rural areas, a single switch may serve multiple census places.

non-uniform Lifeline rates are not included in the study because we are unable to determine the rates faced by the low-income households in such places.

The independent variables of primary interest are the monthly charge for local service and the charge for connecting to the network. Because low-income households are the focus of this study, data on charges to customers eligible for Lifeline and Linkup are used. In the majority of states, low-income customers are allowed to choose from a variety of local-service offerings. Customers may subscribe to a usage-based plan, where they pay for each call or minute of local use in addition to a monthly charge. Customers subscribing to a flat-rated plan pay only the monthly charge and are allowed to make an unlimited number of local calls. The majority of the states in the sample offer subscribers both flat-rated and usage-based plans. Only Vermont and Wisconsin and portions of New York (NYC) and Illinois require that consumers subscribe to a usage-based plan, while Kansas, Kentucky, North Carolina and Maine do not offer usage-based options.[9] For the empirical work, the variable *Lifeline Rate* is equal to the lowest-priced offering available to Lifeline customers.[10] *Lifeline Rate* equals the non-Lifeline monthly charge, including the federal SLC, less the total Lifeline discount.[11] The other variable of primary interest is *Linkup Charge*, which is equal to the connection charge paid by customers eligible for the Linkup subsidy.

[9] Washington state requires Lifeline customers subscribe to a flat-rated plan, while Maryland, Arkansas and West Virginia require Lifeline customers subscribe to a usage-based plan. In each of these states non-Lifeline customers may subscribe to either flat-rate or usage-based plans.

[10] The price used is the basic monthly connection charge for usage-based or flat-rated plans, assuming the customer completes zero calls. Similar variables were created where we included any usage-based charges for 50, 100 or 200 calls. The results of regressions run using these alternative price variables are largely consistent with the results reported below.

[11] *Lifeline Rate* includes extended area of service surcharges when such surcharges are non-optional.

To control for characteristics of the service provided, two variables, *Flat Dummy* and *4-Minute Call Allowance*, are included in the analysis. *Flat Dummy* is an indicator variable, which is set equal to one when the lowest-priced Lifeline offering is a flat-rated plan that offers unlimited local calling.[12] Several usage-based Lifeline offerings allow customers to make a limited number of local calls at price of zero. *4-Minute Call Allowance* is equal to the number of calls customers are allowed to make before paying usage-based charges each month.[13] We expect penetration rates to be increasing in both these variables.

Another important characteristic of the service provided is the number of people within a customer's local calling area (LCA). Customers with flat-rated service can make an unlimited number of calls to customers located within their LCA. When subscribing to a usage-based plan, the rates for local calls are lower than charges for calls outside the customer's LCA. To account for the size of the LCA, *Ln*(*Local Calling Area)*, which is equal to the natural logarithm of the number of households within a customer's local calling area, was created. Tariff data were used to identify the localities included in each wire center's LCA. Claritas data and data from the census were then used to calculate the number of households within each wire center's LCA.[14] We expect a positive

[12] The minimum value for *Lifeline Rate* is $0.00. Texas set a minimum Lifeline Monthly Price of $2.50 for all types of calling plans and in many cities the usage-based Lifeline option has the same monthly price as the non-Lifeline usage-based option.

[13] Because some states based usage charges on minutes of calling time, while others base usage charges on the number of calls, *4-Minute Call Allowance* is equal to the number of 4-minute calls a customer is allowed each month.

[14] In places served by more than one wire center, the household-weighted average LCA is used for the place.

relationship between *Ln*(*Local Calling Area)*and penetration rates, holding other factors constant.[15]

To capture the effect the price of calls outside the customers LCA has on penetration, intrastate access charges are included in some specifications of the model.[16] Intrastate access charges are the fees that local exchange carriers charge long-distance companies for completing non-local intrastate calls. The variable *Ln(4-Minute Access Charge)*, which is equal to the natural logarithm of the access charge for a four-minute intrastate long-distance call, is included in the analysis and is expected to receive a negative coefficient. [17]

We include only intrastate access charges because interstate long-distance prices in states do not reflect the each state's interstate access charge. Section 254(g) of the Telecommunications Act forbids long distance carriers from charging different rates in different states, even if the states have different costs. As a result, there would be little basis for inclusion of interstate access charges, and we do not have the requisite information to determine if there is a systematic difference in actual retail rates paid by consumers in different places.

[15] Many states use value-of-service pricing, where local rates are directly related to the size of a customer's LCA.

[16] Because customers make both local and long-distance calls, the price of long-distance calls affect subscriber decisions. *See* Hausman, Tardiff, and Belinfante (1993).

[17]The access charge included includes charges for originating and terminating minutes for carrier common lines charges, switched access, transitional and call-set up charges, along with any charges for state universal service programs. In New Jersey, Maryland, Virginia and West Virginia, the CCLC is determined by a long-distance carrier's share of total intra-state long-distance minutes. In these states, the state commission determines the total amount of money to be recovered through the CCLC and charges carriers on a retroactive basis. Using ARMIS data and information contained in tariffs we estimate the CCLC in these states.

The last variable included to control for service characteristics is *Rural Percent*, which is equal to the percentage of households within a census place living in what the census classifies as a rural area. It is likely that the value of a telephone service is higher for customers living in rural areas. Finally, the FCC Penetration Report indicates that penetration rates for Blacks and Native Americans are lower than White penetration rates. To control for differences in ethnicity, we include the variables, *Blacks, Native Americans, Asians and Other*, which are equal to the percentage of the population that is below the poverty level and belongs to the respective ethnic group.

In our two-stage regressions, we use information on the average cost within a state, as obtained from the FCC's Hybrid Proxy Cost Model, and a variety of political variables to create instruments for *Lifeline Rate, Linkup Charge and Ln(4-Minute Access Charge)*. The variable *State Ave Cost* is expected to increase prices because state regulators are required to set rates that recover the carrier's cost of service. We also include variables that capture whether state public utility commissioners are elected or appointed (*State PUC Elected*), percentage of state legislator that are democrats (*Democrat Ratio*), the ratio of business to residential lines in 1999 (*Bus/Res Ratio*), the percentage of a state's population that is below the poverty level (*Pct Poor*) and the state's penetration rate in 1991 (*State Penetration in 1991*). Similar state-level variables are created for the ethnicity variables, which are discussed above. These variables are included in only the first-stage regressions.

Table 1 provides summary statistics on the variables used in the analysis.

Table 1
Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Hook Up	35.68	12.10	12	65
Linkup Charge	11.09	7.70	0	22.95
Lifeline Rate	3.09	2.03	0	10.88
Non Lifeline Rate	11.10	2.30	7.3	21.05
Access Charge 4 Minutes	0.15	0.09	0.03	0.47
Local Calling Area	202,314.7	308,669.1	203	1,810,226
State Ave Cost	22.77	4.59	16.09	38.96
Rural Percent	0.29	0.43	0	1
Telephone Penetration	0.93	0.09	0.26	1
Whites	0.75	0.27	0	1
Blacks	0.13	0.24	0	1
Native Americans	0.02	0.07	0	1
Asians	0.02	0.06	0	0.78
Other	0.08	0.13	0	1
White state	0.58	0.14	0.14	0.93
Black state	0.25	0.16	0.01	0.77
Native American state	0.02	0.04	0	0.29
Asian state	0.03	0.03	0.01	0.1
Other state	0.12	0.09	0.02	0.35
State Telephone Penetration	0.94	0.03	0.87	0.98
Democrat ratio	0.75	2.61	0.11	33.30
Bus/Res Lines	0.49	0.077	0.35	1.96
Pct poor	0.08	0.02	0.05	0.15
State Penetration in 1991	0.93	0.03	0.86	0.97
State PUC Elected	0.17	0.38	0	1

Results

The basic form of the regression analysis based on equation (6) above. The relationship that we estimate is of the form:

$$\ln(\textit{Telephone Penetration}) = \text{Constant} + \beta_1 * [\ln(\textit{Lifeline Rate} + \beta_2 * \textit{Linkup Charge})] + \ln[\textit{Whites} + \beta_3 * \textit{Blacks} + \beta_4 * \textit{Native Americans} + \beta_5 * \textit{Asians} + \beta_6 * \textit{Non-whites}] + \beta_7 * \textit{Rural Percent} + \beta_8 * \textit{Flat Dummy} + \beta_9 * [(1 - \textit{Flat Dummy}) * \textit{4-Minute Call Allowance} + \beta_{10} * \ln(\textit{Local Calling Area}) + \beta_{10} * \ln(\textit{4-Minute Access Charge}) + \textit{Error}$$

The parameters of interest are β_1 and β_2. As discussed earlier, the coefficient β_1 estimates the elasticity of the monthly price of Lifeline service, including an estimated amortization of Linkup charge. The coefficient β_2 estimates the amortization rate for the Linkup charge. The regression controls for the demographic characteristics of the local population, how rural is the locality, the characteristics of Lifeline calling plan, including the size of the local calling area, and (in some specifications) intrastate long distance access charges. All variables are measured at the Census "place" level, for which we have 9,060 observations.

The regression equation is nonlinear because of the treatment of the amortized Linkup charge and the aggregation of demographic groups. Both sources of non-linearity are suggested by economic theory, as discussed earlier. We use non-linear least squares to estimate the regression. Because of the possibility that the prices are endogeneously determined, we also estimate the relationships using a two-stage regression approach. In the first stage, we estimate the *Lifeline Rate*, *Linkup Charge*, and (where applicable) *4-Minute Access Charge* variables as functions of the exogenous state-level variables discussed above. The fitted values from the first-stage regressions are used as

independent variables in the second-stage regressions.[18] The regression results are presented in Table 2.

The coefficients from the single-step estimation show a negligible price elasticity of demand for low-income consumers of about -0.008. The estimated elasticity (reported in the second line of the table) is negative and significantly different from zero, but not quantitatively significant. This is so whether or not ln(*4-Minute Access Charge*) is included in the regression specification. These low elasticities are similar to elasticities reported in previous studies like Taylor (1994) and Crandall and Waverman (2000).

Because of the possible endogeneity of prices, we focus on the two-stage regression results. The first-stage regression estimates *Lifeline Rate*, *Linkup Charge*, and *4-Minute Access Charge* as a function of *Rural Percent*, *Flat Dummy*, *4-Minute Call Allowance*, ln(*Local calling area*), and a number of state-level variables. The joint estimation of these equations enables us to use the estimated a variance-covariance matrix to adjust the standard errors in the second –stage equation that employs the predicted values of *Lifeline Rate*, *Linkup Charge*, and *4-Minute Access Charge*. We do not focus on the first-stage results except to remark that the instruments are generally statistically and quantitatively significant.[19]

[18] The standard errors in the two-stage regression are adjusted in the second stage using the Murphy and Topel (1985) methodology that is also discussed in Greene (2000, 4th edition)

[19] The coefficient on ln(*Local calling area*) is positive and significant – the larger the number of households within a local calling area, the greater the rate. This is consistent with the "value of service" pricing discussed in Wimmer and Rosston (2003).

Table 2
Regression Results

Dependent Variable: Ln(Telephone Penetration)
(Std. errors in parentheses)

	1SNLLS	1SNLLS	2SNLLS	2SNLLS
Constant	-0.22273**	-0.21639**	-0.16632**	-0.18515**
	(0.00845)	(0.00897)	(0.01162)	(0.01395)
β_1*[ln(Lifeline Rate + β_2* Linkup Charge)]	-0.00811**	-0.00756**	-0.03594**	-0.03494**
	(0.00177)	(0.00180)	(0.00439)	(0.00440)
β_2*Linkup Charge	0.17949**	0.20573*	0.29287**	0.26466**
	(0.08484)	(0.10663)	(0.03800)	(0.04268)
β_3*Blacks	0.90297**	0.90349**	0.90976**	0.90729**
	(0.00418)	(0.00419)	(0.00429)	(0.00442)
β_4*Native Americans	0.73605**	0.73528**	0.75139**	0.75491**
	(0.01166)	(0.01165)	(0.01194)	(0.01205)
β_5*Asians	1.05487**	1.05962**	1.04481**	1.03651**
	(0.01865)	(0.01882)	(0.01860)	(0.01885)
β_6*Non-whites	0.92867**	0.92910**	0.92675**	0.92657**
	(0.00808)	(0.00809)	(0.00802)	(0.00802)
β_7*(1-Flat Dummy)* Allowance w/ 4minute calls	0.00030**	0.00030**	0.00030**	0.00028**
	(0.00005)	(0.00005)	(0.00005)	(0.00005)
β_8*Rural Percent	-0.02144**	-0.02157**	-0.01883**	-0.01882**
	(0.00276)	(0.00276)	(0.00278)	(0.00278)
β_9*Flat Dummy	0.00043	-0.00096	0.01085**	0.01291**
	(0.00354)	(0.00361)	(0.00385)	(0.00394)
β_{10}*ln(Local Calling Area)	0.01619**	0.01625**	0.01558**	0.01549**
	(0.00067)	(0.00067)	(0.00067)	(0.00068)
β_{11}*Ln(4-Minute Access Charge)		0.00358**		-0.00806**
		(0.00168)		(0.00324)
N	9060	9060	9060	9060
Adj. R-Squared	0.206	0.206	0.210	0.211

* significant at the 90% level
** significant at the 95% level

In the two-stage regression results, the estimated price elasticity of monthly Lifeline/Linkup service rises to about -0.035. This estimated elasticity is statistically and quantitatively significant. This estimated elasticity is still small, but it is roughly four times the estimated elasticity when not accounting for potential endogeneity problems. The results presented suggest that price endogeneity is a potentially important source of estimation bias.

In these regressions, the coefficient on *Linkup Charge* ranges between about 0.18 and 0.29. This result is consistent with the results in Hausman et. al. (1993) that find a discount rate of greater than 100 per cent per year and is consistent with work in other fields finding similar results for low-income households for consumer durables (Hausman (1979) and Dubin and McFadden (1984)). Crandall and Waverman (2000) also find that subscription is sensitive to the hookup charges, but, possibly because of the nature of their data and estimation, find inverse relationships between subscription and Linkup programs.

All of the racial variables that are included are statistically significant. Whites are the excluded group so the coefficients on each race are the effect on penetration relative to whites. As expected, Asians have a higher penetration rate than whites while all other groups have a coefficient less than one, indicating lower penetration rates for these groups relative to whites.

The local calling area variable is also positive and significant in all of the estimations with a magnitude of about 0.15-0.16 in all regressions. This means that as the number the number of people that low-income households can call for a local call has a positive effect on the subscription decision. Since there is a high correlation between

the number of people within a local calling area and the number of people nearby (urban vs. rural), it is not entirely clear why *Rural Percent* receives a negative coefficient.

Policy Experiment

Using the estimates from the regression equations, it is possible to estimate the impact of the Lifeline and Linkup plans on low-income penetration. We use the elasticity estimates and the prices for non-eligible customers to see how the penetration rates for low-income customers would change if the Lifeline and Linkup programs were discontinued. We do this using our preferred regression estimates that include intrastate long distance access rates (Ln *Access charge 4 minutes*) and control for the possible endogeneity of prices. Table 3 shows the result.

Table 3
Predicted Penetration for Low Income Households

(using 2SNLLS with Access Charge for 4 minutes)

With Lifeline and Linkup	92.90%
Without Lifeline or Linkup	88.00%
Difference	4.9%* (95% confidence interval 3.7% to 6.0%)
Difference due to Lifeline Alone^{+}	3.6%* (95% confidence interval 2.7% to 4.6%)
Difference due to Linkup Alone^{+}	2.7%* (95% confidence interval 2.0% to 3.5%)

* Statistically significant at the 1% level
$^{+}$The nonlinear functional form estimated results in the sum of the separate effects being greater than the joint effect where Lifeline and Linkup are both in place.

The predicted penetration rates for low-income households with Lifeline and Linkup rates are significantly and substantially higher than the predicted penetration rates without these reduced rates. The estimated difference in the penetration rates of low-income households is almost 5%. It should be noted that these predictions do not include

possibly offsetting factors that might increase the penetration rates for low-income groups. These subsidy programs are funded by taxes on interstate revenues. To the extent that such extra charges are also borne by low-income households, their bills would decrease somewhat, offsetting the increase in hookup and monthly charges

To get an idea of the magnitudes of the numbers that are concerned here, the annual federal funding for Lifeline and Linkup was about $730 million. If the states put in enough to get to the maximum match of Federal money, then they would put in about 3/8[20] of the Lifeline amount or $300 million for a total low-income support of about $1 billion per year. There are about 12.6 million low-income households in the country as a whole.[21] A 5% increase in penetration among low-income households, means that these programs encourage 630,000 more households to subscribe to the telephone network. This works out to a cost of $1,587 per household per year.

Linkup appears to be much more cost effective than Lifeline. Linkup costs less than 5% of the Lifeline program, yet has nearly 3/4 of the effect of Lifeline. Using the regression results, the Linkup program costs about $175 per subscriber (assuming that states match Linkup dollars on a one for one basis). In contrast, the Lifeline program costs about $2,000 per subscriber kept on the network.[22]

[20] States that reduced the charges by $3.50 per month, in 2000, qualified for $7.00 per month in federal price reductions for a total of $10.50. Because not all states have low-income programs, or do not provide enough support to qualify for the full federal subsidy, our estimate of the total cost of the program is conservatively high.

[21] Note that this is an estimate and will be revised. Using 12% of 105 million households. 12% is an estimate of households under the poverty line.

[22] A subsidy that included only Lifeline is estimated to add about 450,000 households, while Linkup alone is estimated to add about 340,000 households. Again, the functional form results in a the sum of the individual effects of Lifeline and Linkup exceeding the effect when the programs are both in use.

Another way to look at this is to see what the effective equivalent monthly rate reduction is for a reduction in the linkup charge. The Census Bureau (1998) reports that the median duration for renters is 2.1 years or about 25 months.[23] If low-income households are typical of renters and stay on average 25 months, then each dollar of installation charge would be viewed as costing them about $6.25 over their tenure at that residence (without discounting) because they view it as an the equivalent of an additional $0.25 per month (from the 2SNLLS results). According to our results, regardless of the views one has on the effectiveness of either low-income program, regulators could get the same effect on penetration with substantially less money by increasing the Linkup program and reducing the Lifeline program. Currently, the Universal Service Administrative Company (2003) reports that the Federal government is spending about $700 million per year on Lifeline and about $30 million per year on Linkup so there is room to undertake this proposed change.

Conclusions

Using data from 9,060 places, we find that low-income subsidy programs have increased low-income telephone penetration by about 5%. The elasticity of demand, while still relatively low at –0.035, appears to be higher than previous estimates because of the correction for the endogeneity of prices. Even with a low elasticity, the large amount of money in the Lifeline and Linkup programs are sufficient to reduce substantially the effective prices paid by low-income households so that telephone penetration increases.

[23] Note that this duration is confirmed by data in the 2000 Census.

Because of the high discount rate that low-income households have, the Linkup program has a much higher effect on penetration per dollar spent than the Lifeline program. One possible explanation for this is that low-income households may be credit constrained and even the typical 50% discount for Linkup charges could be a large amount to put up for telephone service if the expected tenure in the residence is low.

The bottom line from the low-income programs is that for approximately $1 billion per year, an additional 630,000 low-income households subscribe to the telephone network.[24]

[24] We should note again that this analysis does not address the effects of the costs of raising this $1 billion on other distortions and possible decreases in penetration due to increases in other prices. While the $1 billion is to a large extent a transfer payment from high- to low-income households, it also includes some direct real costs and the funding mechanism has distortionary effects.

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