A RAND NOTE

REPRESSION EFFECTS OF MANDATORY VS. OPTIONAL LOCAL MEASURED TELEPHONE SERVICE

Bridger M. Mitchell and Rolla Edward Park

March 1981

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Prepared For

The National Science Foundation

Rand
SANTA MONICA, CA. 90406

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PREFACE

This Note describes research undertaken as a part of a larger study of the allocative and distributive effects of usage-sensitive pricing of local residential telephone service. The research is funded by grants to The Rand Corporation from the National Science Foundation. The Note was prepared for presentation at the twelfth annual conference of the Institute of Public Utilities, Michigan State University, held at Williamsburg, Virginia, in December 1980. It will also appear in Harry Trebing (ed.), New Challenges for the 1980s, Institute of Public Utilities, East Lansing (forthcoming).

ABSTRACT

When all residential telephone subscribers in three Illinois communities are charged for local telephone calls (at the rate of 2.5¢ per call plus 1¢ per minute) telephone use is repressed (reduced) by some 15 percent. However, if subscribers are offered a choice between a measured rate and the customary flat rate, repression will be much less because households who choose measured rates tend to make fewer than the average number of calls and to make smaller reductions in use. If 50 percent of the households select the measured rate, the reduction in calling will be only 12 percent of the reduction if the rate were mandatory. To track the repression effects of optional rates, data systems must be carefully designed to account for substitution of calls between measured and flat-rate subscribers and to control for trends in use.

ACKNOWLEDGMENTS

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CONTENTS

I. INTRODUCTION

Two major telephone companies are taking two different approaches to introducing usage-sensitive pricing for local telephone service. General Telephone (GTE) has announced that it intends to seek mandatory measured service tariffs for local calling in the areas it serves (Schmidt, 1979). In contrast, the Bell System intends to introduce local measured service as an option, allowing the customer to choose between one or more measured service tariffs and a premium flat-rate service (Garfinkel and Linhart, 1979).

The different dimensions on which these two strategic choices might be compared include economic efficiency, distributional equity, public acceptability, and ease of implementation. We stop far short of so complete a comparison. Instead, we shall focus on a narrower question related to economic efficiency: How do mandatory and optional measured service compare in their effects on local telephone use? In the telephone industry, reduction in use is commonly referred to as "repression." The question is important insofar as more efficient use of local telephone plant is an important goal of local measured service, because of the potential cost savings resulting from a reduction in engineered capacity.

To answer this question, we draw on recent empirical work at Rand. In Sec. II, we use a study of the repression effects of a GTE experimental measured service tariff (Park and Wetzel, 1981) to estimate reductions in use that might be expected for various mandatory tariffs. In Sec. III, we use a study of the distribution of calling rates in the GTE experiment (Park et al., 1981) to estimate the repression that would be achieved if the tariffs were optional rather than mandatory. In Sec. IV, we discuss issues related to tracking the actual effects of measured service.

Optional measured service turns out to result in much less repression than does mandatory measured service. This is true even when a substantial portion (say 50 percent) of residential customers choose measured service, because those customers make less than 50 percent of all calls and are less responsive to usage charges than are larger users.

II. REPRESSION EFFECTS OF MANDATORY MEASURED SERVICE

The best evidence about the effects of mandatory local measured service comes from the GTE experiment in Illinois. Since May 1975, GTE has been recording telephone use in three small cities in central Illinois--first under flat rates, then since September 1977 under a total of three different measured service tariffs.

The effects of the experimental tariffs on telephone use have been analyzed by Jensik (1979), Park and Wetzel (1981), and Wilkinson (1981), with generally similar results. Park and Wetzel, for example, estimate that local usage charges of 2.5 cents per call and 1 cent per minute[1] resulted in a 14.5 percent reduction in the number of local calls and an 18.8 percent reduction in minutes of calling by single-party residential customers. We use the Park-Wetzel estimates here with some adjustments.

Our goal in this section is to describe quantitatively the effects of mandatory local measured service for residential subscribers on total local telephone use during peak periods. The Park-Wetzel estimates describe the effects of an almost mandatory tariff on local use by single-party residential subscribers during the full day; hence the need for the adjustments described below.

A FLAT-RATE MULTI-PARTY OPTION

In the GTE experiment, measured service is mandatory for single-party subscribers but multi-party service continues to be priced at flat rates. This difference opens up possibilities for substituting usage that must be taken into account. For example, some single-party subscribers may arrange with their multi-party friends for the following sort of "code calling": When the single-party customer wants to talk to his multi-party friend, he dials his number, lets it ring once, and hangs up. His friend then calls right back for free. And apart from such explicit code calling, multi-party customers will become accustomed to originating most of the conversations with their single-party friends. Although this substitution contributes to the observed reduction in single-party telephone usage, it results in an offsetting increase in multi-party usage. This it has no net effect on total telephone use in the experimental cities.

The Park-Wetzel model yields separate estimates of the reduction in single-party use due to substitution and that due to repression that would occur even if there were no substitution opportunity. Because the reduction in single-party calling due to substitution is exactly offset by an increase in multi-party calling, it has no effect on required size of plant. When the substitution effect is removed, Park and Wetzel estimate the pure repression effect of the 2.5 cents per call and 1 cent per minute tariff to be a 12.4 percent reduction in calls and a 14.4 percent reduction in minutes.

A CEILING ON USAGE CHARGES

The experimental tariff limits usage charges to $19 per month per telephone line. In a typical month, a little over 1 percent of single-party customers exceed this ceiling. Thus the experimental tariff is equivalent to an optional tariff under which the top 1 percent or so of customers, ranked by telephone use each month, choose flat rate, and the remainder choose measured rate. Because of the ceiling and the availability of the multi-party flat-rate option, local measured service under the experimental tariff is not quite mandatory.

Marginal prices are zero for customers above the ceiling, so those customers presumably do not reduce their telephone use at all because of the experimental tariff.[2] Under flat rates the top 1 percent of users each month make about 5 percent of all calls. Moreover, under measured rates, the very largest users reduce their calling about twice as much as the average user. Thus, if there were no ceiling, we would expect to observe about 10 percent more repression than was actually observed.[3]

When the Park-Wetzel estimates are adjusted appropriately, the repression effects of the current experimental tariff, with no multi-party option and no ceiling, would be a 13.6 percent reduction in calls and a 15.9 percent reduction in minutes.

PERSONAL CALLS FROM WORK

When residential service is changed from flat rate to measured, there is surely some increase in the number of personal calls placed from business telephones. This increase will offset some of the decrease in residential use and should be netted out to get the effect on total local calling. But we have no way to measure the substitution of business for residential calling. In the case of multi-party substitution discussed above, we could ascribe the entire increase in multi-party calling to substitution, because multi-party usage prices remained unchanged at zero. Business usage prices, in contrast, were increased in the GTE experiment at the same time as single-party residential prices. Therefore, we cannot separate the repression and substitution effects on business calling. The small reduction in business use that occurred could as well be the net effect of small repression partially offset by small substitution or of larger repression partially offset by larger substitution.

Lacking any solid information about the business substitution effect, we make no additional adjustment. If the business substitution effect is small, our numbers will closely approximate the effect of local measured service on total calling. In any event, they are an upper bound on total repression due to residential local measured service in the experimental exchanges.

TIME-OF-DAY DISCOUNTS

The experimental tariff includes discounts of 20 percent evenings and Sundays, and 50 percent nights. We must be concerned with the effect of the tariff on the shape of the load curve, because telephone plant is designed to accommodate peak loads.[4] There is some evidence that the experimental tariff uniformly reduced telephone use around the clock: Jensik (1979) reports that minutes of telephone use declined by the same percentage in each of the three discount periods. Considerably more detailed analysis would be necessary to establish that any shifts of usage patterns within tariff periods left the ratio of peak to aggregate use unchanged. However, in the absence of any evidence to the contrary, it seems reasonable to assume that the adjusted Park-Wetzel estimates apply to peak, as well as aggregate, use.

In some circumstances, however, a different discount structure would result in peak-hour repression that differed from the Park-Wetzel estimates of aggregate repression. For example, if cross-price elasticities between tariff periods were large, greater off-peak discounts would result in more peak-period repression than estimated for the same peak-period price. We have no estimates of cross-price elasticities and hence no way to evaluate the magnitude of this effect. Thus it seems prudent to specify that the adjusted Park-Wetzel estimates apply only to peak use under tariffs with time-of-day discount structures similar to the one used in the GTE experiment.

ADJUSTED REPRESSION ESTIMATES

Park and Wetzel estimate usage response functions--the repression to be expected from any combination of price per call P_C and price per minute P_M, not merely repression at the illustrative prices ($P_C = 2.5$, $P_M = 1$). (Of course, repression estimates are probably more accurate in the vicinity of the experimental prices than those in price ranges with which there is no actual experience.) One way to represent the estimated response functions is by plotting "repression contours" as in Fig. 1.[5] For example, one can find the change in use due to the current experimental tariff at the intersections of the dashed $P_M = 1$ and $P_C = 2.5$ lines. For the number of calls (Fig. 1a), the intersection is about three-quarters of the way from the 10 percent represssion contour to the 15 percent controut, corresponding to a 13.6 percent decrease in calls.

The effect of per-minute charges P_M alone (no per-call charges) is read off the horizontal axes. For example, a charge of $P_M = 4.8$ cents would be needed to reduce calls by 25 percent. To reduce the

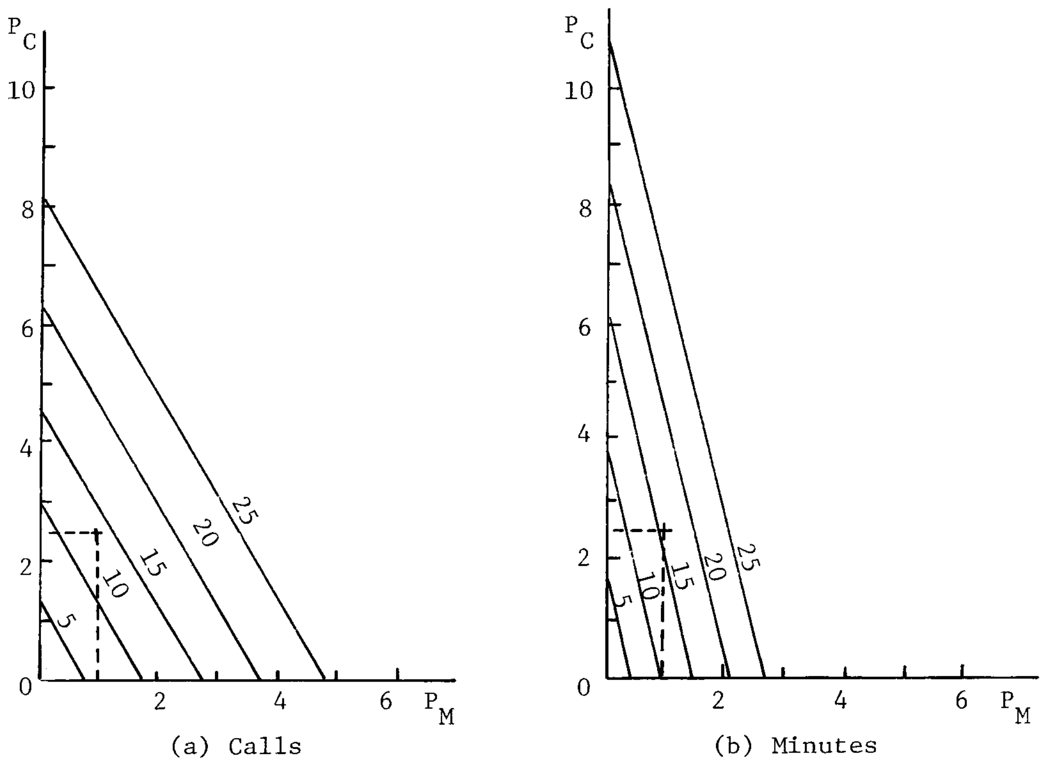

Fig. 1--Percent reduction in calls and minutes for various combinations of price per call P_C and price per minute P_M

number of minutes by the same percentage (Fig. 1b) would require a considerably smaller charge, $P_M = 2.7$. On the vertical axes, one can read the effect of per-call charges P_C when $P_M = 0$. For example, 25 percent reductions in calls and minutes would require $P_C = 8.2$ and $P_C = 10.9$, respectively.[6]

REPRESSION EFFECTS MAY BE DIFFERENT IN OTHER CITIES

The results presented above apply to the three cities in central Illinois where the GTE experiment is taking place. Price effects may differ elsewhere. In Park et al. (1981), repression by individual households within the experimental exchanges is systematically related to certain household characteristics. If the same relationships apply in other communities as well, we would expect to find more repression than shown in Fig. 1 in areas with:

- a higher level of calling under flat rates;
- larger (many-person) households;
- lower income;
- older population.

Until we have data from other locations, it is hard to say much more than that. One should be cautious in applying the results for central Illinois to other locations.

III. REPRESSION EFFECTS OF OPTIONAL MEASURED SERVICE

The previous section indicated that small mandatory charges for local telephone use can substantially reduce use. For example, a charge of 2.5 cents per call and 1 cent per minute was estimated to reduce use by roughly 15 percent.

The effect of optional tariffs will be smaller. Optional tariffs typically offer the subscriber a choice between one or more measured service rates and a premium-priced flat rate. Households that choose the flat rate will have no incentive to reduce their telephone use.[7]

The repression effect of an optional tariff is not simply proportional to the fraction of customers choosing measured service. If half of all subscribers choose measured service, repression will be much less than half of that under mandatory measured service. The reason is twofold: (1) Customers choosing measured service will tend to be those who use their phones the least. Thus, if half of all customers are measured, much less than half of all calls will be measured. (2) Small users tend to reduce their calling in response to usage charges less than do large users, and the very smallest users tend not to repress at all. Thus, the fraction of mandatory repression achieved by an optional tariff will be even smaller than the fraction of calls that are measured.

We shall quantify these effects in this section, based on empirical work by Park et al. (1981) and Infosino (1979). For expository purposes, we start with the unrealistic assumptions that all households (a) reduce calling in the same proportion in response to usage charges, and (b) choose between measured and flat-rate service in order to minimize their telephone bill each month. We then relax first assumption (a) and then assumption (b) to establish a realistic relationship between the fraction of customers on measured service (which, in the telephone industry, is commonly called the "take rate") and the fraction of repression under mandatory measured service that would be achieved by the optional tariff.

PROPORTIONAL REPRESSION AND BILL-MINIMIZING CHOICE OF SERVICE

Under an optional tariff, measured service will be cheaper for households that make a small number of calls, and flat rate will be cheaper for those that make a large number. Just where the dividing line (the "breakpoint") is depends on the monthly service charges and the usage prices of the options. Here we assume that all households that make fewer than the breakpoint number of calls[8] choose measured service each month, and all those that make more choose flat rate.

We shall show the relationship between take rates and repression achieved by optional tariffs by means of graphs such as the one in Fig. 2. If all households reduced their telephone use by an equal amount (say 10 calls per month) in response to measured service, the relationship would be the diagonal dashed line, curve (1). For example, a 50 percent take rate would result in 50 percent of mandatory repression. But reductions are not the same for all households. On present assumptions, reductions are proportional to use, and use is well known to be unequal. For example, the smallest 50 percent of users account for only 20 percent of calls, and the smallest 80 percent account for 53 percent, as shown by the solid curve (2) in Fig. 2.[9] Under the proportionality assumption, the same curve describes the relationship between take rates and total repression under an optional tariff.[10]

MORE THAN PROPORTIONAL REPRESSION AND BILL-MINIMIZING CHOICE OF SERVICE

Park et al. (1981) found that households making a lot of calls under a flat rate tend to reduce their use proportionately more under a measured rate than do those making fewer calls. Taking this into account (but maintaining the assumption of bill-minimizing choice) results in the more sharply dished relationship between take rate and repression, curve (3) in Fig. 3.

The smallest 50 percent of users, who make 20 percent of the calls, account for only 5 percent of all potential repression. The reason is simple: The smallest 30 percent tend not to repress at all,[11] and the next 20 percent repress very little.[12] This and similar

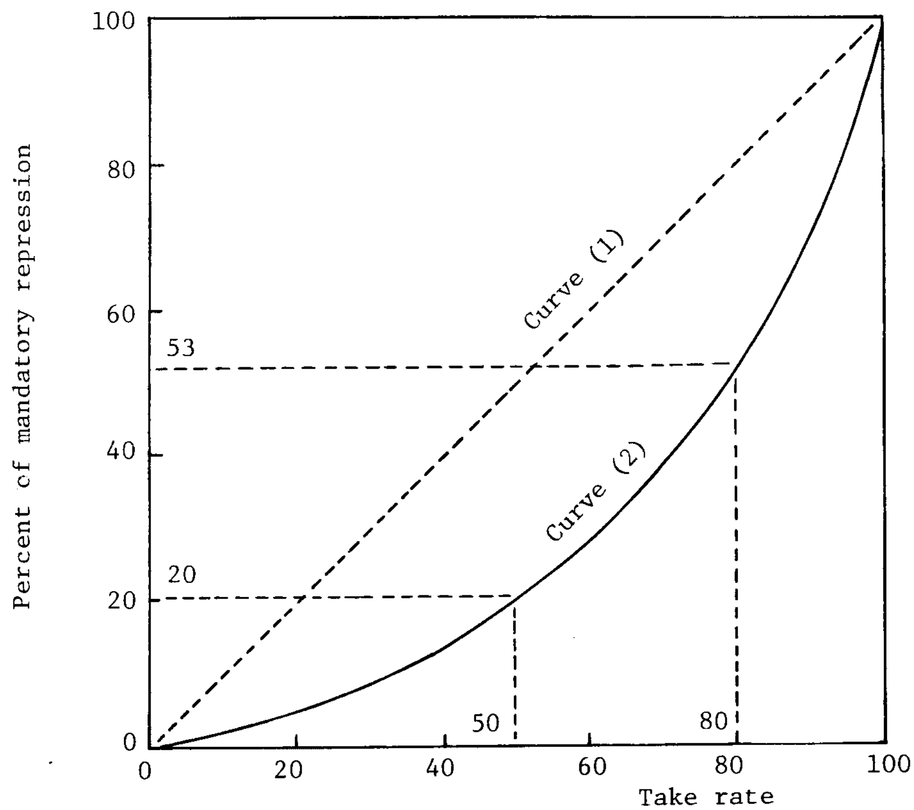

Fig. 2--Relationship of repression to take rate on the unrealistic assumptions of
(a) proportional reduction and
(b) bill-minimizing choice

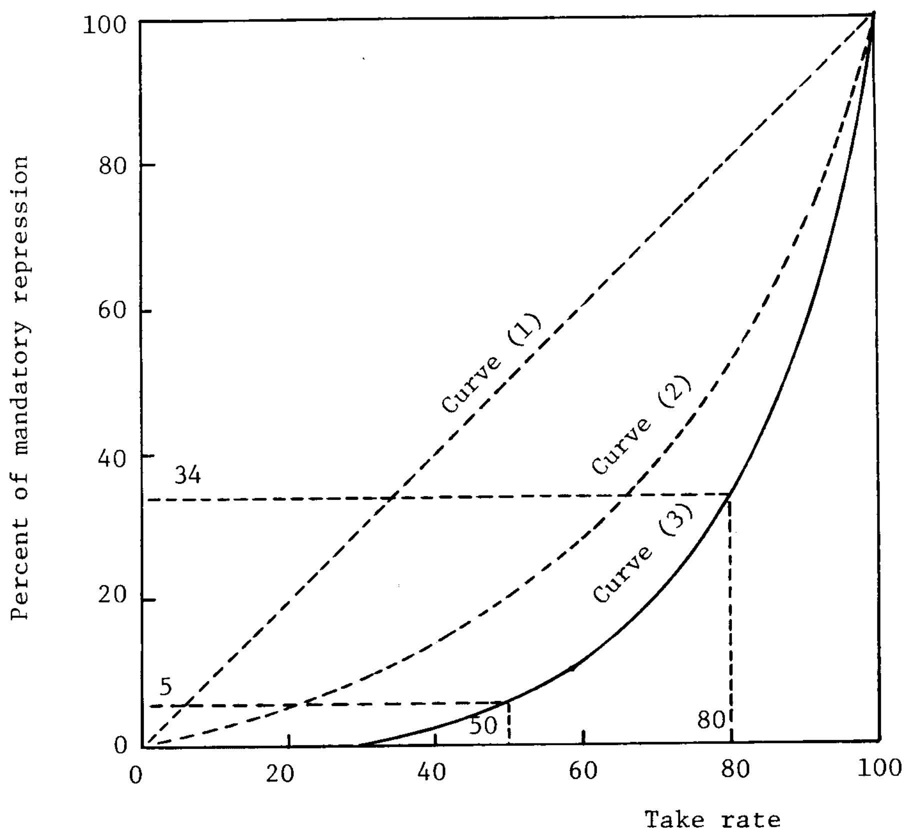

Fig. 3--Relationship of repression to take rate on the unrealistic assumption of bill-minimizing choice

observations for other usage fractiles form the basis for the calculations underlying Fig. 3.[13]

REALISTIC RELATIONSHIP BETWEEN TAKE RATE AND REPRESSION

So far we have assumed for convenience that customers choose between measured and flat rates in order to minimize their bills each month. In fact, some do not. Where measured service is available, many flat-rate customers would have lower bills if they switched to measured rate, and a few measured rate subscribers could lower their bills by switching to flat rate. The reason is at least threefold: (1) Telephone use by any particular household varies from month to month. Some customers who choose class of service to minimize bills in the long run will find themselves in the "wrong" class during some months. But month-to-month variation is not in itself sufficient to explain the large number of "wrong" choices. (2) Some customers are willing to pay more for flat-rate service to have the freedom to talk without charge. They don't like to have the clock ticking during their telephone conversations. (3) Ignorance may be a factor in some cases. Customers may be unaware of the measured service option, or, if they do know about it, they may overestimate their telephone use and erroneously think it would not be a good deal for them.

Whereas we previously assumed that all customers below the breakpoint take measured service, we now assume more realistically that some fraction of customers in each usage fractile take it, and that that fraction declines with usage level.

Infosino (1979) has estimated this relationship for different breakpoints. For example, if the breakpoint is 100 calls per month, he estimates that 78 percent of households making 20 calls during a particular month will choose measured service, but only 31 percent of households making 80 calls will choose it.[14] And some 4 percent of customers making 180 calls during a particular month--well over the breakpoint--will be on measured service.

To calculate a realistic relationship between take rate and repression, we apply Infosino's estimates of take rates to each usage fractile. At each usage level, both the take rate and the repression will be less than that used to calculate curve (3). As a result of this calculation,[15] we estimate that the overall take rate (for a breakpoint of 100 calls) will be 28 percent and that the overall repression will be only 3 percent of that achieved by mandatory measured service.[16]

Making similar calculations for other breakpoints gives us several realistic repression vs. take-rate points that define the solid curve (4) plotted in Fig. 4. Over most of its range, this curve lies between the curves based on the two sets of simple, unrealistic assumptions we used in previous subsections. The realistic curve is higher than the sharply dished curve (3) because for any given take rate, say 50 percent, curve (3) shows repression by the smallest 50 percent of all customers, while curve (4) shows repression by a mixture of small and larger users. Larger users repress more than do small users, therefore the realistic curve (4) lies above curve (3), which is based on bill-minimizing choice. If enough large users choose measured service, curve (4) may even lie above the unrealistic curve (2). Infosino's result, however, is that sufficiently few large users choose measured service that the realistic curve does indeed lie between the two others unless take rates are very high.

The realistic curve (4) shows, for example, that:

- A 50 percent take rate yields only 12 percent of repression achieved by mandatory measured service.
- An 80 percent take rate gives only half of mandatory repression.

The exact numbers would differ if we had used different assumptions to calculate the realistic curve.[17] However, the general conclusion would stand: With optional measured service, the take rate must be very high before there is substantial repression.

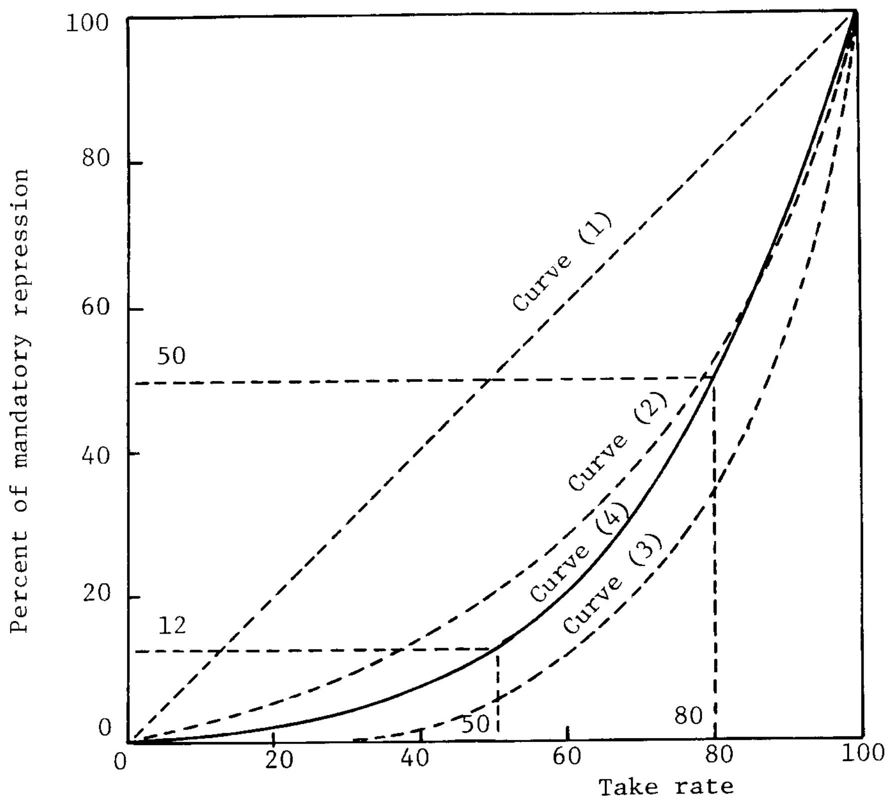

Fig. 4--Realistic relationship of repression to take rate

IV. TRACKING REPRESSION UNDER OPTIONAL MEASURED SERVICE

Our analysis in the preceding sections was largely based on a single data set--the GTE experiment with mandatory measured service in smaller Illinois communities. Although the results are derived from carefully processed and rigorously analyzed measurements of both individual customer and aggregate class telephone use, their direct applicability across the country is open to question.

Additional measured service experiments will probably not be undertaken. The Bell System, after initially proposing a mandatory experiment in Cincinnati, has shifted to a policy of introducing optional measured service plans. However, the areas where these optional rates are now going into effect are possible sources of additional data for assessing repression.

Reliable measurement of repression of local telephone use should be an important objective of the initial measured service plans. Price-induced reductions in use are central to determining the economic efficiency of measured versus flat rates. Repression measurements provide information about both the value of calls to consumers and the concomitant savings in investment and expenses that can be realized if use is reduced.[18] Determining the degree of repression will also improve the basis for forecasting revenue, investment requirements, and costs--both when an optional measured rate is introduced and later when the flat rate is increased.

Measuring repression when measured service is optional is, if anything, more complicated than when the measured rate is mandatory. Local residential telephone use is not routinely measured because its price is zero, and therefore a special usage study will be required before the measured rate option is put into effect. Moreover, the study must be continued during the period of measured service, because otherwise only customers choosing the measured rate will have data on their use routinely collected.

Under most of the optional plans that have been proposed to date we expect that considerably less than half of the residential calls will be subject to usage-sensitive charges. A minority of customers, those with less than average use, will tend to choose measured rates. And when optional plans incorporate usage allowances, the calls of some of these customers will be insensitive to usage rates. The combined effect of these factors is that the total amount of repression will be quite small when an optional plan is introduced. But other factors that cause use to vary will continue to operate: If there is an over-all trend in local use, it will (presumably) cause average calling rates to increase over time. Seasonal variability causes calling to fluctuate, not completely predictably, from month to month. And community growth causes aggregate volume to increase and, perhaps, use per line to change as well. These factors combine to make it difficult to reliably detect any repression.

Two methods are available to track repression under optional rates. An aggregate exchange-wide analysis can be conducted with the standard usage-measuring equipment normally employed for special traffic studies. Or a more detailed analysis of individual customers can be undertaken by linking usage measurements over time for each customer and line.

AGGREGATE REPRESSION ANALYSIS

In concept, one can conduct an aggregate analysis by measuring all local use for at least one year before and one year following the introduction of optional rates and calculating separate mean usage rates per line for residential and business customers. Using the same months for the "before" and "after" estimates minimizes the effect of seasonal variation. If there is evidence of a trend in use per line, calling rates could be adjusted by an estimate of the annual change from a similar area with unaltered rates.

We illustrate this approach in Table 1 using a stylized example of an exchange of fixed size with 10,000 residential and 2000 business subscribers, assuming that trend and seasonal effects can be neglected and summarizing use simply by the number of calls. Suppose that by offering one or more measured rate options, the telephone company succeeds tin attracting 50 percent of the residential subscribers who

Table 1

AGGREGATE ANALYSIS OF REPRESSION UNDER OPTIONAL RATES[a]

(50% residence take rate)

	Before		After	
	Calls	Calls per line	Calls	Calls per line
Residence	1,200,000	120	1,177,000	117.7
Business	500,000	250	504,000	252
Total	1,700,000		1,681,000	
Repression	--		19,000	

[a]Hypothetical data for a community with a fixed population of 10,000 residential and 2000 business subscribers. In the "before" period, residential subscribers are on flat rates; business subscribers are on measured rates. After measured service has become effective, residential subscribers have the option of flat or measured rates; business subscribers remain on measured rates.

account for about 27 percent of the total calls. Across all customers in the exchange there is a reduction of 19,000 calls per month, amounting to a repression effect of 1.6 percent of all residential calls and 5.9 percent of the calls subject to usage charges. Note, however, that some increase in business class use is expected (despite the unchanged measured rates for that class) because some formerly residential calls will now be made from business phones. This substitution effect must be deducted from the change in the total residential class calling rate to obtain an accurate estimate of repression.

INDIVIDUAL CUSTOMER ANALYSIS

If the system for processing usage data is carefully designed, the calling patterns of individual customers can be tracked before and after measured rates are introduced. Such data sets would permit several types of detailed analyses to be conducted, including ones similar to those we have described for the Illinois experiment.

But to carry out a customer-specific analysis of repression it is necessary to account for call substitution. This is illustrated in Table 2 using the same stylized example. By identifying the use of individual customers over time, one can determine the previous (flat-rate) use of the subscribers who choose measured rates. In this example, measured rate customers initially made 324,000 calls per month (an average of 65 calls per line) and reduced that to 291,000 calls per month (58.2 calls per line) in the first year of measured service. Residential customers also altered usage patterns to avoid the charges, with the result that calls originated by flat-rate customers increased from 876,000 to 886,000 (175 to 177.2 per line). In addition, as observed earlier, some substitution to business phones also occurs.

Although measured rate customers reduced their calling by 33,000 calls per month, only a part of the change is actual repression. Calls originated by flat-rate customers increased by 10,000 and calls from business phones increased by 4,000. Thus the actual repression was only 19,000 calls per month.

Table 2

CUSTOMER-SPECIFIC ANALYSIS OF REPRESSION UNDER OPTIONAL RATES[a]

(50% residence take rate)

	Before		After	
	Calls	Calls per line	Calls	Calls per line
Residence customers[b]				
Measured rate	324,000	65	291,000	58.2
Flat rate	876,000	175	886,000	177.2
Business customers	500,000	250	504,000	252
Total	1,700,000		1,681,000	

[a]See Table 1 for assumed conditions.

[b]Customers are classified by the type of rate chosen in the "after" period.

V. CONCLUDING OBSERVATIONS

Optional measured service, at least in the form being proposed by most operating companies today, will result in very modest reductions in overall local telephone use. Indeed, it is possible that these repression effects will go undetected because of changes in use due to trends, seasonal factors, and population movements. However, changes in use by the class of subscribers who do select measured rates will overstate actual repression because of the opportunities to substitute calls that originate at flat-rate and business phones.

The small initial repression under optional rates does not necessarily imply that measured rates will not eventually account for economically significant reductions in local use. It is widely expected that flat rates will be raised over time in response to changes in procedures for allocating revenues from interstate toll calls to state jurisdictions; if measured rate options remain unchanged, the proportion of subscribers and the use subject to measured rates could increase substantially. In Illinois, where usage changes have been systematically measured, we found that repression increases more than in proportion to monthly use. These factors will combine to amplify the importance of repression in the future, affecting both revenue and investment requirements.

Table A.1

REPRESSION CALCULATIONS ASSUMING BILL-MINIMIZING CHOICE OF SERVICE

	Calls			Repression		
Fractile (percent)	Range (1)	Fraction (2)	Cumulative (3)	Relative (4)	Fraction (5)	Cumulative (6)
0-10	0-27	1.3	1.3	--	--	--
10-20	27-44	2.8	4.1	--	--	--
20-30	44-60	4.0	8.1	.00	0.0	0.0
30-40	60-78	5.4	13.5	.30	1.6	1.6
40-50	78-96	7.0	20.5	.52	3.6	5.3
50-60	96-118	8.4	28.9	.71	6.0	11.2
60-70	118-146	10.4	39.3	.87	9.0	20.3
70-80	146-182	13.5	52.8	1.04	14.0	34.3
80-85	182-209	8.0	60.8	1.16	9.3	43.6
85-90	209-245	9.6	70.4	1.26	12.1	55.7
90-92	245-265	4.3	74.7	1.33	5.7	61.4
92-94	265-291	4.8	79.5	1.38	6.6	68.0
94-96	291-329	5.2	84.7	1.45	7.5	75.6
96-97	329-355	2.8	87.5	1.50	4.2	79.8
97-98	355-392	3.3	90.8	1.55	5.1	84.9
98-99	392-458	3.8	94.6	1.60	6.1	91.0
99-100	458 -	5.4	100.0	1.65	8.9	100.0

Col. (1) is the usage range (calls per month) for each fractile in a Pavarini type of distribution with mean usage equal to 120 calls per month. In the Pavarini distribution (1979, p. 54), the power function of the number of calls $C^{.27}$ is normally distributed, and the standard deviation of C is .8 times its mean.

Col. (2) is the percentage of total calls made by each usage fractile. It applies to any Pavarini distribution, regardless of its mean.

Col. (3) is the cumulation of Col. (2).

Col. (4) is the relative repression by customers with calls per month equal to the midpoint of the range in Col. (1). It is read from Park et al. (1981), Fig. 5) and expressed as a fraction of average repression. For example, repression at the midpoint of the 50-60 percent fractile (102 calls per month) is 9.7 percent. Average repression is calculated to be 13.7 percent by taking a weighted average of similar percentage repression figures for each usage fractile, using the fraction of calls, column (2), as weights. Relative repression is then calculated as, for example, 9.7/13.7 = .71.

Col. (5) is the percentage of repression due to each usage fractile. It is calculated as percentage of calls times relative repression, Col. (2) times Col. (4).

Col. (6) is the cumulation of Col. (5).

Table A.2

REPRESSION CALCULATIONS ASSUMING REALISTIC CHOICE OF SERVICE

Fractile (percent)	50-call Breakpoint Take rate (1)	50-call Breakpoint Repression (2)	100-call Breakpoint Take rate (1)	100-call Breakpoint Repression (2)	200-call Breakpoint Take rate (1)	200-call Breakpoint Repression (2)	300-call Breakpoint Take rate (1)	300-call Breakpoint Repression (2)	400-call Breakpoint Take rate (1)	400-call Breakpoint Repression (2)
0-10	39	--	78	--	97	--	99	--	100	--
10-20	28	--	67	--	92	--	98	--	99	--
20-30	17	.0	53	.0	86	.0	95	.0	98	.0
30-40	9	.1	39	.6	78	1.2	90	1.4	96	1.5
40-50	3	.1	23	.8	62	2.2	82	3.0	90	3.2
50-60	1	.1	13	.8	48	2.9	71	4.3	83	5.0
60-70	--	--	4	.4	25	2.3	49	4.4	65	5.9
70-80	--	--	2	.3	16	2.2	34	4.8	51	7.1
80-85	--	--	1	.1	11	1.0	28	2.6	45	4.2
85-90	--	--	--	--	7	.8	20	2.4	36	4.4
90-92	--	--	--	--	5	.3	17	1.0	28	1.6
92-94	--	--	--	--	3	.2	13	.9	24	1.6
94-96	--	--	--	--	2	.2	10	.8	19	1.4
96-97	--	--	--	--	2	.1	7	.3	16	.7
97-98	--	--	--	--	1	.1	5	.3	12	.6
98-99	--	--	--	--	1	.1	4	.2	9	.5
99-100	--	--	--	--	--	--	2	.2	5	.4
	9.7	.3	28.0	3.0	51.5	13.5	65.2	26.4	74.1	38.2

Col. (1) is the percentage take rate for each usage fractile read at the midpoint of Col. (1), Table A.1, from Infosino (1979, Table 12). The total for Col. (1) is the overall take rate for each breakpoint. It is obtained by weighting the take rate for each fractile by the size of that fractile and summing over all fractiles.

Col. (2) is the percent of mandatory repression due to each fractile. It is calculated as Col. (1) in this table times Col. (5) in Table A.1. The total of Col. (2) is the total percent of mandatory repression for a tariff with the given breakpoint.

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NOTES

1. This is the GTE experimental tariff that has been in effect since June 1979.
2. However, to the extent that such customers are uncertain about whether they will exceed (or have exceeded) the ceiling during a given month, they will reduce usage.
3. See Park and Wetzel (1981) for sources and qualifications.
4. For engineering purposes, peak load is typically defined as the average load during the busiest hour of the 10 busiest days during the year.
5. Fig. 1 is based on the adjusted Park-Wetzel repression estimates.
6. Note, however, that these figures are not necessarily accurate because they are extrapolated far beyond observed prices.
7. In addition, measured rate options offered by Bell operating companies typically include an allowance of "free" usage. Customers who do not expect to exceed their allowance would have no incentive to reduce calling. However, as we shall see below, the effect of an allowance on repression is very small.
8. More precisely, fewer than the usage-price-weighted average of calls and minutes.
9. Figure 2 is plotted for the distribution of calls found by Pavarini (1979, p. 54) to apply to 73 Bell System exchanges charging flat rates. In such a distribution, the power function of the number of calls, $C^{.27}$, is normally distributed, and the standard deviation of C is .8 times its mean. Such a distribution also describes calling rates in the GTE experimental exchanges quite well; see Park et al. (1981).
10. The same curve does not precisely describe the relationship between usage and number of customers under any particular optional measured rate, but that relationship is of no particular interest here.

11. In Park et al. (1981), we actually estimate a very slight increase in calling by the smallest users; we ignore the increase in the calculations that underlie Fig. 3.
12. Clearly, the effect of call allowances that apply to the low end of the usage spectrum will be very small, because customers whose calling rates are under the allowance would repress very little, if at all, even if the allowance did not exist.
13. The calculations themselves are in Appendix Table A.1. The same calculations are the starting point for the more realistic case described in the next subsection.
14. These figures are for Infosino's "R" parameter equal to .5, read from his Fig. 12. An R value of .5 is consistent with observations within New York State, where customers have had the option of measured service for a fairly long time.
15. Shown in detail in Appendix Table A.2.
16. Repression calculated in this way may be understated. We have used average repression in each usage fractile in the calculations. In fact, however, customers with higher than average repression may be more likely to choose the measured service rate.
17. For example, we have done the calculation for a community that averages 120 calls per subscriber per month. The curve would be higher or lower in areas with higher or lower calling rates.
18. Mitchell (1980b) outlines the basic elements of a cost/benefit analysis of measured service rates.

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