UNIVERSAL SERVICE IN TENNESSEE:

A PRE-COMPETITION, PRE-LIFELINE ASSESSMENT

By

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ABSTRACT

A multiple regression model is used to assess the determinants of penetration rates in local exchange telephone service areas in Tennessee. The penetration rate is the percentage of households with telephone subscriptions in a given area. Since this study uses 1990 data, it is called a pre-competition, pre-Lifeline assessment. In 1992, Tennessee was certified for participation in the Lifeline, a program to provide assistance for local telephone service to low income households. The Telecommunications Act of 1996 allowed local telephone service competition. The study finds that education level, lack of home ownership, rural residency, poverty among certain age groups, and service connection fees have a significant relationship with the penetration rate.

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HISTORY AND BACKGROUND

What Is Universal Service With Respect to Telephony?

This is not an easy question to answer. The definition has changed considerably over time and continues to change. Moreover, there is lack of consensus over what the term means today. To understand the term, it is best to look at the history of universal service.

Much of the literature on the subject cites Theodore Vail, president of AT&T in 1907, as first using the term "universal service" for telephony. He used the term to express his belief in a need for a standardized system of connectivity throughout the country. He argued against competition since this would mean a lack of interconnection among competing networks. (Preston and Flynn 1999:91-92) The meaning of the term has changed considerably since then.

The Federal Communications Act of 1934 led to joint regulation of the telephone industry by the Federal Communications Commission and state agencies. Its preamble stated a goal "to make available, so far as possible, to all people of the United States, a rapid, efficient, nation-wide, and world-wide, wire and radio communication service with adequate facilities at a reasonable charge." This goal is subject to interpretation. A paper by Dinc, Haynes, Stough and Yilmaz see this statement as a "provision for affordable telephone service for everybody, everywhere." (Dinc, et.al. 1998:541) Preston and Flynn do not interpret this language to mean a goal of a phone in everybody's home, but rather a goal to insure that every subscriber, through rate averaging, would receive the same treatment. (Preston and Flynn 1999: 91-92)

During the post World War II era, technology was changing so that the cost of long distance was decreasing relative to the cost of the more labor-intensive local service. A "separations system" was devised. Regulation dictated long distance service to be priced high relative to its cost in order to keep prices for local service low. In effect, there was an implicit subsidy for local phone service. This was seen as necessary to maintain a high penetration rate. *The penetration rate is the percentage of households that subscribe to phone service*. Economists are not in agreement concerning whether or not such subsidies actually encourage a high penetration rate. The penetration rate grew substantially through the 1970s. Preston and Flynn argue that this was not a result of universal service policy but rather a result of declines in real costs and increases in demand. (Preston and Flynn 1999:91-92)

In the 1980s there were two major policy changes that in turn prompted policy initiatives in universal service. First, the End-User Access Charge Plan was instituted in January 1984. This was designed to bring local and long distance prices closer to their economic costs through a subscriber line charge. Since this charge was added to the flat rate charged for local service, concerns were raised about policy makers' commitment to universal service. Second, the divestiture of AT&T on January 1, 1984 gave rise to concerns that the introduction of competition in long distance service would end cross subsidization through the separations system. Three programs were devised as a result of these changes: Lifeline, Link-up, and High Cost Assistance. (Eriksson, et. al. 1998:481-482)

More recently, the Telecommunications Act of 1996 has had two major types of influences on universal policy. First, it enlarged the scope of universal services to the fields of education, public library services, healthcare, and access to various information services. Second, it allowed competitors to enter local markets. Implicit cost subsidies through the separations system as described above are no longer sustainable in a competitive environment. Such subsidies must be made explicit. This has caused universal service programs to come under closer public scrutiny as these subsidies are exposed. (Rousston and Wimmer 2000:2-3)

Universal Service Programs

In 1984, the FCC in conjunction with states and local telephone companies, established the Lifeline program in an effort to help low income families afford the cost of telephone service. This program went through some revisions in 1985. The FCC agreed to waive the subscriber line charge for approved low-income subscribers provided that the state match the federal reduction. The Link-up program was implemented in 1987. This program provides subsidies to low-income families for one-time expenses associated with subscription for local service. It provides up to one-half of the installation charge, up to a maximum of $30, whichever is less. Also, federal assistance is provided to defer interest expenses associated with subscription for up to 12 months. States determine the criteria for eligibility subject to approval by the FCC. Lifeline and Link-up programs are financed from charges imposed on interexchange companies based on their market shares of presubscribed callers. (Eriksson, et. al. 1998:481-482) Tennessee was certified for participation in the Link-up program on November 3, 1988. It was certified for participation in Lifeline on January 8, 1992. (FCC 1997 Monitoring Report, Table 2.1)

The High Cost Assistance Program differs substantially from the Lifeline and Link-up programs in that it is not specifically targeted at low-income subscribers. Instead, it subsidizes local exchange companies serving mainly rural areas where costs are considerably higher than the national average. Long distance companies sell their services across local access transport areas (LATA). The FCC supervises these companies. It charges and collects monies that go into the Universal Service Fund. These funds are allocated to local intrastate (intra LATA) telephone service providers to support universal service objectives. (Dinc, et.al. 1998:541) Tennessee local exchange companies receive little funding from the Universal Service Fund. In 1991, only 4 Tennessee companies received subsidies totaling $2,215,794. (FCC 1991 Monitoring Report, Table 3-6) Recently, the name of the Universal Service Fund was changed to High Cost Loop Support to avoid confusion with other universal service programs. Since this is a very recent development, FCC rules still refer to the Universal Service Fund. (FCC Monitoring Report, September 2000)

Background Study Concerning Determinants Of The Penetration Rate

This study focuses on determinants of the penetration rate in Tennessee in 1990. In that year, the penetration rate for the state was 92.9%. This is a high rate compared to many other states. Several studies have examined the penetration rate at the state level. This study, by contrast, examines penetration rates by telephone service exchanges. This reveals that there are areas where the penetration rate is dramatically lower than the average. For example, the lowest penetration rate for an exchange was only 76.6%. Since we are concerned about the determinants of low penetration rates, we now turn to a discussion of recent literature on this subject.

Schement and Forbes identify three dimensions to the problem of low penetration that seem to be fairly consistent in various studies: demographics, ethnicity, and geography.

Demographic factors include income, housing characteristics, gender of head of household, age of head of household, and unemployment. Several studies point to income at low levels as the most relevant factor. Edward Renshaw cites a 1980 study of New York counties that finds that the best predictor of the penetration rate was not the median household income but rather the proportion of households below the poverty line. (Renshaw 1985:517) Renters usually have lower penetration rates than homeowners. Families with women heads of household are more likely to be phoneless. Younger households have lower

penetration rates than older ones. Schement and Forbes find that penetration rate is especially low among minority households with householders from 15 to 24. Unemployment is highly correlated with the penetration rate, with unemployed Blacks affected to a greater extent than unemployed Whites.

Minority households consistently rank 8% to 10% below their White counterparts. Differentials exist between the minority groups. Hispanics and Native American households usually rank below Blacks. This may be in part associated with a language barrier. Camp and Tsang point out that low penetration rates have been found among those who speak English as a second language. (Camp and Tsang 1999:2)

State data on the penetration rate reveal significant variation among the states. In 1998 Nebraska and Pennsylvania had the highest penetration rates of 97.1% while New Mexico had the lowest of 88.1%. Analyzing the penetration rate based upon smaller geographic regions as in this study poses some problems. There are few data available that tabulate the penetration rate by demographic factors. (Schement and Forbes 2000:120-121) For example, the Census data summary provides us with the number of Black heads of household in any census block group. It also provides us with the number of housing units with telephones in that census block group. However, it does not inform us as to how many Black householders have telephones.

An often-cited study of the penetration rate from 1996 involved using ethnographic methods and geographic information systems to investigate telephone disconnection in Camden, New Jersey. According to that study, the most extensive pockets of low penetration rates were found in the inner city and were associated with the young, the transient, and ethnic minorities. It further demonstrates that many of those that do not have phones subscribe to a cable TV service, arguing that the perceived priorities of policy makers are at odds with the priorities of many phoneless households. The study also points to the effect of credit worthiness on the penetration rate. The article concerning the study is editorial in nature, going beyond mere findings of fact. The following is a quote from the abstract of that study:

> Given prevailing consumption patterns… "electronic redlining" seems less of a threat than that poor Americans will, upon exposure to the advanced features of the national information infrastructure (NII), buy services that they cannot afford….In reformulating universal service policy, we must…keep in mind the importance of credit risk as a factor…
>
> (Mueller and Schement 1996:Abstract)

An article by Camp and Tsang focuses on telephone disconnections. The number one reason given for a loss of telephone service is a high long distance bill. Other common reasons are high calling

card or collect call charges. Furthermore, Camp and Tsang state, "The poor use more expensive telecommunications services per dollar of income than users in any other quintile." They see a main problem as a delay in feedback with regard to these services. Households are not aware of what the price of services will be until they receive the bill. Also, telephone services often escape the control of the party responsible for the bill due to the actions of adolescents, irresponsible guests, and relatives. Without going into detail here, suffice it to say that Camp and Tsang advocate various innovative measures to provide quicker feedback concerning price and to put control of service in the hands of the phone owner. Such steps may also reduce the need for deposits to obtain service, thereby minimizing another obstacle to achieving a higher penetration rate. (Camp and Tsang 1999:5)

Claire Milne observes the concept of universal service from an international perspective. Milne points out that industrialized countries have a mass market that has already been connected: "…the residual market is dominated by minority segments, typically remote residents, low-income groups and disabled people." It is interesting that Milne sees the problem as being one that affects "remote" residents whereas Mueller and Schement see the problem as mainly one of the inner city. Milne asserts that since a residual market is the concern of universal service for industrialized nations, mass-market approaches are ineffective. Consumer research is vital. (Milne 1998:780)

EMPIRICAL MODEL

Basic Demand Function of Model and Aggregation of Data

The basic function of the model proposed is expressed with the following equation:

$$PEN = f(P, C, L, Z, \varepsilon)$$

where *PEN* is the penetration rate, *P* is the price of single line residential service, *C* is the connection fee associated with subscription, *L* is the effect of Link-up subsidies, *Z* is a vector of demographic characteristics, and ε is the random error term.

Values for the demographic variables are obtained by census block group from the Census of Population and Housing 1990: Summary Tape File 3 On CD-ROM. These values are matched to local exchange areas through the use of Common Language Location Identifier data (CLLI).

Why choose the telephone exchange as the level of aggregation? A smaller level of aggregation such as the census block group would allow a greater sample size and allow us pinpoint small concentrated

areas of low penetration. The answer to this question lies in the variables used that are *not* from the Census. Namely, in addition to demographic variables, this study examines the effects of monthly prices for residential service, connection fees, and Link-up subsidies. The monthly rate for local service does not vary within an exchange. This price variable cannot possibly explain any variation within an exchange. Thus, a linear regression model that examines smaller areas would tend to understate the effect of this price variable. Only company-wide data are available for connection fees and Link-up subsidies. Since there are 25 companies in the state of Tennessee, company areas are larger than exchanges. Thus, aggregating at a level smaller than an exchange would tend to understate the significance of these variables to an even greater extent. To study these variables effectively with a linear regression model, one would need to be able to aggregate at the company level. With only 25 companies, we are not able to do this. Indeed, this is a shortcoming of this study. It might be interesting to conduct a nation-wide study of the penetration rate by local exchange company.

Another reason to aggregate by exchange is that this may provide better policy guidelines. Although it may be interesting to pinpoint very small areas of low penetration rates, there is some doubt that this would produce feasible policy implications. While Schement and Forbes advocate examination of penetration rates at small levels of aggregation, they admit problems with this approach with regard to policy: "Yet county- or town-specific universal policies are not currently feasible." (Schement and Forbes 2000:124)

Why 1990 Information is Used

It is hoped that this study can be used as a benchmark to compare the effects of changes regarding the introduction of competition, the introduction of Lifeline, and the expansion of Link-up. This is the "before" study. Supposedly, there will be one or more "after" studies that will allow comparison. Why is only one year used? After all, information from the Current Population Survey concerning the penetration rate is published three times a year. Would a time-series or panel-data study be more appropriate?

Gorbacz and Thompson provide an answer. They performed rigorous tests comparing differences between decennial Census data and the data from the Current Population Survey. They demonstrate that the CPS data contain significant sampling errors. This problem is related to the small range in variation of the data and small sample size. The range in the penetration rate across states varies only by 11.6% from

the highest to the lowest state in March 1998 data. The sample consists of only 0.05% of the estimated number of total households. (Gorbacz and Thompson 2000:1-3) These findings suggest that the best approach for this study is to limit analysis to the 1990 Census data.

Variables Chosen

Table 1 contains definitions and descriptive statistics for the variables included in the penetration rate model. The dependent variable for this analysis is *PEN*, the percentage of occupied housing units with a telephone. This is computed by dividing the number of occupied housing units with a telephone by the total number of occupied housing units. A telephone must be inside the house or apartment for the unit to be classified as having a phone. It is interesting to note that the Census does not inquire as to whether the phone is connected. Penetration rates may in fact be overstated considering that some households with disconnected phones may answer this question in the affirmative.

The demographic variables discussed in this paragraph are expected to have a negative effect on the penetration rate. To measure the effect of education level, *PUEDUC*, the proportion of adults age 25 or older with less than a high school diploma, is used. The effects of ethnicity and language barriers are examined by the use of (1) *PBLACK*, the proportion of Black householders, (2) *POTHRACE*, the proportion of householders other than White or Black, and (3) *PLINGISO*, the proportion of households with linguistic isolation.[*] The effects of lack of home ownership are analyzed with *PRENT*, the proportion of rented occupied housing units. The combined effects of age and poverty are to be assessed with the use of the variables *PPOV1824* through *PPOV75UP*. These variables examine age groups of persons below the poverty level as a proportion of the adult population. The variable *MEDHHI*, median household income is expected to have a positive impact on the penetration rate but to be less significant than the *PPOV* variables.

The effects of population densities are examined by the variables *PRURAL*, the proportion of rural housing units, *HOUSEHLD*, the number of households, and *HOUSESQR*, the number of households squared. Since *PRURAL* and *HOUSEHLD* are almost certainly negatively correlated with each other, their

[*] A household with linguistic isolation is defined as one in which no person age 14 years or over speaks only English and no person age 14 years or over who speaks a language other than English speaks English "very well."

TABLE 1: VARIABLE DEFINITIONS AND DESCRIPTIVE STATISTICS
DEPENDENT VARIABLE: PEN NUMBER OF OBSERVATIONS: 249

VARIABLE	DEFINITION	EXP. SIGN	MEAN	STD DEV
PEN	Percentage of occupied housing units with phone*		91.080	3.970
PUNEDUC	Proportion of persons age 25 without high school diploma	-	0.407	0.098
PBLACK	Proportion of black heads of household	-	0.068	0.101
POTHRACE	Proportion of heads of household who are other than white or black	-	0.005	0.006
PLINGISO	Proportion of households with linguistic Isolation**	-	0.004	0.002
PRENT	Proportion of rented occupied housing units	-	0.226	0.075
PRURAL	Proportion of rural housing units***	-	0.766	0.294
HOUSEHLD	Number of households in hundreds	+	70.361	240.970
HOUSESQR	HOUSEHLD squared	?	6.278×10^4	5.794×10^5
MEDHHI	Median household income in thousands	+	28.058	6.211
PPOV1824	Proportion of adult population age 18 to 24 below poverty level.****	-	0.020	0.010
PPOV2534	Proportion of adult population age 25 to 34 below poverty level.	-	0.027	0.013
PPOV3544	Proportion of adult population age 35 to 44 below poverty level.	-	0.021	0.011
PPOV4554	Proportion of adult population age 45 to 54 below poverty level.	-	0.015	0.009
PPOV5564	Proportion of adult population age 55 to 64 below poverty level.	-	0.018	0.009
PPOV6574	Proportion of adult population age 65 to 74 below poverty level.	-	0.021	0.010
PPOV75UP	Proportion of adult population age 75 and over below poverty level.	-	0.023	0.011
PPRICE	Predicted price from price regression	-	10.272	1.457
LINKPOV	Link-up dollars by company / adults below the poverty level in company area	+	0.163	0.275
CONNECT	Connection charge for residential service	-	27.400	8.778

*Some variables are defined in terms of households, others by household units. The census uses the term household for 100% tabulations. The term housing units is used in sample tabulations. The numbers may differ as a result of the weighting process.
**A household with linguistic isolation is defined as one in which no person age 14 years or over speaks only English and no person age 14 years or over who speaks a language other than English speaks English "very well."
***Rural areas are those areas other than: (1) places of 2,500 persons incorporated as cities, vilages, and burroughs, (2) census designated places of 2500 or more persons, and (3) some other territories included by the census in urbanized areas.
****The adult population is defined as those persons 18 years of age and over. "Below poverty level" in this table refers to persons for whom poverty status has been determined.

signs should be opposites. There are a number of factors that could influence these variables in one direction or another. Mueller and Schement see the penetration problem as one that affects mainly the inner city. This would imply that *PRURAL* would have a positive affect on the penetration rate if penetration problems in the inner city were great enough. However, Milne sees the problem as one that affects mostly remote areas. In this study, the "remote" effect would probably outweigh the "inner city" effect. Exchanges for major cities will include rich and poor alike, thus the "inner city" effect will be diluted. There are other effects that could come into play. If access to more local subscribers has a significant influence on demand, *HOUSEHLD* is expected to have a positive affect. However, households in rural areas could be more dependent on local phone service since substitutes such as pay phones and other households' phones are less available. These two effects may cancel each other out, leaving the "remote effect" as predominant. Therefore, this study expects a negative sign for *PRURAL* and a positive sign for *HOUSEHLD*. The variable *HOUSESQR* is added to capture possible nonlinear effects of the *HOUSEHLD* variable.

From background research and common sense, it is easy to see that the price faced by a non-subscriber may be much more than the monthly residential fee for service. A new subscriber must pay a connection fee. Some companies charge two fees: service order charges and central office wiring charges. Other companies combine these as one charge. If there has been a credit problem with previous phone service, a household may be required to pay a connection fee, a deposit, and back charges from a past due bill. Also, the effects of the Link-up program should be taken into account.

Data for the Link-up program were obtained from the FCC Federal-State Joint Board Monitoring Report. (FCC Monitoring Report 1997, Table 2.10). This report contains the total subsidy amount for Link-up per company. The total dollar amounts for Link-up assistance alone are of little value to us. However, when combined with census data, they may be useful. For each company, the total assistance amount per company is divided by the number of adults below the poverty level in that company's service area. The term adult is defined as a person age 18 years or older. The term poverty level is used in this study to mean persons for whom poverty status has been determined. This ratio should give us the amount of assistance per impoverished adult for each company. This variable is designated as *LINKPOV*. If Link-up programs were successful, we would expect *LINKPOV* to have a positive relationship to the penetration

rate. (A variable for Lifeline is not included because Tennessee was not participating in this program in 1990.)

There are some difficulties in including variables for connection fees and deposits. Due to the passage of time, it is not an easy matter to obtain comprehensive data. In order to obtain data concerning connection fees and deposits, a simple survey of phone companies was conducted. Representatives from telecommunications companies were asked to examine their records in order to supply the amounts of their service order charges, central office line connection charges, and deposit requirements in 1990. Responses were received from 16 out of the 25 companies. Fortunately, most of the companies for which the data are missing cover a small number of exchanges. We have designated connection charges for residential service as the variable *CONNECT*. For companies that separately charge service order charges and central office wiring charges, these two amounts have been added together to form *CONNECT*. A negative relationship is expected between *CONNECT* and the penetration rate. Adding the variable *CONNECT* generates missing values for our observations, reducing the sample size from 316 to 249 observations. Nonetheless, *CONNECT* is likely to be significant, so it is included in the model.

A variable for deposits cannot be quantified due to the differences in credit policies of the companies. The maximum amounts that companies were allowed to charge was regulated by the Tennessee Public Service Commission, but the amounts actually charged may have been considerably less than the maximum allowed. Some companies had simple policies that were sometimes fairly subjective: "We would usually charge $75, but if the customer's credit history was *really bad*, we might charge up to 2 ½ times their estimated monthly bill." Other companies spelled out the terms of their credit policy with greater precision.

The variable *PPRICE*, the predicted price, is also included as a variable. It is expected to have a negative relationship with the penetration rate. This variable is discussed in the following section.

A Possible Identification Problem

In any attempt to estimate a demand function when price and quantity demand vary across observations, one must suspect the possibility of an identification problem with regard to price. Therefore, a two-stage approach for estimating the penetration rate is considered. Before constructing the penetration rate model, an equation to predict the monthly price of residential service, *PRICE*, is considered. The

predicted values from this regression are then used in the regression for *PEN*. The equation below is an expression of the specification used:

$$PRICE = \beta_0 + \beta_1 (HOUSEHLD)_i + B_2 (HOUSESQR)_i + B_3 (PRURAL)_i + \sum_k \beta_k (COMPANY_k)_i + \phi_i$$

Descriptive statistics for this regression are shown in Table 2. The values for the dependent variable, *PRICE*, were taken from public information supplied by the Tennessee Regulatory Authority. The chosen regression reflects the traditional "value of service" approach in setting telephone rates. For exchanges with a larger number of households, there is a greater value in local phone service, *ceteris paribus*, because a larger number of households can be reached through local phone service. Therefore, we expect higher prices for exchanges with more households. The household-squared term is included in order to reflect possible nonlinear effects. The *PRURAL* variable is expected to have a negative impact on price. For exchanges with a large percentage of rural households, we expect a lower price reflecting a lower value due to the lower population served. A dummy variable for each company ($Company_k$) is used, with the exception of South Central Bell, in order to reflect differences per company that are not easily quantifiable. South Central Bell is omitted such that the estimated coefficients reflect the effect of company *k* relative to South Central Bell.

Digression Concerning Descriptive Statistics

In examining the descriptive statistics, it is easy to see that they vary considerably from statistics for Tennessee as a whole. A few examples serve to make this point. The 1990 penetration rate for Tennessee was 92.9%. However, our sample mean is 91.1%. For the state, the percentage of persons age 25 or older with an education level of less than a high school diploma was 32.9%. Our sample mean is 40.7%. The percentage of households served by South Central Bell in 1990 was 78.3%. Our sample mean is 47.5%. These differences are due to the aggregation of the data. Less populated exchanges are given the same weight as the more populated ones. Though it would be preferable to have an aggregation that would line up closely with the state statistics, such differences would most likely be apparent using any area boundaries.

TABLE 2: DEFINITIONS AND DESCRIPTIVE STATISTICS
Dependent variable: PRICE Number of observations: 316

Variable	Definition	Exp. Sign	Mean	Std Dev
PRICE	Monthly price of local residential service	Dependent variable	10.387	2.013
AARD	Ardmore Telephone Co., Inc.	?	0.006	0.079
BLRT	Ben Lomand Rural Telephone Cooperative, Inc.	?	0.047	0.213
BLED	Bledsoe Telephone Cooperative	?	0.016	0.125
CENA	Century Telephone Of Adamsville	?	0.009	0.097
CENC	Century Telephone Of Claiborne	?	0.006	0.079
CENO	Century Telephone Of Ooltewah – Collegedale	?	0.009	0.097
CITT	Citizens Telecomm. Co. Of Tennessee	?	0.041	0.199
CTVS	Citizens Telecomm. Co. Of The Volunteer State	?	0.016	0.125
CONC	Concord Telephone Exchange, Inc.	?	0.003	0.056
CROC	Crockett Telephone Co., Inc.	?	0.006	0.079
DEKA	Dekalb Telephone Cooperative	?	0.032	0.175
HIGH	Highland Telephone Cooperative, Inc.	?	0.025	0.157
HUMP	Humphreys County Telephone Co.	?	0.003	0.056
LORE	Loretto Telephone Co., Inc.	?	0.016	0.125
MILL	Millington Telephone Co., Inc.	?	0.022	0.147
NOCE	North Central Telephone Cooperative, Inc.	?	0.025	0.157
PEOP	Peoples Telephone Co., Inc.	?	0.009	0.097
(omitted)	South Central Bell	(omitted)	0.475	0.499
TELLICO	Tellico Telephone Co., Inc.	?	0.022	0.147
TENTELCO	Tennessee Telephone Co.	?	0.044	0.206
TWLA	Twin Lakes Telephone Cooperative Corp.	?	0.047	0.213
UNIMT	United Inter-Mountain Telephone	?	0.066	0.249
UNITEL	United Telephone Co., Inc.	?	0.025	0.157
WESTCO	West Tennessee Telephone Co., Inc.	?	0.013	0.112
YORK	Yorkville Telephone Cooperative	?	0.013	0.112
HOUSEHLD	Number of households in hundreds	+	58.181	215.159
HOUSESQR	HOUSEHLD squared	?	49,532.000	514,769.080
PRURAL	Proportion of rural housing units	-	0.809	0.278

Testing For an Identification Problem

Before proceeding with the price regression, a Hausman specification test is used to determine if this is a proper approach. (Pindyk and Rubinfeld 1998:197-198) This procedure involves two regressions. In the regression displayed in Table 3, price is used as the dependent variable. Independent variables from both proposed stages are included as independent variables in this regression. The variables *LINKPOV* and

HAUSMAN SPECIFICATION TEST
TABLE 3
PRICE REGRESSION
DEPENDENT VARIABLE: PRICE

VARIABLE	COEFF.	T-STAT	P-VALUE
INTERCEP	6.82	4.11	0.00
PUNEDUC	-0.77	-0.44	0.66
PBLACK	-2.07	-1.89	0.06
PLINGISO	-7.37	-0.16	0.88
PRENT	-3.19	-1.82	0.07
PRURAL	0.00	0.00	1.00
HOUSEHLD	0.00	2.46	0.01
HOUSESQR	0.00	-1.72	0.09
MEDHHI	0.13	4.44	0.00
PPOV1824	12.99	1.34	0.18
PPOV2534	6.63	0.85	0.40
PPOV3544	6.23	0.65	0.52
PPOV4554	10.77	1.00	0.32
PPOV5564	4.41	0.41	0.68
PPOV6574	-3.50	-0.37	0.71
PPOV75UP	-18.40	-2.24	0.03
AARD	0.23	0.25	0.80
BLRT	0.12	0.31	0.76
BLED	2.79	4.57	0.00
CENA	3.51	4.47	0.00
CENC	4.75	4.84	0.00
CENO	0.97	1.20	0.23
CITT	0.62	1.55	0.12
CTVS	0.75	1.22	0.22
CONC	-2.21	-1.58	0.11
CROC	1.18	1.24	0.22
DEKA	3.47	7.68	0.00
HIGH	0.04	0.09	0.93
HUMP	-5.24	-3.92	0.00
LORE	4.01	6.18	0.00
MILL	3.32	5.83	0.00
NOCE	2.54	4.99	0.00
PEOP	-2.53	-3.25	0.00
TELLICO	2.92	5.17	0.00
TENTELCO	2.67	6.95	0.00
TWLA	1.28	3.26	0.00
UNIMT	1.52	4.70	0.00
UNITEL	0.97	1.92	0.06
WESTCO	-2.85	-4.15	0.00
YORK	1.54	2.21	0.03
R-square	0.6328		

White's Heteroskedasticity test
Chi-square 269.62 p-value 0.92

TABLE 4
RESULTS OF HAUSMAN TEST
DEPENDENT VARIABLE: PEN

VARIABLE	COEFF.	T-STAT	P-VALUE
INTERCEP	102.57	33.36	0.00
PUNEDUC	-10.89	-3.332	0.00
PBLACK	-0.87	-0.424	0.67
POTHRACE	23.62	0.73	0.47
PLINGISO	138.20	1.584	0.11
PRENT	-12.17	-3.664	0.00
PRURAL	-1.04	-1.225	0.22
HOUSEHLD	4.21×10^{-3}	1.563	0.12
HOUSESQR	-9.36×10^{-7}	-0.899	0.37
MEDHHI	0.10	1.778	0.08
PPOV1824	-26.38	-1.424	0.16
PPOV2534	-54.27	-3.641	0.00
PPOV3544	-8.77	-0.503	0.62
PPOV4554	-108.46	-5.257	0.00
PPOV5564	-40.42	-1.927	0.05
PPOV6574	15.93	0.868	0.39
PPOV75UP	0.34	0.021	0.98
PRICE	-0.29	-2.56	0.01
RESID	***0.30***	***1.814***	***0.07***
R-square	0.6382		

White's hetereroskedasticity test
chi-square 157.50 p-value 0.75
RESID is the residual value computed in the regression to the left.

CONNECT are not included because this would create an equation of less than full rank. The values of these two variables are determined by the company and are therefore exactly correlated with the company dummies. The residual from the regression in Table 3 is then used as an independent variable in Table 4 regression for the penetration rate. If it is found to be significant, an identification problem is determined to exist. In examining the results of this test, we find a p-value for this residual of 0.07. This correlation falls within a "gray" area. It is hard to know whether to use a predicted price in the model for the penetration rate or to use a one-stage regression with the actual price as an independent variable. This study uses the predicted price since this approach more closely follows conventional economic theory.

The Price Regression

Table 5 displays the results of the price regression. A White's test reveals that there is a problem with heteroskedasticity in this model. Several attempts to respecify the model were unsuccessful in producing a superior model to this one.[*] Therefore, the model is left as it stands. Rather than using the usual t-statistics in order to assess significance of variables, chi-square tests are performed using a consistent covariance matrix as suggested by White. (SAS Technical Support 2000; and White 1980: 820-821) The predicted values for *PRICE* are designated as *PPRICE*. See Table 1 for the univariate statistics associated with this variable.

Interpretations Of Results: Models For The Penetration Rate

Table 6 displays the results of the regressions for the penetration rate. For the variables determined to be significant, the coefficients have the expected signs. It is also important to notice that all of the predicted values for *PEN* fall between the range of 0-100%. Similar studies have made use of models other than linear ones because predicted values have extended outside of this range. However, there does not seem to be such a problem with the models of this study.

Race and linguistic isolation variables do not appear to be significant. Of course, one must be cautious in interpreting such results. Due to the level of aggregation, the effects of these variables

[*] Attempted respecifications of the price model included using various cost figures for the companies in place of the dummy variables, converting variables to their logs, use of interaction terms, and weighting the model by the either the square root of the *PPRICE*, *HOUSEHLD*, or *HOUSESQR*. These methods were all inferior because they either did not remove the heteroskedasticity problem or they produced an R-squared value that was very low.

may be "washed out." Minorities may be concentrated in exchanges where the overall penetration rate is mitigated by other variables. For races other than White or Black, the mean is only 0.5%; for those with linguistic isolation, the mean is only 0.4%. Therefore, it is understandable that these minorities would have little influence on the penetration rate.

It is interesting that *PRURAL* has a significant negative effect and that *HOUSEHLD* appears as

TABLE 5
DEPENDENT VARIABLE: PRICE
NUMBER OF OBSERVATIONS: 316

VARIABLE	COEFFICIENT	CHI-SQUARE*	P-VALUE
INTERCEP	9.94	530.41	0.00
AARD	0.38	3.90	0.05
BLRT	0.44	5.21	0.02
BLED	2.58	176.88	0.00
CENA	3.40	304.81	0.00
CENC	5.08	123.03	0.00
CENO	2.22	82.80	0.00
CITT	0.29	2.34	0.13
CTVS	1.26	9.19	0.00
CONC	1.75	39.77	0.00
CROC	1.29	44.27	0.00
DEKA	3.48	332.60	0.00
HIGH	0.18	0.92	0.34
HUMP	-3.99	425.79	0.00
LORE	4.11	425.79	0.00
MILL	3.37	62.95	0.00
NOCE	2.61	187.93	0.00
PEOP	-2.58	177.47	0.00
TELLICO	2.85	157.39	0.00
TENTELCO	2.81	56.08	0.00
TWLA	1.21	41.02	0.00
UNIMT	1.71	34.63	0.00
UNITEL	2.11	10.04	0.00
WESTCO	-3.38	305.60	0.00
YORK	1.62	70.27	0.00
HOUSEHLD	3.94E-03	10.51	0.00
HOUSESQR	-1.17E-06	7.57	0.01
PRURAL	-0.73	2.37	0.12

R-square 0.4964
White's heteroskedasticity test:
Chi-squrare 183.34 p-value 0.00
*Chi-sqare test of parameters using consistent covariance matrix as suggested by White.

TABLE 6: MODELS FOR PENETRATION RATE

DEPENDENT VARIABLE: PEN
NUMBER OF OBSERVATIONS: 249

VARIABLE	MODEL A COEFFICIENT (T-STAT)	MODEL B COEFFICIENT (T-STAT)	MODEL B ELASTICITIES
INTERCEPT	106.66	106.93	
	(31.09)	(-93.68)	
PUNEDUC	-9.94	-11.65	-0.052
	(-2.69)	(-5.06)	
POTHRACE	0.30		
	(0.01)		
PBLACK	-2.19		
	(-1.11)		
PLINGISO	101.14		
	(1.13)		
PRENT	-13.87	-13.61	-0.034
	(-3.97)	(-5.10)	
PRURAL	-1.89	-2.22	-0.019
	(-2.27)	(-2.96)	
HOUSEHLD	3.27×10^{-3}		
	(1.32)		
HOUSESQR	-5.94×10^{-7}		
	(-0.62)		
MEDHHI	0.01		
	(0.12)		
PPOV1824	-12.89		
	(-0.58)		
PPOV2534	-43.98	-49.35	-0.015
	(-2.65)	(-3.38)	
PPOV3544	0.47		
	(0.02)		
PPOV4554	-135.48	-139.61	-0.023
	(-5.66)	(-6.52)	
PPOV5564	-70.94	-74.99	-0.015
	(-3.15)	(-3.54)	
PPOV6574	-11.84		
	(-0.53)		
PPOV75UP	7.82		
	(0.43)		

(Table 6 continued on next page)

TABLE 6 CONTINUED

LINKPOV		-0.58		
		(-0.92)		
CONNECT		-0.05	-0.06	-0.018
		(-2.25)	(-3.30)	
PPRICE		-0.14		
		(-1.06)		
R-square		0.6720	0.6561	
White's heterosk test:				
Chi-square		202.26	41.16	
(p-value)		(0.60)	(0.22)	
Predicted value of PEN				
	Mean	91.08	91.08	
	Std. Dev.	3.26	3.22	
	Min.	79.28	80.14	
	Max.	99.61	99.69	

F-test, H_0: Coefficients of variables omitted from Model A to form Model B
Are jointly zero: 0.093 < critical value 1.75 at .05 significance level
Elasticities are computed using sample means of independent variables.
Predicted value of PEN for Model B computed with this point = 90.99.
Elasticity ≈ Coeff X (Mean of independent variable) / (Predited value of PEN)

insignificant. This may be due to factors that work against each other as explained in the *ex ante* discussion. It is actually not very surprising that median household income appears as insignificant. Since low penetration rates are exceptional, median household income should be a factor only when it is exceptionally low.

The poverty variables yield some surprising results. Attempts to explain them are very speculative. The younger groups were expected to be the most significant. However, the youngest group, *PPOV1824*, appears as insignificant. This group may see a telephone as being very important. As people mature into their late twenties and early thirties, budgetary constraints for impoverished persons are learned "in the school of hard knocks." Thus, *PPOV2534* would be significant. The gap of apparent insignificance in *PPOV3544* is indeed strange. From our background study, it is not surprising that groups 65 and older appear as insignificant.

It is not surprising that *LINKPOV* shows up as insignificant. In 1990, the Link-up program had only been in place for two years. Eight companies were not participating and have total dollar amounts

factored in at $0. Other companies had very small figures. This variable had little chance of being influential.

Connection fees, as expected, show up as significant. There is a good chance that they are even more significant than the model would suggest. As noted, there are only 16 values for this variable. These 16 values are applied to 249 exchanges. The same figure for *CONNECT* may apply to many contiguous exchanges. *CONNECT* cannot possibly explain variation in the penetration rate within a company's service area. If, for example, we were studying observations by company across the United States, a variable such as *CONNECT* would have the opportunity to be more significant.

Caution is advised in interpreting the significance of *PPRICE*. With this variable, there is a similar problem to that of *CONNECT*. Across the sample there were 43 rates for monthly residential service. The same figure for the price may apply to many contiguous exchanges. For example, there were 48 exchanges that had a price of $7.55. The predicted price, *PPRICE*, from the price regression, is a unique value for each observation. However, the fundamentals behind *PPRICE* are suspect. The R-square value for the price regression is only 0.4964. The existence of heteroskedasticity in the model also points to a possible problem with specification.

All of the significant variables have small point elasticities when using the means of the independent variables. This is to be expected since low penetration rates are exceptional. Small variations around the mean values would be expected to have little impact. It may be of greater interest to consider an extreme value for a particular independent variable while keeping the other independent variables constant at their means. For example, the model predicts that raising *CONNECT* from its mean of $27.40 by two standard deviations to $44.96 reduces the penetration rate by about 1 percentage point. For an average exchange of 7,036 households, this would mean that about 74 households would be priced out of the market. The variable that produces the greatest difference is *PPOV4554*. Elevating this variable by 2 standard deviations takes about 2.5 percentage points off of the penetration rate. For the average exchange of 7,036 households, this translates into about 177 households.

CONCLUDING REMARKS

This study sheds some light on the demographic aspects of the penetration rate. This may be helpful in determining how to best target Lifeline and Link-up promotional efforts. Although such efforts

should consider all for whom these programs are eligible, this study suggests promotional emphasis for those people below the poverty level who fall between the ages of 25 to 34 and 45 to 64. The significance of the education level in the study underscores the need for public information concerning Lifeline and Link-up to be written in easy-to-read language. Furthermore, promotional efforts should be more heavily emphasized in rural areas and in those areas where there are a large proportion of renters.

Connection fees vary widely from one company to another. This study indicates that connection fees are an important factor in the penetration rate. This study suggests that the Tennessee Regulatory Authority place emphasis on this factor with regard to universal service objectives.

Although this study was unable to assess the impact of credit policies on the penetration rate, the survey points to a potentially troubling aspect of these policies. As stated, some of the companies appear to have very subjective credit policies. Although flexibility is important, policies that are highly subjective are more prone to conscious or unconscious discrimination of one form or another. Although it would clearly not be in the state's interest for a regulatory agency to micro-manage the credit policies of telephone companies, perhaps credit policies need to be more closely examined to assure fair standards. Of course, companies should not be exposed to undue credit risk in order to meet any particular goal for the penetration rate.

Finally, this study may serve as a benchmark to use for comparison to the present situation. There have been several potentially significant changes in telephony since 1990. In 1992, Tennessee was certified for the Lifeline program. Since 1990, participation in the Link-up program has increased. This study may help to evaluate effectiveness of these programs. Local calling areas have changed since 1990. For example, Tennessee now has countywide toll-free calling. Competition in local markets has begun as allowed by the Telecommunications Act of 1996. Long distance rates have also come down as competition has intensified. This study may help to evaluate changes in the penetration rate in conjunction with these developments.

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