9

Telephone Penetration

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Like the comet Kahoutek and Sherlock Holmes' dog that did not bark, the most notable effect of divestiture on universal telephone service is what did *not* happen. Despite dire predictions of massive reductions in subscribership, the single largest restructuring of the U.S. telecommunications industry occurred without a visible effect on the percentage of households subscribing to telephone service or having access to a telephone. Since divestiture was accompanied by significant changes in rate structure which shifted costs from usage to access, the fact that subscribership remained largely unchanged over the period is something of a paradox.

Almost all observers of the data agree that penetration, even (espe-

cially) among disadvantaged demographic subgroups, has continued to rise since divestiture. On the other hand, some disagreement concerning the effect of divestiture (and associated rate changes) on penetration arises from three observations: the level of penetration may be too low for some demographic subgroups and the rate of growth of overall penetration may have slowed since divestiture; the implementation of federal SLCs may have reduced the level of penetration below what it otherwise might have been; and the aggregate nature of census statistics may not reveal geographic or demographic pockets in which penetration rates might be deteriorating.

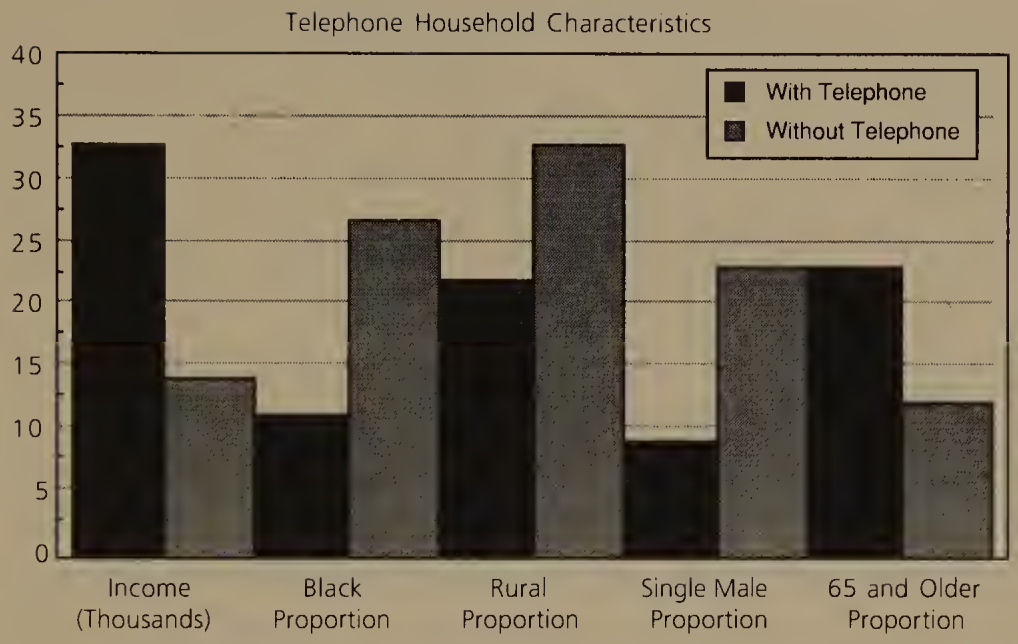
We will explore three areas of inquiry: what do the current population survey (CPS) statistics and other aggregate statistics collected in the FCC "Monitoring Reports"[1] actually show about the level and change in penetration since divestiture; what changes in the environment over the post-divestiture period explain these changes in demand, and what would be the level of penetration today if divestiture (and related rate changes) had not occurred; and to what extent are analyses based on aggregate statistics—such as those produced by the Census Bureau or the series of FCC "Monitoring Reports"—inadequate to monitor the state of universal service.

Despite significant increases in residential access charges, telephone penetration—as measured by the CPS—has actually risen since divestiture. In March 1984, 91.8 percent of all U.S. households had telephone service; by March 1987, penetration had risen to 92.5 percent, and by March 1990 to 93.3 percent.[2] This change represents nearly a 10 percent drop in the number of U.S. households *without* phones, and thus it reflects a significant improvement in overall telephone availability. This outcome is quite surprising because, at divestiture, widespread increases in monthly residential access charges, due to local rate increases as well as the federal subscriber line charge, were expected by some analysts to threaten universal service.[3]

If the 6.7 percent of households without telephone service in March 1990 were average households—so that the incidence of nonsubscription were distributed uniformly among all economic and demographic groups—there would be little need to worry about universal service. However, the low level of aggregate nonsubscription hides nonsubscription rates significantly above 10 percent for identifiable subgroups of the population, and much of the concern about post-divestiture subscription rates focuses on these subgroups.

In March 1987, who did not subscribe to telephone service? As shown in figure 9.1, nonsubscribing households are more likely to be rural, black, low-income, and comprised of a single male than subscrib-

FIGURE 9.1



ing households. Nonsubscription rates fall sharply with income (from about 24 percent below $5,000 to above 98 percent above $30,000) and with age (from about 20 percent for household heads between 16 and 24 years of age to about 95 percent for households older than 55) as shown in figures 9.2 and 9.3. To place these levels in context, note that

FIGURE 9.2

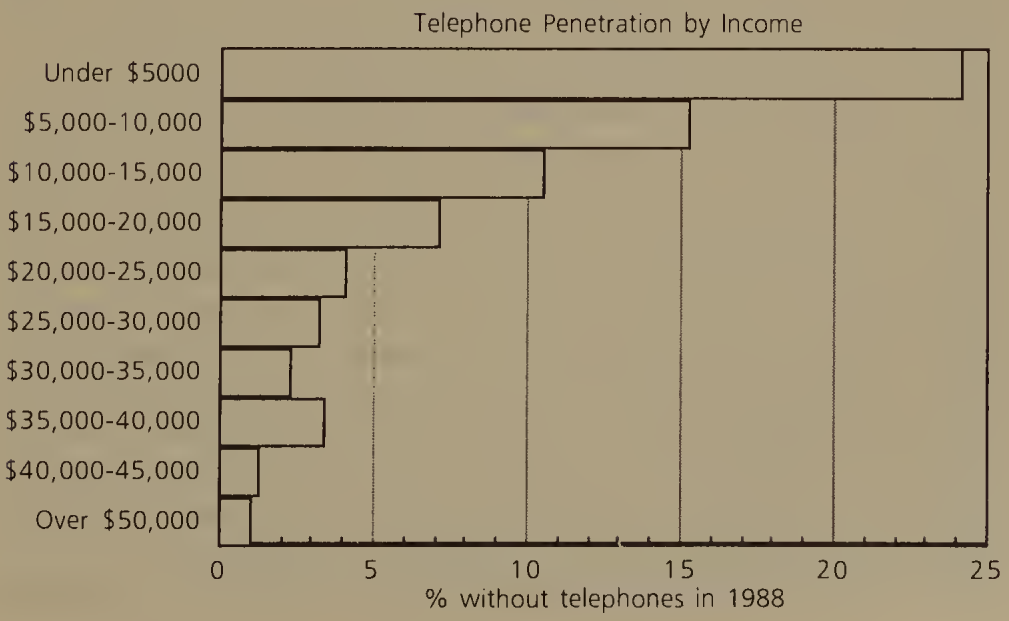
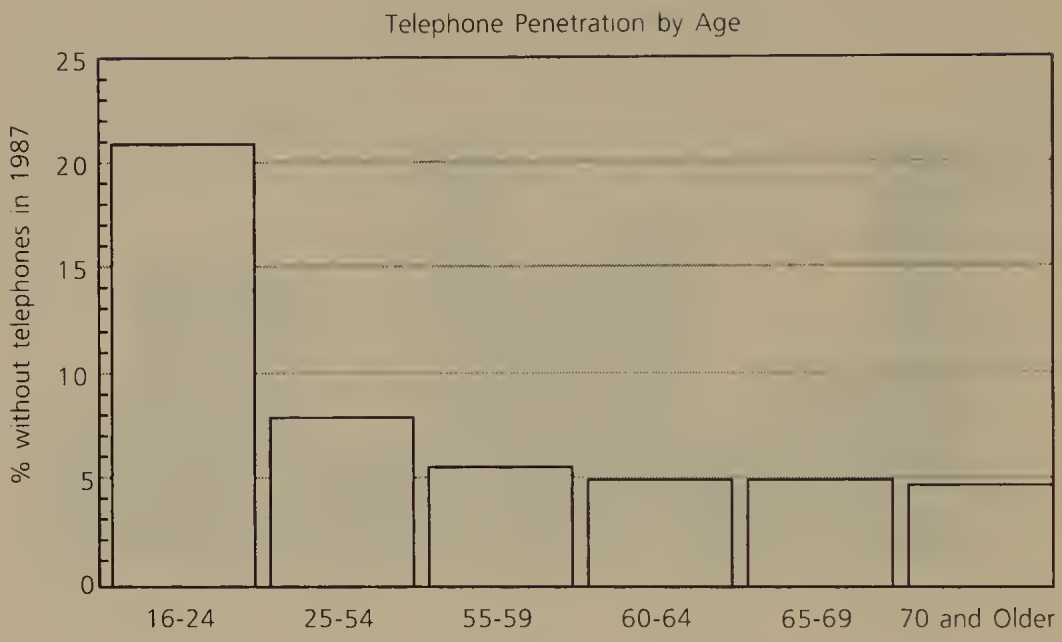


FIGURE 9.3

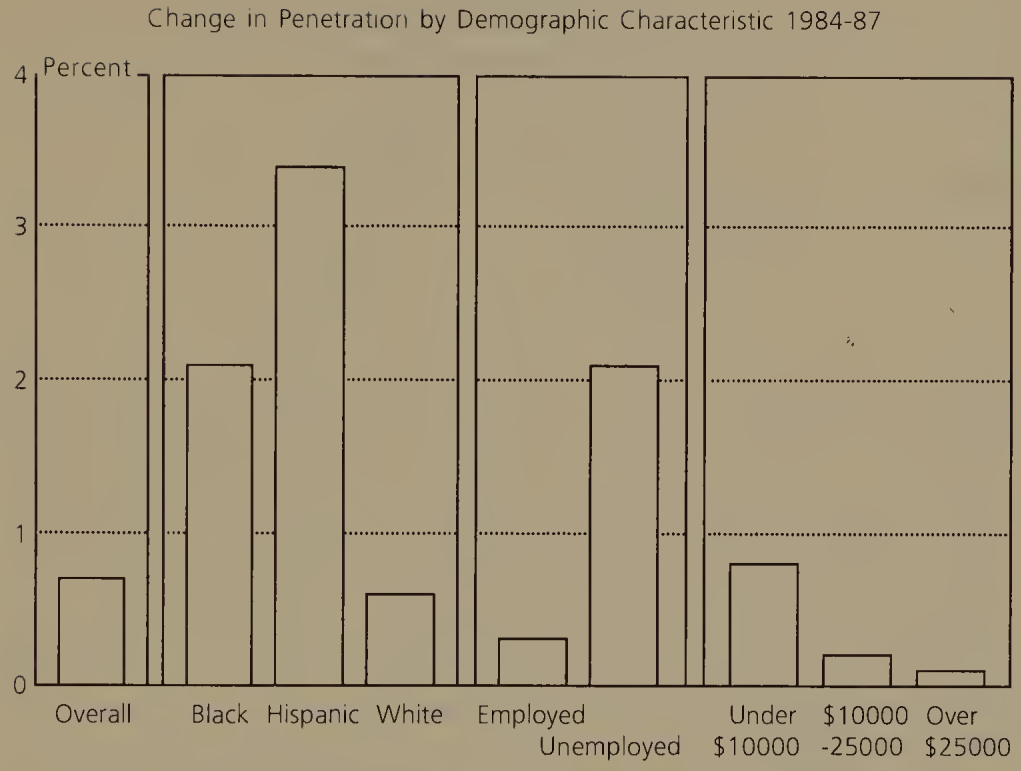


telephone nonsubscription as measured by the decennial census has ranged from 25.2 percent in 1960 to 12.8 percent in 1970 to 7.1 percent in 1980, so that the nonsubscription rate for the poorest segment of the population in 1988 was about the same as the average nonsubscription in 1960.

In the three years immediately following divestiture, not only did penetration increase on average, but, perhaps surprisingly, penetration increased most among demographic groups having the lowest initial penetration. This is illustrated in figure 9.4. While penetration increased by about 0.7 percentage points on average, it increased by over 2.1 percentage points for blacks and 3.4 percentage points for families of Hispanic origin. The increase for employed household heads was about 0.3 percentage points, compared with a 2.1 percentage point increase for unemployed household heads. An equally striking result emerges when we examine changes in penetration by income level. For those with incomes under $10,000, the increase in penetration between 1984 and 1987 was about 0.8 percentage points. For those with incomes between $10,000 and $25,000, the increase was approximately 0.2 percentage points, and for those with incomes over $25,000, there was virtually no change in penetration. Since penetration has increased most where penetration rates were lowest at the outset, this pattern mitigates distributional concerns about universal service.

Even though penetration continued to rise over the post-divestiture

FIGURE 9.4



period, there may be some concern that it is rising at a diminishing rate; indeed there is some evidence that penetration actually fell between 1980 and 1983, as measured by the decennial census and the CPS respectively. Of course, since penetration is bounded by 1.0, it cannot continue to increase at a constant rate. For this reason, it is more appropriate to examine the rate of decline of nonsubscription, as opposed to the rate of increase of penetration. By this measure, there has been a small secular decline in the rate of progress towards universal service, although, as table 9.1 indicates, the decline began well before divestiture. Note that this comparison ignores differences in sampling methodologies across the decennial censuses, but does not require that the census methods be comparable to those of the CPS.

Notwithstanding a reduction in the rate of decrease of non-subscription, the pattern of change in penetration levels between 1984 and 1987 was not what was expected to occur following divestiture. At that time, two indepcndent effects of separating the ownership of the local and long-distance networks were thought to have serious consequences for universal services. First, the requirement that the local and long-distance networks interact at arm's length through access tariffs meant

TABLE 9.1
Annual Rate of Growth
of Nonsubscription

Period	*Growth*
1960–1970	−6.6%
1970–1980	−5.7%
11/83–7/88	−5.0%

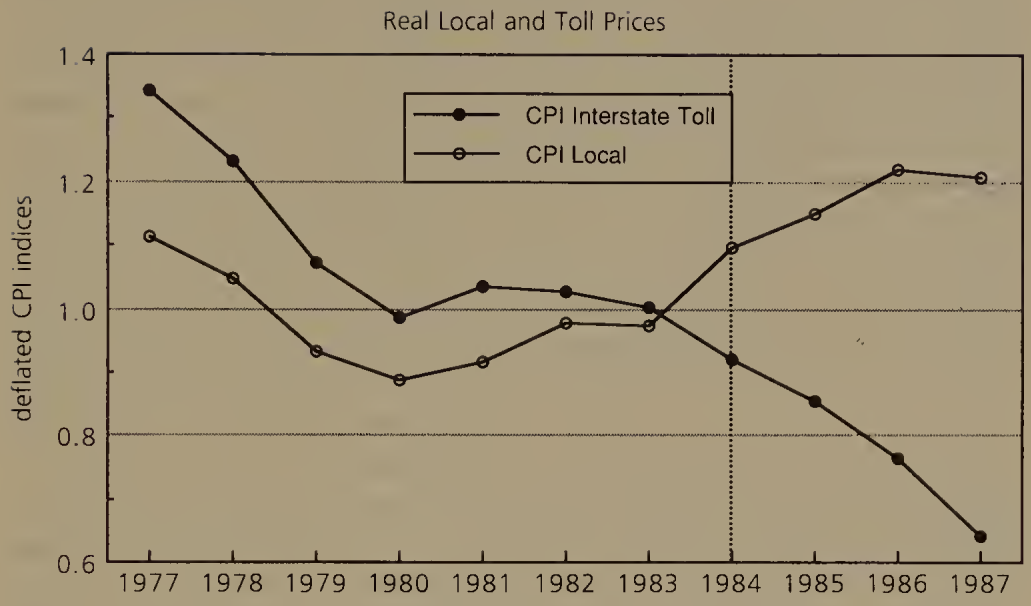
that the traditional support for local rates from toll rates would become difficult to sustain.[4] As a result, the FCC felt compelled to reduce the amount of interstate costs of the local network recovered from usage-based charges, and increase the amount of those costs recovered in monthly charges from subscribers. These residential subscriber line charges were implemented on June 1, 1985 at $1.00 per month, were increased to $2.00 per month one year later, and rose to $2.60 on July 1, 1987. During a period in which flat-rate local service prices averaged about $13 per month, the SLCs represented a significant increase in the price of residential access.

Second, the financial prospects for the LECs were thought to be questionable, and a number of state rate cases had been delayed due to divestiture. As a result, intrastate rates were increased by roughly $4 billion in 1984, resulting in an unusually high increase in local service rates. The combined effect of these factors is shown in figure 9.5, in which it is apparent that the real increase in local rates began before divestiture. Indeed, the real annual rate of growth of local rates between 1980 and 1984 exceeded the rate of growth between 1984 and 1987, as measured by the CPI. It is thus difficult to attribute local rate increases between 1984 and 1987 entirely to divestiture per se, and it is probably accurate to say that local rates increased much less than was forecast at the time.

In summary, the effect of divestiture and its concomitant rebalancing of local and long-distance rates on the level of penetration is nearly unobservable. Since local rates rose dramatically since 1980, this observation comes as something of a surprise to an economist, and one must look elsewhere to find other changes in the environment which offset the effects of local rate increases during this period.

There are several likely reasons for the relative stability of the penetration rate since divestiture. *First,* the increase in basic service charges has probably been less than anticipated. It was commonly thought that

FIGURE 9.5



rate restructuring following divestiture would raise basic service charges by 50 to 100 percent. But, because it proved impolitic to shift all non-traffic-sensitive costs into basic service charges, actual increases to date have been under 30 percent. *Second,* the decreases in penetration that might otherwise have been caused by rising basic service charges have been offset by changes in income and other demographic characteristics. Increases in income and the age of household heads have generally led to increases in telephone penetration. *Third,* exogenous increases in demand for telephone service may have served to offset price trends. For example, from 1970 to 1980 changes in taste increased demand by roughly four percentage points. Continuation of these trends would cause a significant increase in demand in the 1980s, thereby further offsetting effects of rate increases. *Fourth,* long-distance rates fell significantly, and since access and usage are complementary goods, demand for access increased. *Finally,* changes in the structure of telephone prices may have mitigated the effects of price increases. In particular, there has been a significant increase in the availability of local measured service. Since this reduces the minimum price at which access is available, this change tends to offset the effect of any general increases in the price level. There also has been some increase in the availability of lifeline service, which has reduced the cost of telephone service for the low-income households most likely to be adversely affected by any rate increases.

To examine these influences quantitatively, we have made use of NERA's (National Economic Research Associates) 1983 access demand model[5] which relates the demand for telephone service to price, income, and demographic characteristics. This model has been used here to predict changes in penetration which might be expected to occur from 1984 to 1987 as a result of changes in price, income and demographic characteristics, and changes in taste for phone service. By comparing predicted with actual changes in penetration over this period, we can see how well the model accounts for the changes which actually occurred. If the model predicts actual changes accurately, we can determine the change in penetration which would have occurred under various assumptions about the rate of growth of basic service charges.[6]

The application of the model to explain the change in penetration over the post-divestiture period is summarized in table 9.2. For each of the key factors influencing penetration, this table describes its percentage increase or decrease from 1984 to 1987 and the effect of this change on the penetration rate. The model suggests that, taken in isolation, the increase in telephone prices occurring over this period was associated with about a 0.8 percentage point *decrease* in the fraction of

TABLE 9.2
Change in Penetration from 1984 to 1987

	Change in Characteristic	*Change in Penetration*	*Cumulative Penetration*
Actual Penetration in 1984			91.80%
(1) Prices			
Measured rate price	16.6%		
Flat-rate price	16.6%		
Installation charge	1.8%	−0.80%	90.99%
(2) Income	10.1%	0.85%	91.84%
(3) Demographics			
Age	0.2%	+0.03%	
Proportion black	2.8%	−0.01%	
Number of persons	−1.1%	+0.01%	
Income/Age	0.2%	−0.20%	
Total		−0.16%	91.68%
(4) Historical trend	—	0.95%	92.63%
(5) Measured-rate availability	12.2%	0.02%	92.65%
(6) Total predicted	—	0.85%	92.65%
Actual Penetration in 1987	—	0.70%	92.50%

households with phones. On the other hand, the 10 percent real increase in income from 1984 to 1987 would have been expected to increase penetration by about 0.85 percentage points, more than offsetting the price effect. In addition, other demographic changes, principally the aging of household heads offset by the interaction of age and income, causes penetration to fall about 0.16 percentage points.[7] Finally, the continuation of the 1970 to 1980 trend in telephone demand would account for a 0.95 percentage point rise in penetration from 1984 to 1987. In combination, these factors would predict about a 0.8 percentage point rise in penetration compared with the 0.7 percentage point rise which actually occurred. The consistency between this prediction and the actual change occurring gives us some confidence in this model of telephone demand.[8]

While we have not tried to quantify their effects, other factors could account for any remaining difference between actual and predicted changes. *First,* there was some increase in the availability of lifeline rates over this period, and this may have offset the effect of rising charges for low-income consumers. *Second,* there may have been some narrowing of income distribution from 1984 to 1987. This often occurs during upswings in economic activity. If income were rising somewhat faster for low than for high-income groups, income effects would be somewhat larger than that described above. *Finally,* there was a significant decline in toll rates over the period and since access and toll usage are complementary services, this rate reduction would mitigate some of the effects of the increase in local rates.

Although they were more than offset by other forces, these data suggest that price changes did cause some decrease in penetration. Thus, had prices not risen, 1987 penetration would have been 93.3 instead of 92.5 percent. How should this be viewed? Some clearly feel that any decrease in penetration or potential penetration is to be deplored. Others (ourselves included), would argue that since the price changes did not decrease penetration, but merely slowed its growth, they are of less concern. Thus, despite the price increases, the 1987 share of households with phones is higher than in 1984 and about even with the level observed in the 1980 census. In fact, since the census and CPS surveys are somewhat different, when adjusted for differences in the sampling approach, penetration in 1987 may in fact be higher than in 1980. Moreover, this slowdown in the growth in penetration must be viewed in context. It occurred because rates became more closely aligned with cost, and this has resulted in substantial increases in the overall value of phone service. As we have argued elsewhere,[9] the price changes occurring from 1984 to 1987 have increased the value

of phone service to the *average* consumer by nearly $4.68 per month, and any losses in penetration must be balanced against these gains.

The link between divestiture per se and penetration rates is federal subscriber line charges. From a residential consumer's perspective, these charges had the same effect as an increase in local rates, and the implicit increase was quite significant. From divestiture to April 1987, these charges rose $2.00 (not counting intrastate SLCs enacted by some state commissions) which represents roughly a 17 percent increase in the flat-rate price and a 28 percent increase in the measured-rate price. Thus, one clear measure of the effect of divestiture on universal service is the effect on penetration of SLCs, holding all other variables at their observed levels.

This calculation is presented in line (1) of table 9.3. When the $2.08 federal and state SLCs are removed from the estimated 1987 rates, predicted penetration in 1987 rises by 0.76 percentage points. In March 1987, there were approximately 90.2 million households in the United States, so that a penetration increase of 0.76 percentage points would represent approximately 686,000 additional households having access to telephone service. Whether this number is large or small depends on the perspective of the reader.

Moreover, this estimate undoubtedly overstates the adverse effect of the implementation of SLCs on the penetration rate. While SLCs increased access rates between 1984 and 1987, they also resulted in declines in interstate toll rates, which would be expected to increase the demand for access. While the existing access demand model does not relate toll prices to access demand directly, it can be used to estimate this effect.[10] Doing this suggests that about 25 percent of the effect of increased subscriber line charges is offset by the corresponding fall in toll prices. Thus the net effect of subscriber line charges was to reduce penetration by roughly 0.6 percentage points.

Instead of confining the effect of divestiture on penetration to the impact of subscriber line charges, suppose we ask what penetration would have been in March 1987 if local rates had continued to grow at their pre-divestiture rate. From 1977 to 1984, the BLS CPI-Local index fell by about 12 percent in constant dollars—an annual rate of roughly 2.5 percent. Had local rates fallen in real terms at this rate between 1984 and 1987, penetration would have been approximately 1.37 percentage points higher than under observed rate increases, as shown on line (2) of table 9.3. On the other hand, if local rates had grown at the same real rate of growth as the BLS CPI-Local index grew between 1980 and 1984,[11] penetration would have been approximately 0.22 percentage points lower than under observed rate increases. As a middle ground,

TABLE 9.3
The Effect of Residential Rate Changes on Penetration, 1984–1987

	Change in Prices	*Change in Penetration*	*1987 Predicted Penetration*
Actual Price Changes: 1984–1987		−0.80%	92.65%
Measured-rate price	16.6%		
Flat-rate price	16.6%		
Installation charge	1.8%		
(1) Eliminate state and federal subscriber line charges		−0.04%	93.41%
Measured-rate price	−5.5%		
Flat-rate price	3.2%		
Installation charge	1.8%		
Difference		0.76%	
(2) Assume access rates grow at 1977–1983 growth rate		0.57%	94.02%
All access rates	−6.68%		
Difference		1.37%	
(3) Assume access rates grow at 1980–1984 growth rate		−1.60%	91.85%
All access rates	17.2%		
Difference		−0.80%	
(4) Assume access rates remain constant in real terms		0.01%	93.46%
All access rates	0.0%		
Difference		0.81%	

if local rates had remained constant in real terms over the period, penetration would have been roughly 0.83 percentage points higher than predicted under observed rate increases.[12] Without offsets, the 44 percent increase in price from 1980 to 1987 would have reduced penetration from 93 to about 90 percent. This potential decline, however, was essentially offset by a continuation in the historic trends in demand for phone service, and to a lesser extent by increases in the age of the population and increased availability of measured service.

Thus far, we have described the effect of divestiture on universal service exclusively in terms of penetration: how penetration changed in the post-divestiture period in the aggregate and among demographic groups of concern, and what underlying factors produced that change. In this section, we assume the relevant goal of public policy is universal

service, and question our implicit reliance on the CPS penetration rates and on penetration rates in general in light of that goal. Two issues must be clearly distinguished. First, do the CPS reports provide a sufficient measure of penetration to guide regulatory policy? Second, is the penetration rate—even if available in a timely manner for all demographic or geographic groups of interest—sufficient information to gauge the state of universal service?

The telephone penetration questions asked by the CPS every four months were instituted at the request of the FCC to monitor the effects of its decisions on subscribership. The monitoring program began as Phase IV of the access charge docket (CC Docket 78-72) in response to concerns raised by the states. The decisions in question were initially SLCs, but since the implementation of the SLCs coincided with a reform in jurisdictional separations (which increased, on average, the intrastate share of loop costs), the Commission's charge was to monitor the effects of all its actions on universal service. For this broad requirement, a compilation of national survey data at four-month intervals seemed appropriate.

However, the effects of post-divestiture FCC decisions did not fall equally on all demographic or geographic groups. In separations policy, the transition of the subscriber plant factor[13] to a uniform 25 percent raised intrastate revenue requirements in some states and lowered them in others. Effects in some states for some local exchange companies were enormous, while on average, the intrastate assigned portion of NTS costs increased only about two percent. Subscriber line charges were assessed as a fixed dollar amount per line (at different rates for residential and multiline business subscribers) which represented a larger percentage increase for customers subscribing to lower-priced services: customers in small exchanges, rural customers, and measured-rate subscribers.

With these policy changes, one might expect small changes in national average penetration to mask unacceptably large changes among customers of particular LECs in particular states. And for this purpose, the CPS sample is inadequate. At a state level, the sample is too small to identify penetration changes with sufficient precision, and no information whatever is provided by telephone exchange or by serving LEC. More precisely, the sampling error in the national estimates is about 0.5 percentage points (at a 95 percent confidence level), while state-level sampling errors range from 2 to 6 percentage points, varying inversely with the square root of the sample size. The inability to detect penetration changes of this order of magnitude is a significant limitation on the usefulness of the CPS data for its intended purpose.

Penetration changes among particular demographic groups are observable at the national level, but with much less accuracy at the state level. An attractive benefit from additional sampling among demographic groups would be to enable analysts to gauge the effectiveness of federal and state programs focused on those groups: e.g., Lifeline and Link-Up America subsidies for low-income households. There is considerable variation in the implementation of these plans across the states, and if the results could be monitored with accuracy, improvements in assistance plans could probably be devised.

Measurement of penetration is difficult because the calculation requires knowledge of quantities which are not normally measured by the telephone companies. The numerator of the penetration estimate is total subscribership, not number of access lines. The denominator is number of households, which is difficult to monitor reliably between the decennial censuses.[14] Monitoring changes in the numerator (or changes in connection and disconnection rates) is relatively easy to do, but the vast majority of connects and disconnects are associated with moves or household formation, and thus do not reflect changes in penetration. Identifying and tracking involuntary disconnections is a more fruitful approach, but reports from the disconnect monitoring plan suggest involuntary disconnections are more related to general financial or personal distress than to the level of monthly access charges.

In sum, current monitoring of penetration rates is probably adequate to track national effects of state and federal policy changes, but probably inadequate to detect the type of universal service problem—if any—that might be caused by access charges or separations policy changes. Other, cheaper, monitoring measures are suggestive at best. The most straightforward solution—expanding the CPS sample—is prohibitively expensive. Fortunately, decisions concerning local rates are largely in the hands of state commissions, where benefits from subsidizing customers of particular telephone companies or particular demographic groups or geographic regions can be weighed against their costs.

Penetration technically measures the proportion of households which subscribe or have access to telephone service. However, the object of universal service must be the capacity to reach individuals, not households. In this view, additional lines beyond the first increase universal service, in that the probability of completing a call to a particular individual is increased. Lines to second homes, public telephones, and mobile telephones contribute towards universal service to individuals in the same sense. All of these methods of accessing the network are ignored by a penetration standard of universal service.

Penetration also measures the fraction of households which actually

choose to subscribe to telephone service, as opposed to the fraction for which service is available at a reasonable and affordable price. One of the largest demographic groups with low penetration is households headed by young, single males. Similarly, elderly households exhibit high levels of penetration across all income classes. Taste for telephone service, not service quality or affordability, appears to be an important determinant of demand, acting differently among different demographic groups. A better measure of universal service would differentiate between availability and actual subscription.

Finally, the use of penetration rates for households to monitor universal service ignores entirely a large segment of the telecommunications market. One of the most significant developments in the national network since divestiture is that a majority of its capacity is no longer owned or controlled by traditional common carriers. Private networks —real or virtual, facilities-based or resold—have proliferated, and an increasingly important role of the public switched network is to provide universal service—connectivity—to these customers. The arguments which justify traditional universal service as an appropriate public policy goal apply with equal force to the interconnection of networks. Measuring the penetration rates of households does not monitor this increasingly important dimension of universal service.

Bridger M. Mitchell

Why didn't the dog bark? Perl and Taylor address three questions about the availability of residential telephone service since divestiture: What has happened? What if? What should be?

Determining what has happened to telephone penetration is an exercise in accounting. The authors provide useful statistics computed from recent CPSs. In the aftermath of divestiture, two "what if" questions remain—first, what would penetration be today in the absence of divestiture? And, second, what would it have been had the initially predicted increase in local rates actually occurred? Economic analysis is required to answer these questions, and my comments will focus on that aspect of Perl and Taylor's discussion. The normative aspects of universal service—what should be—are in the category of social and political choice. They are addressed by some of the other discussants.

Household telephone penetration did not decline following divestiture—the dog did not bark—despite widely voiced prediction to the contrary. Perl and Taylor establish that penetration has, in fact, increased in the post-divestiture years.

They then examine the counterfactual scenario of no divestiture, by predicting penetration for local telephone prices that exclude the federal subscriber line charge ($2 in 1987). After accounting for lower toll prices, the authors estimate the net effect of the price change alone was to reduce penetration by about 0.6 percentage points. This effect was, however, more than offset by higher incomes, favorable demographic shifts, and most importantly, an increased taste for a telephone.

A second, and equally interesting, "what if" question concerns the quantitative predictions of the effects of divestiture made at the time that AT&T was broken up. Many public commentators and telecommunications analysts predicted the dog would at least bark, if not howl —that penetration would decline to a considerable degree.

Why were these predictions wrong? These alternative hypotheses could be tested: local telephone rates did not increase to the extent assumed by the analysts; the effect of increasing real income was not considered, or was mismeasured; specific policies have offset higher local rates—introduction of measured service and lifeline rates; or the forecasting models were fundamentally incorrect. Using their model, Perl and Taylor provide some information bearing on these hypotheses.

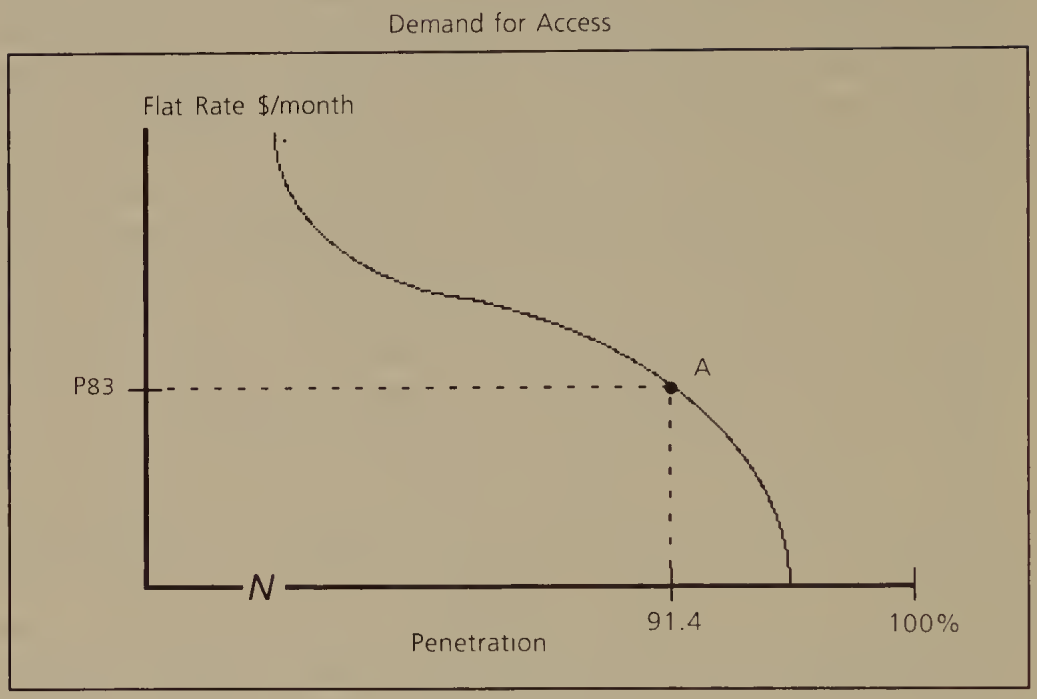
Divestiture affects penetration through telephone prices—higher local flat rates, reduced toll rates, possibly greater prevalence of measured-service rates, more widely available lifeline rates, and possibly higher connection rates. Divestiture does not affect trends in income, changes in demographic factors, and changes in tastes, the net effect of which has been to increase penetration since 1984. Thus, the task for economic analysis is to model and estimate the marginal effect of prices on telephone penetration, given the changes in penetration that would have occurred due to other factors.

Perl and Taylor rely on the model developed earlier by Perl (1983)[15] using revised estimates in Perl (1984).[16] It postulates a demand function for access to the network, and estimates the factors from 1980 census and telephone operating company data. The estimated model's predictions are then checked against actual penetration rates in 1984 and 1987.

In the Perl model, an individual household's demand for access is a logistic function of prices, income, demographic characteristics, and fraction of measured service subscribers. In addition, changes in unmeasured factors, collectively labelled "tastes," cause demand for access to shift over time.

As shown in figure 9.6, demand for access—the probability of a given household subscribing to telephone service, or the percentage of similar households who subscribe—is a decreasing function of the

FIGURE 9.6

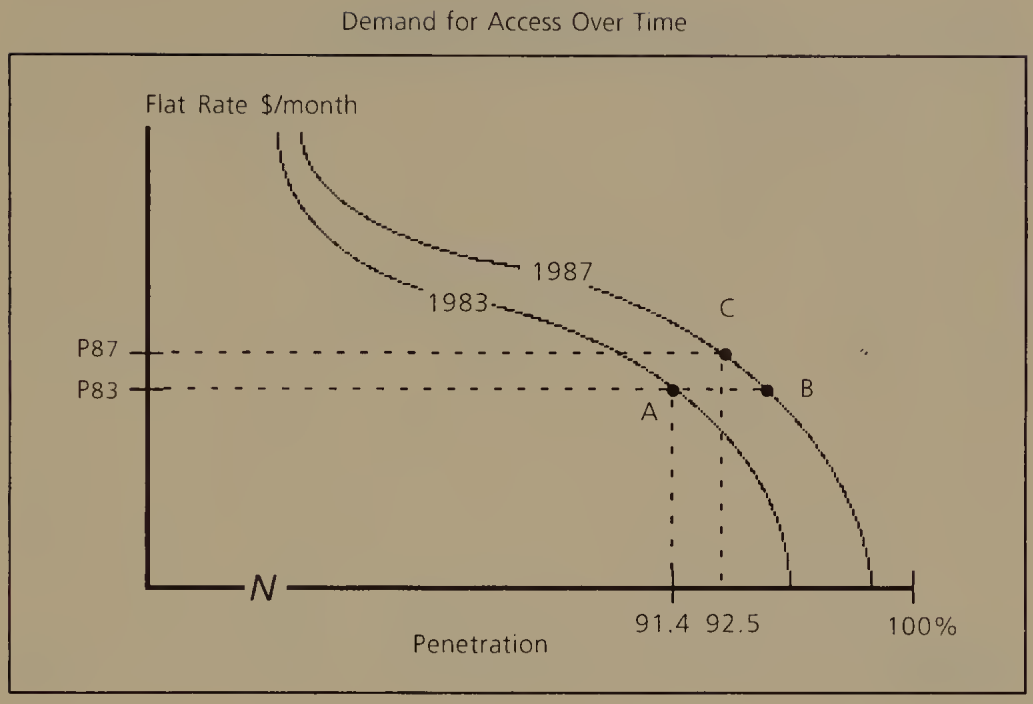


monthly flat rate. In 1984, at the average flat rate, approximately 91.8 percent of U.S. households subscribed. At lower prices, penetration would increase, but even if the price were zero, penetration would fall short of 100 percent.

By 1987, the effect of higher real incomes, an older population, other demographic changes, and an increased taste for telephone service had shifted the demand curve to the right (figure 9.7). Perl's model estimates that these exogenous changes would have increased penetration to about 93.7 percent, had the flat rate remained unchanged in real terms (point B). But the increase in the local rate moved penetration up to the demand curve (point C) and reduced it to just 92.5 percent.

Perl and Taylor's tabulation of penetration by different demographic groups reveals that, since divestiture, the net effect of all factors combined has increased actual penetration. The increase has been greatest for low-income, nonwhite, and unemployed households (figure 9.4, p. 361)—generally, the groups with the lowest overall penetration. Since the local telephone rates paid by these groups rose during this period, it is non-price factors that have had the predominant effect on penetration. In terms of figure 9.7, the data suggest that access demand curves have shifted outward more rapidly for the lowest-penetration groups.

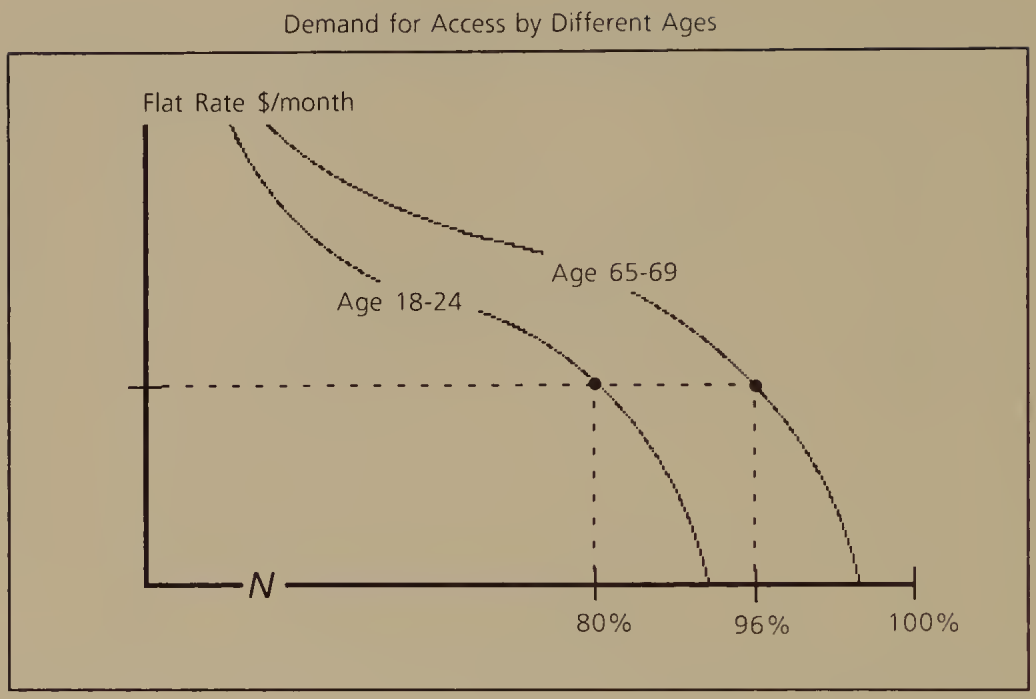
FIGURE 9.7



The extent to which a change in local rates affects penetration also appears to vary by income and by demographic group. For example, figure 9.8 shows the access demand curves for households with a head aged 18–24 and those with a head aged 65–69. In 1984, at the then-prevailing flat rates, only 78 percent of the younger households had a telephone, compared with some 96 percent of those age 65–69. The Perl model predicts, at a zero price, penetration would increase to 92.6 percent for those 18–24 and to 99.7 percent for those 65–69. This larger percentage increase in the predicted penetration for the younger group appears to be similar to the nonprice effect just discussed—a greater increase in penetration observed in the low-penetration groups in the 1984–1987 data. In fact, it is a consequence of the logistic functional form of the demand curve. Both age groups—and indeed all households—are assumed to have the same underlying coefficient of price-responsiveness.

In this model, when two groups of households pay the same prices, the group that has the lower penetration rate in 1984 will also have the lower rate in 1987. Furthermore, the model implies that service will always be less "universal" among younger households, even if local telephone service were free. To put it differently, in this model the effect of a lower (or higher) telephone price depends only on the group's

FIGURE 9.8



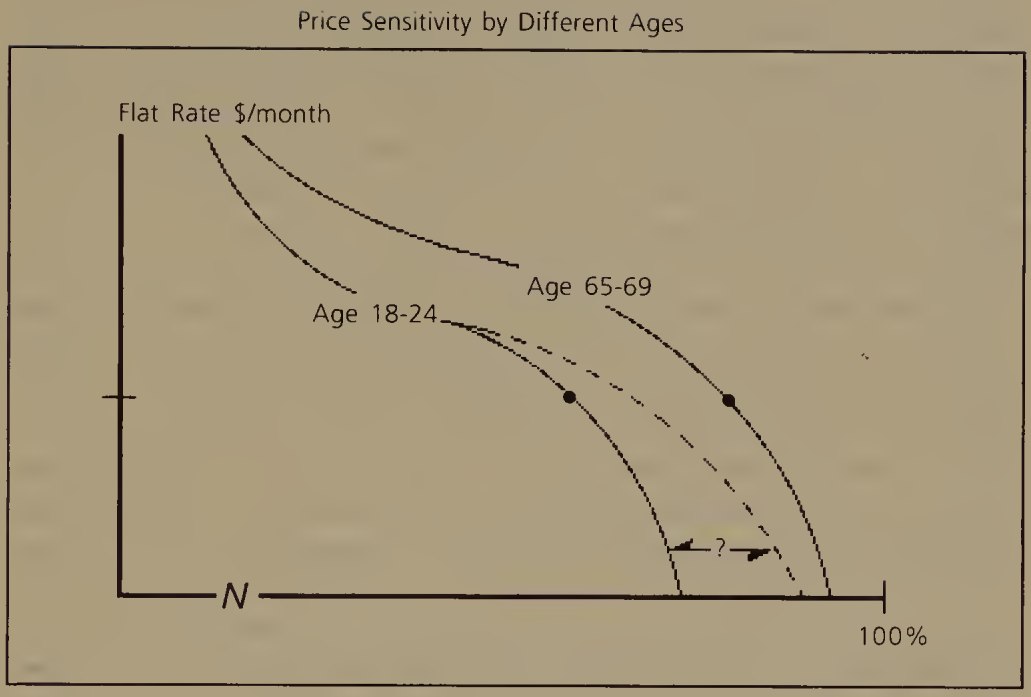
initial fraction of telephone service, not on its income or demographic characteristics.

Figure 9.9 illustrates how this assumption limits the analysis of penetration under alternative pricing scenarios. The dashed segment of the demand curve is not possible in the model—even if local rates were subsidized for young households, their telephone access would not increase to the level that would exist for older households. In similar fashion, initial differences in penetration that exist between different racial and gender groups will persist even if rates are reduced to zero. Of course, it may be the case that some groups would consistently have lower penetration if telephones were free. In the current model, however, this result is an assumption, not an empirical finding.

To the counterfactual question—to what extent would penetration in different groups have been reduced by the sharply higher rates expected at the time of divestiture?—the model has a uniform answer. Changes in predicted penetration depend only on initial penetration in each group, and one common coefficient of price responsiveness.

Because local exchange companies do not systematically collect statistics on nonsubscribers, empirical estimation of an access demand equation requires merging population survey data (census or CPS) with telephone company data on rates and number of subscribers by rate

FIGURE 9.9



plan. The access demand variable must therefore be binary-valued, and represents the sum of demand for flat-rate and demand for measured-rate service.

The availability of both flat-rate and measured-rate service in a single locality complicates the estimation of demand for access. Perl's 1983 demand model incorporates the effects of measured rates indirectly, by including, in addition to the flat-rate price, the prices of measured service. Unfortunately, this specification is not consistent with an economic model of consumers' choices of class of service, and leaves the reliability of the estimated price elasticities in some doubt.

The model could usefully be elaborated to represent the choice of class of service explicitly. In this framework, Perl and Taylor could then derive demand for access in a given market as the sum of demand for flat rate plus the demand for measured rate.[17] Telephone company data on the number of flat and measured subscribers for the same geographic areas offer the opportunity to estimate such demand functions, conditional on subscribing to some class of service. These additional data promise to improve estimates of the access demand equation, and to test its predictive accuracy.

In Perl and Taylor's analysis, the most important quantitative factor affecting penetration is one that is, in fact, not measured in the model

—an increasing "taste" for telephone service. This taste shift is estimated by the increase in actual penetration from 1970 to 1980 (measured by the decennial census) that is not predicted by the econometric model. This unmeasured effect no doubt captures many characteristics of telephone service that have made a telephone increasingly desirable —improved quality, a larger network of subscribers, and lower prices of toll service. In the current model it amounts to more than 60 percent of the total increase in penetration.

Interstate toll rates, which were declining rapidly in the pre-divestiture period, must have accounted for an important part of this unmodeled effect. And divestiture caused toll rates to fall even more rapidly (figure 9.5, p. 363). Although an unknown fraction of the residual taste effect is indeed a price effect, Perl and Taylor are unable to capture it directly in their model. However, they make a side calculation (based on the consumer surplus derived from toll calls) that suggests about one-fourth of the marginal reduction in penetration due to subscriber line charges is offset by lower toll rates. This important, but indirect, evidence may suggest that lower toll prices have contributed more to keeping penetration high than was expected when divestiture occurred.

Using data from the CPS, Perl and Taylor establish the dog did not bark—household telephone penetration has risen following divestiture. But the intriguing question remains: why did it not bark? Perl and Taylor provide one part of the answer: local rates did not rise to the expected levels. And other factors—principally, higher incomes and a trend in telephone penetration—more than offset the higher prices that did occur.

Given the exogenous forces working to increase penetration whether or not divestiture occurred, would larger access rate increases have had only minor effects on penetration anyway? Were those who proclaimed the end of universal service only crying wolf? Or was it the political constraint on higher subscriber access charges that prevented a decline in penetration among the groups with fewest telephones?

An economic analysis of the counterfactual scenarios requires a well-specified model of demand for access. The underlying model by Perl and Taylor reprcsents an important beginning. It can be developed further to allow price response to vary by demographic group, capture choices between flat-rate and measurcd-rate service, and perhaps include toll calling as well. With such extensions it may be possible to answer a key "what-if" question: would full-scale local rate restructuring have jeopardized universal service?

Alexander Belinfante

I cannot argue with the general discussion of recent trends in telephone penetration by Perl and Taylor. Indeed, much of it is derived from information that I have been responsible for releasing[18] and from analysis I have conducted.[19] However, I think their analysis is incomplete, because it does not incorporate information that has recently become available. As a result, I disagree with their conclusion that penetration would have been higher if SLCs had not been introduced. In fact, I believe the restructuring of rates resulting from the access charge program has stimulated telephone penetration.

When residential SLCs were first introduced, there were many predictions that the increase in the fixed cost of subscribing to telephone service would cause many households to lose telephone service. This has clearly not happened. One question is whether this is purely because we have experienced an expanding economy. A more fundamental question is whether the FCC's access charge program has been beneficial or harmful in promoting universal service.

I think everyone agrees the increases in telephone penetration are at least partly the result of the growth in real household income in the past few years. The impression left by the use of the Perl model, however, is that penetration would have grown faster in the absence of the access charge program. I disagree with this impression.

I believe the access charge program has stimulated telephone penetration in three ways: the Lifeline and Link-Up America parts of the program have helped low-income households obtain and maintain telephone service; the restructuring of rates that resulted from the program have benefited the class of households most vulnerable to disconnection—namely, low-income high-volume users; and the efficiency gains from the program have helped stimulate the economy. I will not dwell on the third of these here, but simply note that there is at least one study which links at least a small portion of the growth in the economy to the SLC.[20]

Prior to conducting my own analysis, I tended to agree with the widely held view that subscriber line charges would be detrimental to telephone penetration. This view is bolstered by the Perl estimate of a drop in penetration of 0.76 percent due to SLCs. Estimates such as this were instrumental in causing the establishment of the Lifeline and Link-Up America programs as part of the access charge program, in causing the Joint Board and the FCC cautiously to say that the SLC would preserve (rather than promote) universal service, and in causing

the Joint Board and the FCC to establish a monitoring program to assure that universal service would be preserved. My own analysis, however, indicates the increases in telephone penetration are more than can be explained by income increases alone.

The first piece of evidence that caused me to reconsider the impact of SLCs was an econometric study I conducted using cross-section and time-series data from the March CPS of 1984 through 1987.[21] Included in this model were various demographic and economic variables, including household income, the price of local service, the price of installation, the SLC, and an indicator of the availability of a lifeline program.[22] The household income and price of local service variables had signs and magnitudes that were in line with my expectations. The Lifeline and SLC variables, however, failed to meet my expectations. I had expected the SLC to have a negative coefficient, as is normally the case for a price variable. Instead, it had a significant positive coefficient. I concluded the coefficient must reflect something other than the direct effect of SLCs, and that a likely candidate was the effect of the accompanying reduction in toll rates. (My model did not include a toll rate variable.)

I attributed my failure to find a positive coefficient for my Lifeline variable to the newness of the Lifeline program, and the failure of my variable to distinguish between programs for which income is the only eligibility criterion, and programs which additionally have non-income eligibility requirements, such as being elderly or disabled. The programs that have such additional requirements generally have few households that qualify for Lifeline assistance, and thus do not effectively promote universal service. In spite of my failure thus far to find an econometrically estimated effect, however, I still believe the Lifeline and Link-Up America programs have helped stimulate penetration, judging from the number of households that have taken advantage of these programs.

The second piece of evidence causing me to reconsider the impact of SLCs was the set of disconnect studies submitted by the RHCs and GTE in the monitoring docket during 1988. Among the findings of these studies were: virtually no households disconnected due to the SLC increase, indicating a price elasticity for access of close to zero; most of the households disconnected for economic reasons were involuntarily disconnected due to nonpayment of their bills; and most involuntarily disconnected households were heavy users of telephone service, including toll service. These findings led me to conclude there are far more households without phone service because of their inability to pay for

toll charges, than because of their inability to pay for SLCs. This conclusion was reinforced by the observation that involuntary disconnects declined after toll rates were reduced.

The third piece of evidence causing me to reconsider the impact of SLCs was the analysis of changes in penetration for income groups reported in the December 1988 "Monitoring Report." This analysis indicated that the only income groups having significant changes in telephone penetration in the last few years have been low-income groups, which have experienced significant increases in penetration. This led me to conclude that recent penetration increases cannot be just the result of increases in income, because the effect of such income increases would be to cause more households to move into higher income categories (which have higher penetration levels), rather than to increase the penetration rate within any one income category. The relationship between penetration and income has thus shifted, particularly in the low end of the income scale. This indicates that the Perl model overstates the magnitude of the income effect on penetration, since it does not reflect this shift.

The final piece of evidence causing me to reconsider the impact of SLCs was a study conducted by Southwestern Bell submitted in the monitoring docket.[23] This study analyzed the bills of a sample of about 500,000 of Southwestern Bell's customers, and compared them with the bills of another sample of 500,000 Southwestern Bell customers living in low-income areas. Among the conclusions of this study were: the reductions in toll rates since the introduction of SLCs have more than offset the amount of those charges for the average customer in both samples, resulting in a lower total bill; the reduction of toll rates has greatly stimulated toll usage since divestiture, the growth rate of toll usage has been about twice as great for low-income subscribers as for subscribers in general, resulting in toll usage patterns that are now nearly equal for both groups; and the SLC constitutes a small percentage of the average subscriber's total bill (including subscribers in low-income areas). This study provides evidence the reductions in toll rates have provided significant benefit to low-income households in two ways—first, by making toll calls more affordable, and removing them from the class of luxury goods and services, and, second, by reducing the total bill of average and above average users of interstate toll service. The study also shows the number of low-income high-volume users is greater than previously believed.

All of this evidence combined leads me to conclude that the restructuring of rates resulting from the access charge program has stimulated

telephone penetration. While the direct effect of the SLC may have lowered penetration slightly, this effect may have been offset by the Lifeline and Link-Up America programs. On the other hand, the accompanying reduction in toll rates has undoubtedly resulted in fewer low-income heavy users of toll service being subject to disconnection because of their inability to pay their total bill.[24] Since the Perl model does not include any variable for toll rates, it largely overlooks this beneficial impact on penetration.[25]

Finally, some comments on the discussion of proposed changes in the definition of universal service. The increasing number of vacation homes and introduction of multiple telephone lines into residences forced a change in the way telephone penetration is measured. This introduction forced the abandonment of measuring penetration as the number of residential lines divided by the number of households. While multiple lines improved telephone availability, they did not increase universal service as traditionally defined. Similarly, pay phones, phones in cars, airplanes, and trains, and paging devices have increased telephone availability.

A new measure of availability, such as the percentage of time an average person can be reached by telephone, might be useful, but will probably be difficult to measure. Furthermore, it is not clear universal availability is desirable, as evidenced by the high percentage of households with unlisted numbers, and the annoyance of being called at inconvenient times, or by parties with which one does not wish to communicate. Until telephone penetration (as currently measured) for low-income households approaches the level currently enjoyed by high-income households, it will remain useful to continue to measure penetration as it is currently done.

Gene Kimmelman and Mark N. Cooper

Discussions about decreased penetration since divestiture have always involved small numbers and these discussions have never been earth-shattering. It is not death and destruction in terms of public policy, but it is a very important public policy issue and, therefore, I think the small numbers matter.

One thing everyone has mistaken about the dog that did not bark is that we, the Consumer Federation of America, *were* the dog, and we barked—and policymakers listened to some extent. Furthermore, 600,000 households within six blocks of the White House without access to the telephone network should constitute at least a small bark. And in fact,

the dog was threatening to bite off our leg. At that time, the proposed SLC (previously called the access charge) was the six dollars at the state level plus another six or seven dollars at the federal level for every residential telephone subscriber. That was a policy matter the dog barked at.

Affordability of telephone service is indeed an important issue. Another reason why the dog did not bark so loudly was that requests for local rate increases were only partially granted, the SLC was decreased, and Lifeline was implemented—all measures which contributed to basic service affordability for low-income subscribers. Lifeline, however, was not a result solely of divestiture. It was implemented because many of us fought for it. Nor was divestiture the reason why many telephone companies were willing to go along with it. As Alex Belinfante points out, the FCC viewed Lifeline as an essential element of its SLC plan.

In this normative context of universal service, the elements of concern have been quite simple. We should be concerned about drop-off, about *who* drops off the network, and about failure to expand the network in a manner consistent with the historic rate of expansion. Most importantly, we should worry about the financial burden we have placed on people for whom the telephone is a necessity item—those with what some would call inelastic demand for telephone service. Is it fair to put that burden on people of low and fixed income, who may have to give up other important resources to pay for the telephone? We believe this financial burden should be minimized. These are all the consumer goals pertaining to universal service, and these goals need to be recognized because universal service is more than penetration rates.

The consumer advocate's approach to the issue of universal service lies between the two extremes presented by William Baxter and Charles Brown. On the one hand, Baxter seemed unconcerned with price increases so long as prices were based on costs; on the other hand, Brown seemed to propose that the objective affordable residential service was feasible in the monopoly environment, but now AT&T was obliged to compete. Since we believe the Consumer Federation of America's stance is often not understood completely, we will state it clearly: we espouse a kind of incrementalism, allowing competition and allowing a restructuring of the industry; with some skepticism, but not total antagonism. But we also advocate the use of regulation to protect the concept of universal service. We believe that many of the "inefficiencies" of regulation are vastly outweighed by the benefits these "inefficiencies" bring us, such as pricing policies that promote affordable universal basic phone service. That is the approach we have taken through the divesti-

ture era, and plan to continue to take. It involves a very simple formula with the maximum contribution possible to the rate base from all interconnecting services, to keep local rates low, given what the market will bear. This is something economists hate to hear, but it is the kind of pricing approach we believe promotes both universal service and fair competitive rules.

But the most important question at this point is, do the data in figure 9.10 indicate that telephone penetration is at saturation? Have we done as much as we can? I do not think anyone has ever advocated that everyone in society should have a telephone. We have stated that everyone who wants a telephone, but who cannot afford one, should be subsidized. That was the issue in the lifeline debate, and that is the direct issue related to the comparison of the penetration data. I believe lifeline is often dismissed by those who claim, "it is done, don't worry about it." But I do not think the issue is resolved yet. As Belinfante points out quite clearly, our data show that less than half the states actually have a lifeline program. More have signed on for Link-Up, but less than half the low-income people in this country qualify for lifeline programs. And many of the programs are woefully mistargeted. They certainly should not be targeted to include people who do not need the service, while ignoring some who clearly are underrepresented on the network. However, as suggested by the following, this is the case in a number of states.

For example, Hawaii only offers discount rates to individuals who fit the following criteria: they are at least sixty years old or are handicapped, and have income below $10,000.[26] Of the states that have a lifeline program, almost half include restrictions similar to Hawaii's, which make a large segment of the low-income community ineligible for discounted service.[27] In addition, most states with broader lifeline programs exclude low-income individuals who do not go through the often complex, stigmatizing process of applying for welfare benefits. As a result of the FCC's and states' failure to mandate the availability of discounted local service for individuals below the poverty line, more than 50 percent of low-income Americans are not offered affordable local phone service today. The goal of universal service is being thwarted by these inadequate federal and state Lifeline efforts.

What about the data presented in the Perl and Taylor discussion, and the conclusions we can draw from it? First, measuring the effects of divestiture is not a straightforward exercise. Most will agree that other factors were sources of change, and divestiture did not change many things. Moreover, to the extent that the effects of divestiture are measurable, they still are not of primary concern to policymakers. It is

those other factors, such as pricing policy, that matter. A basic problem with the data presented in Perl and Taylor is that 1960 was not a "benchmark." As we enter the 1990s, to say that things were pretty good in 1960 is not relevant in a policy context (see figure 9.11 and the recent trend in local prices).

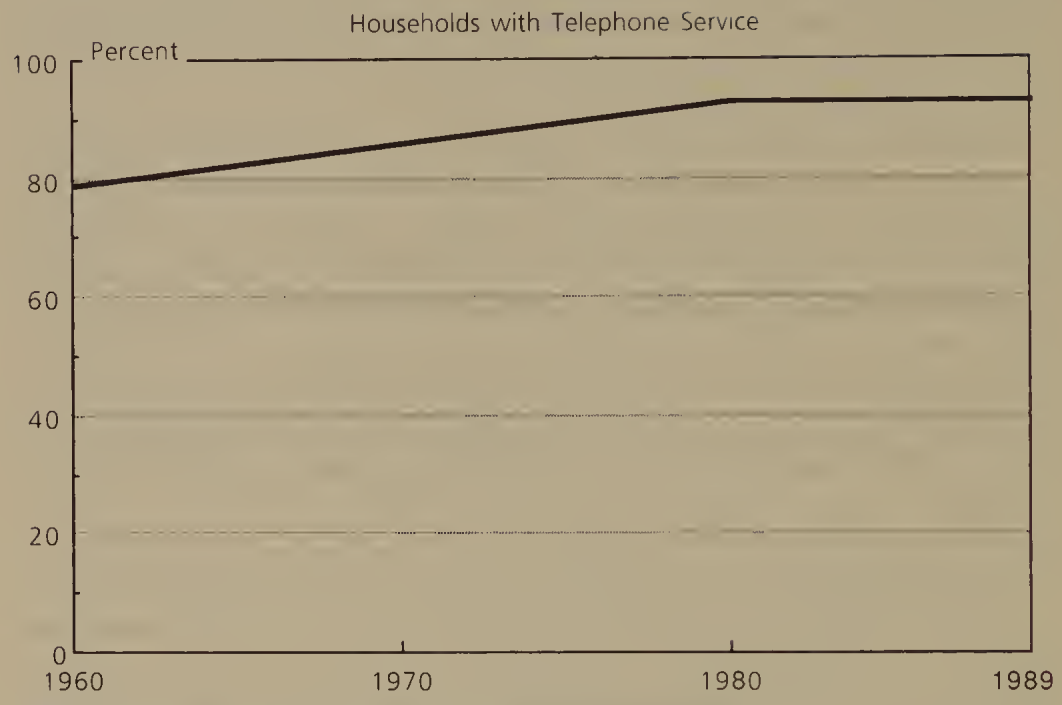
Another problem with the timeframe of the data lies in the calculation of relative rates of progress toward universal service. Taylor and Perl compared 1960 to 1970, 1970 to 1980, then 1984 to 1988. But 1980 to 1983 are missing; this was a period of recession, and the end of 1983 was the bottom of the cycle. As a result, the data compare the bottom of a recession to the top of the highest, most rapid growth in a business cycle the U.S. has seen since the Second World War. Drawing conclusion from such a comparison is analogous to analyzing the effects of the air traffic controllers strike after airline deregulation. We will never be able to properly specify the effects of these two massive events, which occurred at the same time.

Accordingly, we do not know if we can draw meaningful conclusions without filling the gap. Perhaps when we look at the 1990 census and compare it to 1980, we will be able to fill that gap. It is our impression that some very important events happened during the first three years of the 1980 decade. Historically, eras of dramatic income growth have also witnessed a real decline in local rates and fairly large increases in penetration rates. We believe that during the recession of the 1980s and the real rate increases the Perl and Taylor data show, there probably was some dropoff. However, we do not have any measurements, since CPS data do not exist for that period. Neither do we know whether there was a resurgence in penetration during (1) the recent period of real income growth or (2) the real local rate increases and the beginnings of Lifeline service in some areas. The 1980s look like a rather stagnant period. We would have to go back and look carefully at the 1960s to 1970s to 1980s comparison (given that 1980–1983 data are missing) to see if the overall conclusion is correct.

But when we examine this data, we should attempt to determine how to include Lifeline programs in our modeling, in order to give them credit if it is due. On another note, second homes that qualify for Lifeline service are not the policy issues, but that is normative, and that we cannot resolve.

We need to examine the way prices are modeled. Perl's model used the Bureau of Labor Statistics' (BLS) numbers to escalate rate increases. But the BLS escalator includes Lifeline, installation prices, changes in touch-tone, and more. BLS takes a sample of bills; it is not monthly access prices, and therefore the data are escalated at an average rate

FIGURE 9.10



Source: Bureau of Census, *Housing Characteristics*, various issues.

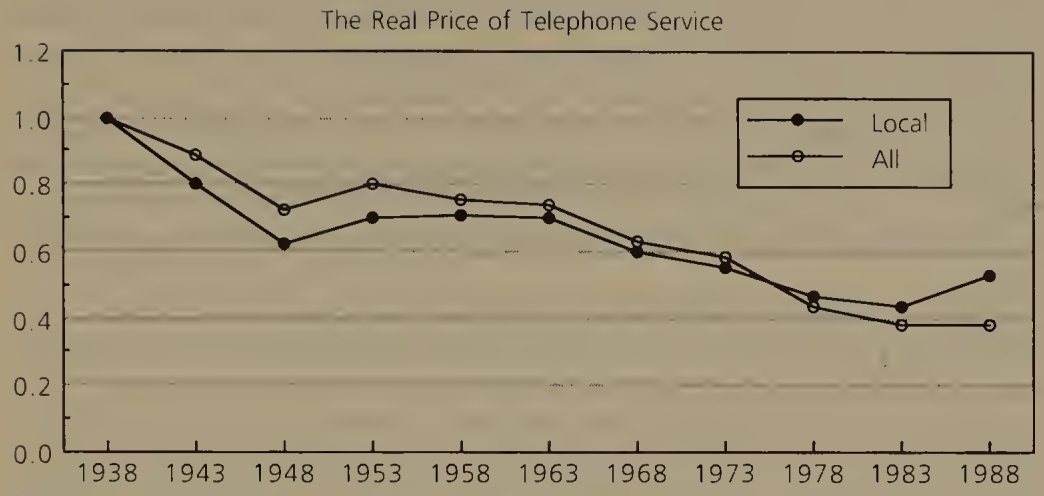
that probably does not reflect actual monthly access prices. And we question whether installation charges were included separately, but obviously there is a massive federal program to offset them.

Another set of concerns has to do with toll rates. I have never seen the price elasticity of demand for access for toll rates specified. It could be treated as an income effect, but the result would be too small. Belinfante almost got it right. The answer is that by lowering toll rates, you increase the value of the phone, and therefore there is a price elasticity with respect to access. This is a legitimate issue.

Although we disagree with some details of the Perl and Taylor analysis, and concur with some of the methodological questions raised by others in this chapter, our greatest concern is in the focus of the introduction and how Perl and Taylor address concerns of universal service. We believe penetration rates could be much better. How much? We are not sure. But start with cleaning up the Lifeline programs, expanding them, and establishing them in states that do not have them.

Our interest focuses on data collection, and in getting all the data analyses debated on paper. We need to look toward the future, and we need to think about the 1990 census and whether it can in some way help us in analyzing that 1980-to-1983 data gap. I think today's public

FIGURE 9.11



Source: Bureau of Labor Statistics, *Consumer Price Index.*

policy debate illustrates the need to look toward information services and how that issue relates to universal service. We need greater information about low-income households, because they are obviously where the greatest affordability problem lies. We need to look toward affordability questions as we develop information services, to make sure that, this time, as we proceed into the 1990s, we actually have benchmarks (i.e. some data). We need to have an empirical basis to do an analysis of what universal service is ten years after divestiture and beyond.

ENDNOTES

1. As outlined in the quarterly "Monitoring Reports," filed in CC Docket No. 87–339. These reports typically present the basic post-divestiture data on penetration levels, lifeline assistance plans, eligibility for the high cost fund, network usage, local and long-distance rates and revenues, bypass, and the financial performance of the National Exchange Carrier Association mandatory and voluntary pools.

2. March over March penetration rates are used to eliminate seasonal effects, and March was chosen because the March reports contain more demographic information.

3. Whether or not penetration has increased since the 1980 decennial census is still an open question. National average penetration in the 1980 census was 93.4 percent while the November 1983 CPS estimate was two percentage points lower. Some analysts ascribe the drop in measured penetration to differences in sampling methodology between the census and the CPS, while others attribute the drop to federal policies. For our present purposes, it is enough to note that

the drop, if real, occurred before divestiture and cannot be associated with rate changes implemented as part of divestiture. In the next section, we show that our econometric model would have forecast a penetration drop of roughly the magnitude observed, due primarily to large increases in real telephone prices and a fall in real income over the 1980–1984 period.

4. In an integrated network, a customer would have to bypass the entire switched network in order to avoid the local support embedded in long-distance rates. When the support for the local network became a part of carrier access charges, a customer only had to bypass the local network to avoid paying local support.

5. Lewis J. Perl, "Residential Demand for Telephone Service, 1983," National Economic Research Associates Memorandum, December 1983; revised May 1984 to correct installation charge data.

6. The 1983 access demand model was developed by examining the demand for telephone service in a large sample of individual households. Data from the 1/1000 sample of the 1980 census indicated whether or not each of 80,428 households subscribed to telephone service, described the demographic characteristics of the household in detail, and assigned the household to one of 1,154 geographic areas. NERA then obtained exchange-specific rate data from the (then) BOCs for the 71,979 households assigned to Bell territory. From this large cross-section of households in 1980, a logit equation was estimated, relating the probability of a household subscribing to telephone service to the prices it faced and to its socioeconomic characteristics.

The coefficients of the demand equation are summarized in William E. Taylor and Lewis J. Perl, "Telephone Penetration and Universal Service in the 1980s," Center for Telecommunications and Information Studies, Columbia University Graduate School of Business, Working Paper, 1989. These coefficients measure the change in the natural log of the odds of a household subscribing to telephone service associated with a one-unit change in the variable in question. Price and income elasticities from this model depend upon the penetration level at which they are measured; for 1984 or 1987, the flat-rate price elasticitites are roughly -0.05 and the income elasticity is about $+0.190$.

7. Note that the race effect does not dominate despite the fact that there was a comparatively large proportionate change in percentage nonwhite, and that race has a high coefficient in the model. Average number of persons per household is 2.68 in the sample, while percentage nonwhite is roughly 10 percent. The race elasticity is thus about -0.005 $(= -0.52 * 0.11 * (1-0.918))$ while the "persons" elasticity is roughly -0.01 $(= -0.05 * 2.68 * (1-0.918))$.

8. The three factors which are important in determining the change in penetration between 1984 and 1987 are prices, income, and an exogenous trend in the taste for telephone service. The measurement of both price changes and the trend in tastes is explained in William E. Taylor and Lewis J. Perl, "Telephone Penetration and Universal Service in the 1980s."

9. Lewis J. Perl, "Welfare Consequences of Competition in Telecommunications;" presented at the International Telecommunications Society 7th biannual conference Cambridge; Mass., July 1988; table 7, p. 20.

10. Recall that the demand for access to the telephone network is determined by the consumer surplus associated with using the network at prevailing usage rates. In this view, a $1 change in consumer surplus has the same effect on a consumer's likelihood of subscription regardless of its source. If this is the case, the effect of a change in toll prices can be estimated by first calculating its effect on consumer surplus for a representative sample of consumers. Then, using the coefficient relating access prices to penetration, we can assess the effect of these changes in consumer surplus on access demand.

11. Between 1980 and 1984, the BLS CPI-Local index grew 24 percent in real terms or about 5.7 percent per year.

12. While the principal focus of this analysis is on changes in penetration since divestiture, it is also of some interest to examine changes from 1980 to 1984. Prices also rose during this period (about 24 percent above inflation) and published data appear to suggest that penetration fell. Penetration in 1984, as estimated in the current population survey, was 91.8 percent. By comparison, 1980 penetration, as reported in the decennial census, was 93 percent. Did the rise in prices from 1980 to 1984 *cause* the apparent decline over this period? If it did, why didn't income and taste changes also offset decreases during this period?

To resolve this question, we have sought to determine whether the apparent change in penetration from 1980 to 1984 can be explained by reference to changes in price, demographic characteristics, and a continuation of historic taste changes. The change predicted by the model matches the actual change very closely.

This result has several implications. First, the ability of the model to account for both the 1980–1984 and the 1984–1987 change increases our confidence in its predictive power. Second, since the model predicts the apparent 1980–1984 change, perhaps previous concerns that the CPS and census estimates are not comparable have been misplaced. Finally, if the model is valid, it enables us to assess the effect of price on penetration over the entire period 1980–1987. The net effect of these forces was to leave penetration essentially unchanged (it was about 0.5 percentage points less in 1987 than in 1980.)

13. The subscriber plan factor (SPF), calculated separately for each local exchange carrier in each state, is used to divide loop costs between the state and interstate jurisdictions. In the previous decade, the factor was based on a multiple of the proportion of interstate usage, and it grew rapidly with the increase in interstate usage. SPF was frozen at its 1983 level by a Federal-State Joint Board decision and transitioned to a uniform 25 percent (the gross allocator) over an eight-year period. Frozen SPF averaged about 27 percent nationally, but the average conceals about a 60 percentage point range across the states.

14. Consulting services which provide local area population estimates between census years frequently use telephone access line growth to interpolate between census estimates or to distribute more reliable aggregate population changes across geographic areas.

15. Lewis J. Perl, "Residential Demand for Telephone Service, 1983," National Economic Research Associates Memorandum, December 1983.

16. Lewis J. Perl, "Revisions to NERA's Residential Demand for Telephone Service, 1983," National Economic Research Associates Memorandum, April 24, 1984.

17. This approach is used, for example, in a simulation model of class of service choice and penetration in Park and Mitchell (1989).

18. Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission, "Telephone Subscribership in the U.S.," released three times per year, in January, May, and September. Tables 2 to 6 in this report are prepared by the Current Population Survey, Bureau of the Census, U.S. Department of Commerce, under contract from the FCC, and the remaining tables are based on data provided by the Current Population Survey.

19. Staff of the Federal-State Joint Board in CC Docket No. 80-286, "Monitoring Report," and CC Docket No. 87-339, December 1988, Sec. 1, "Subscribership and Penetration Levels."

20. Wharton Econometric Forecasting Associates, "Pricing Telecommunications Service: The Impact on the U.S. Economy of Subscriber Line Charges," 1986.

21. Alexander Belinfante, "The Analysis of Telephone Penetration: An Update," *Review of Business,* (Spring 1989), 10(4):9–14, 32.

22. Link-Up America was not adopted until April 1987 and thus was not available during the period for which I had data.

23. Alexander C. Larson, Thomas J. Makarewicz, and Calvin S. Monson, "The Impact of Subscriber Line Charges on Residential Customer Bills," Southwestern Bell Telephone Company, January 17, 1989. Submitted as part of Reply Comments in the Matter of Establishment of a Program to Monitor the Impact of Joint Board Decisions, CC Docket No. 87-339.

24. In addition, the reduction of toll rates has increased the value of phone service for all users.

25. Since the Perl model is estimated from cross-sectional data alone, it is difficult to include toll rates directly in the model, because the variation in toll rates occurs mostly over time. Perl and Taylor do attempt to estimate the effect of toll rate changes indirectly through the impact on consumer surplus. However, this estimate is based on untested assumptions, and its magnitude is therefore questionable.

26. "Monitary Report," CC Docket No. 87-339, July 1989. Prepared by the staff of the Federal-State Joint Board in CC Docket No. 80-286.

27. Id. However important exceptions are New York and California.