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12 Bypass of the Local Exchange A Quantitative Assessment

September 1984

Gerald W. Brock

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BYPASS OF THE LOCAL EXCHANGE

A QUANTITATIVE ASSESSMENT*

Gerald W. Brock

September 1984

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Executive Summary

The quantity of bypass which will occur as a result of any particular access tariff is an important factor in the design of access tariffs to replace the separations and settlements process. If usage based access tariffs induce large amounts of bypass, then the actual revenue obtained from such tariffs will be far less than the expected revenue computed by multiplying the currently used number of access minutes by the access charge. If bypass is extensive enough, it may be impossible to raise the entire interstate portion of the local revenue requirement through usage based access charges.

This paper explores the incentives for bypass created by the imposition of usage based access tariffs to recover the portion of local revenue requirements assigned to the interstate jurisdiction. "Bypass" is defined as the use of alternative facilities between a user's location and the long distance carrier's Point of Presence (POP) to avoid usage based access charges. The alternative facilities may be either a local private line obtained under the carrier's special access tariff or a privately constructed facility.

Incentives for Bypass

The portion of local costs assigned to the interstate jurisdiction increased rapidly during the 1970's. The Ozark Plan separations procedures adopted in 1970 assigned a percentage of local non-traffic-sensitive (NTS) costs to the interstate jurisdiction based on multiplying the percentage of interstate traffic by approximately three. As the percentage of interstate traffic increased from five percent in 1970 to eight percent in 1981, the fraction of local NTS costs to be paid from interstate toll calls rose to about one quarter. The interstate fraction is now scheduled to move toward a fixed twenty-five percent nationwide (plus some additional assistance for high cost areas), with no further adjustments for changes in the proportion of interstate calls.

The large amount of local costs assigned to the interstate jurisdiction caused long distance toll prices to be far above the cost of providing long distance service in order to cover the payments to local carriers. So long as AT&T was the monopoly carrier of switched long distance service, the only way a user could avoid paying the separations costs embedded in toll prices was to set up a complete network of private microwave or private line facilities and thus bypass the switched toll network. This option was taken by the largest users who set up extensive networks of switched private lines to provide a private version of the switched toll network outside of the separations process. However, many users have large total demand but limited demand between any two points and thus are not candidates for complete private networks.

The divestiture of the Bell operating companies from AT&T together with the growth of competitive long distance companies greatly increased the ability of large users to avoid the local cost contribution built into the long distance rate structure. The division of revenues process was replaced with access charges for providing service from the customer location to the long distance company's Point of Presence (POP). In order for access charges to provide as much contribution to local costs as the separations process had done, it was necessary to set the charges quite high. Under the access charge system of cost recovery, a moderately large business user which could not utilize a full private line network has an incentive to bypass switched access service and use an alternative means of carrying traffic between the customer location and the POP. If, for example, a particular company makes a hundred calls to each of a hundred different points each month, it would not bypass the interexchange switched network because the traffic density between any two points would be too low to justify alternative facilities. But that traffic implies 10,000 calls between the customer location and the local POP. If the local company charges for each of those calls at a high access rate, then the interexchange carrier is likely to find that a private line or privately constructed facilities between the customer's location and the POP will be cheaper than paying the switched access charge.

If some companies bypass the switched access facilities and the revenue requirement to be provided from switched access remains constant, then access prices will be raised for the remaining customers. The higher prices will then induce further bypass and further increases until either an equilibrium access price is reached (which provides the necessary revenue from customers who have no incentive to bypass at that price) or all customers find alternatives to switched access. Consequently, it is necessary to estimate how much bypass will take place at each access price, whether an equilibrium price exists for a given revenue requirement, and how much price increase is required to reach the equilibrium if it exists.

The Impact of Bypass on Required Access Charges

Bypass facilities have a usage cost which is lower than the access price per minute but also have a fixed cost which must be paid regardless of usage. For example, a private line incurs a fixed monthly cost per line regardless of usage and consequently the usage cost is zero until the capacity of the line is reached. Bypass facilities are therefore profitable to customers above a particular level determined by the point where the savings on usage charges pay for the fixed charge.

Given the cost of bypass facilities, the amount of bypass which results from any level of access charges is the total usage of all customer locations which each have more than the breakeven level of usage at the given price level. After the level of bypass is computed, the revenue requirement is then divided by the number of remaining switched access minutes to get a new level of access charges which must produce a corresponding increase in the total price of long distance service. The adjustment causes two effects. The higher price of long distance service reduces the total demand for long distance service and the higher access charges increase the incentive for customers to obtain access from bypass facilities. Accounting for these effects produces a new level of bypass and a new number of remaining switched access minutes and then a new level of required access charges. The process continues until further cycles produce no significant change or until it becomes clear than no equilibrium exists.

The 1984 interstate revenue requirements to be met from usage charges are $9.0 billion of NTS costs and $5.5 billion of traffic sensitive (TS) costs. The first set of results assumes that only the

$9.0 billion in NTS costs must be recovered in full and that the TS revenue requirement remains a constant cost per minute regardless of the level of switched access usage. In that case, the NTS portion of the access price would have to be raised 70 percent over the current level to compensate for bypass. Varying the assumptions used varies the required increase from a low of 34 percent to a high of 93 percent. The current rate of $.0524 per minute for NTS would increase to $.089 in the "base case" with a range from $.070 to $.101 using alternative assumptions.

At the equilibrium level of access charges, 21 percent of the total business access minutes are served by privately constructed facilities and 55 percent are served by private line connections between the customer and the interexchange POP. Less than five percent of business customers utilize bypass facilities but those customers account for three quarters of the total minutes. The revenue requirement is raised from the smaller business customers and residence customers.

Although TS costs are defined as "traffic sensitive", they do not decrease smoothly with reductions in usage. With current procedures, the TS costs assigned to the interstate jurisdiction decline with reductions in usage but the underlying costs to the carriers do not decline significantly and would have to be made up through higher local rates. Consequently, in order to evaluate the full impact of bypass it is useful to treat the entire $14.5 billion NTS plus TS revenue requirement as fixed independent of usage. In that case, the level of access charges necessary to meet the revenue requirement increases over the current level by 121 per cent (from $.0845 per minute to $.187 per minute) using the base case parameters of the model. More optimistic assumptions reduce the required increase to 50 percent ($.127) but more pessimistic assumptions lead to the conclusion that no equilibrium value exists. Under those conditions no level of usage based access charges meets the revenue requirement because increases in access charges induce enough additional bypass and enough reduction in total demand to produce practically no net gain in revenue.

When access charges are near their current level of $.085 per minute, a one percent increase in the access charge produces a net access revenue gain of only .45 percent. The revenue gain is less than half of the access charge increase because the increased access charge induces additional use of bypass facilities and a reduction in total long distance demand. Alternatively, a one percent reduction in required access revenue allows more than a two percent reduction in the access charge required to generate that revenue because the lower access charge is applied to a larger total of switched access minutes.

Conclusion

Bypass is a serious threat if usage based access charges continue to be used to meet revenue requirements similar to the 1984 level. The necessary usage charges are high enough to make alternative access facilities profitable for the largest business customers. Because the switch to alternative facilities produces little if any cost savings for the local carriers, the revenue requirement is then spread over a smaller base of access minutes causing higher charges to the remaining customers. Using the most likely estimates for the parameters of the model, large increases in access prices will be necessary to provide the current revenue requirements after bypass has occurred. Using pessimistic but plausible assumptions, no equilibrium level exists and an attempt to provide the current revenue requirements from usage charges will cause the switched network to unravel in a cycle of increased access charges, increased bypass and decreased demand, increased access charges, and so forth with no stopping point.

BYPASS OF THE LOCAL EXCHANGE

A QUANTITATIVE ASSESSMENT

I. Introduction

This paper explores the incentives for bypass created by the imposition of usage based access tariffs to recover the portion of local revenue requirements assigned to the interstate jurisdiction. "Bypass" is defined as the use of alternative facilities between a user's location and the long distance carrier's Point of Presence (POP) to avoid usage based access charges. The alternative facilities may be either a local private line obtained under the carrier's special access tariff or a privately constructed facility.

The quantity of bypass which will occur as a result of any particular access tariff is an important factor in the design of access tariffs to replace the separations and settlements process. If usage based access tariffs induce large amounts of bypass, then the actual revenue obtained from such tariffs will be far less than the expected revenue computed by multiplying the currently used number of access minutes by the access charge. If bypass is extensive enough, it may be impossible to raise the entire interstate portion of the local revenue requirement. Fears that bypass might be very extensive were part of the reason for the Commission's 1983 decision to phase in customer access line charges (CALC) in fixed amounts per line as a replacement for usage based charges.[1] However, extensive opposition to the implementation of the 1983 access charge plan caused the Commission to delay the CALC for residential and single line business users until June 1985 and to initiate further studies on the extent of bypass in preparation for possible revisions to the access charge plan at the end of 1984.[2]

This paper first describes the incentives to bypass the local exchange which resulted from the AT&T divestiture, the growth of long distance competition, and the associated change in the method of recovering the interstate portion of local exchange costs. The paper then describes a model which predicts the magnitude of bypass as a result of the size distribution of customers, the costs of bypass facilities, and the level of usage based access charges. The model is used to compute the equilibrium level of revenue resulting from various levels of usage based access charges. The yield of increased revenue

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1 CC Docket 78-72, Memorandum Opinion and Order (Access Charge Reconsideration Order), FCC 83-356, released August 22, 1983.

2 CC Docket 78-72, Memorandum Opinion and Order, (Access Charge Further Reconsideration Order), FCC 84-36, released February 15, 1984. The Commission's intention to conduct additional bypass studies during 1984 and to make any necessary revisions to the access charge plan at the end of 1984 is expressed in paragraphs 20 - 26 of that order.

resulting from increased access charges is analyzed by decomposing the effect into the minutes lost to demand reductions, the minutes lost to bypass, and the net gain in revenue.

The model is based on data collected in the spring of 1984 in response to a public notice requesting the submission of data and studies on bypass.[3] Although many responses were received on the filing date of May 21 or soon thereafter, some parties promised more complete data at a later date. This study is based on data available in June 1984.

II. Background Events Relevant to Bypass Incentives

A. Growth of the Interstate Revenue Requirement

Prior to 1930, long distance service made no contribution to the local exchange costs. In that year, the Supreme Court ruled that because a long distance call required use of the local exchange as well as of separate toll facilities, the interstate jurisdiction must pay some of the costs of the local exchange as compensation for the

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3 Public Notice, "Request for Data, Information, and Studies pertaining to Bypass of the Public Switched Network," Mimeo No. 3206, (March 28, 1984).

facilities used.[4] Thus was born the separations and settlements procedures. Separations refers to the allocation of portions of the local exchange cost to the interstate jurisdiction and settlements refers to payments among the carriers to divide up the toll revenue in accordance with the revenue requirements determined by separations.

Much of the cost of local telephone plant does not vary with usage. Each subscriber requires a telephone instrument and a wire to the local exchange office. The cost of that equipment is the same whether the customer uses it for making local calls, for making long distance calls, or for making no calls at all. Consequently, the process of allocating the cost of that equipment, referred to as non-traffic sensitive (NTS) costs, was inherently arbitrary. It was determined by negotiation among AT&T, the independent telephone companies, state regulators, and the FCC. Because of overlapping jurisdiction in separations matters between state and federal regulators, responsibility for proposing separations agreements was vested in a Joint Board composed of representatives from the FCC and state regulatory commissions, while responsibility for approving the agreements remained with the FCC.

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4 Smith v. Illinois Bell Telephone, 282 U.S. 133 (1930).

The initial separations formula was a simple function of relative use. Approximately three percent of the total calling minutes were used for interstate calls; consequently approximately three percent of the local exchange plant was assigned to the interstate jurisdiction to be recovered through the settlements process. Over time the formula was modified to weight interstate minutes more than intrastate minutes and consequently to increase the proportion of costs assigned to interstate. In addition interstate calling increased faster than intrastate calling which caused further growth in the proportion of costs assigned to interstate. The last separations formula was the Ozark Plan adopted in October 1970 which increased the weighting of interstate minutes to approximately 3.3.[5]

When the Ozark Plan was adopted in 1970, the Bell System interstate usage as a proportion of all calling minutes was 5.08

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5 The Ozark formula determined the revenue requirement as

$$SPF = .85(SLU) + 2(SLU)(CSR)$$

where SPF is the subscriber plant factor (the proportion of local costs to be assigned to the interstate jurisdiction), SLU is the subscriber line usage (the fraction of interstate calls in the study area), and CSR is "(a) the average composite interstate initial 3 minute station rate at the study area average length of haul divided by (b) the composite average total toll initial 3 minute station rate at the nationwide average length of haul for all toll traffic for the total telephone industry." 26 FCC 2d 248 at 251 (1970).

percent which the Ozark Plan translated into an allocation of 16.71 percent of non traffic sensitive costs to the interstate jurisdiction. As the relative use of interstate calls increased during the 1970s, the multiplicative nature of the Ozark Plan caused rapid increases in the proportion of local costs assigned to the interstate jurisdiction. By 1981, the Bell System's SLU factor had risen from 5.08 to 7.93, causing a corresponding increase in the SPF factor from 16.71 to 26.09 percent. Concern that the interstate allocation was increasing far faster than envisioned when the Ozark Plan was adopted caused the FCC to freeze the SPF factor at the 1981 level while examining more permanent changes in the separations formula.[6]

Under the separations formulas, separations factors were determined by separate study areas (generally a particular company's area within a state). Consequently, total allocations to the interstate jurisdiction varied with interstate usage. Although the Bell System 1981 average factor was 26 percent, allocations varied from a low of 13 percent in the part of Kentucky served by Cincinnati Bell to a high of 62 percent in Nevada. The percentages translated into

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6 "Amendment of Part 67 of the Commission's Rules and Establishment of a Joint Board", 89 FCC 2d 1 (1982).

interstate allocations ranging from $3. per line per month in part of Kentucky to $26 per line per month in Nevada.[7] At the end of 1983, the Commission accepted a Joint Board recommendation to move toward a constant 25 percent SPF factor nationwide, supplemented by a Universal Service Fund to provide assistance to high cost areas. The 1981 "frozen SPF" factors for each area were to remain in effect through 1985 followed by a gradual transition to the flat 25 percent factor. The decision provided for additional revenue for areas with costs more than 115 percent of the national average, with the amount of assistance to depend upon the local cost level relative to the national average.[8]

B. Competition in Long Distance Service

The impact of the separations growth was to support an increasing share of local expenses out of long distance toll revenue. The burden of separations and the resulting pricing of switched services above the cost of service made switched services an attractive target for

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7 "Comments of the Bell Operating Companies," CC Docket 78-72 (August 6, 1982); the numbers are summarized in Congressional Budget Office, "The Changing Telephone Industry: Access Charges, Universal Service, and Local Rates," (June 1984), Table 3.

8 "Amendment of Part 67 of the Commission's Rules and Establishment of a Joint Board," CC Docket 80-286, FCC 83-564 (Adopted December 1, 1983; released February 15, 1984).

competitors. If a competitor could set up a long distance network and secure local connections at the regular business line rate rather than participating in the separations process, it could make a substantial profit. MCI attempted to take advantage of that opportunity with its Execunet service introduced in January 1975. Execunet used MCI's established competitive network previously devoted to private line service and connected that network to the local exchange switch with ordinary business lines to provide the equivalent of switched long distance service. At the time Execunet was introduced, MCI's authority to offer switched service was in doubt. After extensive controversy the right of competitors to offer switched long distance service and the obligation of local exchange companies to provide the necessary connections was affirmed.[9]

The beginning of competition in long distance service created a severe problem for the separations process. The process was established over a long period of time with the concurrence of the Commission, state regulatory agencies, AT&T, and the independent telephone companies. The Commission lacked the authority to abolish

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9 For further discussion of the development of competition in switched long-distance service see Gerald Brock, The Telecommunications Industry: the Dynamics of Market Structure (Cambridge: Harvard University Press, 1981), pp. 224-230.

the process. Yet the process as established was incompatible with competition. If a new competitor could gain access by using ordinary business lines, it would have an artificial incentive to expand at AT&T's expense simply because it was avoiding the payments AT&T was required to make to the local companies. There was no provision in the established procedures for adding another long distance company to the existing separations process. A further complication was the fact that AT&T and MCI received technically different kinds of connections and the operating companies were incapable of providing the same kinds of connections to MCI as they provided to AT&T. Consequently, an attempt to bring MCI into the settlements process required a determination of the relative value of "trunk side" connections utilized by AT&T and "line side" connections utilized by MCI.

The complex questions raised by the introduction of competition into switched services caused the FCC to convene the parties to negotiate an interim agreement for access while a more permanent solution was being developed. In December 1978 the parties reached an agreement which was to last three years by which time the Commission was expected to reach a final decision on permanent arrangements.[10]

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10 At the time of the agreement, AT&T's cost per access minute was 5.5 cents through the separations and settlements process. The negotiated ENFIA tariff (Exchange Network Facilities for Interstate Access) called for the competitors to pay thirty-five percent of that factor initially and to

While the Commission investigation of possible modifications to the settlements process was underway, the proceedings were overtaken by the 1982 settlement of the U.S. Department of Justice's antitrust suit against AT&T. According to the terms of the Modified Final Judgment (MFJ), the local exchange portions of AT&T were to be divested from the long distance company. The MFJ provided that the separations and settlements process be cancelled and that future payments from long distance carriers toward the local exchange be only in the form of tariffs for access service. As a result, the Commission modified its continuing investigation to focus on the appropriate form of access tariffs to replace the settlements process.

In December 1982, the Commission reached a decision on access charges which was reconsidered and modified in August 1983 and further modified in February 1984.[11] The essential feature of the Commission's revised access charge decision was to initially retain the usage charges from the settlements process in the form of access tariffs for

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increase payments to a maximum of fifty-five percent of the AT&T figure when the competitive revenue passed a specified level. Exchange Network Facilities (ENFIA), 71 FCC 2d 440 (1979).

11 CC Docket 78-72, Third Report and Order, FCC 82-579 (Adopted December 22, 1982; released February 28, 1983); Memorandum Opinion and Order, FCC 83-356 (Adopted July 27, 1983; released August 22, 1983); Memorandum Opinion and Order, FCC 84-36 (Adopted February 3, 1984; released February 15, 1984).

providing service between the interexchange carrier's Point of Presence (POP) and the customer premise, but to gradually replace the usage charges with fixed charges on each customer line. Extensive opposition to the proposed Customer Access Line Charges has provoked debate over the wisdom of implementing the Commission's long range plan and raised the possibility of continuing to raise much of the interstate revenue requirement through usage based access tariffs. Although continuation of usage sensitive tariffs would appear to maintain the status quo with regard to pricing, the change from settlements to access tariffs greatly increases the incentive to bypass the exchange. The change in incentives can most easily be illustrated by an example.

C. An Example of Bypass Incentives

Customers have a demand for communication with many different points. As part of the divestiture of AT&T, the country was divided into Local Access and Transport Areas (LATAs). Intra-LATA calls are handled by a local operating company while inter-LATA calls are funneled to an interexchange carrier's Point of Presence (POP) for transmission over the interexchange network to the terminating city POP, then are transmitted over a local exchange carrier's lines to the final customer. Consider a hypothetical XYZ Corporation with headquarters in New York, branch offices in Chicago and Dallas, and a telephone sales force located in New York. The company's demand for calls at existing prices is 3000 minutes per month from the headquarters to each of the branch offices. The sales force calls 100 people per month in each of 50 cities with calls averaging 5 minutes apiece. Total outgoing demand is 31,000 minutes per month (3000 minutes to each of the branch offices and 500 minutes to each of 50 cities). The company would minimize its telecommunications costs by ordering private lines from its headquarters to the two branch offices and using switched WATS service for the sales calls.

The two interstate private lines do not count either for the Subscriber Line Usage (SLU) factor of the separations system or for access minutes in the access tariffs which replaced settlements. Private lines are "directly assigned" and their costs are recovered but no contribution is made on a usage basis to the switched local exchange costs. Consequently, XYZ would demand 25,000 outgoing minutes of switched service and would account for 50,000 total access minutes (one access minute on each end for each calling minute) rather than 62,000.

Even though the 25,000 outgoing minutes included a substantial payment for non traffic sensitive costs, the situation was stable when switched services were provided by a monopoly carrier and the separations system was in effect. The dispersed nature of the calls made both private lines and privately constructed facilities infeasible so that the only option this large user had was to pay the tariff or forego the communication. However, in the divested world of competitive long distance carriers and usage based access charges, the situation is not stable. At the non-discounted access rate of the May 1984 tariff, the long distance carrier pays $.0845 per minute to the local exchange company for access, or $2113. per month for the originating switched traffic of XYZ. The service received by the interexchange carrier for that particular access charge is bulk transmission between two points - - XYZ's New York office and the carrier's New York POP. The carrier could more cheaply obtain the equivalent service by ordering private line circuits between its POP and XYZ headquarters from the exchange carrier's special access tariff or by building its own facilities directly to XYZ. Either method would bypass switched access service provided by the local exchange carrier and would reduce the total revenue obtained from switched access. Because the access tariffs are designed to recover approximately one quarter of the total local exchange costs rather than only the actual costs of providing access, the bypass facility between XYZ and the POP will have little effect on the total required revenue and will consequently require an increase in the access tariffs in order to develop the required revenue from a reduced number of access minutes.

In this example, bypass would only take place at the originating end. At the terminating end, the calls go to a large number of individual customers and consequently would not in themselves induce bypass. In this hypothetical case, total potential access minutes generated by XYZ's calls are 62,000. Of those, 12,000 were lost to interLATA private lines under the old regime and are not counted. Of the 50,000 remaining minutes, 25,000 are lost to bypass leaving 25,000 for the switched access tarifffs.[12]

III. An Economic Model for Analyzing Bypass

A. Description of the Model

Components of a long distance call include the originating local access which connects the customer premises with the long distance carrier's Point of Presence (POP), the POP to POP service which connects the POP closest to the originator to the POP closest to the

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12 This study is only concerned with bypass of the switched access tariffs from current levels of usage. It does not deal with the bypass of those tariffs which has already occurred by use of private line networks. In terms of the example above, it is concerned with computing what fraction of the 50,000 switched access minutes will be lost to bypass, not with computing bypass from the 62,000 total access minutes. A rough estimate of the magnitude of private line losses prior to divestiture can be made from AT&T's estimate that it served 834,000 voice grade private line main telephones in 1983. (Tariff Reference Filing Package, March 1983, Volume 3-2, Figure 5-2). Adding in an estimate of non-AT&T private lines and using 3000 minutes per line usage suggests that pre-divestiture private line usage was on the order of 15 to 25 percent of total switched usage.

receiver, and terminating local access which connects the receiving POP to the receiving customer premises. The carriers will attempt to minimize the cost of each of the components of the call. To avoid unnecessary complexity in the evaluation of local bypass options, assume that the POP to POP service is provided at a constant average price of P per minute.

This paper evaluates the long run bypass possibilities, after equal access has been obtained and after AT&T has the capability to provide dial tone and other line control functions from its own equipment in the POP rather than depending on the local exchange carrier for those functions. When equal access is in place, the transitional differential between premium and non-premium access charges will be abolished. When all companies can offer dial tone from long distance offices, they will be able to choose among the switched access tariff, private line service obtained from the local exchange company, or specially constructed facilities to minimize the cost of providing communication between each customer's premises and the POP.

The minimum cost alternative will depend upon the magnitude of the customer's demand as well as upon the relative prices of the alternatives. Figure 1 illustrates the choice. Switched access provides a fixed cost per minute regardless of scale and consequently generates a straight line total cost curve. Bypass alternatives (including private line circuits from the local exchange carrier's special access tariff) have a fixed cost and a low marginal cost. Consequently, it is cheaper to serve customers with access demand below some fixed number of minutes through the switched access tariffs and to serve customers with demand above that level with alternatives. The breakeven level is illustrated on Figure 1 where the lines cross and is given by solving:

$$(1) \qquad C(m) = Am$$

for m where C(m) is the total cost of supplying m minutes of access through bypass facilities and A is the price per minute of switched access from the exchange carrier. Equation (1) implicitly defines a function M(A) which gives the breakeven number of minutes for any level of access charges A.

The price to the customer is P + 2A, the price for POP to POP service plus the access charge on each end.[13] The demand function for

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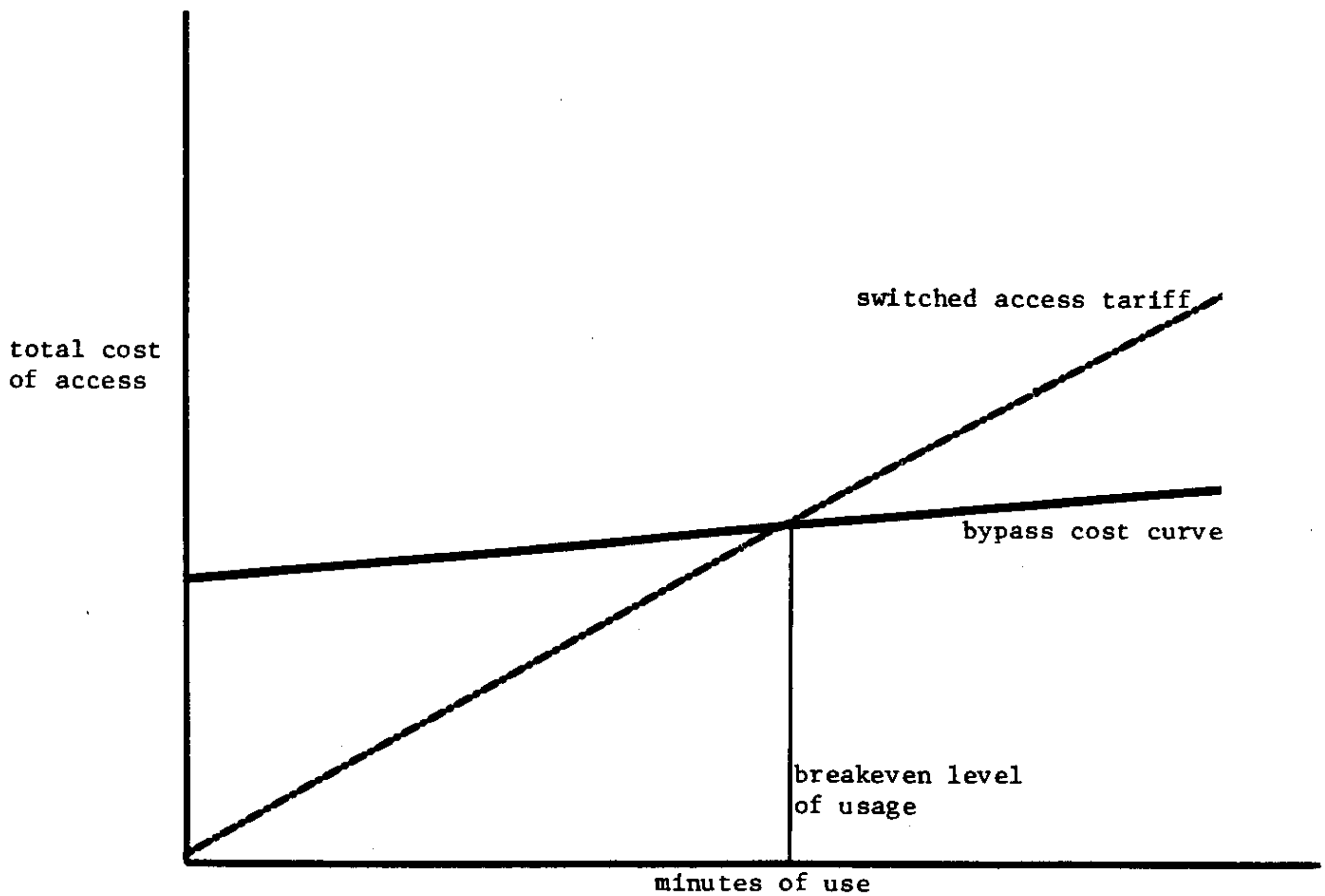
13 If the long distance company passes savings on access charges through to the final customer in the form of lower charges per call, customers served with bypass facilities will have a total price between P + A (no access charge on the originating end) and P + 2A. Taking account of the additional demand generated by lower prices to some customers makes no significant difference in the results and is ignored for simplicity.

FIGURE 1

BYPASS BREAKEVEN LEVEL



total long distance access minutes is given by $Q(P + 2A)$. Because each conversation minute requires two access minutes, the demand function for total conversation minutes is $0.5Q(P + 2A)$.

Assume the customers are ordered by the number of total access minutes demanded by that customer (outgoing plus incoming). Let x represent the position of any particular customer in the ordering as the fraction of all customers with demand greater than that of the particular customer. If a customer is at position x=.25, then 25 percent of all customers have greater demand than that customer. Define $F(x)$ as the fraction of all access minutes demanded by customers with demand higher than the customer in position x. The function $F(x)$ is similar to a probability distribution function. The total range of x is 0 to 1; $F(0) = 0$ and $F(1) = 1$.

Let N be the total number of customers. Then each customer accounts for a change in x of $1/N$. Figure 2 illustrates the computation of the fraction of demand from a single customer located at the position x=a. Adding one customer increases x from a to a + $1/N$ and increases $F(x)$ from $F(a)$ to $F(a + 1/N)$. The increase in $F(x)$ is the fraction of demand from one customer located at position x=a and is given by the slope of $F(x)$ at x=a times the change in x which is $1/N$. Consequently the fraction of demand from a single customer located at position x is given by:

$$(2) \qquad (1/N)D_xF(x) = (1/N)f(x)$$

where D is the differentiation operator with a subscript to show the variable with respect to which the differentiation takes place and f(x) is the derivative of F(x). The function f(x) is similar to a probability density function.

Because the breakeven number of minutes is given by M(A), total demand for access minutes is given by Q(P+2A), and the fraction of total demand accounted for by one customer in position x is given by (1/N)f(x), then the fraction of customers for whom some form of bypass is profitable is given by solving

$$(3) \qquad (1/N)f(x)Q(P+2A) = M(A)$$

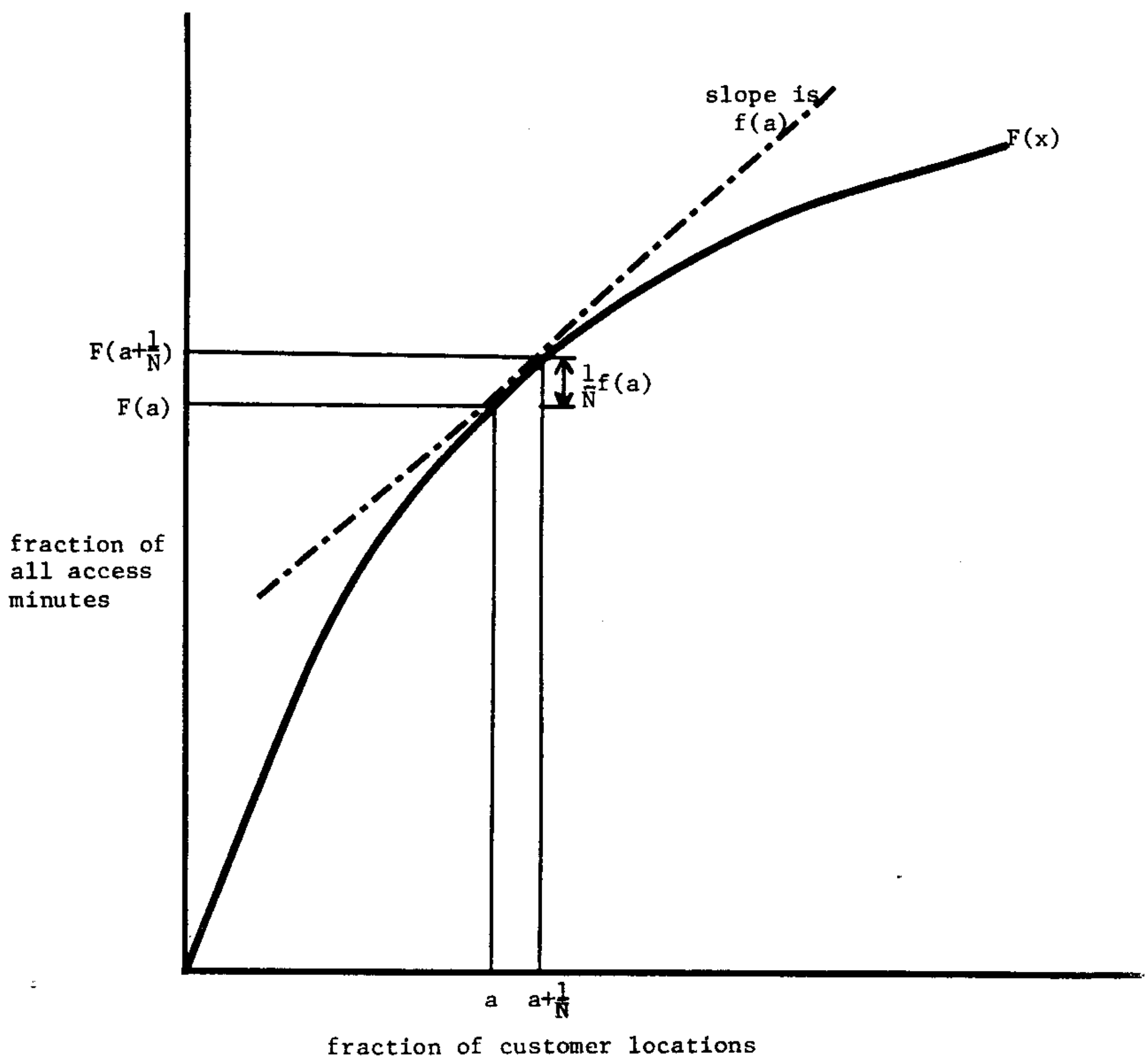
for x as a function of A. Equation (3) implicitly defines a function X(A) given by

$$(4) \qquad X(A) = f^{-1}[NM(A)/Q(P+2A)]$$

where X(A) is the fraction of customers who will be served with bypass facilities for any level of access charges A.

FIGURE 2

DEMAND FRACTION OF A SINGLE CUSTOMER



The total number of access minutes served with bypass facilities will be given by:

$$(5) \qquad B(A) = Q(P+2A)F[X(A)]$$

where B(A) is the total number of bypass minutes as a function of the access price. The function F evaluated at the level X(A) gives the fraction of all access minutes served with bypass facilities and multiplying that fraction by the demand for access minutes gives the number of access minutes served with bypass facilities.

Access minutes not served with bypass facilities are served with switched access service from the carrier. Consequently the number of switched access minutes is given by:

$$(6) \qquad S(A) = Q(P+2A)[1-F[X(A)]]$$

where S(A) is the total number of switched access minutes as a function of the switched access price A.

Switched access revenue is the switched access price times the number of switched access minutes. The revenue requirement is given exogenously as a result of the Joint Board allocation of local costs to the interstate jurisdiction. To meet the revenue requirement, a switched access price must be chosen to solve:

$$R(A) = AS(A) = R_r \tag{7}$$

where R(A) is the total revenue received as a function of the access price and R_r is the revenue requirement.

B. The Question of a Vicious Cycle

Several analysts of bypass have alleged the possibility of a "vicious cycle" in which switched access charges induce bypass causing a revenue shortfall, then prices are raised to increase revenue causing more bypass and then higher prices until the network is largely destroyed.[14] This section analyzes the question of whether or not a vicious cycle can occur in terms of the framework developed above.

The question is whether a price A exists which solves equation (7) for the given revenue requirement, and if so, whether the necessary

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14 For example, AT&T states: "The snowballing effect of subsidy, bypass, increased subsidy, toll repression, more bypass and so on, will continue until all customers who are able to bypass do so." Response of American Telephone and Telegraph Company to the Commission's Request for Bypass Information, May 21, 1984, p. 23.

price is in the "reasonable range" which does not induce "too much" bypass. If R(A) reaches a maximum level below the revenue requirement and then decreases with increases in A, no solution for equation (7) exists. If R(A) increases with increases in A until the revenue requirement is met, then a solution exists and we then need a measure of the efficiency with which increases in A increase R(A) in order to judge whether the necessary price is in the reasonable range.

The function S(A) is a demand function for switched access minutes and is analogous to ordinary demand functions. It is composed of the product of an ordinary demand function for total access minutes and a function representing the fraction of those minutes available to switched access. Both factors decrease with increases in A. So long as the elasticity of S(A) with respect to A is greater than -1 (less than 1 in absolute value), increases in A always produce increases in R(A). The maximum value of R(A) occurs where the elasticity of S(A) with respect to A is equal to -1. The elasticity of S(A) can be found by taking the log of both sides of equation (6) and differentiating with respect to the log of A. This yields:

(8) $e_s = D_{\ln A}(\ln S(A))) = D_{\ln A}(\ln Q(P+2A)) + D_{\ln A}(\ln[1 - F[X(A)]])$

where e_s is the elasticity of S(A) with respect to A and ln means the natural log.

The first term on the right hand side of equation (8) is the elasticity of the demand for access minutes with respect to the switched access price. It can be rewritten as:

$$(9)\ D_{\ln A}(\ln Q(P+2A)) = D_{\ln(P+2A)}[\ln Q(P+2A)]D_{\ln A}[\ln(P+2A)] = e[2A/(P+2A)]$$

where e is the ordinary price elasticity of the demand for total access minutes and the term [2A/(P+2A)] is the fraction of the price represented by switched access charges. Equation (9) therefore says that the elasticity of demand for access minutes with respect to the switched access price is the elasticity of demand for switched access minutes with regard to the total price times the fraction of the total price represented by switched access charges.

The second term on the right hand side of equation (8) is the elasticity of the fraction of total access minutes served by switched access with respect to the switched access price. If we designate that term by e_f, we can rewrite equation (8) as:

$$(10)\quad e_s = e(2A/(P+2A)) + e_f = e_A + e_f$$

where e_A is the elasticity of demand for long distance service with respect to the price of access service. Equation (10) says that the elastiticy of demand for switched access minutes with respect to the switched access price is the ordinary elasticity of demand times the fraction of total price represented by switched access charges plus the elasticity of the fraction of total access minutes served by switched access with respect to the switched access price. The first term on the right hand side of equation (10), e_A, is bounded between zero and e. As A increases, the term approaches the price elasticity of demand. The shape of the second term, e_f, depends on the size distribution of customers. If the sum e_s remains greater than -1 regardless of the level of A, then any revenue requirement can be met. If the sum declines to -1 for some level of A, that level is the maximum revenue which can be obtained from switched access charges.

The rate at which increases in the access price increase total access revenue can be measured by computing the elasticity of total access revenue with respect to the access price. This elasticity gives the percentage change in access revenue resulting from a one percent change in access price. When this elasticity is at its maximum value of 1.0, the revenue yield is 100 percent because no demand effects occur and increases in access price translate into proportional increases in access revenue. When the elasticity declines to 0, the revenue yield is 0 because increases in access price have no effect on access revenue. The elasticity can be computed by taking the log of the revenue expression from equation (7) and differentiating with respect to the log of the access price. This gives:

(11) $$D_{\ln A}[\ln R(A)] = 1 + D_{\ln A}[\ln S(A)] = (1+e_s)$$

The term $(1+e_s)$ measures the revenue yield. When that term is equal to 1, a 1 percent increase in revenue can be obtained with a 1 percent increase in the access price. When that term is 0.5, a 1 percent increase in revenue requires a 2 percent increase in price. As that term approaches zero, enormous price increases are required to produce moderate revenue increases.

As indicated in equation (11), the revenue yield depends on the elasticity of switched access minutes with respect to the access price (e_s). That elasticity is the sum of the elasticity of total access minutes and the elasticity of the fraction of total access minutes served by switched access ($e_A + e_f$).

If the ordinary elasticity of demand for long distance service is -0.75 and the access price accounts for 33 percent of the total price, then e_A is -0.25. If the ordinary elasticity of demand is -1.0 and the access price accounts for 75 percent of the total price, then e_A is -0.75. Within the range of common estimates for the elasticity of demand for long distance service and the range of likely access charges, e_A ranges from near zero to approximately -1.0.

The second component of e_s can be expressed as:

(12) $e_f = D_{lnA}(\ln[1-F(f^{-1}[NM(A)/Q(P+2A)])])$

The expression in equation (12) is rather confusing but is written out to show the explicit dependence of (1-F(X)) on the price A. The expression is found by substituting the definition of X(A) from equation (4) as the argument of F(X), then taking logs and differentiating to get the elasticity of (1-F(x)).

Suppose F(x) is of the general form $F(x) = 1 - e^{-bx}$ with b a positive constant much greater than 1. Then F(x) has the empirically observed general shape of the distribution function and rises rapidly from 0 at x=0 and more slowly toward 1 at x=1. With that functional form, $f(x) = be^{-bx}$ and $f^{-1}(x) = (-1/b)\ln(x/b)$. Substituting into equation (12), we get:

(13) $e_f = D_{lnA}M(A) - D_{lnA}Q(P+2a) = e_M - e_A$

where e_M is the elasticity of M(A) (the breakeven number of minutes as a function of the access price) and e_A is the elasticity of long distance demand with respect to the access price.

With this functional form, f(x) reaches a maximum value of b for non-negative values of x. Because negative values of x are not meaningful, it may be impossible to obtain a meaningful solution to equation (3). However, if NM(A)/Q(P+2A) is greater than b for some meaningful range of x, no bypass takes place in that range. Consequently, the elastiticy e_f is zero if no solution for equation (3) exists. In that case, $e_s = e_A$.

Substituting equation (13) into equation (10), we get

(14) $e_s = e_A + e_f = e_M$

Equation (14) shows that with the exponential form for F(x), the elasticity of switched access minutes with respect to the access price is equal to the elasticity of breakeven minutes with respect to the access price.

If the bypass technology has the characteristic of a fixed charge for capacity greater than or equal to the breakeven amount and no marginal cost for usage within that capacity range, then M(A) takes the form M(A) = Z/A where Z is the fixed charge. In that case the elasticity e_M is a constant -1 regardless of the level of A. With e_s then equal to -1 from equation (14), we conclude that under these conditions increases in access charges have no effect at all on total revenue. The decrease in total demand and increase in bypass exactly cancel out the increased price on the remaining switched access users. If bypass technologies incur a constant marginal cost as well as a fixed cost, then the breakeven function takes the form $M(A) = Z/(A-c)$ where Z is the fixed cost and c is the cost per minute for bypass service. Then the elasticity e_M is given by $-A/(A-c)$. Because this is greater in absolute value than 1, increases in access charges will decrease total revenue.

Another distribution with the right general shape is the distribution given by $F(x) = x^b$ where b is a positive constant less than 1.[15] Substituting that form into equation (12) and performing the necessary manipulations to simplify the result leads to the conclusion:

$$(15) \qquad e_f = (bx^b)(e_M - e_A)/[(1-b)(1-x^b)]$$

The change in functional form causes the expression derived in equation (13) from the exponential form to be multiplied by a factor which

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15 As explained more fully in the next section, the exponential function rises more rapidly than the observed function and the power function rises more slowly. A linear combination of the exponential and power functions provides a good approximation to the observed distribution.

increases in x. Subtituting equation (15) into equation (10), we get an expression for e_s which is a weighted average of e_M and e_A, with the weight placed on e_M increasing as x increases. When x=0, $e_s = e_A$. When the multiplicative factor $(bx^b)/[(1-b)(1-x^b)]$ increases to .5, then $e_s = .5e_M + .5e_A$. When the multiplicative factor increases to 1, then $e_s = e_M$. Because we expect e_A to be rising with A but bounded by the ordinary elasticity of long distance demand and we expect e_M to be equal to or greater than 1 in absolute value, the elasticity of switched access minutes should be equal to 1 when the multiplicative factor approaches 1. Thus there is a maximum revenue which can be obtained and attempts to go beyond that cause actual decreases in revenue with further increases in the access price.

We conclude that a "vicious cycle" is possible if the revenue requirement is high enough. At some point, revenue is actually decreased by increases in the access price. Consequently, it is necessary to evaluate the model with empirically determined parameters in order to evaluate the difficulty of raising the required revenue through access charges.

IV. Quantitative Analysis of Bypass

A. Estimates of the Parameters of the Model

The model specified the demand function as Q(P + 2A) where P is the averge price charged for POP to POP service and A is the switched access price for POP to final destination service. For empirical specification it is useful to distinguish two separate demand functions. Information on the distribution of customers is available separately for business and residence customers. The price of long distance service depends upon the time of day, with a 40 percent discount over full rates for evening service and a 60 percent discount over full rates for night and weekend service. Because most long distance calls paid for by residential customers are placed in the evening or on weekends and most business calls are placed in the business day period, little distortion results from identifying the residential market with the market for calls placed during the discount periods and the business market with calls placed during the full rate period. This results in two separate demand functions; a business demand composed of WATS and full rate MTS calls and a residential demand composed of discounted MTS calls.

Two complicating factors should be considered. The first is that the incentive to bypass depends on a customer's total traffic (incoming and outgoing) between a particular location and a POP while the demand function is for outgoing traffic only. In the theoretical model this was of little importance because total traffic was simply twice the outgoing traffic. With two market segments, however, explicit account must be taken of the fact that businesses call residences more frequently than residences call businesses. Many large businesses do not receive as many calls as they make because many of their calls are made to residences for sales purposes. A Pacific Northwest Bell special study of its largest customers found that they averaged .89 incoming MTS minute for each outgoing MTS minute and .25 incoming minute for each outgoing WATS minute.[16] Weighting those factors by the proportion of business calls accounted for by WATS and MTS respectively yields a composite factor of .53 incoming minute for each outgoing minute. The "excess" outgoing business minutes are assumed to be directed toward residences, yielding a factor of 1.56 incoming residence minute for each outgoing residence minute. Consequently, total business traffic is computed as 1.53 times outgoing business traffic and total residence traffic is computed as 2.56 times outgoing residence traffic.[17]

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16 Response of Mountain States Telephone and Telegraph Company, Northwestern Bell Telephone Company and Pacific Northwest Bell Telephone Company to FCC request for bypass information, May 21, 1984, Exhibit C, Attachment 1, p 81.

17 If M_B is the number of business minutes, M_R is the number of residence minutes, 1.53 is the ratio of total business minutes to outgoing business minutes, and x is the ratio of total residence minutes to outgoing residence minutes, then because total minutes are twice outgoing minutes it must be true that:

$$1.53M_B + xM_R = 2(M_B + M_R)$$

Solving the equation for x using the existing levels of busines and

The second complication is the distinction between interstate and intrastate traffic. The revenue requirements are the contribution which must be paid by interstate users. Consequently, the relevant quantity for computing the necessary access charges to yield the required revenue is the number of interstate minutes. However, most states are expected to mimic the interstate access charges in charges for intrastate toll calls, causing the relevant quantity for assessing the incentive to bypass to be intrastate plus interstate traffic. The demand functions are expressed in interstate minutes and are then multiplied by 1.61 to convert to total (interstate plus intrastate) minutes for assessing the incentive to bypass.[18]

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residential minutes yields x=2.56. This factor is treated as a constant in the model. It could vary with changes in the ratio of business to residential usage but the results will not change unless the business factor of 1.53 changes substantially.

18 William Taylor of Bell Communications Research reported that intrastate business MTS calls are equal to 61 percent of interstate business MTS calls in "Access Charges and Bypass: Some Approximate Magnitudes," paper presented at the Twelfth Annual Telecommunications Policy Research Conference, Airlie, Virginia, April 24, 1984. The results are relatively insensitive to the intrastate factor. Because the intrastate minutes are not counted in the revenue totals, they only increase the incentive to bypass and move some marginal users from switched access to bypass. The results would be little different if intrastate minutes were ignored altogether.

The Demand Function The demand function for interstate minutes is assumed to have constant elasticity which gives it the form:

$$(16) \qquad Q(P+2A) = K(P+2A)e$$

where K is a constant and e is the elasticity of demand. We need estimates for K, P, A, and e for both business and residence. Estimates of these parameters are computed from numbers presented in the Switched Access Order of May 1984.[19] In that order, the Commission estimated total interstate access minutes in 1984 as 171.9 billion.[20] Of the total, AT&T was expected to provide 105 billion MTS and 47.6 billion WATS access minutes. The total revenue requirement to be met from access usage charges was $9.0 billion in non traffic sensitive (NTS) costs and $5.5 billion in (TS) costs. Dividing the

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19 Common Carrier Dockets 83-1145 and 78-72, Memorandum Opinion and Order, FCC 84-201 (Adopted May 10, 1984; released May 15, 1984).

20 In order to provide easy comparision between the required access charges after bypass is considered and the current access charges, we will use the estimate of 171.9 billion minutes at existing prices as a base. However, when equal access is implemented (as assumed in the model), total minutes will be 15 billion higher (ignoring all other changes that may occur by that time) because the current competitive total of 27.2 billion actual minutes is discounted to 12.2 billion revenue minutes as a result of the 55 percent competitive discount on access charges. Eliminating the competitive discount will reduce the required access charges to meet any given revenue requirement when bypass is not considered as well as when bypass is considered.

revenue requirements by the expected access minutes yields an NTS tariff of $.0524 and a TS tariff of $.0321 per revenue access minute. The total initial access charge (A in the above equation) is $.0845 per minute. Because the NTS costs are fixed independent of amount of traffic, the NTS cost per minute varies with changes in the number of minutes and consequently increases as bypass takes place.

The estimate of the POP to POP margin (P) was made by assuming that the rates prescribed in the Switched Access Order are an equilibrium which allows AT&T to earn its required rate of return. A 1982 AT&T study of MTS and WATS traffic patterns showed that MTS traffic was almost evenly divided among the full rate period (8:00 A.M. to 5:00 P.M. Monday through Friday), the 40 percent discount period (5:00 P.M. to 11:00 P.M. Sunday through Friday) and the 60 percent discount period (11:00 P.M. to 8:00 A.M. Monday through Friday, all day Saturday, and Sunday until 5:00 P.M.).[21] Because we identify

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21 The data is taken from <u>1982 WATS Time-of-Day Peak Usage Study</u> filed by AT&T with the Commission on February 17, 1983. The numbers used are hourly records from October 1982 of MTS "conversation minutes" recorded on the basis of Eastern Daylight Savings Time, reported in Section 4, pp. D-128, D-131, and D-134. Using the reported hourly calling pattern and the rate structure hours, 295 million minutes per week (30%) are made at the full rate, 348 million minutes per week (35%) are made at the 40% discount rate, and 353 million minutes per week (35%) are made at the 60% discount rate. The conversion to EDT biases the full rate total downward because more late afternoon full rate Western calls are classified as evening rate than are early morning discount Western calls classified as full rate. Consequently, the percentages were rounded off to 33% in each category. The

the discount period with residence calls and the full rate period with business calls, we infer that one third of MTS calls are made by businesses at the full rate, one third are made by residences at a 40 percent discount, and one third are made by residences at a 60 percent discount. The average residence MTS rate is consequently one half of the average business MTS rate.

Actual MTS and WATS prices vary with distance. For the model, we need an average price which can be computed from total revenue requirements and total demand minutes. According to the Switched Access Order, AT&T's revenue requirement for domestic MTS in 1984 is $14.7 billion with total demand at 47.25 billion message minutes (94.5 billion domestic access minutes after subtracting 10.5 billion international access minutes from the 105 billion total MTS access minutes) for an average price of $.31 per minute. The average includes both full rate and discounted minutes and implies an average of $.47 per minute for full rate MTS, $.28 per minute for evening calls, and $.19 per minute for night calls. The estimated WATS revenue

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peak MTS usage occurs between 8:00 and 9:00 P.M. on Sunday evenings with a rate of 12.8 million conversation minutes per hour while the business day peak occurs between 10:00 and 11:00 A.M. with a rate of 7.7 million conversation minutes per hour. However, the total switched service peak occurs during the business day because of the large volume of WATS calls which are primarily business day calls.

requirement was $6.8 billion for a demand of 23.6 billion message minutes, yielding an average WATS price of $.29 per minute.

The prices above correspond to (P + 2A), the POP to POP margin plus two access charges. The residence margin is found by subtracting the access charges from the price and taking a weighted average of the evening and night margins. This yields a residence margin of $.065 per minute. The business margin is found by subtracting the access charges from the price and taking a weighted average of the business day MTS margin and the WATS margin which yields a business margin of $.19 per minute.

The elasticity of demand for long distance communications has been examined very carefully in a large number of econometric and non-econometric studies.[22] There is considerable variety in the estimates but many of them fall in the general range of -0.5 to -1.0. After an extensive review of the telephone demand literature, Taylor concluded that the best estimate for interstate toll call price elasticity was -0.75 with a subjective standard error of .20, yielding

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22 A good survey of the econometric evidence is contained in Lester D. Taylor, Telecommunications Demand: A Survey and Critique (Cambridge, Mass.: Ballinger Publishing Company, 1980). More recent econometric studies and non-econometric estimates may be found in almost any rate filing before the Commission or state regulatory agencies.

a range of -0.55 to -0.95 (p. 170). The Commission used an estimate of -0.6 for MTS service and -1.0 for WATS service in the Switched Access Order, implying a weighted average elasticity of -0.72. Taylor's estimate of -0.75 is used as the base case with results also computed for elasticities of -0.5 and -1.0 to clarify the effect of different choices within the likely range for the price elasticity.

The demand function constant is chosen to generate the current number of outgoing minutes at the current price given the estimate of elasticity. We assume the non-AT&T minutes are distributed in the same proportion as AT&T minutes between residence and business customers. For AT&T customers, business access minutes consist of all of the 47.6 billion WATS minutes plus one third of the 105 billion MTS minutes for a total of 82.6 billion. Residence access minutes consist of two thirds of the 105 billion MTS minutes or 70 billion. We need to multiply by 1.126 to convert from AT&T minutes to all interstate minutes and to divide by 2 to convert from access minutes to outgoing message minutes. This yields a total of 46.5 billion business message minutes and 39.4 billion residence message minutes. We then get the demand constants by substituting the quantity, price, and elasticity values into equation (16) and solving for K. This yields

(17) $$A_R = (39.4 \times 10^9)/(0.235^{-0.75}) = 13.3 \times 10^9$$

(18) $A_B = (46.5 \times 10^9)/(0.36^{-0.75}) = 21.6 \times 10^9$

where A_R and A_B are the demand function constants for residence and business respectively in message minutes per year. When a price elasticity of other than -0.75 is used, the constants are adjusted to correspond to the solution of equation (16) with the appropriate elasticity substituted for e.

The Distribution Function The distribution function F(x) which shows the percentage of conversation minutes demanded by the fraction x of the largest users is estimated from Pacific Northwest Bell (PNB) data. The distribution is available for both PNB and Northwestern Bell and both companies show very similar concentration levels. Their data is assumed to be typical of the national market. Among PNB customers, 0.1 percent of the largest business locations account for 26 percent of the company's business switched revenue and 1.0 percent of the locations account for 53 percent of the revenue.[23] In terms of the distribution function, this means F(.001) = .26 and F(.01) = .53. The observed distribution of customers is of a form which is not closely approximated by any simple mathematical function. However, the

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23 Comments of Pacific Northwest Bell in response to the Commission's request for bypass information, May 21, 1984, Exhibit C, Attachment 1, p. 158.

estimated extent of bypass depends crucially on the distribution of the top one percent of business locations so that it is necessary for the estimated F(x) to closely approximate the observed distribution at least in the range of x=0 to x=.01. The function was estimated by choosing two different functional forms with the right general shape, estimating the parameters of each function to require it to exactly match the observed distribution at the end points (x=0 and x=1) and at x=.01, and then using a weighted average of the two functions with the weights chosen to cause the average to exactly match the observed distribution at x=.001. This process yielded the estimate:

$$(19) \qquad F(x) = .6x^{.138} + .4(1-e^{-76x})$$

Figure 3 illustrates the observed distributions for Northwestern Bell and Pacific Northwest Bell along with the estimated distribution computed from equation (19).[24]

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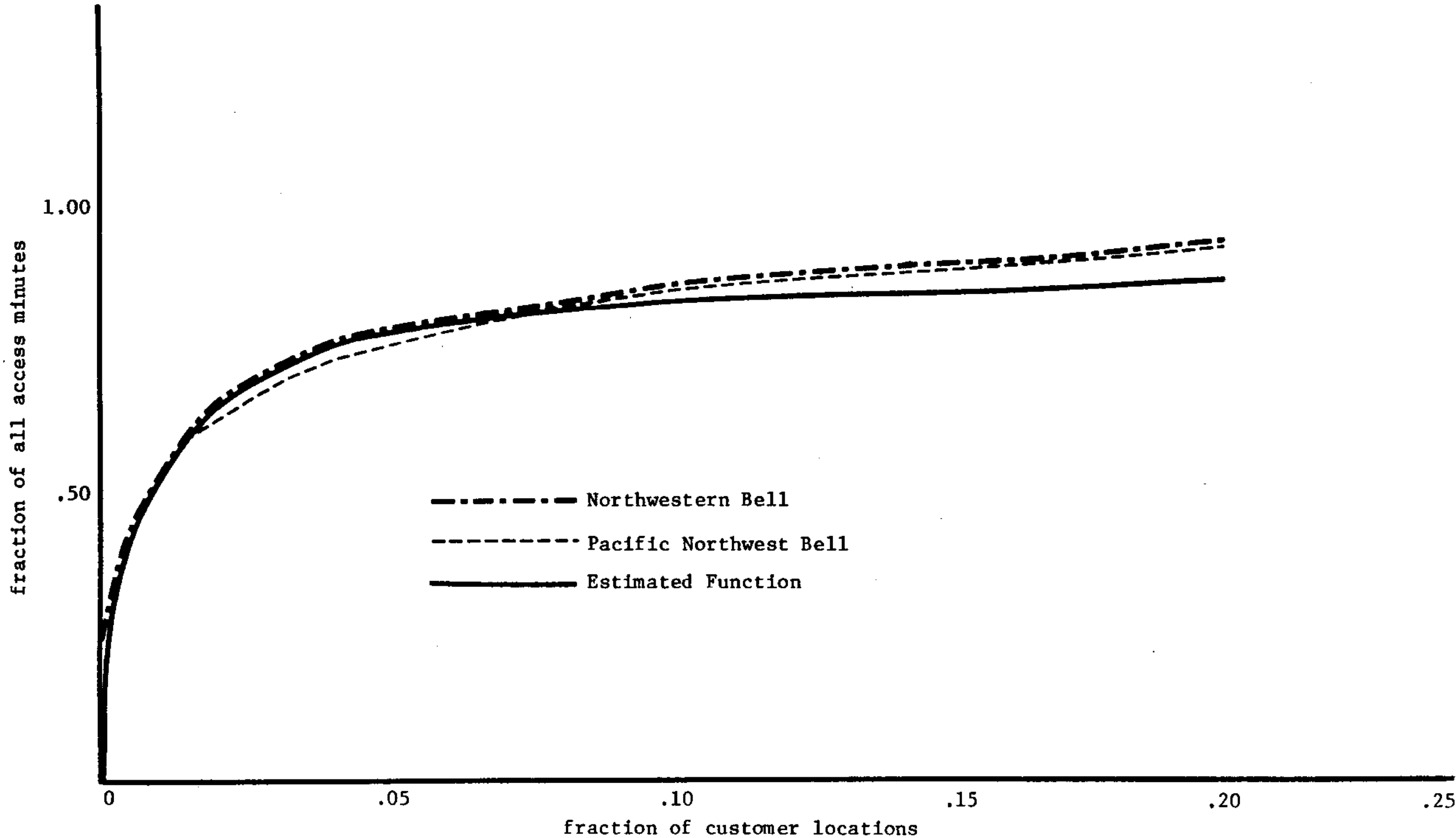
24 In order to determine the fraction of customers subject to bypass, we use equation (3) with f(x) determined by differentiating equation (19) and solve for x. Equation (3) requires an estimate of the number of locations for business customers. The estimate is computed by multiplying the PNB number of business locations by the ratio of all business minutes to PNB business minutes, yielding a total of 18 million business locations nationwide.

FIGURE 3

DISTRIBUTION OF BUSINESS CUSTOMERS



The information available is on revenues while the needed information is on the distribution of minutes. So long as the revenue per minute does not vary systematically with the size of the firm, the two distributions will be equal. It is likely that the revenue per minute is somewhat lower for larger firms because of the greater use of discounted WATS lines instead of MTS calls in the larger firms, but in the absence of reliable information, we will assume that the revenue and minute distributions are equal. If the revenue per minute is systematically lower for larger firms, the concentration of minutes will be somewhat higher than the estimate used here. This would cause the model to underestimate the magnitude of bypass but it is unlikely to make a significant difference in the results.

Residential calling is far less concentrated among the largest users than is business calling. In general, residence calling from a particular location is limited to a single phone from a single family while the business distribution includes locations for which the total demand is the sum of demand from thousands of employees. Bell Communications Research estimated that the top 1 percent of residence customers generate 15 percent of the residence toll revenue, far less than the 53 percent of toll revenue generated by the top 1 percent of business customers.[25] The limited number of calls from a single residence location means that residences are not good bypass candidates at current prices for either private lines or privately constructed facilities. Consequently, residential bypass is ruled out by assumption in the model. Residential customers may reduce long distance calling in response to increases in access charges but they do not switch to alternative forms of access.

Either of two events could change the conclusion that residential users are not subject to bypass. The first is greater effective concentration of residential demand through private systems in apartment buildings. If individual apartments were connected to a PBX and then to the local exchange company, the entire building would appear as a single location and might have an incentive to bypass the local carrier's switched access tariff in favor of alternative methods of accessing the interexchange POP. The second possibility is the development of relatively inexpensive electronic equipment to allow telephone communication over cable television facilities. This would make the current large residential users candidates for bypass without concentrating their demand through a PBX. Consequently, residential users will not necessarily remain "captive customers" to the local

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25 Comments of Bell Communications Research in response to the Commission's request for bypass information, May 21, 1984, p. 15.

carriers' switched access service in the long run, but they are unlikely to be significant bypassers in the immediate future.

The Cost Function In order to estimate the function C(m) which shows the cost of supplying access by some method other than the exchange carrier's switched access tariff, we must evaluate the various alternative supply sources. The two basic alternatives are private lines provided by the exchange carrier between the customer location and the interexchange carrier POP, and privately constructed facilities between the two locations. The current best estimate of local private line costs in the near future is $160. per line per month, composed of $135. per line from the Exchange Carrier Association (ECA) tariff of March 1984 plus the $25. per line surcharge imposed by the Commission as part of the access charge plan. The March 1984 tariff has been suspended. It is substantially higher than the currently effective rates.

A private line imposes a fixed cost with no usage charges so long as usage is below the capacity of the line. As usage rises, marginal costs are imposed either in the form of degraded service requiring calls to be placed at inconvenient times to avoid a busy line or in the form of charges for additional lines. In order for private lines to provide comparable service to switched access, they must be loaded lightly enough to provide a high probability of successful call completion. Using typical traffic patterns as a guide, the effective private line capacity was estimated at 3000 minutes per line per month (30 percent business day utilization and no evening or weekend utilization).[26] A more precise estimate would take explicit account of the rising effective capacity with number of lines utilized and of the cost of using switched access to handle overflow traffic from the

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26 If call originations follow the Poisson distribution and call holding times follow the exponential distribution, there is a 20 percent probability of encountering a busy signal with one line loaded at 25 percent of full utilization if a busy signal causes the caller to give up on making the call (Erlang B formula). If encountering a busy line causes the caller to continue trying until the call is completed, then a 25 percent load causes a 25 percent probability of failure to complete the call on the first try (Erlang C formula). Two lines reduce the probability of a busy signal at 25% utilization to 8 percent and three lines bring the busy signal probability down to 3 percent. Petr Beckman, Elementary Queuing Theory and Telephone Traffic (Geneva, Ill.: Lee's ABC of the Telephone, 1968), p. 43, 45.

Pacific Northwest Bell Engineers examined actual traffic patterns of a sample of large customers and computed the private line capacity necesary to carry that traffic with no greater than a five percent probability of encountering a busy signal during the busy hour. Average utilization ranged up to 6500 minutes per line for a customer with 1.3 million minutes per month served by a group of 208 private lines and down to 372 minutes per line for a customer with 774 minutes per month served by 2 private lines. See Comments of Northwestern Bell Telephone in response to Commission's Request for Bypass Information, Exhibit C, Attachment 1, pp. 81-155. The Pacific Northwest Bell numbers underestimate the effective capacity of small groups of private lines because they do not allow for overflow onto switched access service. Because of the random nature of telephone demand, even very light loading presents a significant probability of a busy line with only one or two lines. In practice, a private line network would probably be engineered to automatically overflow onto the switched access network if the private lines were busy.

private lines. However, such a function would add considerable complexity to the model with little effect on the results. The main effect would be to generate a smoother increase in the number of bypassers as the access price rises rather than creating a sharp increase at the point where private lines first become an economic choice of access method. With the more complex formulation, private line service would show economies of scale in moving from one line to multiple lines even with a constant price per line because of the greater utilization per line. It would then be possible to have access prices such that customers who could only utilize a single private line would find a private line inefficient, but those who could utilize an adequately large number of lines would find private lines efficient.

Construction of private facilities generally imposes a higher fixed cost and lower marginal cost than use of carrier provided private line facilities. Many technologies are available with similar cost characteristics. The general shape is determined by a fixed cost for establishing a communications link (coaxial cable physical link, two stations for establishing a microwave link, and so forth) at a minimum capacity plus a marginal cost determined by the cost of adding electronics to the link to increase its capacity. Figure 4 illustrates the cost per circuit required to establish a two mile privately constructed communications path as computed by Pacific Northwest Bell. The curves were computed on the assumption that the common Bell standard of multiplexing twenty-four voice grade circuits on a 1.544 megabit per second digital bit stream would be used for bypass. Consequently, costs vary in increments of 24 circuits as additional electronics is added to accommodate additional 1.544 megabit bit streams. The costs used in this model are based on the cost of a direct private microwave link using 23 GHz frequencies. As indicated in Figure 4, costs would be similar in both shape and magnitude with either new coaxial cable or a fiber optical system. However, the costs of 23 Ghz microwave vary less from area to area than many of the other technologies because no right of way is required, frequencies are generally available even in central city areas, and the equipment is available on an off-the-shelf basis. Using the cost curve illustrated in Figure 4, the costs of a 23 GHz microwave link can be represented by:

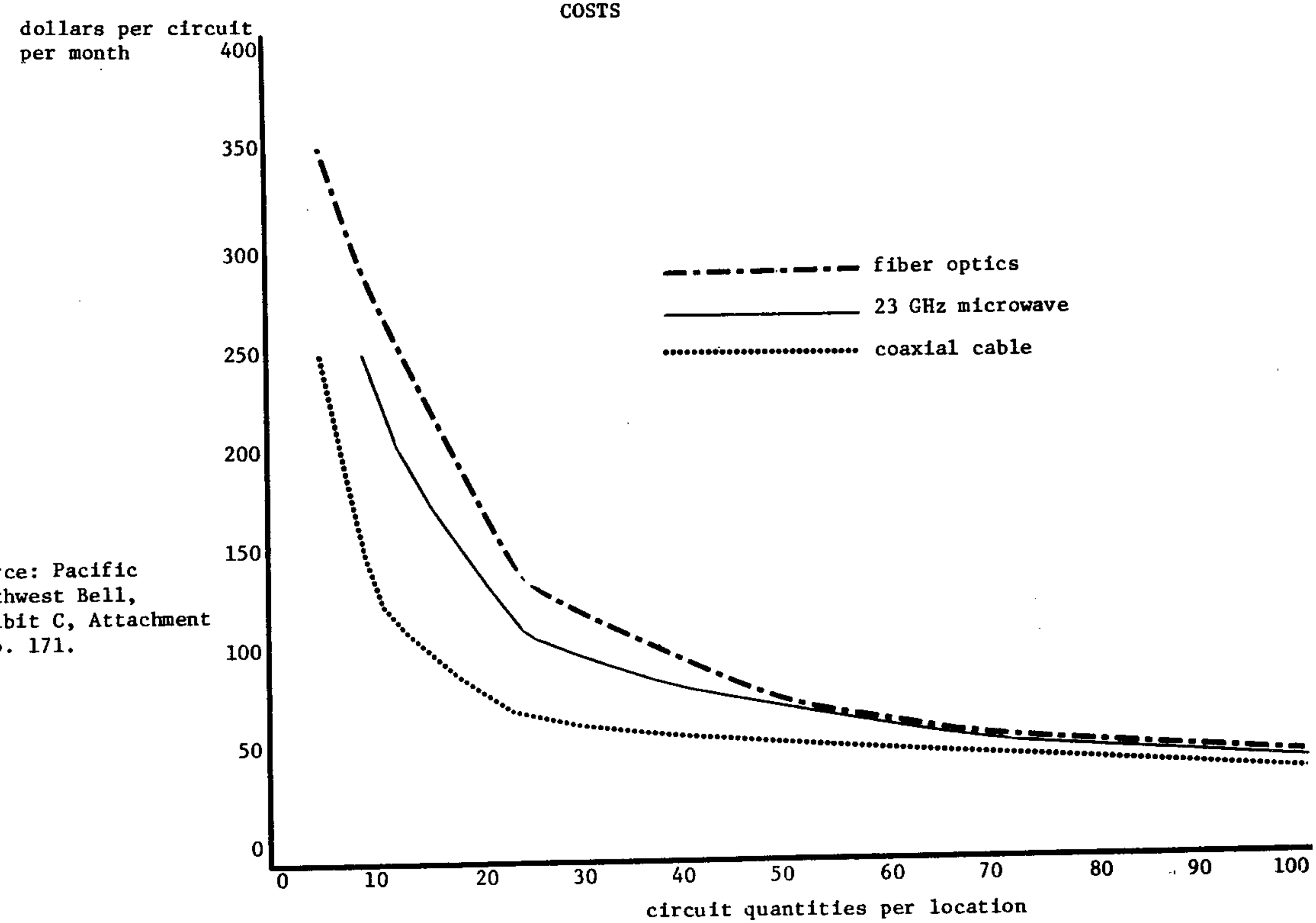
(20) $$TC = \$2000 + \$.01M$$

where TC is the total cost in dollars per month and M is the number of minutes per month carried by the system.

Substantially lower fixed costs may come eventually from competitive networks based on coaxial cable or fiber optic technology. If many customers are connected to such a network, the fixed cost per customer will be limited to the terminating equipment

FIGURE 4

ALTERNATIVE TECHNOLOGY
COSTS



Source: Pacific Northwest Bell, Exhibit C, Attachment 1, p. 171.

and any feeder lines necessary to connect the customer to the main network. However, the potential cost structure of such a network is very uncertain and is likely to vary widely across the country. The least cost systems will be those in which cable TV systems have already established coaxial cable links to many locations and can be converted into feasible access systems with the addition of electronics. The most expensive systems will be those built specifically for telephone systems which require the construction of new ducts rather than the rental of existing duct space.

Rights of way for cable or fiber optic systems appear to be generally available either on public streets or railroads, but costs vary from about $10,000 per mile for aerial installation in residential areas to $10,000 per mile per year for duct rental or $250,000 per mile for new conduit construction along major city roads. Terminal equipment costs range from under $1000. for low speed lines to many times that for high speed lines.[27] Thus it is possible that an extensive coaxial cable bypass network could evolve with fixed charges

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27 Extensive discussions of potential bypass facilities can be found in the responses to the Commission's request for bypass information. See particularly the responses of Comline, Inc., United Telephone System, Inc., American Telephone and Telegraph, Bell Communications Research, Bell Atlantic, and Pacific Northwest Bell, Exhibit C, Attachment 1, Appendix E, and Exhibit C, Attachment 3. The most detailed cost information is in the Pacific Northwest Bell filing.

as low as single line private line rates in the absence of regulatory restrictions. The likelihood of such systems appearing would increase considerably if existing cable TV systems begin to experience financial difficulty from lower than expected demand and consequently seek alternative uses for their sunk investment.

Table 1 summarizes the parameters used in the model. These parameters applied to the equations developed in section III allow the computation of numerical results.

B. Results of the Model

The results of the model are presented in terms of 1984 conditions after the equilibrium access price (which raises the required revenue and do not induce any further bypass) has been found. Obviously, reaching the equilibrium will require a significant amount of real time as access charges are adjusted and bypass decisions are made. During the adjustment time, demand and cost conditions will change as well. Consequently, the numbers presented here should not be regarded as a forecast of the actual access prices necessary to raise the expected revenue requirement at some specific time in the future, but as a measure of how the present conditions will be changed by a consideration of bypass. In economic terms, the analysis is performed in terms of "comparative statics" in which one equilibrium position is

Table 1

Parameter Summary

Demand Function: $Q(P+2A) = k(P+2A)^e$ with quantity in minutes/month

Initial A	$.0844/minute
p	business: $.19/minute residence: $.065/minute
e	-0.75
k	business: 2.325 billion
	residence: 1.592 billion

Distribution Function: $F(x) = .6x^{.138} + .4(1-e^{-76x})$

Cost Function for special construction (per month):
TC = $2000 + $.01 per minute

Private Line Price: $135 per month per line plus $25 surcharge

Non traffic sensitive revenue requirement:
$9.0 billion per year or $0.75 billion per month

Traffic sensitive revenue requirement:
$5.5 billion per year or $0.458 billion per month

compared with another without explicit regard for the time required to move between the two positions. An alternative would be to construct an explicitly dynamic model in which rates of bypass penetration would be estimated and a forecast of changes in other conditions would be used to provide expected access charges for specific times in the future. However, at present too little is known about the likely rate of bypass adoption to provide useful estimates for an explicitly dynamic model.

The result take the 1984 revenue requirements as fixed goals which must be met from the choice of an appropriate level of access charges. The 1984 revenue requirements are $9.0 billion for NTS costs and $5.5 billion for TS costs. Ignoring bypass, the revenue requirements will be met by access charges of $.0524/minute for NTS and $.0321 for TS applied to a total of 171 billion access minutes. Two cases can be distinguished. In the first case, only the NTS revenue requirement is fixed in amount while the TS revenue requirement varies with total usage. In this case, bypass reduces the total number of minutes and consequently increases the charge per minute to meet a fixed NTS revenue requirement but does not affect the charge per minute for the TS requirement. However, TS costs decrease only sightly with reductions in usage leaving the companies worse off with a lower total number of minutes and the same TS price per minute. Therefore, it is possible that the current TS total revenue requirement will have to be met even with a reduction in switched access usage. That leads to Case 2 in which the total of $14.5 billion in NTS + TS revenue requirement is taken as a fixed revenue requirement to be met from access charges on whatever level of switched access service is demanded. In either case, when access is provided by a private line the tariffed revenue for the private line is not credited to the revenue requirement but the surcharge on the private line is credited to the requirement.

<u>Case 1: NTS Revenue Requirement Fixed</u> If TS costs are truly traffic sensitive and vary proportionately to traffic, then the fixed revenue requirement is only for NTS costs. In that case the loss of TS revenue as bypass occurs is of no concern because costs decline as well. However, the NTS requirement must be made up with higher access charges because there is no change in NTS costs when total access minutes decline. The equilibrium level of NTS access charges necessary to meet the $9.0 billion revenue requirement is $.089 per minute, a 70 percent increase over the current level of $.0524 per minute, using the "base case" parameters summarized in Table 1. At the equilibrium level of access charges 22 percent of the total business access minutes are served by privately constructed facilities and 55 percent of the total business access minutes are served by private line connections between the customer and the interexchange POP. Consequently, the number of business minutes paying the switched access tariff is cut to one quarter of the total by the use of bypass facilities. Although three

quarters of the business minutes are served over bypass facilities, only one half of one percent of the the business locations are served by privately constructed facilities and only four percent of the business locations are served by private line facilities because of the high concentration of usage in the largest customers. The required revenue is raised from the residential users and the remaining business users, and to a lesser extent from the private line surcharge.

The results are sensitive the the elasticity of demand. A high elasticity of demand causes total demand for access minutes to decline substantially when the price is raised. With a high enough elasticity of demand, there is no level of access charges which will produce the required revenue because the revenue reduction from the decreasing number of total minutes is greater than the revenue increase from the higher price applied to the remaining minutes. Within the expected range of price elasticity, the equilibrium NTS access charge is reduced by \$.007 to \$.082 per minute at the low end of the range (e=-0.5) and increased by \$.012 to \$.101 per minute at the high end of the range (e=-1.0). Those charges correspond to a 56 percent increase and a 93 percent increase over current charges.

The basic calculation assumes that large users can utilize bypass facilities for both incoming and outgoing calls. It would be more difficult to bypass with incoming than outgoing calls because incoming calls may come from different carriers' Points of Presence and the switching equipment may not be able to identify which calls should be routed to bypass lines rather than local carriers. If only outgoing calls are subject to bypass, less bypass occurs and the equilibrium switched access price is reduced from $.089 to $.070, requiring a 34 percent increase over the present charge rather than a 70 percent increase. However, this case is quite optimistic in assuming that even incoming minutes to the largest customers are completely protected from bypass. The largest customers have so many incoming minutes that even if they were spread among multiple carriers' POPs, it would be profitable for each of the carriers to construct a private facility to that customer rather than paying switched access charges to trasport the customer's incoming calls from the POP to its location.

At present total long distance prices (including access charges as one component) are discounted for off-peak periods, but access charges alone are charged at a flat rate per minute regardless of when the call takes place. Suppose access charges were structured to mirror the MTS rate structure with an average 50 percent discount for off-peak (residence) calls compared to peak (business) calls. Then the equilibrium access charges would change from $.089 for all calls to $.136 for business calls and $.068 for residence calls. The discount structure causes a 53 percent increase for business access charges and a 24 percent decrease for residence calls compared to the non discounted equilibrium price. Business prices are increased more than residence are decreased because the higher business prices induce more bypass by business customers while the lower residence prices do not reduce bypass. Compared to the current price, the discounted equilibrium requires a 160 percent increase in business NTS access charges and a 30 percent increase in residence NTS access charges.

Changes in other parameter values produce relatively small changes in the equilibrium value of NTS access charges. Reducing the level of fixed charges for privately constructed facilities from the estimated level of $2000/month to as low as $250 per month produces practically no change in the equilibrium level of access charges. That change increases the number of minutes served through privately constructed facilities but the additional minutes come out of demand for private line access rather than out of demand for switched access minutes. The change reduces the revenue received from the $25. surcharge on private lines but has little effect on the required switched access price because the surcharge revenue is a small part of the total. If the level of fixed charges for private facilities were to decline significantly below the price of a private line, the equilibrium access price would increase. Similarly, reducing the price of a private line increases the access price because a greater number of customers use private lines instead of switched access. If the private line price is reduced from $135 per month to $67.50 per month, the equilibrium access price increases from \$.089 to \$.091. Considering only interstate minutes as contributing to the incentive to bypass has little effect on the required access price because the intrastate minutes are not counted in the revenue totals and make only a marginal increase in the incentive to bypass. If intrastate minutes are ignored in computing the bypass incentive, the equilibrium access price is reduced from \$.089 to \$.086.

The calculations above assume that the access charges must be set at whatever level is necessary to meet a fixed NTS revenue requirement. However, another option is to adjust the revenue requirement through a change in the allocation of expense to the interstate jurisdiction, implementation of the proposed customer access line charge at some level, or change in exchange carrier expense totals. Consequently, it is of interest to compute the access charges necessary to raise any particular level of revenue rather than only the level needed in 1984. This information is summarized in Table 2 and illustrated in Figure 5. Table 2 presents the NTS revenue which accrues from various levels of NTS access charges after bypass has been taken into account. The first set of figures are for the base case. The second and third columns of revenue numbers present the results of computations based on elasticities of -0.5 and -1.0 to clarify the sensitivity of the numbers to the range of uncertainty regarding the true elasticity. Figure 5 presents the same information in graphical form. The solid line is the

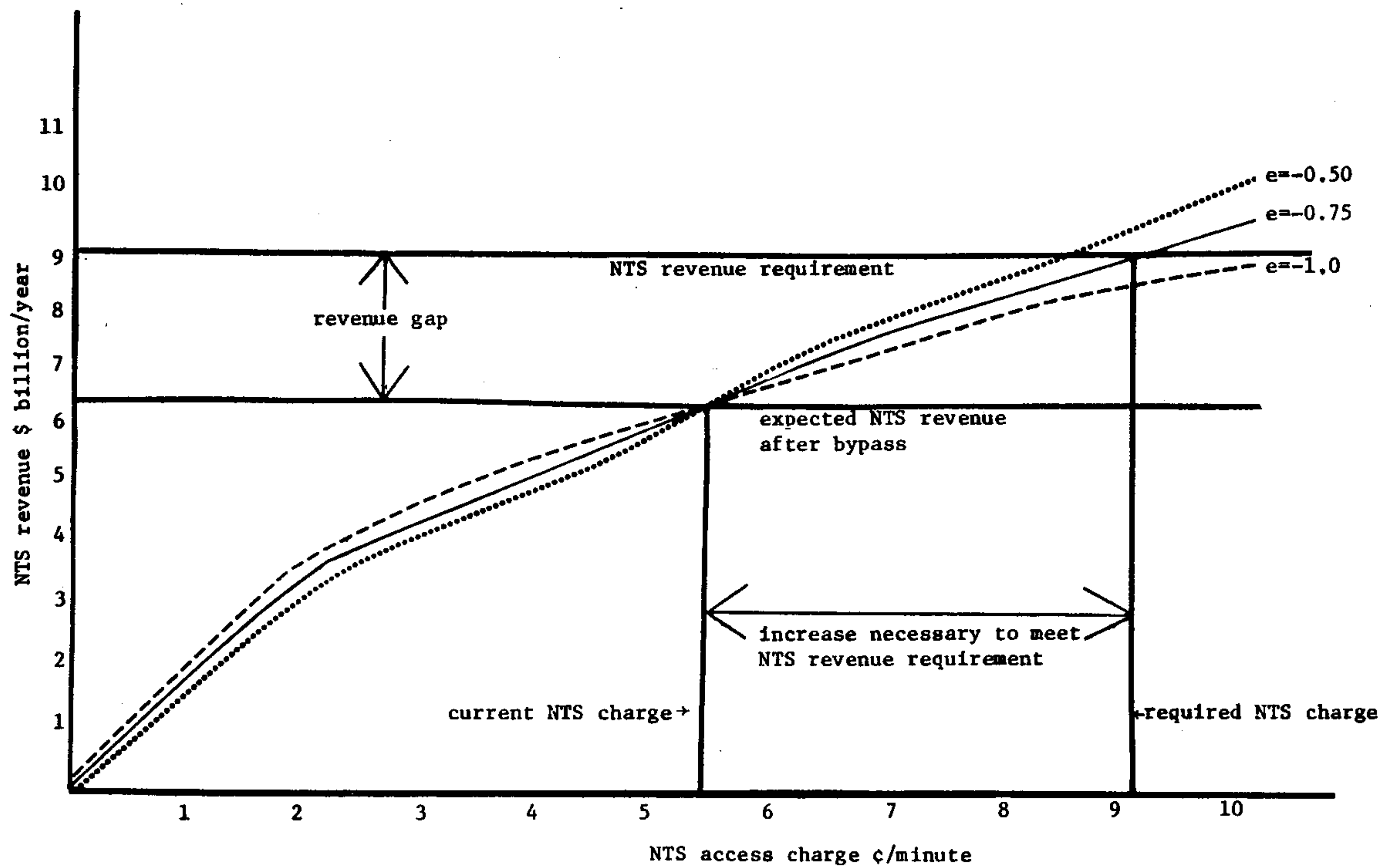
Table 2

NTS Revenue When TS = $.0321/Minute

NTS Charge $/minute	Expected Revenue $ billion/year e = -0.75	Range e = -0.50	Range e = -1.00
.01	2.06	1.88	2.25
.02	3.79	3.55	4.05
.03	4.46	4.26	4.67
.04	5.46	5.33	5.59
.05	6.34	6.30	6.37
.06	7.12	7.21	7.03
.07	7.83	8.06	7.61
.08	8.48	8.87	8.11
.09	9.07	9.63	8.56
.10	9.62	10.35	8.95
.11			9.30

FIGURE 5

NTS REVENUE WHEN TS CHARGE IS FIXED AT $.0321/MINUTE



base case and the two dotted lines are the alternative cases computed from low and high values of the demand price elasticity.

The access charge necessary to provide any particular level of revenue can be found by interpolating between the numbers given in Table 2. For example, to find the access charge corresponding to the $9.0 billion current NTS requirement, we observe that an access charge of $.08 produces $8.48 billion per year and an access charge of $.09 produces $9.07 billion per year so that an access charge of approximately $.089 will be necessary to produce $9.0 billion. If the revenue requirement is reduced by $1 billion, the required access charge drops to $.073. Reducing the revenue requirement by 11 percent cuts the required NTS access charge by 18 percent because there is more total demand and less bypass at the lower access charge.

<u>Case 2: NTS + TS Revenue Requirement Fixed at $14.5 Billion</u>
Although TS costs are defined as "traffic sensitive", they do not decrease smoothly with reductions in usage. The current revenue allocation procedures change the interstate allocation of traffic sensitive costs proportionately to changes in usage but the costs themselves do not change proportionately with usage. If the current allocation procedures remain in effect as usage of switched access declines because of bypass, the traffic sensitive revenue total will not be made up through higher toll charges but through increases in

local rates. However, another possibility is that the allocation procedure could be changed to maintain a constant revenue flow from the interstate jurisdiction to the local exchanges. In order to measure the full impact of bypass, it is useful to treat the entire TS plus NTS revenue requirement as a fixed amount which is not reduced when bypass occurs.[28] In that case, the revenue requirement is $14.5 billion and is currently met by an access charge of $.0845/minute on an estimated 171 billion minutes. When bypass is taken into account, the equilibrium access charge to produce $14.5 billion of revenue using the base case parameters is $.187/minute, a 121 percent increase over the current value. If the elasticity of demand is -0.50, the equilibrium access charge is $.148/minute, a 75 percent increase over the current value. If the elasticity of demand is -1.0, then the $14.5 billion revenue requirement cannot be met with access charges anywhere

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28 The calculations here examine access charges required to meet an unchanging switched interstate revenue requirement. When bypass takes place through the substitution of a private line for switched access, the $25 surcharge on the private line is credited to the revenue requirement but the tariffed rate for the private line is not. If the carrier can utilized idled switched access facilities for private line access, it will see the gain in private line revenue as a definite benefit but that benefit will not necessarily be translated into a reduced interstate switched revenue requirement. The implicit economic assumption of this part of the analysis is that switched access requires particular facilities which have no alternative use and that private lines use different facilities which are charged at their cost. Consequently, the change from switched access to private lines causes the loss of switched access revenue with no corresponding cost savings.

in the reasonable range. The combination of increasing bypass and reduced total demand as a result of increasing access charges leaves revenue practically unchanged. Revenue does continue to increase very slowly and the computations show an equilibrium at $.52 per minute, a 515 percent increase over the current level. This is clearly unrealistic both in a practical sense because it would be politically infeasible to set usage based access charges at that level and in terms of the model because it is well outside the range for which the model is designed. Thus if elasticity of demand is as high as -1.00, an attempt to raise the $14.5 billion TS plus NTS revenue requirement from access charges could result in a "vicious cycle" of increasing access charges and decreasing use of the switched network with a continuing failure to meet the revenue targets.

Table 3 summarizes the results of this case as well as the previous case. The results of the variations from the base case are comparable to the variations discussed under Case 1. Using only interstate minutes to compute bypass incentives reduces the equilibrium slightly from $.187 per minute to $.178 per minute. Using a low price for private lines ($67.50 per month) increases the equilibrium slightly to $.194 per minute. Assuming that no incoming minutes are vulnerable to bypass reduces the equilibrium substantially to $.127 per minute, a 50 percent increase over the current level of charges. Discounting residence access charges 50 percent over business charges results in a price of \$.282 per minute for business and \$.141 for residence, a 51 percent increase for business and a 25 percent decrease for residence compared to the non-discounted equilibrium.

The computations above implicitly assume that when access is shifted from switched access service to exchange carrier provided private line service, different facilities are used. In that case, the private line tariff pays the cost of the new facilities and only the surcharge should be credited to the revenue requirement. However, another possibility is that the private line service could be provided over the same physical facilities formerly used to provide switched access. In that case, the change from switched access to private line access would be only a pricing change and would not affect the utilization of physical facilities or the cost incurred in providing access. Consequently, it would then be appropriate to credit the entire private line revenue (tariff plus surcharge) received for access facilities to the revenue requirement rather than only the surcharge. Crediting the private line tariff and surcharge to the revenue requirement leads to an equilibrium of \$.143 per minute, a 69 percent increase over the current level.

Table 4 shows the total access revenue received as a result of access charges ranging from \$.01 to \$.20 per minute in the same format as Table 2. Figure 6 illustrates the data from Table 4. The drop in

Table 3

Summary of Results

Case 1: Required NTS Access Charges to yield $9.0 billion/year NTS Revenue

	Price Per Minute	% Increase over Current Charge
Current charge	$.0524	
base case	.089	70%
Variations:		
low elasticity (e = -0.5)	.082	56%
high elasticity (e = -1.0)	.101	93%
interstate only	.086	64%
outgoing only	.070	34%
low private line rate ($67.50/month)	.091	74%
discount structure: business	.136	160%
residence	.068	30%

Case 2: Required NTS + TS Access Charges to yield $14.5 billion/year NTS + TS revenue.

Current charge	$.0845	
Base case	.187	121%
Variations:		
low elasticity (e = -0.5)	.148	75%
high elasticity (e = -1.0)	.520	515%
interstate only	.178	111%
outgoing only	.127	50%
low private line ($67.50/month)	.194	130%
discount structure: business	.282	234%
residence	.141	67%
credit all PL revenue to requirement	.143	69%

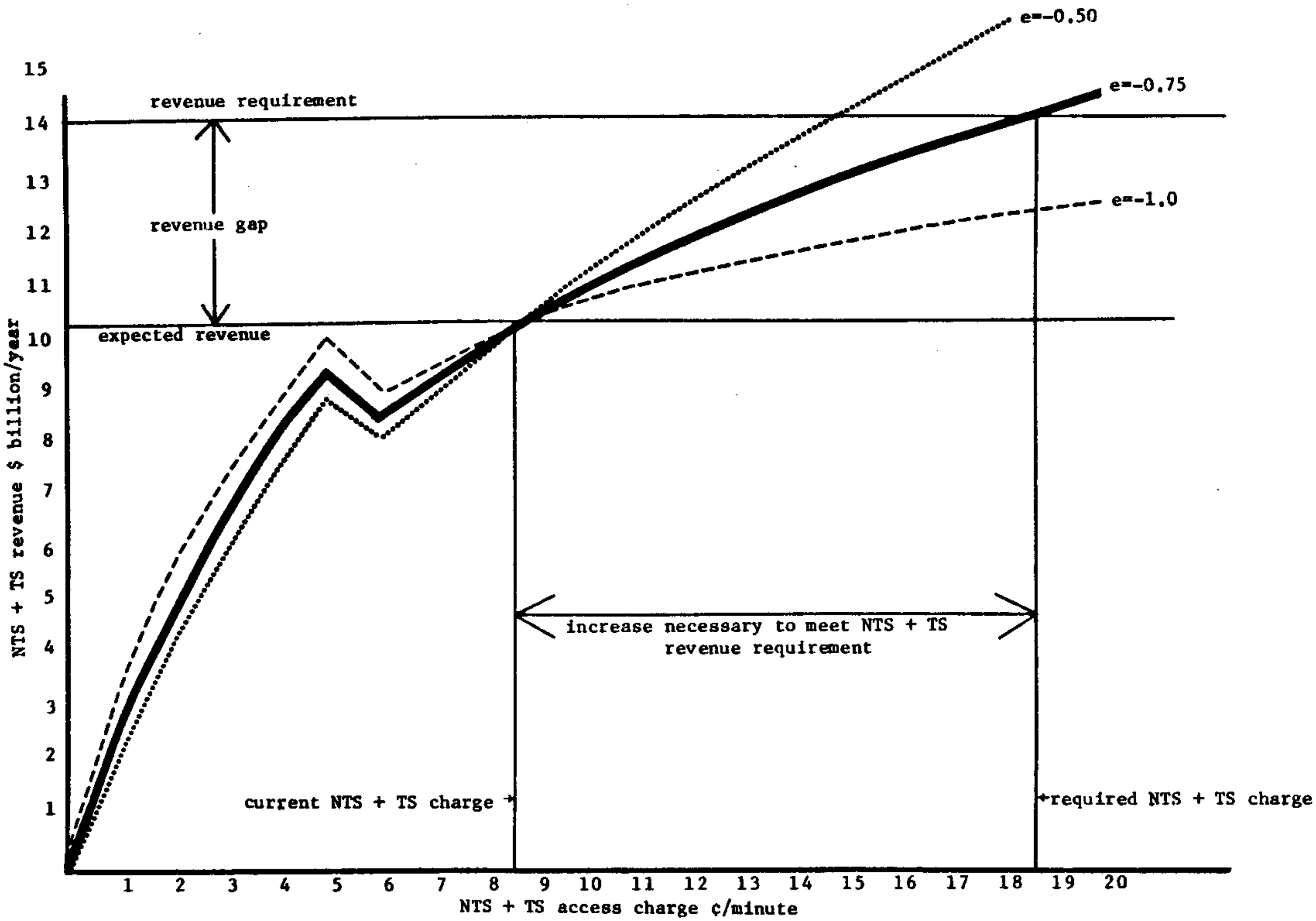
Table 4

NTS + TS Revenue

Access Charge $1/minute	Expected Revenue ($ billion/year) e = -0.75	Range e = -0.50	e = -1.00
.01	3.08	2.53	3.77
.02	5.15	4.39	6.05
.03	6.91	6.10	7.85
.04	8.38	7.62	9.23
.05	9.64	8.98	10.34
.06	8.72	8.30	9.18
.07	9.44	9.17	9.71
.08	10.01	9.98	10.17
.09	10.65	10.75	10.56
.10	11.18	11.47	10.90
.11	11.67	12.16	11.20
.12	12.12	12.82	11.46
.13	12.54	13.45	11.69
.14	12.93	14.06	11.90
.15	13.30	14.64	12.09
.16	13.65	15.20	12.26
.17	13.98	15.75	12.42
.18	14.29	16.27	12.57
.19	14.59	16.79	12.70
.20	14.88	17.28	12.82
.52			14.50

FIGURE 6

NTS + TS REVENUE FROM USAGE ACCESS CHARGES



total access revenue when access charges are increased from \$.05 to \$.06 occurs because private line bypass first becomes profitable when access charges reach \$.053 per minute under the assumptions used here.[29] Consequently, as access charges increase from \$.05 to \$.06 per minute, a large number of customer locations with usage between 2700 minutes per month (the private line breakeven point when access charges are \$.06 per minute) and 50,000 minutes per month (the minimum breakeven usage for privately constructed facilities when access charges are \$.05 per minute) become candidates for bypass. Consequently total revenue declines as a massive shift of business minutes to private line occurs. Although the model predicts a sharp shift, it is more likely that the shift would be gradual because of variations in customer usage patterns which cause private lines to be profitable for some customers at a lower level of access charges than for others. Thus no special significance should be attached to the actual decline in revenue between access charges of \$.05 and \$.06. However, it is significant to note that revenue increases much more slowly as access charges rise above the level at which private line bypass becomes profitable.

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29 \$160 per month in tariff plus surcharge for a private line with capacity of 3000 minutes per month yields a cost of \$.053 per minute for a fully loaded line.

Yield Analysis: Table 5 analyzes the yield of increased revenue which results from an increase in the usage sensitive access charge at levels of access charge ranging from \$.01 to \$.20 per minute. The information is illustrated in Figure 7. If no change in demand occurs when access charges are raised, then a 1 percent increase in the access charge results in a 1 percent increase in the access revenue and the yield is 100 percent. Demand for switched access is reduced in two distinct ways when access charges are increased. An increase in access charges increases the incentive to bypass and therefore reduces the fraction of total access minutes served through the local exchange carrier provided switched access. This effect is shown in the columns labeled e_f for business and residence customers separately. Those columns show the percentage change in the fraction of total access minutes served by switched access resulting from a 1 percent increase in the switched access price. That number is zero for residential customers at all levels of access charges because residential bypass is ruled out by assumption and therefore the fraction of residential total access minutes served by switched access is always 1. The number begins low for business users because little increase in bypass opportunities occurs at low levels of access charges, then jumps sharply between \$.05 and \$.06 when private line bypass first becomes feasible.

The second method by which demand for switched access is reduced is the reduction in demand for total access minutes which occurs when

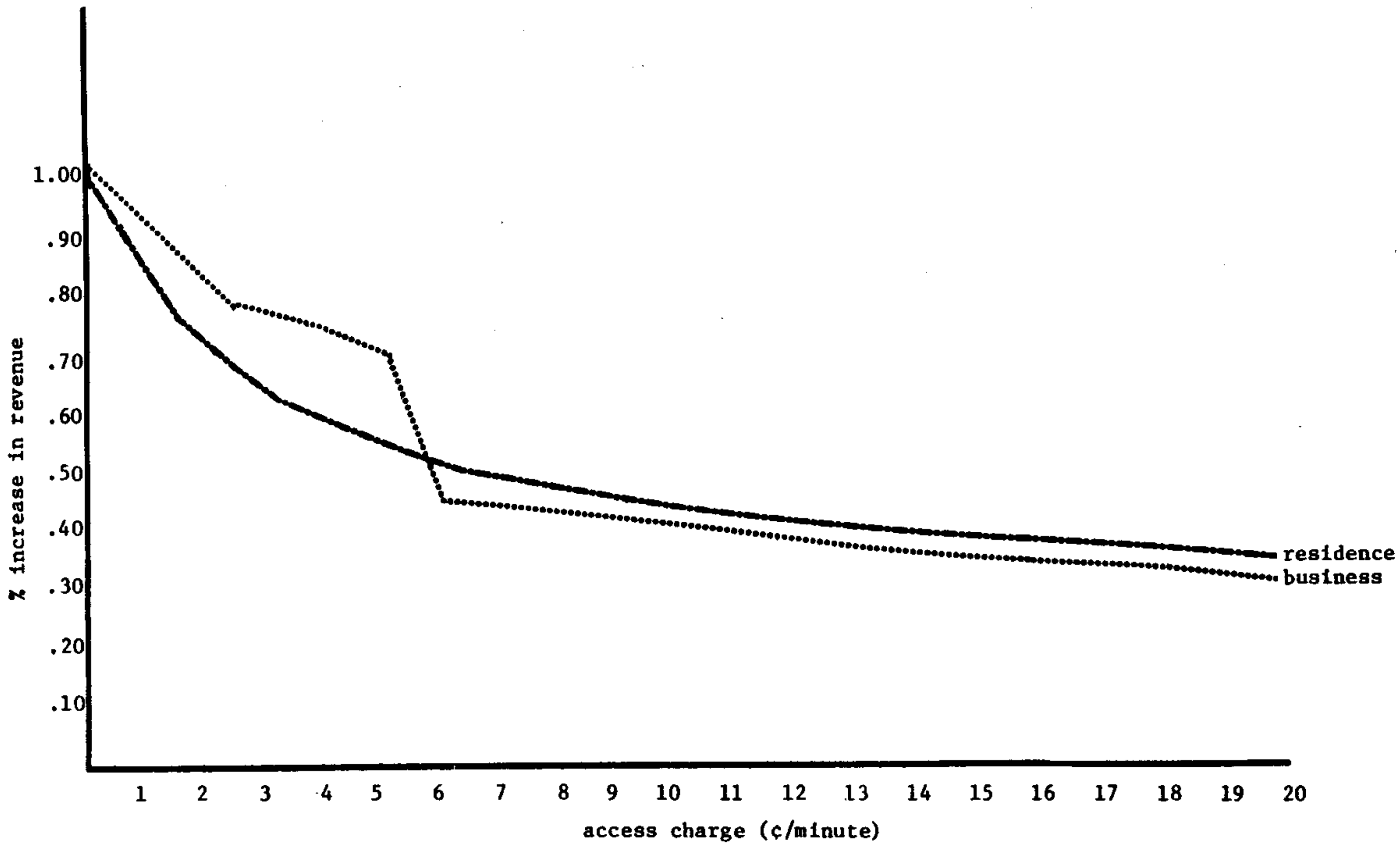
Table 5

Revenue Yield Analysis

Access Charge	Business e_f	Business e_A	Business yield	Residence e_f	Residence e_A	Residence yield
.01	0	-.07	.93	0	-.18	.82
.02	-.06	-.13	.81	0	-.28	.72
.03	-.05	-.18	.77	0	-.36	.64
.04	-.05	-.22	.73	0	-.41	.59
.05	-.04	-.26	.70	0	-.45	.55
.06	-.26	-.29	.45	0	-.49	.51
.07	-.24	-.32	.44	0	-.51	.49
.08	-.23	-.34	.42	0	-.53	.47
.09	-.22	-.36	.41	0	-.55	.45
.10	-.21	-.38	.40	0	-.57	.43
.11	-.21	-.40	.39	0	-.58	.42
.12	-.20	-.42	.38	0	-.59	.41
.13	-.20	-.43	.37	0	-.60	.40
.14	-.19	-.45	.36	0	-.61	.39
.15	-.19	-.46	.36	0	-.62	.38
.16	-.18	-.47	.35	0	-.62	.38
.17	-.18	-.48	.34	0	-.63	.37
.18	-.17	-.49	.34	0	-.64	.36
.19	-.17	-.50	.33	0	-.64	.36
.20	-.17	-.51	.32	0	-.65	.35

FIGURE 7

REVENUE YIELD FROM A 1% INCREASE IN ACCESS CHARGE



the price of long distance service increases. Because access charges form an increasing portion of the long distance total price as access charges increase, the reduction in total demand as a result of increases in access charges becomes more pronounced at higher levels of access charges. The elasticity of demand for total access with respect to the access price increases from zero to the elasticity of demand with respect to the total price as the access charge increases from zero to a very high level. The elasticity of demand for total access with respect to the access price is shown in the columns labeled e_A. For a given access price, the elasticity is higher for residences than for businesses because the access charges compose a higher portion of the total price of long distance service for residences.

The total percentage loss in demand for switched access resulting from a 1 percent increase in the switched access charge is the sum of the numbers in columns e_f and e_A. The net revenue yield is that sum plus 1 and is shown under the column labeled "yield". At the current level of access charge equal to $.085 per minute, for example, the yield from a 1 percent increase in the access charge is a little less than one-half of 1 percent increase in revenue. In other words, the revenue increase from an increase in access charges will be less than half of the amount computed by multiplying the increase by the current level of switched access demand.

To illustrate the use of the yield analysis consider an increase in access charges from \$.10 to \$.11, a 10 percent increase in access price. At an access charge of \$.10, the yield is .40 for business and .43 for residence, for a weighted average of .42. This implies that the 10 percent increase in access price should produce a 4.2 percent increase in access revenue. Table 4 shows computed access revenue is equal to \$11.18 billion per year at a charge of \$.10 and \$11.67 billion per year at a charge of \$.11, a 4.4 percent increase.

An alternative way to view the yield numbers is as the benefit in reduced access charges from reducing the revenue requirement. This benefit is the reciprocal of the yield number and is shown in Table 6. Table 6 shows the percentage reduction in required access price which results from a one percent reduction in the revenue requirement for access prices ranging from \$.01 to \$.20 per minute. For example, the current revenue requirement of \$14.5 billion results in a required equilibrium access price of \$.189 per minute. A one percent reduction in the portion of that revenue paid by businesses would allow a three percent reduction in the business access price. A one percent reduction of the portion of that revenue paid by residences would allow a 2.78 percent reduction in access prices. At high levels of access charges, the percentage reduction in required access charges is more than three times the percentage reduction in the revenue requirement.

Table 6

Access Price Yield Analysis

Access Charge	Business	Residence
.01	1.08	1.22
.02	1.23	1.39
.03	1.30	1.56
.04	1.37	1.69
.05	1.43	1.82
.06	2.22	1.96
.07	2.27	2.04
.08	2.38	2.13
.09	2.44	2.22
.10	2.50	2.33
.11	2.56	2.38
.12	2.63	2.44
.13	2.70	2.50
.14	2.78	2.56
.15	2.78	2.63
.16	2.86	2.63
.17	2.94	2.70
.18	2.94	2.78
.19	3.03	2.78
.20	3.13	2.86

At access charges near the current level, the percentage reduction in required access charges is over twice the percentage reduction in the revenue requirement.

V. Conclusions

This paper examined the incentive to bypass the local exchange company for access to interexchange companies and found that a substantial incentive exists to bypass switched access service between large users and interexchange carrier POPs. The current access charges are likely to produce much less than the current revenue requirements if those access charges are continued long enough to allow customers and interexchange carriers to take advantage of bypass opportunities. The current revenue requirements probably can be met through increases in access charges but the necessary increases will be large because of the low efficiency of raising revenue through high access charges. About a 70 percent increase in NTS charges is necessary to raise the current level of NTS revenue requirement after bypass is taken into account. Using pessimistic but plausible assumptions, there is no level of access charges which meets the $14.5 billion NTS plus TS revenue requirement. In that case, bypass leads to a cycle of increasing charges and decreasing use of switched access with very little net addition to access revenue.

At the current level of access charges ($.0845/minute), the yield from a small increase in access charges is between 40 and 50 percent. In other words, more than a two percent increase in access charges is necessary to produce a one percent increase in access revenue. Alternatively, a one percent reduction in the revenue requirement allows more than a two percent reduction in the required access charge.

Several qualifications to the analysis should be noted. The model assumes that the interexchange carriers can offer line control functions from their switches and that no regulatory restrictions prohibit either the use of private lines for access or the use of privately constructed facilities. AT&T cannot presently offer line control functions from its Class 4 interexchange switches but is expected to upgrade them in the near future to provide that capability. Current regulations do not prohibit the kinds of bypass assumed in this analysis but future restrictions could limit the freedom of large users or interexchange carriers to utilize bypass facilities. If a substantial fraction of interexchange switches remain without line control capability or if regulation effectively restricts the use of bypass by large business customers, then bypass will be less than estimated in this analysis.

The model is dependent upon the size distribution of customers. The basic premise of the calculations is that bypass facilities have a significant fixed cost but lower marginal cost than the switched access price. Consequently, bypass is attractive to users with enough demand to cover the fixed cost through savings on the marginal cost of a large number of minutes. If bypass becomes prevalent and the access price is increased to the equilibrium levels estimated here, there will be strong incentives for smaller users to attempt to combine their demand and take advantage of the cheaper bypass facilities. For example, assume total access charges (NTS + TS) are raised from the current $.0845 to the computed equilibrium level of $.187 to provide the current revenue requirement of $14.5 billion. Then approximately three quarters of the business minutes will be served with bypass facilities causing bypass techniques to be well known. Small business users will see that they are paying $.19 per minute for a service which large users are getting for $.01 to $.05 per minute. This situation would provide a strong impetus to the already observed development of "smart buildings" in which the telecommunications demand from many tennants is combined on a private system. This would effectively increase the concentration of demand and cause many customers who are not now candidates for bypass to become prospects as a partner in a system serving a particular office building. If "smart buildings" continue to develop, bypass will be greater than the amount computed in this analysis.

A further possibility which would increase bypass beyond the levels estimated in this paper is the development of inexpensive electronic equipment to provide some form of telephone service over residential cable TV systems. Cable TV provides a communications link among residential users which could be used to connect residential users to the interexchange carrier's Point of Presence. Such a scheme is not economically attractive for most users with current equipment prices and consequently plays no role in the analysis of this paper. However, if access prices remain constant or increase and electronic components continue to decrease in price, it is likely that cable TV systems will become important alternatives to telephone company switched access for the larger residential users. In that case residential users would no longer be the captive market which absorbs increased access charges while the business users move to less expensive bypass alternatives.

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