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## OPP Working Paper Series

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# **18** Telephone Pricing to Promote Universal Service and Economic Freedom

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# Telephone Pricing to Promote Universal Service and Economic Freedom

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<sup>1</sup> The opinions and conclusions expressed in this paper are those of the author alone. They do not necessarily reflect the views of the Federal Communications Commission or any of its staff other than the author. The author appreciates the comments and suggestions of Peter Pitsch, Tom Spavins, Evan Kwerel, Kenneth Gordon, Florence Setzer, Jon Levy, Lex Felker, and John Haring of the Office of Plans and Policy and Peyton Wynns of the Common Carrier Bureau. None of the above individuals is responsible for any errors in this paper.



## Telephone Pricing to Promote Universal Service and Economic Freedom

### Executive Summary

Competition and the divestiture have increased consumer freedom to choose various kinds of telephone services and have correspondingly reduced the freedom of the telephone companies to price those services in an arbitrary way. The interexchange carriers' ability to bypass switched access services that provide a contribution to other telephone services, together with the increasing opportunities in shared tenant services, have indicated that the current pricing system may not be sustainable. This paper explores the kind of pricing structure that would be sustainable under highly competitive conditions. It finds that price structures exist which raise the necessary revenue under competitive conditions without creating any tendency to reduce the present degree of universal service.

In the era of a unified network with carrier imposed restrictions on the attachment privately supplied equipment to the public network, a wide variety of prices could raise the revenue necessary to cover costs. Individual customers had the choice of paying the specified tariff, doing without service, building a private system, or seeking to change the tariffs through the political process. Private systems were viable in specialized cases (such as along a railroad right-of-way or

to link two corporate locations with a heavy communications demand between them), but the absence of interconnection and economies of scale in transmission equipment meant that private systems were not an optimal choice for most customers. Consequently, practically any tariff that charged customers no more than the value they placed on telephone service was viable. Because many people place a very high value on telephone service, the actual structure chosen was a function of political control over rates, with benefits going to those who could exert effective power in regulatory hearings. The total level of costs determined the total level of revenues, but costs played only a minor role in determining the rate structure.

The current limitations on carrier pricing freedom originate in the interaction of the 1968 Carterfone decision and the 1969 MCI decision. The Carterfone decision found AT&T's restrictions on the connection of customer supplied equipment to the public network unlawful and resulted in customer freedom to use PBX's and other terminal equipment for any purpose the customer desired. The MCI decision authorized MCI to build a common carrier microwave system for supplying private lines. The decisions appeared quite distinct at the time and were based on separate criteria related to the seemingly distinct markets for terminal equipment and private lines. But a PBX is a switching machine and can perform most of the functions of a central office. Allowing private PBX's to be attached to the network,

together with the authorization of new common carriers to supply long distance private lines, brought competition into the switched services business. A call to MCI's office over the ordinary local switched network could be switched on MCI's PBX to the appropriate private line to reach the destination city, then connected back to the destination telephone via an ordinary local call from the MCI office to the final recipient. Such an arrangement could transform MCI's private line facilities into the equivalent of a public switched network. MCI packaged its entry into switched services as a "shared private line service" called Execunet.

The Execunet service threatened the viability of the then existing price structure which passed substantial amounts of long distance toll revenue back to local telephone companies. If a competitor could originate and terminate long distance calls by paying only ordinary business local rates, it could greatly undercut AT&T's rates and still remain profitable. After the Commission's attempt to prohibit the Execunet service was reversed by the Appeals Court, a compromise was developed in which MCI was allowed to offer the service but required to pay a much higher rate for local facilities used for long distance access than for identical local facilities used for purely local calls. The special tariff for long distance access (known as ENFIA) was an explicit case of price discrimination according to use. Exactly the same facilities were charged dramatically different rates depending on

the purpose for which they were used. Its viability was consequently dependent upon the local companies' possession of adequate monopoly power to prevent competitive access provision and also dependent upon the companies' ability to monitor usage and prevent arbitrage between facilities charged a low rate and those charged a high rate.

The ENFIA tariff principle of using price discrimination to maintain the existing system of payments from toll service to local companies was the model used for initial access charge tariffs after the divestiture. The divestiture replaced the settlements process with access charge tariffs but initially did not greatly change the flow of funds from long distance companies to local companies. The access charge tariffs were set at a high enough rate per minute to earn revenue similar to the pre-divestiture settlements level. However, at that level some companies were required to pay more than the cost of alternative private facilities, creating incentives to bypass the switched access service provided by local exchange carriers. Such bypass reduces revenues far more than costs because the access tariffs are designed to provide substantial support for total local exchange facilities.

Because the existing price structure is not stable, the paper examines the alternatives available to raise the needed revenue without driving people off of the network. After an extensive analysis of

demand, supply, and equilibrium conditions in the industry, the paper reaches the following conclusions:

(1) With extensive competition but no regulatory limitations on price discrimination, local companies can easily raise the necessary revenue without driving people off the network simply by charging different fixed prices to different customers in accordance with "value of service" pricing.

(2) With extensive competition and limitations on price discrimination, but no requirement to interconnect, local companies retain a great deal of pricing freedom because competitive opportunities are limited by the requirement to gain a large number of customers in order to make their system useful.

(3) With extensive competition together with a regulatory requirement to provide complete interconnection and to practice non-discriminatory pricing, the local exchange companies' pricing freedom is greatly restricted. Their ability to load costs onto fixed monthly fees is limited by the possibility of drop-off by customers who value telephone service at a low level and by the opportunities to arbitrage through shared tenant services. The exchange companies' ability to charge high usage-based fees for access to interexchange carriers is limited by the restrictions on price discrimination and by the opportunities for bypass. However, they do retain a great deal of market power in the local switched services segment and could raise whatever revenue was necessary through increases in local measured service rates without

inducing customers to drop telephone service altogether.

The optimal price structure for a highly competitive industry would probably offer a series of options, ranging from a very low fixed charge with relatively high usage charges to a substantially higher fixed charge with low or zero usage charges. There would be no distinction between local calls for long distance access and other local calls. In order to move toward such a structure and reach a price structure compatible with both competition and universal service, it is necessary to continue shifting the revenue requirement from long distance to local service. The revenue shift can be accomplished in two ways: (1) by retaining the existing separations formula but increasing the subscriber line charge, or (2) by changing the separations formula to reduce the revenue assigned to the interstate jurisdiction. The economic effects of the two options would be identical if the states chose to recover the additional revenue requirement through an increase in the fixed local charge per month for each access line.

In order to maximize opportunities for innovative use of the telephone network, it is necessary to allow individuals a great deal of freedom to construct alternative communications systems and to interconnect them with the public network without discrimination. Any attempt to solve the current bypass problem or related problems of

potentially uneconomic entry through entry prohibitions will create artificial walls around certain services and reduce the possibilities for innovative use of the telephone network. But a policy of open entry together with price structure reform will lead to maximum consumer freedom together with economic efficiency and protection of universal service.



# Telephone Pricing to Promote Universal Service and Economic Freedom

## I. Introduction

The current structure of local telephone prices is unstable. Two major revenue sources for local exchange companies are monthly fixed charges per subscriber for telephone service and per minute usage charges for access to the long distance carriers. The per minute usage charges are threatened by bypass facilities in which the long distance carriers or individual customers construct private facilities between the customer location and the long distance company's Point of Presence (POP) in order to avoid local exchange company charges. The monthly fixed charges from some customers are threatened by the advent of smart buildings in which a building owner connects all users within the building to a single PBX and passes the combined traffic to the local exchange carrier as if it came from a single user, avoiding the monthly fixed charges for the individual customers. Neither of these options are available to nearly all customers at the present, but the opportunities for profitable entry which they represent are an indication that the current industry pricing structure is not in equilibrium.

The current situation in which profitable niches exist for entrepreneurs has occurred several times since the beginning of competition for telecommunications. In each case a plausible case could be made that the profitable opportunity resulted from the specific way in which fixed costs were loaded onto the prices of individual products, rather than from the superior efficiency of the potential entrants. The established firms have regularly argued for restrictions on entry in order to prevent "cream-skimming" and destruction of established pricing patterns, while the potential entrants have argued for freedom to apply their talents to any opportunity they choose. The Commission has frequently ruled in favor of economic freedom rather than preservation of established pricing patterns, and thus has gradually introduced competition into the industry with resulting changes in the price structure.

As the competitive possibilities in local telephone service have unfolded, the question of whether or not legal restrictions on entry are needed in order to preserve the ability of the local companies to provide effectively universal service has again been raised. This paper examines the price structure necessary in order to allow freedom of entry without encouraging entry by inefficient competitors. Determining a sustainable price structure is not a simple task. Simple formulas such as "adjust prices to cost" are inapplicable in the local

telephone industry because of the complex cost and demand conditions. True marginal costs for either access or usage for any individual customer are very low. One person's demand for telephone service is dependent upon other people's choice of whether or not to subscribe. Under such conditions marginal cost pricing is neither economically optimal nor capable of producing adequate revenue to cover total costs.

The special problems of telephone pricing have inspired an extensive theoretical economic literature. This paper draws on that literature for guidance in approaching the problem of finding a price structure which allows free entry while retaining other desirable policy characteristics. The paper first examines the origin of current pricing problems. It then reviews the supply and demand characteristics of telephones and derives the equilibrium conditions that result. The crucial role of interconnection conditions and the allowable degree of price discrimination in determining the equilibrium allocations is stressed. With the same cost and demand conditions, very different equilibria occur with no limitations on the companies than occur with required interconnection and limitations on discrimination among customers. The paper concludes that prices exist that will sustain the network even with free entry, required interconnection, limitations on price discrimination, and a continuing obligation to serve all customers. Furthermore, such prices will encourage effectively universal service and lead to a high degree of

economic efficiency. However, the local companies cannot move to the more stable price structure on their own, but must have regulatory help in the form of changes in the separations allocations and access charges.

## II. The Origin of Current Pricing Problems

The telephone system is comparable to a system of public roads. A very large investment in public roads is necessary to allow people to move freely from one place to another, regardless of the volume of traffic. As traffic increases, costs increase (to upgrade a two lane highway to a multilane controlled access highway, for example), but many of the costs are incurred simply in providing access to practically anywhere. The value of the roads increases with the range of places to which they reach, as does the value of complementary goods such as automobiles. If the road network is very limited, as in Alaska or in many developing countries, then people must use alternative means of transportation and the roads which exist have lower value than they would in a more fully developed system.

Roads, telephones, and local distribution systems for water, natural gas, and electricity have similar economic characteristics. Their costs are largely determined by the number and specific locations of the places they reach, rather than by the total volume of traffic.

They are so commonly available that most consumers consider it their "right" to have access to them. They are considered of great value to consumers and those who do not have access to the public systems will often incur substantial expense to build a substitute (such as digging a well on rural property or building a private road to a remote location). The savings in system cost from not serving a randomly chosen consumer while still serving the surrounding consumers are very small while the cost of serving one consumer in isolation from all others is quite large. In other words, the cost of the system is not simply the sum of the cost of serving each person. There is no well defined cost of serving a single consumer without reference to what other consumers are being served. Consequently, such systems cannot be financed by simply charging each consumer the cost of service, but must be financed by some kind of cost allocation scheme which spreads the cost of the entire system over the actual or potential users of the system.

A variety of cost allocation schemes are commonly used. Roads are normally financed through a two part tariff. The fixed charge is assessed to all property owners, whether or not they desire to use the road, and is paid in the form of taxes, special assessments, or charges to the builder when an area is developed. The usage charge is paid in the form of a gasoline tax and thus is paid in proportion to usage as measured by gasoline consumption. Sewer and water utilities are

also frequently financed by a mandatory assessment on all property owners in addition to fees based on volume of use. In contrast, electric, gas, and telephone companies generally cannot impose fees on all property owners, but often have two part tariffs (with a fixed system fee for receiving any service plus a fee based on usage) for those who choose to subscribe.

So long as a very high percentage of potential subscribers choose to subscribe to the utilities, there is little financial difference between a mandatory fixed fee and a fixed fee imposed only on subscribers. But whether the fixed fee is mandatory or charged only to subscribers is an important distinction when considering the effect of a pricing structure on the degree of universal service. Universal service in roads is provided by force of law; roads are built and financed by tax revenue and a building permit may be denied for a location with no access to roads. Consequently, consumers do not have the opportunity of deciding whether access to roads is to them worth their share of the cost of the road system. Because access and payment for telephones is not mandatory, the percentage of people who choose to subscribe will be affected by the prices used to distribute the costs of the system over all subscribers.

Prior to the introduction of telephone competition, the total revenue collected was limited by rate of return regulation, but no

competitive forces or arbitrage forced prices to conform to the pattern of costs. Individual customers had the choice of paying the required tariffs, doing without service, or seeking to change the tariffs through the political process. Consequently, the prices became more subject to political strategies than to market forces. Because the "pie" of costs could be allocated in many different ways without inducing significant consumer drop off, the political forces were focused on the distribution of costs among different customer segments.

The basic price structure that evolved was a fixed charge per month for local service and a usage charge for long distance service. An increasing portion of the long distance service revenue was paid back to the local companies over time, gradually reducing local rates and increasing long distance rates over what they would have been if the allocations had remained constant. Because technological progress reduced the cost of long distance service while inflation was increasing the cost of local service, the shifting of revenues from long distance to local helped preserve the status quo and slow down the rate of price change. In the absence of competition, practically any politically attractive allocation of costs was feasible because consumers had little option other than to pay the assigned prices.

In more formal terms, the "core" of the cost allocation game was extremely large. The core is defined as the set of allocations among

a set of players such that no subset of players can guarantee itself a better payoff by withdrawing from the game. In the case of telephones, the entire set is all subscribers to the public network and any subset is a group of customers who might consider building a private system to link themselves. Because of the benefits of being able to reach a large number of customers, together with the economies of scale of telephone equipment and restrictions on entry and resale of circuits, the options of a group considering a private network were extremely limited. Consequently, the prices were viable so long as no group of customers was charged more than the value that group placed on the services received.

Because many people placed a very high value on telephone service, the constraint was very loose, allowing a wide range of feasible telephone price structures. The actual structure chosen was a function of political control over rates, with benefits going to those who could exert effective power in regulatory hearings. The total level of costs determined the total level of revenues, but costs played only a minor role in determining the rate structure.

In the last twenty-five years, the protected market of the 1950's has been gradually exposed to competition. Each increase in competition has reduced the set of viable prices. The first major

event was the Above 890 decision<sup>1</sup> that allowed private companies to establish microwave communication systems. With private microwave, it was possible for companies with a large volume of communications among their own offices to construct a private network. The existing price structure provided no volume discounts and assigned higher prices to a large number of circuits than the cost of providing equivalent circuits with private microwave. Consequently, once private microwave was available, the existing price structure was no longer a "core" allocation because a subset of customers (businesses with high volume internal communications) could construct an alternative system (private microwave) more cheaply than they could lease private lines from AT&T. However, even though the cost of private microwave was less than AT&T's price, the cost of private microwave was not necessarily less than the cost to AT&T for provision of the service.

AT&T responded with a price structure change in the form of the Telpak volume discounts that reduced the price for the targeted customers to within the level of private microwave costs. The increased opportunities for customers translated into a restriction on pricing freedom for the telephone company. The greater the consumer

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<sup>1</sup> Allocation of Frequencies in the Bands Above 890 Mc., 27 FCC 359 (1959), recon. denied, 29 FCC 825 (1960).

freedom, the less freedom the telephone company has to allocate its fixed costs among services. The beginning of private microwave did not harm AT&T's ability to earn its authorized rate of return, but it did imply that more of the fixed costs of the network would be borne by customers other than large users of private line circuits than before.

Assuming the Telpak tariffs were above AT&T's marginal cost as AT&T claimed, other customers were better off with the Telpak customers on the network at the Telpak prices than with them off the network. But the other customers were not better off than they would have been had the Telpak customers remained on the network at the old prices. The private microwave authorization and Telpak response rearranged the allocation of fixed costs, reducing the amount paid by large private line users from its previous level. The restraints on the company's pricing freedom come from the consumer's maximum value from remaining on the network, either because of other alternatives or because of low total valuation of telephone service.

Although the Above 890 decision placed some restrictions on the set of feasible prices, its effect was limited because of the narrow set of customers who could utilize bulk private line service. The two crucial decisions which greatly shrank the set of feasible prices were

the 1968 Carterfone decision<sup>2</sup> and the 1969 MCI decision<sup>3</sup>. The MCI decision allowed MCI to build an alternative common carrier microwave system. Initially it was for the very limited purpose of a small scale system in the St. Louis to Chicago market, but it formed the basis for general authorization of competitive private line systems. The Carterfone decision struck down restrictive carrier tariffs that limited attachments to the network. Although its scope also was initially limited, it led to freedom of choice to attach terminal equipment to the network subject to minimal restrictions to prevent harm.

The immediate effect of the Carterphone decision was to allow the attachment of non-carrier-provided private branch exchanges (PBX's) to the network. Because initial attachment was through carrier supplied connecting arrangements, attachment of consumer telephones was then not economically feasible. The change from treating PBX's as an integral part of the network to treating them as a consumer item was extremely significant. The PBX is a switching machine and can perform most of the functions of a central office. Allowing private PBX's to be

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2 Use of the Carterfone Device in Message Toll Telephone Service, 13 FCC 2d 420 (1968).

3 MCI, 18 FCC 2d 953 (1969), recon. denied, 21 FCC 2d 190 (1970).

attached to the network was essentially a decision to allow a private switched communications system to be attached to the network. This had far greater implications than was realized at the time. The debates over PBX interconnection revolved primarily around network harm and secondarily around the economic effects of PBX competition on carrier finances. But the economic discussion was concerned with revenue from PBX's alone, not with potential changes in the price structure of other services that would be caused by the use of privately owned PBX's.

The immediate effect of the MCI decision was to limit the prices that could be charged on the dense private line routes most subject to competition. It expanded the set of customers affected by the private microwave decision from those with internally dense communications needs to all those whose private line requirements were on routes with total demand high. Consequently, a further price restructuring occurred with the Hi-Lo and MPL tariffs. Those tariffs offered lower prices for high density routes than for low density routes, and also offered lower prices for long distance routes and higher prices for short distance routes than before. As with the Telpak tariff, the new tariffs reallocated some of the fixed cost burden from customers who gained an additional alternative by the new authorization to those who still had no other alternative after the new authorization.

Far more significant than the immediate changes in the PBX and private line market brought about by the Carterfone and the MCI decisions was the unforeseen effect of the combined decisions. Each decision individually opened up a piece of the market to competition. But together, they provided the possibility of connecting MCI's private line microwave network to the local switched network through a PBX. Such a connection would allow anyone to place a local call to the MCI office that would proceed as any other local call to MCI's PBX, then be switched out over the MCI long distance system to the destination city, then forwarded to the final recipient via another local call. The privately owned PBX would therefore serve as the equivalent of a central office. It would transform MCI's microwave facilities into the equivalent of a public switched network that could be accessed from any telephone. MCI packaged such an arrangement as a "shared private line service" called Execunet.

The Execunet service was an unexpected entry composed of perfectly legal components packaged to provide an alternative to ordinary MTS and WATS service. MCI was entitled to use a PBX to send and receive local calls and it was entitled to use its microwave network to transmit long distance messages. But when it combined the two together to provide competition to MTS service, the Commission rejected the service as outside of MCI's operating authority. When that decision

was overruled by the Appeals Court,<sup>4</sup> the Commission endorsed a plan to distinguish local service used for "interstate access" from identical local service not used for such access through the the ENFIA (Exchange Network Facilities for Interstate Access) tariff. The ENFIA lines used for interstate access were ordinary business lines charged at a much higher rate than other business lines in order to recoup some of the subsidy for local service built into AT&T's pricing structure.

The ENFIA tariff was a compromise between two competing considerations. To allow Execunet as MCI proposed it would have destroyed the viability of the entire switched long distance price structure and would have required massive repricing of both long distance and local services - all because of the unforeseen consequences of earlier decisions believed to be limited in scope. Yet to prohibit MCI from offering the service was not a viable option because of the appeals court rulings. With the ENFIA tariff, competition came to switched service but the subsidy structure was preserved. Without the ENFIA approach, either MCI would have been prohibited from entering

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<sup>4</sup> MCI Telecommunications Corp. v. FCC, 561 F.2d 365 (D.C. Cir. 1977), cert. denied, 434 U.S. 1040 (1978) (Execunet I). MCI Telecommunications Corp. v. FCC 580 F.2d 590 (D.C. Cir. 1978), cert denied, United States Independent Tel. Assoc. v. MCI Telecommunications Corp., 439 U.S. 980 (1978) (Execunet II).

the long distance market or the subsidy structure would have been competed away. The ENFIA tariff was an explicit discrimination according to use. It was consequently a movement away from the general trend of allowing consumers to use any given service provided by the telephone company in any way the consumer chose. With ENFIA, exactly the same facilities were charged at dramatically different rates depending on the purpose for which they were used.

The ENFIA tariff illustrates the power of price discrimination for maintaining a given price structure in the presence of competition. The natural implication of the ability to combine a privately owned PBX with free entry into private line service was that the long distance contribution to local costs would have been eliminated, just as the earlier decisions had changed the contribution of various classes of private line users. But with the ability to distinguish interstate access from other local calls and to charge a higher price for interstate access, the price structure could be maintained even in the presence of competition.

Although the ENFIA tariff was successful in meeting the immediate goals of allowing some competition in switched service without destroying the existing flow of funds from long distance to local service, its viability was dependent upon the local exchange companies' possession of monopoly power in local distribution. The

ENFIA tariff charged a price far above the average cost of all business lines for the line connecting a local office with the competitive long distance carrier's office. So long as MCI had no alternative for local distribution, the ENFIA prices could be maintained. But although most customers had no feasible alternative to using the local telephone company to connect to a long distance carrier, the prices for ENFIA lines were high enough to make it potentially profitable for MCI to construct special facilities for access to the largest customers. This was the origin of the bypass problem: prices for local lines providing long distance access which are far above cost and high enough to make private facilities less expensive for some customers. The bypass incentives were weak at the time because of uncertainty over MCI's future ability to provide ubiquitous service, and because the ENFIA tariff was set lower than it would have been if the entire level of AT&T's payments to local companies had been included in the ENFIA price.

The bypass possibilities inherent in the ENFIA tariff were greatly magnified by the pricing adjustments associated with the separation of the Bell Operating Companies from AT&T on January 1, 1984. The previous flow of funds from long distance revenues to the local companies paid by AT&T in settlements payments was converted into access charges. The initial access charge for service between a customer's premises and AT&T's Point of Presence was set at \$.0845 per

minute, equivalent to over \$500 per month per line for a heavy long distance user with 100 hours per month per line. The price was high enough to produce substantial incentives for large customers to either build special facilities or to substitute private line facilities to bypass local exchange company switched access service.<sup>5</sup> Although the switched access price has now been reduced slightly to \$.0795 per minute, the price remains above the cost of alternatives for some customers and thus attempts to extract more revenue from those customers than the local exchange company's market power can support.

While the possibility of bypass limits the revenue requirement that can be loaded onto access usage charges, the possibility of "smart buildings" limits the revenue requirement that can be loaded onto fixed monthly access charges per line. With a smart building, individual tenants subscribe to extension lines into the building PBX rather than to local access lines providing direct connection with the telephone

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5 For an estimate of the potential amount of bypass see Gerald Brock, "Bypass of the Local Exchange: A Quantitative Assessment," OPP Working Paper # 12 (September 1984) NTIS # PB85 107811. Additional estimates with different assumptions and methodology are contained in the Commission's bypass proceeding, comments filed in CC Docket 78-72 in response to Public Notice 3206 (March 28, 1984) seeking bypass information.

company central office. All traffic in the building is consequently aggregated as if it came from a single customer. The aggregation increases the feasibility of bypass facilities, but it also limits the fixed monthly charge per access line to the cost of providing an access line substitute through a PBX and extension lines. Although the smart building concept is currently limited to large business buildings, it could conceivably be applied to apartment buildings or even residential subdivisions if the fixed monthly access charges were high enough to justify the substitution of a PBX and extension phones.

The possibility of bypass and smart buildings indicates that local exchange companies do not have complete market power. Just as earlier reductions in long distance monopoly power limited AT&T's freedom to choose a price structure, the current alternatives to local exchange company service reduce the set of feasible price structures for recovering a given revenue requirement. The remainder of this paper explores the sources of exchange company monopoly power in an effort to clarify the feasible price structures in an increasingly competitive environment.

### III. Demand Conditions

The demand for local telephone service is generally described as demand for communication with anyone who can be reached on the

network. Using that definition, demand from one person depends upon the choices of others to subscribe. That creates an externality which has been extensively discussed in the economics literature.<sup>6</sup> However, the externality is a function of the definition of the product rather than an intrinsic characteristic of telephone demand.

A person's demand for telephone service in a particular network is a derived demand resulting from the person's demand for telephone communication with specific individuals. Each person has a large number of demand curves for telephone communication with specific individuals. There is no externality involved in those individual demand curves. A person's demand for service from any particular telephone network is the sum of that person's demand curves for communication with the individuals who can be reached on that network. Some of the individual demand curves may be probabilistic or contingent

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6 A demand externality exists whenever one person's demand for a good depends upon the amount of that good purchased by some other person. Major studies of the externality aspect of telephone demand appeared in a series of articles in the Bell Journal of Economics including R. Artle and C. Averous, "The Telephone System as a Public Good: Static and Dynamic Aspects," (Spring 1973): 89-100; L. Squire, "Some Aspects of Optimal Pricing for Telecommunications," (Autumn 1973): 515-525; J. Rohlfs, "A Theory of Interdependent Demand for a Communications Service," (Spring 1974): 16-37; and S. C. Littlechild, "Two-Part Tariffs and Consumption Externalities," (Autumn 1975): 661-670.

on certain events, but they can be expressed in terms of willingness to pay for the option to make calls.

The definition of telephone demand in terms of underlying individual demand curves is not a mere terminological quibble, but is important to understanding the equilibrium pricing conditions in telecommunications. The costs of communications among various sets of customers vary. For example, it costs less to provide communications among a compact set of customers who are all in one office building than to provide the same amount of communication to the same number of customers spread all around a city. Similarly it costs less to provide a high volume of communications from one customer to one other customer than to provide that same volume of communications from one customer to a large number of other customers. These cost distinctions are lost when the telephone product is defined in terms of access to the network plus usage of the network. In order to evaluate the effect of competition on existing networks, it is necessary to explicitly consider the underlying demand elements and the costs of supplying those elements by both the established company and by potential competitors.

The standard definition of telephone service (access to the network plus usage) is based on established pricing patterns. Those pricing patterns are practical solutions to the problem of pricing a

large bundle of goods for each customer. It is analogous to the common practice of pricing delivery service for appliances, lumber and so forth at a flat rate for a given radius from the store. The actual costs of delivery will vary within the area but the transactions costs of setting up a more precise delivery charge are not justified by the improvement in pricing accuracy.

Because demand for telephone service is demand for communications from specific points to specific other points, the total market demand consists of a matrix of individual demand curves. Each entry in the matrix,  $d_{ij}$ , represents the demand curve for communications from location  $i$  to location  $j$ . These are ordinary demand curves based strictly on the characteristics of person  $i$  with no dependence on the decision of person  $j$  to subscribe. Whether that demand is satisfied or not depends upon whether persons  $i$  and  $j$  both subscribe to a network which allows them to communicate, but person  $i$  may have demand for communication with  $j$  even if that demand is not satisfied. The externality only arises for the composite good "communication from location  $i$  to all locations connected with a particular network." That composite good is formed by summing the demand curves  $d_{ij}$  over all persons  $j$  attached to the network and obviously depends on which persons are attached to the network.

The demand for telephone communication between any two points is a derived demand based on the underlying demand for communication between the two points. The elasticity of that demand is consequently dependent upon the price of the inputs other than telephone service that are used to fulfill the demand for communications, and is also dependent upon the price of alternative means of communication that do not require telephone service. For voice communication, the most important input is the time of the people conversing. For practically all local calls and for many long distance calls the time cost of the conversation is far more significant than the telephone cost. Time costs are also crucial in determining the feasibility of substitute means of communication such as personal visits or writing letters.

The elasticity of demand for telephone service is derived from the elasticity of demand for telephone communication and the proportion of the total cost of telephone communication accounted for by telephone service. For example, assume that the elasticity of demand for telephone communication is quite elastic with a value of  $-2.0$ . Assume the person's time value is \$9.00 per hour and the usage charge for local measured service is \$1.00 per hour while the usage charge for long distance service is \$9.00 per hour. Then the total cost of telephone communication to that person is \$10.00 per hour for local and \$18.00 per hour for long distance calls. A 50 per cent increase in the local price increases it by \$.50 per hour and is only a 5 per cent

increase in the total price of local telephone communication. Consequently it will induce a 10 percent decrease in the quantity demanded (by the assumed elasticity of -2.0). This means that a 50 per cent increase in the local price resulted in a 10 per cent decrease in the quantity demanded yielding an inelastic demand of -0.2 for the local telephone service. By the same reasoning, the derived elasticity of demand for long distance service for this person is -1.0, half the elasticity for telephone communication and five times the elasticity with respect to local telephone usage price. This example is consistent with econometric estimates which show local service demand much less elastic than long distance demand.<sup>7</sup>

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7 For a comprehensive summary of telecommunications demand estimates in various market segments, see Lester Taylor, Telecommunications Demand: A Survey and Critique (Cambridge, Mass.: Ballinger Publishing Company, 1980). For a survey of issues involved in measuring local demand and some specific results see Charles River Associates, Demand for Local Telephone Services upon the Introduction of Optional Local Measured Service (LMS) (Boston, Mass., 1982).

#### IV. Supply Conditions<sup>8</sup>

There is no single product of "telephone service" with identifiable cost characteristics. Instead there are a vast number of products of the form "a communications path of a particular bandwidth and other technical characteristics between points A and B beginning at time x and extending for y minutes." The cost of providing the products varies with the technical characteristics required, the specific points requiring service, and the time distribution of the service requirements.

There are many potential technologies and network topologies for supplying the demand for telecommunications services. For some products (high volume continuous demand between two reasonably close points with line-of-sight access), a dedicated facility such as a private microwave facility may be the lowest cost configuration. But

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<sup>8</sup> There is a great deal of uncertainty about the current cost conditions in the industry and even more uncertainty about the cost structure of the future telecommunications industry. The purpose of this section is not to present an empirical analysis of current costs or an estimate of future costs. Instead, this section attempts to clarify the general form of the cost structure to the degree that the cost structure is relevant to the theoretical analysis of this paper. The statements in this section could be considered "stylized facts" structured to clarify the pricing problems of telecommunications. Such "stylized facts" substitute an easily comprehensible general structure for the complex detail of a full empirical study.

for most telecommunications products (characterized by random demand for service and low density between any two points), some kind of network configuration which concentrates the demand for many two-point communication paths through a small number of switches is the lowest cost alternative.<sup>9</sup> Because of the network nature of efficient telecommunications facilities, there are strong economies of scope among the various telecommunications products.<sup>10</sup>

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9 The differences in minimum cost configuration are analogous to similar differences according to location and density for transportation. In railroads "unit trains" carry a commodity such as coal between two defined points with a high volume traffic in that commodity, while lower volume commodities are carried on cars which are switched and formed into new trains as they make their way from origin to destination. Similarly, the airline "hub and spoke" configuration provides a way of switching passengers in order to provide lower costs than serving the same number of points with direct flights.

10 Economies of scope exist over a given set of products when it is cheaper to produce those products by a single firm than to produce them by a set of specialized firms. The definition of a telecommunications product as communication between two specific points at a given time means that there are no demand externalities but there are strong economies of scope because of the cost advantages of supplying many such products by the same firm. If the product is defined more conventionally as telephone service from a particular network, then there is only one product and there are no economies of scope, but there are demand externalities. The advantage of the narrow definition of the product for analyzing competitive issues is that competitive possibilities do not occur uniformly for all parts of the service provided by a network, but vary with the specific characteristics of the product demanded. It is consequently necessary to be able to distinguish demand arising from communications among various customers within a building (subject to competition from "smart buildings") from communications among widely scattered residential users (not subject to competition at all at present) even though both may be receiving the general product "telephone service" from the same network.

The costs of wiring a new neighborhood for telephone service are dominated by the fixed cost of bringing a cable from the central office to the neighborhood (a line of poles or underground trench) and the construction costs of bringing the wires to the individual homes, rather than the cost of the wire itself. The average cost of providing telephone capability to a home when the entire neighborhood is being wired is much lower than the cost would be to bring a special wire from the central office to that home. Given the high probability that the occupants of the home will want telephone service, it is cheaper to plan as if telephone service will be universally desired than to provide the physical facilities only when service is actually ordered. Consequently feeder cables to individual neighborhoods generally provide substantial excess capacity so that additional lines can be utilized without adding to feeder cable capacity, and it is common to bring the wires to homes and to provide inside wiring before knowing whether or not individual occupants want telephone service.<sup>11</sup>

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<sup>11</sup> For a discussion of typical wiring plans, see Bell Telephone Laboratories, Engineering and Operations in the Bell System, 2nd. ed. (Indianapolis, Indiana: Western Electric Company, 1983), pp. 289-290.

The cost characteristics of telephone service are similar to those of a public good.<sup>12</sup> Most of the costs are fixed by the decision to provide a network capable of connecting all the individuals of a given area with each other. Providing the capability to connect all the individuals of an area requires an extensive set of switches, feeder cables, and drop wires, whether or not any particular individuals utilize the service. The marginal cost of serving any one individual in isolation is very high (requiring a special cable from the central office to that location), but the marginal cost of serving any particular individual in an area already wired for service is very low. There is no single well defined marginal cost of access; rather, the marginal cost depends upon the unit of observation and the time period considered. Consider, for example, the marginal cost of access for a new subdivision built on farm land that had no previous telephone wiring. There is a well defined marginal cost for wiring the entire subdivision. Dividing the marginal cost of the subdivision by the number of houses gives a reasonable proxy for

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<sup>12</sup> A pure public good is one in which the costs are independent of the number of users. The standard example is national defense. Many goods have public goods characteristics over a range of demand but are not pure public goods. In many areas of the country, highways are effectively a public good because they are so uncongested that an additional user imposes no additional cost. But highways are not public goods in Washington D.C. at rush hour because an additional user increases the congestion and reduces the utility of the road to other users.

the marginal cost per house, but that "average marginal cost" will be quite different from the marginal cost of any particular house alone. The marginal cost for wiring one house will be higher than the "average marginal cost" if no other houses are being wired, and will be lower than the "average marginal cost" if all other houses are being wired.

The dependence of marginal cost upon the unit of observation is similar to the problem of measuring marginal cost of airline travel per passenger. A single passenger in isolation imposes a very high marginal cost (the cost of sending an airplane), while a single additional passenger on a flight that is not full imposes a very small marginal cost (the extra fuel for additional weight and possibly a meal). Similarly, telephone cables come in conventional packages (50 pairs, 300 pairs, etc.) and the utilization of an additional wire pair within a cable imposes practically no marginal cost.

An additional consideration for telephone marginal cost is the time perspective. Telephone plant is a long lived capital good with limited salvage value. Once a house has been provided with telephone service, including a drop wire and inside wiring, the capital necessary to provide that service will normally remain in place even if service is discontinued. Although the feeder cable could be reallocated to another customer, the telephone company's

obligation to serve causes it normally to maintain enough excess capacity to reconnect any dwellings in its service area. Consequently, discontinuance of service once it has been established provides practically no cost savings. Insofar as the marginal costs of access can be defined, they are caused by the first occupant of the dwelling who orders service. The decision of subsequent occupants to order or not to order service makes very little difference to telephone company costs.

The distinctions among various kinds of marginal costs are important because they determine a telephone company's incentive to induce potential customers who place a low value on telephone service to subscribe. If the marginal cost of providing access to those customers is the average non-traffic sensitive plant per customer (as is often assumed in discussions of cost-based telephone pricing), then the telephone company has no market incentive to retain marginal customers on the network. But if the cost savings from having a customer discontinue service are very small, as is suggested by this analysis, then under competition the telephone companies have an incentive to design price structures that retain practically all of their potential customers on the network.

## V. Equilibrium Conditions

The equilibrium price structure depends crucially on the degree of price discrimination allowed and on the interconnection requirements. If no limitations are placed on price discrimination (so that persons receiving exactly the same service may be charged very different prices), then the equilibrium price structure will attain the maximum allocative efficiency and will achieve extremely high penetration rates. However, under those conditions, there are many possible distributions of the costs of the network, and some people could pay very high prices. In the absence of regulation, these conditions would allow the companies to exercise a great deal of market power.

If the companies are required to charge a single price to all customers, then interconnection conditions become crucial. With no interconnection required, there remains a very large set of price structures that cannot be undercut by free entry. This occurs because the company's pricing freedom is limited by the attractiveness of a private network connecting only its own members. Because the value of a network increases with the number of people attached to it, many different price structures will meet the requirement for sustainability if no interconnection occurs.

If non-discrimination and interconnection are required, then the price structure is greatly restricted. Competitive alternatives are increased by the possibility of replacing a portion of the system and connecting that portion with the remaining public system. Under these conditions, it is still possible to develop sustainable prices, but the prices must be closely tied to the customer's valuation of the service and the cost of alternatives.

Case 1: No Limitations on Price Discrimination or Interconnection<sup>13</sup>

Consider first a simple case in which two people consider telephone communication between them. Each person values the opportunity to call the other person at \$1. A telephone system linking the two people can be built at a price of \$1. Will the system be

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13 Although the ideas of this section are presented in a non-technical manner with numerical examples, they are based on a well-developed theoretical literature and could be put into a more general form with formal proofs of the assertions. This section is based on the concept of a transferable utility game, particularly as developed in W. W. Sharkey, "Suggestions for a game-theoretic approach to public utility pricing and cost allocation," Bell Journal of Economics, Vol. 13 (Spring, 1982): 57-68. The analysis draws on the analytic framework of contestable markets in which we imagine the possibility of wholesale replacement of an existing firm, putting aside real-world constraints of financing, personnel policies, and fixed capital, in order to clarify the competitive possibilities. See W. J. Baumol, J. C. Panzar, and R. D. Willig, Contestable Markets and the Theory of Industry Structure (New York: Harcourt Brace Jovanovich, Inc., 1982).

built, and if so how will the cost be distributed?

The sum of benefits is \$2 and the total cost is \$1; thus the system is feasible. In this symmetric case, the natural way to split the cost is for each person to pay \$.50, leaving each person with a net benefit or consumer surplus of \$.50, but that is not the only solution. In this case, neither person can achieve any positive surplus alone. Thus each person is better off to accept any positive surplus than to refuse to participate.

Because neither person can achieve any positive payoff alone, the core consists of all feasible allocations of the surplus. It can be represented by a line segment extending from the point (0,1) to the point (1,0). The solution point is indeterminate within that segment; it is possible to have one person pay the entire cost of the system and gain no net benefit while the other person pays no cost and enjoys the entire net benefit. Although such a solution may seem unfair, it is in the core because the disadvantaged person has no recourse other than to refuse to participate. Because refusing to participate leaves the person with a net surplus of zero, refusing to participate makes him no better off than being stuck with the entire cost of the system.<sup>14</sup>

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<sup>14</sup> That the core is a range of values in a two person game is an expected result consistent with core analysis in other markets. In the Edgeworth

As the number of players increases, the core remains large because existing subscribers benefit when one additional person joins the network. However, the indirect benefits generated when an additional person joins the network are also computed as direct benefits for other subscribers to the system. It is impossible to allocate to each person the total benefits that person contributes to the system because such an allocation would require twice the total benefits provided by the system. In a costless symmetric system, each person's direct and indirect benefit to the system will be exactly twice the person's direct benefit and will be exactly twice the average payoff which can be distributed. But there is nothing to require the benefits to be distributed evenly. There are consequently a large number of very different allocations of the total benefits to individual members that

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box diagram in which two people participate in free trades, the core solution consists of a range of values outlined by the points at which each person is at the same utility level as he would be without trading. However, in that case, as the number of traders increases, the core shrinks toward a single point. In this case, the core does not shrink toward a unique point, but remains large even with an arbitrarily large number of traders. In the symmetric game with  $n$  players, the ratio of the maximum payoff to the average payoff converges to 2 as  $n$  increases. The core is a segment of an  $n-1$  dimensional hyperplane in  $n$  space, with the boundaries of the hyperplane segment determined by the non-negativity conditions and by the maximum payoff that an  $n-1$  person coalition could guarantee for itself.

remain in the core of the game even with an arbitrarily large number of players.

An important characteristic of real world telecommunications demand is the great variety in quantities of service demanded by the various subscribers, and the correspondingly great variety in their valuation of telephone service. An important question is whether or not persons who value telephone service at less than the marginal cost of serving them will ever be served under free market conditions. In order to answer that question, assume that there is a wide variance in consumer valuations of telephone service. Ignore the role of fixed costs in real networks and assume that costs are completely determined by a constant cost for each customer connected to the network plus a constant cost for each unit of communication that flows over the network.

Consider a numerical example. Suppose there are five potential subscribers and usage is priced at its marginal cost. The company wants to compute the set of access prices (not necessarily the same for each person) that cover its total access costs while not allowing any other company with the same costs to enter the market. The value to any customer of communicating with any other customer (above the

marginal usage charge) can be expressed in a value matrix as follows:<sup>15</sup>

	1	2	3	4	5	Total Direct Value
1	0	40	30	20	10	100
2	40	0	15	10	5	70
3	30	15	0	5	3	53
4	20	10	5	0	3	38
5	10	5	3	3	0	21
Indirect Value	100	70	53	38	21	

The matrix says that subscriber 1 receives an expected value of 40 from communication with subscriber 2, an expected value of 30 from communication with subscriber 3, and so forth for a total expected value of 100 if all five people subscribe. The remaining people receive lower expected values ranging down to subscriber 5 who receives a total direct value of 21 if all subscribe.

<sup>15</sup> The symmetry of this matrix is purely for computational convenience. There is no reason why person A necessarily values communication with person B at the same rate that person B values communication with person A.

Assume that access cost is a constant 40 per person and consider potential equilibrium pricing combinations. The most obvious price is the cost-based non-discriminatory price of 40 per person. At that price the first three people will subscribe. Person 1 receives an expected value of 70 and pays 40 for access, leaving net consumer surplus of 30. Person 2 receives an expected value of 55 and a net consumer surplus of 15. Person 3 receives an expected value of 45 and a net consumer surplus of 5. Persons 4 and 5 value the network less than the access fee of 40 and both decline subscription.

Now consider the effect of potential entrants with access to the same technology. In order to attract customers, the potential entrant must make them better off than with the current network; that is, the potential entrant must improve upon the consumer surplus vector of (30, 15, 5, 0, 0). One possible way to do that is to offer person 4 an access price of 30, leaving a deficit of 10 from the marginal cost of 40. However, adding person 4 to the network makes person 1 better off by 20, person 2 better off by 10, and person 3 better off by 5. Any distribution of the 10 unit deficit among the first three persons that costs each of them less than the benefit to them of having person 4 on the network will cause them to join the new competitor. Suppose, for example, a competitor offers an access price vector of (50, 40, 40, 30, 30). This will result in a 4-person network and a net consumer surplus vector of (40, 25, 10, 5, 0) that improves all four subscribers

compared to the earlier consumer surplus vector.

The second price vector is an unambiguous improvement over the first, but it is still not a sustainable equilibrium. Consider another entrant that offers a price of 20 to person 5 and distributes the deficit of 20 over the other subscribers. There is less freedom in this choice because the total indirect benefit of person 5 is only 21. The requirement that each person remain at least as well off as before almost determines the distribution. One possibility is to offer an access price vector of (59.75, 44.75, 42.75, 32.75, 20). This distribution provides the required 200 of revenue to cover the 200 in access cost and leaves a net consumer surplus vector of (40.25, 25.25, 10.25, 5.25, 1). All five participants find the new consumer surplus vector superior to the previous one and would consequently join the new proposed system.

Although the price vector discriminates among customers, charging person 1 a price of 59.75 for precisely the same service for which person 5 is charged 20, it is sustainable against new entry. If all demands were independent, as is normally assumed in economic analysis, and if the costs were linear as assumed here, then a new entrant would serve only the three people who value the service above the marginal cost of serving them. However, in this case, serving only those three people does not make them better off because they gain enough

additional value from the larger network to compensate for the higher price they are charged. If there were another potential customer with total direct plus indirect value less than the marginal cost of access, then any network which attempted to serve that customer could be displaced by another one that dropped that customer from the network because the customer would be causing more total costs than total benefits.

With a large number of customers of varying sizes, all prices that are sustainable against entry will induce any customer to join the network for whom the direct plus the indirect benefits of that customer's participation are less than the marginal cost imposed by that customer's participation. The sum of direct benefits for all participants is necessarily equal to the sum of indirect benefits because both sums are simply the total of all entries in the value matrix. However, there is no necessary relationship between the direct and the indirect benefits for any one individual. It is possible to have a person who greatly values communication with other people but with whom no other person values communication, or vice versa. If the average conditions hold true in individual cases, so that the direct benefits are equal to the indirect benefits as in the example above, then the optimal pricing rule will be to charge the marginal customer exactly half of the marginal cost of access.

The degree of pricing freedom is dependent upon the customer's total valuation and the historical situation. If no telephone network exists, there is a great deal of freedom to allocate benefits among the high value customers. The example above used net consumer surplus in proportion to the customer's total valuation, but that is not necessary. It would be possible to devise sustainable prices that give more consumer surplus to person 2 than to person 1. The only constraint is that the maximum distribution to a person or group is the amount that leaves the remaining customers with the same benefit as they could obtain by forming a network excluding the person or group receiving maximum benefits. But within wide ranges, any price which brings all the viable subscribers onto the network will be sustainable, regardless of the actual distribution of consumer surplus which results. However, once a distribution has been developed, it constrains the future distributions because any entrant must match the welfare of each person in order to induce that person to switch. If the initial firm priced to give an "unfair" amount of consumer surplus to person 2, a new entrant must also do that in order to get person 2 to switch. Thus pricing patterns established in a somewhat random way could be continued by the process of successive entrants.

There is less pricing freedom for persons near the margin than for those who value the network far above the marginal cost of serving them. The marginal customers must be given low enough prices to induce

them to join the network, but such prices leave little net consumer surplus to be distributed. In the example above, both the price for person 5 and the additions to the prices of other subscribers were determined within narrow limits by the fact that person 5's total direct and indirect benefit was 42 while the marginal cost was 40, leaving only 2 units to be distributed among the five people.

We conclude that with no limitations on price discrimination and with no interconnection requirements, the costs will be allocated toward those customers who value the network most highly. There will not be a single cost allocation but rather a wide variety of stable cost allocations in the core. However, the subscribers who value the network near the marginal cost of serving them will not bear any of the fixed costs of the network, nor will they necessarily even bear the entire marginal cost that they impose. Any customer for whom the direct plus the indirect value of subscription is at least equal to the marginal cost of service will be on the network. If the valuations are continuously distributed, ranging down to very low valuation (and there is a high degree of connectivity among the participants), any network which charges every customer at least that customer's marginal access cost will be displaced by another network with more discriminatory pricing. For high value customers, there is no rule that determines the allocation of costs among them. Two customers who value the network equally may be charged very different costs and still

have the customer discriminated against unable to improve his situation by forming a coalition with others. The reason is that for any efficient network, rearranging the cost allocation is a pure income transfer, but unanimous agreement is required in order to form a new network with all participants. Consequently, those who are disadvantaged by the income transfer will block the proposed new network.

With no limits on price discrimination, the network can always attain full allocative efficiency, regardless of the degree of economies of scale or of the amount of fixed costs. Fixed costs can be allocated as a flat service charge to those customers who place a high value on telephone service. Consequently, usage charges for all customers can be set at the marginal cost and access charges for customers who place a low value on the network can be set below marginal cost, while still covering all costs. This situation is analogous to the public finance problem of raising a given tax revenue. If lump sum taxes are allowed, then no pricing distortion results from the tax. If the tax must be levied on any activity (sales, income, etc.), then it always has some distorting effect and reduces allocative efficiency. Similarly, if the fixed costs of the network can be allocated in a lump sum to customers who will still accept the service, they have no distorting effect. But if they must be spread evenly across customers in either access or usage charges, they will reduce

allocative efficiency to some degree.

Case 2: No Discrimination Limitations but Interconnection Required

So long as no limitations are placed on price discrimination, the company with whom interconnection is desired can charge an arbitrarily high price to stop interconnection. Alternatively, it can charge a price equal to the benefits it would have received if there had been no separate system. Assume, for example, that a "smart building" connects together 40 customers, each of whom previously produced \$20 a month in revenue above marginal cost, and then attempts to connect the combination to the telephone company as a single customer. If the telephone company is able to charge \$800 above marginal cost for the interconnection, then it generates the same contribution to fixed cost from the customers of the smart building as it did from retaining them as individual customers. Consequently, the interconnection requirement is ineffective and this case is equivalent to the first case.

Case 3: Price Discrimination Prohibited, Interconnection not Required

In this section we assume that the existing company specifies a price structure and must follow that price structure for any customer that it chooses to serve, without discrimination. However, there is

no common carrier type of requirement to serve and no requirement to interconnect with other companies that may choose to enter the market. Consequently, a new entrant must attract enough customers to have a viable network without exchanging traffic with the established network. A private microwave link used exclusively for communications among offices of a single company would be viable entry under these assumptions, but a "smart building" that concentrates traffic from a building through a PBX would not be viable because that procedure depends on connection with the existing network.

The significance of the non-discrimination requirement depends upon the definition of the product. If the product is defined narrowly as a communication path between specific points, then the non-discrimination provision is of no significance because each customer is located at a different point and is therefore ordering a different service from any other customer. Consequently, any amount of effective discrimination could be implemented by an appropriately chosen price structure with different prices for communication originating at each specific geographical location.

In this section and the next, assume that the non-discrimination provisions must apply to telecommunications products as conventionally defined; that is, to elements such as access, usage, bandwidth, and total distance traveled. The standard anti-discrimination provisions

as currently used in the telecommunications industry require the companies to offer bundles of similar but not identical products, that may have different cost characteristics, at the same price. For example, there may be real cost savings from connecting together a large number of customers in the same building, compared to connecting the same number of customers spread around a substantial area, but so long as those are all the same class of customer (business or residential) in the same service area, they are all charged at the same rate.

The anti-discrimination assumption of this section does not limit the company to simple linear prices. It may use any combination of two part tariffs, volume discounts, and so forth but is required to offer the same set of prices to all customers. The question to be examined is: What range of price structures are sustainable against entry when there are no barriers to entry? A price structure is sustainable if there is no other price structure (with higher access charges and lower usage charges, for example, or with higher prices for low-volume users and lower prices for high-volume users) that would cover the entrant's costs if all customers who had an incentive to switch to the new entrant did so.<sup>16</sup>

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<sup>16</sup> In more precise language, assume the existing firm specifies a revenue function  $R(u)$  where  $u$  is the customer's usage,  $R(u)$  is the total revenue

The idea that without interconnection a wide variety of prices are sustainable against competition is consistent with the key role that interconnection issues have played in the history of telecommunications competition. Interconnection was a crucial competitive weapon even in the original telegraph wars of the mid-nineteenth century.<sup>18</sup> Interconnection has remained a crucial competitive issue in all phases of telephone competition - from the original competitors after the expiration of the Bell patent to the microwave authorizations for television transmission networks after World War II to the disputes of the 1970's over various forms of interconnection for MCI and other new competitors.<sup>19</sup> Even with the

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subgroups that only call among themselves) increases the range of sustainable prices. In simulation experiments with parameters approximating actual telephone characteristics, simple two part tariffs (an access charge plus a usage charge) were sustainable almost regardless of the relative weight put on access or usage. If most costs were recovered through an access charge, the low usage customers did not have enough demand among themselves to benefit by a private system. If most costs were recovered through a usage charge, the high usage customers could not benefit from a private system because the gains from changing the price structure were outweighed by the losses from being unable to call the low usage customers.

18 For an excellent account of the development of telegraph companies in the United States, see Robert L. Thompson, Wiring a Continent (Princeton, N.J.: Princeton University Press, 1947).

19 These competitive issues are examined in detail in Gerald Brock, The Telecommunications Industry: The Dynamics of Market Structure (Cambridge: Harvard University Press, 1981).

price structure of the 1960's (with prices not at all closely related to telecommunications costs), it is unlikely that competition would have been successful without a requirement to interconnect. The only successful entry without interconnection has been in cases where there was no previous service availability (such as small towns after the expiration of the original Bell patent that had not been offered service by the Bell companies) or where the customer had a high volume of demand for communication among a small number of locations (such as private microwave systems for internal company communications).

Case 4: Non-Discriminatory Pricing, Full Interconnection, and Obligation to Serve

The first three cases illustrate that neither interconnection requirements nor non-discrimination requirements place significant constraints on the carrier's pricing freedom. The first three cases are essentially alike in showing a large variety of feasible equilibrium allocations of the costs among the various parties. Even with free entry, the interconnected nature of telecommunications and the large role played by fixed costs leaves wide latitude for

allocating costs among the participants. However, the combination of the two requirements is very restrictive. It allows companies to avoid the problems of setting up a complete self contained network and to search for profitable niches in which a combination of new services and resale of existing services can better the price offered by the established firm for some customers. In the previous cases, a large number of customers had to be attracted to the new network in order to make it viable. In this case, it is only necessary to attract a few customers whose requirements make the new offering seem more attractive than the existing offering.

In order for a price structure to be sustainable with no barriers to entry, no price discrimination, and required interconnection, there must be no subset of products for which the total price of those products is greater than the cost of producing them alone. That is a very restrictive requirement in this case because the ability to produce partial products and combine them with resale of products from the established firm greatly reduces the cost of producing them alone compared to the case where the potential entrant has to find a viable independent system. Consider, for example, the price system defined by charging for usage at marginal cost and charging each customer the average remaining costs as an access fee. Such a scheme would produce high allocative efficiency, but it might not be sustainable. A set of tenants in a single building could combine their telephone demand

by connecting to a single PBX and order service as one customer from the phone company. The usage fee would remain the same. If the cost of the effort to combine is lower than the access charges imposed on the tenants individually, the access charges will fail the test for sustainability.

The potential nonsustainability of using fixed access fees to recover the fixed costs of the network arises from two factors. First, fixed the access charges are the same across customers while the actual product of access has different costs. Consequently, the prices must be set at the lowest cost of all the various products in order to achieve sustainability. The same prices that would induce tenants in the same building to combine their traffic in a shared PBX would not induce widely scattered businesses to combine into one unit. Second, the fixed price is designed to recover costs spread throughout the network, but is charged only to the final end element. Thus the telephone company does not save all the costs which would have been paid by the various tenants' access fees when the tenants combine into one customer.

Because the competitive conditions assumed for this case are stringent, a sustainable price structure must place the revenue requirement on the parts of the service that cause the costs and have no lower cost alternative. In local service, the least alternatives

exist for the exchange of calls among a large number of points with low volume on any particular two-point path. The access function is subject to competition from local PBX's (that could conceivably link up tenants in an apartment building, dormitory rooms in a college, or even a residential neighborhood as well as the tenants in commercial buildings). High volume two point demand can be served with private facilities. But the large fixed costs of the public network are a function of its ability to reach effectively all customers and that ability is what must be charged for the fixed costs.

#### VI. Application to Current Policy Issues

The current issues related to this analysis include long distance access charges, bypass, and smart buildings. Current long distance access charges include a large usage sensitive charge, far above either the cost of service or the price charged for similar local calls that do not provide long distance access. The high usage charges provide an artificial inducement to find alternatives that are privately cheaper even though they may cost more than the telephone company's cost for the same service. The problem is compounded by the fact that long distance access for large customers consists of a high density two point circuit (from the customer to the long distance company Point of Presence). Such high-density two point circuits are the form of communication with the most alternatives.

The Commission has been reducing the problems created by the high usage charges on long distance access by switching some of the revenue requirement to local fixed charges. A charge of up to \$6.00 per line per month for multiline business customers was imposed in 1984; a charge of \$1.00 per line for residential and single line business customers became effective in June 1985, and an additional charge of \$1.00 per line is scheduled to begin in June 1986. However, even after the 1986 charges are in place, substantial usage based long distance access charges will remain.

The essential lesson of the economic analysis contained in this paper is that in order to have efficient free competition, without price discrimination and with an obligation to interconnect all telephone systems, the fixed costs of the telephone network cannot be arbitrarily assigned to any one element of service. To avoid uneconomic bypass, long distance access usage charges must be reduced to the level of other local usage charges. To avoid uneconomic substitution of PBX connections for direct access to the local telephone company, fixed local access charges must be limited to the cost of substitutes.<sup>20</sup>

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<sup>20</sup> At present the constraint that fixed local access charges be limited to the cost of substitutes is not very restrictive. Even if the entire

The problem of generating the revenue to pay the fixed costs of the network is formally the same as the problem of designing a good tax structure to generate a fixed amount of revenue. The current access charge structure is analogous to a decision to generate the entire sales tax revenue for a city from a tax on a single item. Suppose, for example, that a city decides that it will generate all of its sales tax revenue from a large sales tax on bread and save the effort of taxing every purchase. Such a tax would induce a great deal of effort to avoid it - home baking of bread, providing close substitutes for bread which can avoid the technical definition of the taxed commodity, and simply switching to other foods. It is certain that the bread tax would raise substantially less revenue than a simple multiplication of the tax rate times pre-tax sales would indicate. Furthermore, the revenues would probably decline over time as the population became more

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interstate non traffic sensitive revenue requirement were converted into fixed end user charges, it would be unlikely to induce a large increase in shared tenant services (STS). But technological progress in PBXs and changes in the regulatory structure could make STS a more significant constraint in the future. Even though STS is not an important current constraint on pricing, it is an important factor for evaluating the long run pricing structure of the industry because it provides a substitute for the local line. If STS costs decline, the local access line cannot be treated as an inelastic commodity to which all residual costs can be assigned. Instead, the local lines will have to be priced with regard to the opportunities for STS, and any residual revenue requirement made up from usage charges.

sophisticated in avoiding the tax. A smaller tax on a broad base of items is both less distorting of consumer decisions and harder to avoid. Similarly, the current tax on long distance access provides strong incentives to develop methods of bypassing the specific taxed commodity of switched access to interexchange carriers, but a broad based charge on all local usage would be both less distorting and harder to avoid.

Several factors account for the lower distortion that would result from spreading over all local calls the revenue requirement that is currently raised by long distance access usage charges. The loss in allocative efficiency from pricing above marginal cost is proportional to the square of the distortion (the percentage by which price exceeds marginal cost) multiplied by the elasticity of demand. Local service has a lower price elasticity than long distance service.<sup>21</sup> Spreading

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<sup>21</sup> Current estimates indicate that access elasticity is even lower than the elasticity of local usage. Those estimates suggest that a fixed customer line charge is more efficient than local measured service for raising the revenue requirement. However, existing estimates do not take into account the potential effect of shared tenant services, the externality effect that a decision by some people not to subscribe reduces the value of the network for remaining subscribers, or any special social welfare weight to be attached to universal telephone service above any other commodity people choose to purchase. If those factors are significant, then either local usage charges or adjusted fixed charges (with reduced rates for people most likely to drop off the system and for people most likely to switch to shared tenant services) may be more efficient than a single fixed charge for all subscribers.

the burden over the much larger volume of local calls would greatly reduce the percentage distortion. Both factors would reduce the total loss in allocative efficiency. Spreading the burden over all local calls would also greatly reduce the artificial incentives to bypass the local telephone company because there would be no single group of products with a high tax imposed on it.

In order to sustain an efficient open network with free entry, it will be necessary to place greater reliance on local measured service than is currently done. The traditional telephone price structure (a fixed monthly charge for service, no usage charge for local calls, and a substantial usage charge for calls outside the local calling area) is becoming less viable because of technological change as well as competition. The increasing use of computers on telephone lines has resulted in some lines with usage far beyond the typical level and has placed an increased load on switches and trunk lines. The availability of electronic switching equipment, capable of low cost usage measurement, has reduced the cost of charging for local usage. Many companies have already established local measured service plans.

The optimal price structure for a highly competitive industry would probably offer a series of options, ranging from a very low fixed charge with relatively high usage charges to a substantially higher fixed charge with low usage charges. There would be no distinction

between local calls for long distance access and other local calls. A long distance call would consist of two local calls (origination and termination) plus the long distance company's charge for service between its offices.<sup>22</sup> A series of such self selecting two-part tariffs would be equivalent to a nonlinear revenue function with a low fixed charge for access, relatively high usage charges for the first units of usage, and volume discounts for larger amounts of usage. A special discount for high volume two-point business (equivalent to current private lines) would be necessary because of the ease of entry for such business. Such a scheme could generate the same amount of revenue as the current rate structure without reducing universal service, without generating incentives for uneconomic entry, and without creating unnecessarily large amounts of allocative efficiency losses.<sup>23</sup>

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22 This kind of non-discrimination between local calls which access a long distance carrier and other local calls was what MCI originally sought for its Execunet service.

23 The conclusion that a series of self selecting two-part tariffs can provide an efficient way to recover the revenue requirement has been extensively discussed in past literature. See, for example, Jerry Duvall, "Telephone Rates and Rate Structures: A Regulatory Perspective," in A. Baughcum and G. Faulhaber, Telecommunications Access & Public Policy (Norwood, New Jersey: Ablex Publishing Corporation, 1984) which contains a good discussion along with extensive references to related literature.

The type of rate structure described above is already being implemented in many jurisdictions. For example, the C&P Telephone rates for Northern Virginia residential customers include a choice of three plans: (1) \$5.00 fixed charge plus \$.106 per outgoing call, (2) \$9.20 fixed charge plus \$.106 per outgoing call after the first 50 calls, (3) \$16.48 per month for unlimited local service. This is equivalent to a revenue function with an initial charge of \$5.00 for access, a charge of \$.106 per call for the first 40 calls, a charge of 0 for calls between 40 and 50, a charge of \$.106 per call for calls between 51 and 119, and a charge of 0 for calls above 119. It is essentially a small fixed charge with a volume discounted usage charge. The present general approach of self selecting "economy" and "unlimited" tariffs could easily be adapted to generate the revenue currently obtained from long distance without any increase in the fixed charges for economy customers and consequently without any diminution of universal service.

The income distribution effects of moving some revenue requirement from long distance access usage charges to all local usage charges would be relatively neutral. One criticism made of the Commission's efforts to substitute fixed subscriber charges for usage charges was that the change would benefit heavy long distance users at the expense of low volume users. Moving some revenue requirement from long distance usage to all usage will have no income transfer effect on

customers who have an average mix of local and long distance usage, whether they are small users or large users. Compared to the present situation, it would benefit customers with an above average ratio of long distance to local usage and hurt customers with a below average ratio. However, the present situation is not stable because of the bypass incentives that exist. Consequently, even customers with a below average ratio of long distance to local calling could benefit from a change that generated the necessary revenue without creating incentives for uneconomic bypass.

There is widespread recognition that the existing access plan is unstable, and that it reduces long distance calling below the economic level, encourages the substitution of private line access for switched access even when switched access is cheaper to provide, and creates an incentive for construction of expensive private facilities to provide capacity that could be provided more cheaply over local exchange company facilities. However, there is less agreement on the best solution to these problems. Alternatives to the current access charge plan can be classified into four general categories:

- (1) Change the basis of allocating non traffic sensitive costs to long distance carriers (currently computed from the relative minutes of switched access usage) to some other basis that would produce the same amount of revenue with less distortion. Proposed alternative allocators include the number of equal access lines served by an

interexchange carrier, the total capacity connecting an interexchange carrier and the local exchange carrier, and a modified minutes of use allocator that includes a substantial volume discount for traffic between interexchange carriers and individual final users.

(2) Use regulatory tools to limit competition with the local exchange carrier in order to protect the existing price structure. Proposals for regulatory limitations include taxing or prohibiting private bypass facilities, prohibiting AT&T from substituting special access for switched access, and prohibiting resale of local services in order to discourage smart building competition.

(3) Substitute an increased subscriber line charge (flat fee per end user with the revenue applied to the interstate requirement) for the carrier common line charge.

(4) Modify the separations formula to reduce the share of NTS costs assigned to the interstate jurisdiction. The change in allocation would increase the revenue requirement of the intrastate jurisdiction. The additional revenue requirement could be recovered through ordinary local rate-making procedures as increases in either fixed monthly charges or local usage charges.

The analysis of this paper suggests that options three and four are the best long term solution to the pricing problem. Although it may be possible to devise a better allocator of NTS than minutes of use, no allocator will avoid distorting both consumer decisions and

investment decisions. Consequently, option one should only be viewed as a temporary measure to solve urgent problems if it is pursued. The use of regulatory tools to prevent entry requires restricting the consumer's freedom to use the telephone system in ways the consumer sees as beneficial, and locks in the misallocation of resources that occurs from wrong price signals. There is also serious doubt that effective regulatory constraints could be devised that would protect local telephone companies from the strong incentives to develop competition. Option two would require a significant increase in intrusive government regulation and might still be ineffective.

Options three and four are quite similar. Both effectively shift the revenue requirement from a tax on long distance usage to an increase in local charges. Both solve the bypass problem and increase the efficiency of the telephone network. The difference is that option three continues to treat the revenue requirement as an interstate requirement and therefore requires federal determination of the method of recovery while option four places a greater responsibility on the states to determine the method of recovery. The economic effects of the two options would be identical if the states chose to recover the additional revenue requirement through an increase in the fixed local charge per month for each access line. The choice between the two options is largely dependent upon federalism arguments (such as the relative weight to be placed on local determinations tailored to local needs versus the federal interest in promoting interstate commerce)

which are beyond the scope of this paper.<sup>24</sup>

## VII. Conclusion

Free entry combined with a non-discrimination requirement and an interconnection requirement puts a severe constraint on the pricing freedom of local companies. However, the companies can remain viable under those conditions so long as they are allowed to adjust their pricing structure to the competitive requirements. The alternative to allowing pricing adjustments is to attempt to solve the current problems through increased regulation. Long distance access bypass and smart buildings can be prohibited or taxed in an attempt to maintain the existing price structure. But there are great advantages to allowing free entry.

A prime function of entry is to produce information, including information that indicates the existing firm has made mistakes. Especially in a dynamic industry such as telecommunications, one firm

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<sup>24</sup> For a discussion of some of the federalism issues in telecommunications, see Peter K. Pitsch, "Harmonizing Deregulation and Federalism: A Conservative Dilemma," in J. R. Foster, et. al. eds., Boundaries Between Competition and Economic Regulation (Washington, D.C.: Institute for Study of Regulation, 1983), pp. 71-81.

cannot always make the right choices. Free entry gives entrepreneurs an option to challenge the decisions of the established firm by attempting to make a profit on an alternative perception of the correct product mix or pricing structure. But such entry is only useful if the industry is operating within a reasonable price structure. It does not require new entrants to inform us that the current access charges are above the costs of service. Any analyst of the issue is already aware of that fact. In order to make open entry serve its proper information generating function, the existing prices must be restructured into a more rational form.

A second reason for supporting open entry is that the industry boundaries are changing. Even though basic local service has natural monopoly characteristics, there are many areas in which local service competes with non-regulated alternatives. The wisdom of limiting the monopoly boundaries by the open entry policy for terminal equipment has been amply demonstrated by the rapid pace of innovation and competition in that segment. Yet there is no clear demarcation between terminal equipment and other parts of the network. A large PBX is essentially a small central office. Lines from a PBX to extension telephones ("inside wiring") are functionally indistinguishable from access lines connecting telephones with local offices. In order to maximize opportunities for innovative use of the telephone network, it is necessary to allow individuals a great deal of freedom to construct

alternative communication systems and to interconnect them with the public network without discrimination.

The increasingly close association of the computer and telecommunications industries suggests that no sharp boundary exists between them. Many products could come out of either the regulated communications industry or the unregulated computer industry. Any attempt to solve the current bypass problem or related problems of potentially uneconomic entry through entry prohibitions will create artificial walls around certain services and reduce the possibilities for innovative use of the telephone network. But a policy of open entry together with price structure reform will lead to maximum consumer freedom together with economic efficiency and protection of universal service.



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