Interconnection Conditions, Access Charges, and Universal Service

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Interconnection Conditions, Access Charges, and Universal Service[1]

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I. Introduction

The development of competition in the local exchange is still in an early stage. The competitive revenues are tiny in comparison to the LEC revenues. However, the competitors have already created changes in the LEC practices and gained interconnection rights with the LEC networks. Thus the MFJ defined LATA boundaries are no longer the demarcation point between monopoly and competive services. The local exchange itself is a mixture of competitive and monopoly services with no stable dividing line. With further developments in cable TV capability and radio based services, it is likely that competition in the local exchange will spread well beyond the current services provided by Competitive Access Providers.

As in many previous cases, the network nature of telecommunication causes interconnection arrangements to be a crucial competitive issue in the emerging local competition. Earlier competition controversies led to a general right to interconnection for each competitive service, but with two distinct models followed regarding the prices of interconnection. In the terminal equipment case,

1 Research for this paper was supported in part by a grant from the Markle Foundation.

interconnection was required at a zero price. That is, any consumer with equipment conforming to specified publicly available standards could be connected to the network with no fee charged for the type of interconnection. The development of standards for interconnection together with the Computer II rules that deregulated terminal equipment allowed interconnection at a zero price. It would have been possible to charge a connection fee for each piece of terminal equipment attached to the network (though detection and enforcement would have been problematic) in order to generate subsidies for other aspects of the network. It was a policy choice to eliminate the revenue flows that had previously come from extension phones and other high priced terminal equipment, not an inevitable result of competition in terminal equipment.

The original MCI Execunet service was an attempt by MCI to apply the terminal equipment model to the interconnection of local and long distance service. MCI wanted to procure local service at the established tariff rate and connect that service to MCI's facilities as would have been clearly allowed for connecting a private communications system (such as a system of extension telephones connected through a PBX) to the local network. As a result of the complex and drawn out access controversy, the decision was reached to impose a specific and substantial connection charge on long distance service and not to allow free interconnection as with terminal equipment. The access rules and tariffs are

formally charges for the service of local origination and termination of long distance calls, but the subsidies built into the charges are effectively an interconnection fee charged to long distance networks that connect with local networks. That fee is charged on a per minute basis. The December 1982 FCC access charge plan envisioned that the interconnection fee would be primarily a transitional measure to avoid rapid changes in rate levels as the Subscriber Line Charges were gradually increased. The Congressional Universal Telephone Service Act of 1983 envisioned a high permanent interconnection fee that would provide large amounts of revenue to subsidize local exchange service. The political compromise resulted in a modest long term interconnection charge paid by long distance networks to local networks.

In both the terminal equipment and the long distance cases, interconnection rules were determined for communication crossing a particular defined boundary (from public right of way to the customer premises for terminal equipment, interstate communication for federal access charges, intrastate interLATA communication for state access charges). The emerging local competition will still require interconnection, but at present there are no well defined boundaries. Thus the problem of developing appropriate policies for interconnection is more complex than in the previous cases because the policies must apply to a wide variety of cases.

In the most general case, the competitive issues created by local network competition are analogous to the competitive issues of product standardization. Standardization and network interconnection both increase the value of the product to consumers. Both can play an important part in competitive strategy. Free interconnection is analogous to the case of a public industry wide product standard while interconnection fees are analogous to licensing fees paid to achieve compatibility with proprietary technology. There is a considerable formal economic literature on network and standardization issues.1 However, the results depend upon specific features of the model construction that do not closely match the communications issues and it is therefore difficult to draw directly applicable conclusions from the general theoretical models.

This paper examines the effects of various interconnection arrangements through a numerical simulation model. The simulation model is a modification of the Littlechild model of two-part tariffs with network

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1 Michael L. Katz and Carl Shapiro, "Network Externalities, Competition, and Compatibility," 75 A.E.R. (1985) 424-440; Joseph Farrell and Garth Saloner, "Standardization, Compatibility, and Innovation," 16 The Rand Journal of Economics (1985) 70-83; for a review and additional references, see Jean Tirole, The Theory of Industrial Organization (Cambridge, MA: The MIT Press, 1988), pp. 404-421.

externalities.2 In the Littlechild formulation, the demand function of each person for access to the telephone network is determined by price, income, and the number of other subscribers. Individuals differ by income but otherwise are identical. Thus the individual demand functions differ only by the income of the individuals and the aggregate demand function is dependent only on the number of people connected to the network, not on the identity of those people.

The Littlechild formulation assumes a single network and is concerned with profit maximizing and surplus maximizing two part tariffs for that network. Many of the policy issues concern problems of connecting multiple networks and of the prices for such interconnection. They are also dependent upon diffferences in communities of interest that lead to such specialities as corporate networks. Those issues require taking account of specific calling patterns of various groups of the population because a small specialized network may be either of no value to an individual (if it does not contain the people that person wishes to call) or similar in value to a universal network (if it contains the people that person wishes to call).

The Littlechild formulation can be adapted to the interconnection issues by generalizing and reinterpreting it. Littlechild represented the differences among people by

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2 S. C. Littlechild, "Two-Part Tariffs and Consumption Externalities," Bell Journal of Economics (Autumn 1975): 661-670.

an income distribution function in one dimension. In order to examine interconnection issues among individuals with different communities of interest, the simulation model represents the community of interest over pairs of individuals represented as points in two dimensions. The demand among pairs of individuals is computed from the bivariate normal density function scaled to provide convenient size numbers.

Within a local area, the bivariate density function is the coefficient for a linear demand function of the form

$$Q(x,y,p) = f(x,y)(1 - .5p)$$

where $Q(x,y)$ is the demand function for calls from person x to person y at price p, and $f(x,y)$ is the bivariate density function that represents the intensity of demand of calls from x to y. The demand function intersects the price axis at 2 regardless of the size of $f(x,y)$ and intersects the quantity axis at the point $f(x,y)$. Thus if the usage price is 2, quantity demanded is zero and if the usage price is zero, quantity demanded is $f(x,y)$. The total area under the demand curve for any pair of individuals (consumer surplus when the usage price is zero) is $f(x,y)$. The aggregate demand curve for any set of individuals is of the same form with $f(x,y)$ replaced by the sum of $f(x,y)$ over all of the individuals represented.

II. A Three Person Example

Consider first the case in which there are only two people, A and B, and each values communication with the other at 2. In order for A and B to communicate, a telephone company must build a wire from each of them to a costless central switch. Each wire from a location to the switch costs 1. If only one subscribes, there are no communication paths and no value. If both subscribe, there are two communication paths (A to B and B to A) and total value of 4 while the total cost is 2.

If this is a contestable market (no barriers to entry so that any pricing plan that yields total revenue above total cost will be eliminated by competition), then total revenue must be 2 and the natural price in this symmetric example is 1 per subscriber. A price of 1 charges each subscriber the cost created by that subscriber. However, because of the network externality, the cost based price of 1 is not the only sustainable price even in a contestable market. Suppose, for example, that the telephone company charges 1.5 to A and 0.5 to B. Normally, competition eliminates price discrimination because the entrants attempt to serve the customers paying the high price and leave the customers paying the low price to the incumbent. That strategy is not feasible in this case because a competitor must attract both A and B. Although A would be pleased to switch to a system offering a price of 1, B would not and therefore the system would not be viable.

The discriminatory price would not be feasible against competitors if the incumbent were required to offer free interconnection. With free interconnection and the (1.5, 0.5) price vector, an entrant can compete for A alone by building a wire from A to the central switch at a cost of 1 and demanding interconnection. A prefers the entrant's price of 1 to the incumbent's price of 1.5 and receives the ability to communicate with B because of interconnection. The incumbent is left with a system consisting only of B that costs 1 and receives revenue of 0.5. The incumbent must consequently raise its price for B to 1, eliminating the discrimination. In this two person case and in general, a company can sustain price discrimination against entry if it retains control over interconnection, but cannot sustain price discrimination against entry if free interconnection is required.

Now consider the addition of a third person C to the network of A and B. C adds four new communication paths; A to C, B to C, C to A, and C to B.[3] Assume that each of those paths is valued at 0.4. In other words, A and B each value the ability to communicate with C at 0.4 and C values the ability to communicate with A and B and 0.4 each. The total value of the network increases by 1.6 when C joins while the total cost increases by 1. Thus it is socially beneficial to have C on the network. However, from C's

3 In general, the addition of the (n+1)th person to a network of n people adds 2n new communication paths.

perspective, the value of subscription is only 0.8 (C's value in calling each of the other two people). Therefore if the telephone company charges the non-discriminatory price of 1 to all subscribers, C will decline subscription.

In a contestable market with no interconnection requirements, a non-discriminatory price structure that excludes C is not sustainable against a discriminatory price structure that includes C. For example, a price vector of (1.3, 1.3, .4) will induce all three to subscribe, exactly cover total cost, and make each person better off than that person would be under the non-discriminatory two-person network. However, that price vector is not sustainable under conditions of required free interconnection because an entrant would attempt to serve A and B at a lower price than the combined 2.6 that they pay the incumbent and then interconnect with the incumbent to reach C.

In this three person example, there is no non-discriminatory price that reaches maximum efficiency. There is a discriminatory price that reaches maximum efficiency and is sustainable against competitors when interconnection is not required. There is no price that reaches maximum efficiency and is sustainable in an environment of free interconnection.

III. Free Interconnection and Efficiency

In the above example, the two-person symmetrical case provides an argument for the advantages of free

interconnection. With contestability and free interconnection, prices are forced to marginal cost and both customers are served at maximum efficiency. That result generalizes so long as all potential customers have private value above the marginal cost of serving them. When all customers place a high valuation on service relative to cost, then the difference between social value and private value is irrelevant. However, if there are significant numbers of customers with the characteristics of person C (with marginal cost between the private value and the social value of service), then free interconnection reduces efficiency by making it impossible to serve those customers. If the average private value is only a little above the average cost of service, it is possible for the network to completely unravel leading to a null service equilibrium as a result of the marginal cost pricing induced through free interconnection.

The three possible cases are illustrated on Figures 1 through 3. The horizontal axis measures potential customers arrayed from those with the greatest demand to those with the least demand. The vertical axis measures price and cost of service. The marginal private value (MPV) curve in each diagram (solid line) is similar to the ordinary demand curve, but takes account of the dependence of demand on the set of other individuals that have subscribed. The MPV curve measures the private value of subscription to a particular individual assuming all those

Figure 1 - Full Subscription at P = MC

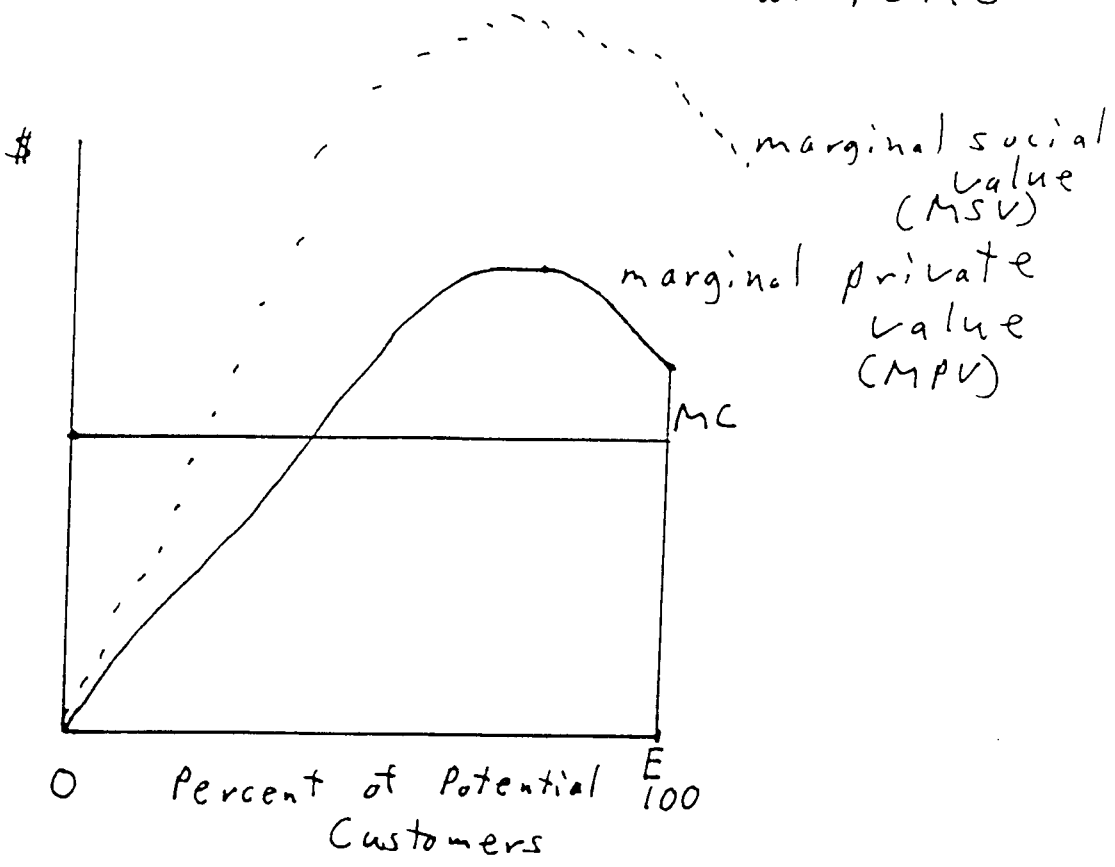


Figure 2 - Partial Subscription at P = MC

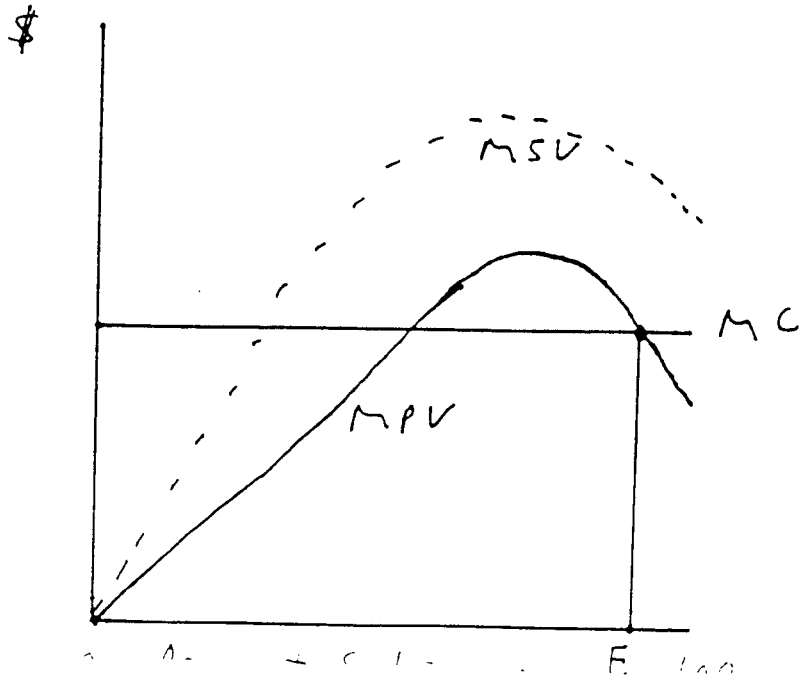
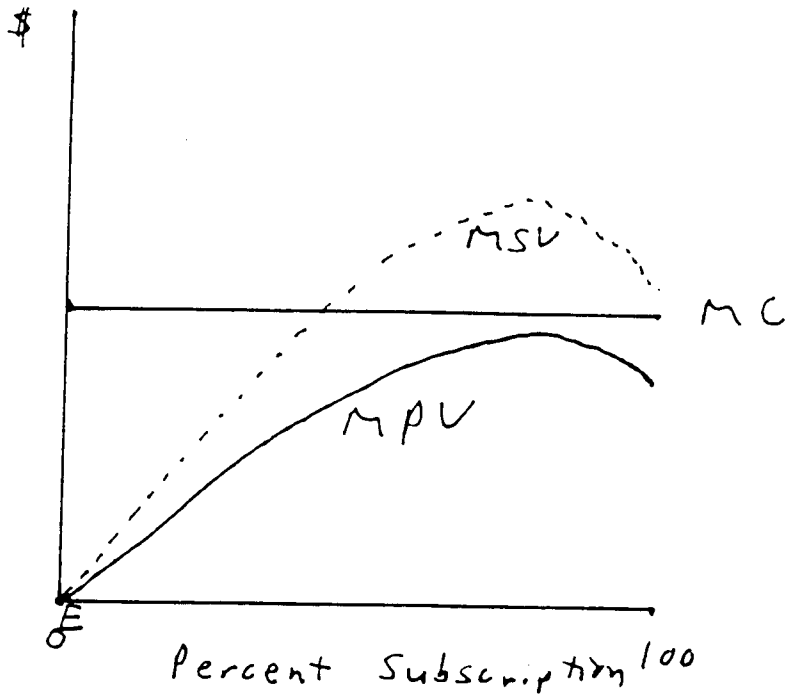


Figure 3

Network Unravels at P = MC



to the left of that individual are already subscribers. It rises over an initial range as the network becomes more valuable because of the larger number of subscribers, then falls as the subscribers with less interest in communicating are considered. The shape shown is the standard one used in the simulation model, but is not the only one. If all customers are identical, for example, the MPV curve would rise continuously.

The marginal social value (MSV) curve (broken line) measures the additional social value created by adding an additional subscriber, assuming that all individuals to the left of the that person have already subscribed. The MSV is the sum of the MPV and the additional value to all previous subscribers of having the new person on the network. If valuation is symmetrically distributed (each person i values calls to person j at the same level as j values calls to i), then the MSV curve will be exactly twice the height of the MPV curve. In order to maximize economic efficiency, it is necessary to have all individuals for whom the MSV is greater than the marginal cost subscribe to the network. In all three cases illustrated on Figures 1 through 3, maximum economic efficiency requires 100 percent subscription.

In the constant returns to scale technology used in these examples, contestability together with free interconnection forces prices to marginal cost. Any price structure that charges a customer more than the cost of serving that customer can be eliminated by an entrant that

serves that customer and interconnects with the rest of the system.

Figure 1 represents a telephone system with a high ratio of average value to cost. The MPV is above MC even for the potential customer with the least demand. Consequently, setting price at marginal cost results in an efficient equilibrium with 100 percent subscription, represented as point E on the horizontal axis. The fact that MPV is different from MSV is irrelevant because both are above marginal cost.

Figure 2 represents a telephone system with a lower ratio of average value to cost. Some customers have MPV above the MC, but some have MPV less than MC and MSV greater than MC. With the P=MC condition required by contestability and free interconnection, the equilibrium is at point E (less than 100 percent subscription) where the downward sloping portion of the MPV curve intersects the MC curve. The equilibrium is inefficient because potential customers to the right of E have MSV greater than MC. In this case, the failure to account for the difference between MPV and MSV results in less than universal service and reduced efficiency. Greater efficiency could be obtained with a discriminatory price structure that induced universal service, but no discriminatory price structure is sustainable with contestability and free interconnection.

Figure 3 represents a further reduction in the ratio of average value to cost in which the MPV is entirely below the

MC. In this case, with marginal cost pricing there is no equilibrium other than the null equilibrium of zero subscription. However, the maximum social value would come from 100 percent subscription because the MSV is above the MC at 100 percent. A contestable market with no interconnection requirement in this case would sustain discriminatory prices that induced 100 percent subscription.

Numbers from one particular case from the simulation model may help clarify why the network unravels with a low ratio of value to cost and marginal cost pricing. A town has 35 potential customers, each of whom can be served at a constant marginal cost per customer of 100. The marginal usage cost, interconnection cost, and switching costs are zero. Based on the expectation that all 35 subscribe, the individual valuations of the network range from a high of 195 (195 percent of the cost of service) to a low of 67 with an average of 147. The MSV of the customer with the lowest demand is 134 because that customer has a private value of 67 and also adds 67 to the total value of the other 34 customers. With contestability and no interconnection requirement, a discriminatory price scheme will be designed that causes each potential customer to subscribe, has total cost of 3500 (35 customers times 100 each), total payments of 3500, and total consumer surplus of 1645 (35 customers with an average valuation of 147 and average payment of 100). There are many different such discriminatory pricing schemes that are sustainable under contestability with

interconnection requirements. One possible pricing plan would be to equalize consumer surplus among all customers (47 each) and charge individual prices ranging from a high of 148 to the customer that values the network at 195 down to a low of 20 for the customer that values the network at 67.

When a free interconnection requirement is imposed on this example, all customers who are charged more than 100 form a new network and demand interconnection with the remaining customers. Because cost is a constant 100 per customer, the loss of high paying customers forces the remaining network to raise its price to 100 in order to remain viable. The free interconnection requirement thus reduces the set of sustainable prices to the single cost based non discriminatory price of 100 per person.

When all 35 potential customers subscribed, 27 valued the subscription at more than 100 and 8 valued subscription at less than 100. When the price is changed to 100 per person, the 8 with valuation less than 100 drop their subscription. Their loss to the network reduces the value to the remaining subscribers because of inability to call the 8 people who discontinue service. When the values are recomputed based on the expectation of a 27 person network, only 25 value the 27 person network above the price of 100 and persons 26 and 27 discontinue service. The loss of number 26 and 27 further reduces the value of service for the remaining customers, causing number 25 to drop service.

The process continues until the network completely unravels leaving no subscribers.

A small difference in the ratio of value to cost may change the equilibrium from one of near universal service to no subscription at all. If the MPV rises and then falls as illustrated in Figures 1-3, then a slight reduction in value that moves the peak of the MPV from above MC (Figure 2) to below MC (Figure 3) causes subscription to decline from a high level to zero. There is a range of continuous response of subscription to price changes (Figure 1 to 2) and then a discontinuous response when the network collapses (Figure 2 to 3).

IV. Pricing Policies With Interconnection Fees

In this case the incumbent must interconnect with any systems that request interconnection, but is allowed to charge a fee for the interconnection. This case is analogous to the long distance competition in which local systems were required to interconnect but allowed to charge an access fee set by regulators for the interconnected traffic. As illustrated by the many controversies over access charges in the long distance case, the significance of the interconnection right varies with the level and structure of the interconnection fees.

A. Incumbent firms set interconnection fees.

When the incumbent firms have full control of the interconnection fees, the interconnection requirement is

irrelevant. An incumbent can effectively prohibit interconnection by setting the fees high enough. For example, AT&T's original ENFIA tariff for local interconnection with competitive long distance providers (prior to the negotiated settlement) was so high that it removed all incentives to interconnect and was economically equivalent to a prohibition of interconnection. Any of the efficient discriminatory price structures that were sustainable without an interconnection requirement remain sustainable with an interconnection requirement so long as the incumbent is allowed to set the interconnection fee.

B. Interconnection Fee to Maintain Past Subsidies

In this case, the interconnection fee is designed to maintain the relative contributions of various sets of customers that were established at some time in the past (such as before competition was feasible or before interconnection was required). With the simplified conditions of the simulation model, this case is equivalent to the non-interconnection case. Because all potential entrants and the incumbent have the same cost, all parties have full knowledge of the cost, price, and contribution arrangements, and the interconnection fee is designed to maintain the past contributions, then entry and interconnection do not change either the price structure or the level of efficiency achieved. However, in the real world, this case may have significant benefits. There is

great uncertainty regarding both the efficient cost levels for providing various kinds of service and regarding the contribution flows among various classes of customers. Much of the debate over early long distance competition related to varying perspectives on the then existing contribution flows between long distance and local service, and there is even greater uncertainty regarding contribution flows among various kinds of local service. The past practice has been for the incumbents to claim that whatever services entrants wish to enter were providing a contribution to other services that were not at that time subject to competition. Such claims are greeted sceptically by potential entrants who interpret them as efforts to exclude competition.

Under the type of interconnection fee considered in this case, the incumbents would be required to specify the entire contribution scheme among various classes of service in advance of the observation of attempted entry. Entrants would then be free to enter any segment of the market and interconnect by paying the previously specified contribution as an interconnection fee, and would be entitled to receive the previously specified contribution if they choose to serve customers who received a contribution in the past. In other words, the contributions among various classes of service (either positive or negative) would be specified in advance by the incumbent and any entrant could serve a subset of customers and pay or receive the specified amount for interconnecting with the incumbent. Suppose, for

example, that the initial prices were 150 for business customers and 75 for residential customers when the cost was 100 per customer. Then the connection fee would be 50 for each business customer and -25 for each residential customer (75 price minus 100 cost). An entrant that chose to serve 10 residential customers would be entitled to receive 250 as an interconnection payment from the incumbent that served the business customers, while an entrant that served 10 business customers would be required to pay 500 (150 price - 100 cost) as an interconnection fee to the obtain access to the subsidized residential customers.

Such as scheme of contribution and interconnection payments preserves the status quo distribution of payment burdens and eliminates the normal condition that the competitive market forces prices toward cost. It is equivalent to the position advocated by some in the original long distance access payment controversy that the access charge plan should maintain the revenue flows of the past from long distance to local. If incumbents and entrants have the same cost, competition under this scheme makes no difference at all. If entrants have higher cost than incumbents, the entrants cannot compete for customers that are priced above cost. If entrants have lower cost than incumbents, the incumbents cannot hide behind the contribution flows to protect their inefficiency against competition.

C. Competitive Networks Treated as Individual Customers

Under this arrangement, a competitive network pays the ordinary usage rate charged to any other customer for traffic delivered to the incumbent's network, but receives no payment for traffic passed from the incumbent's network to the competitive network. The competitive network is treated as a customer of the incumbent and pays the same rates as any other customer rather than having a separate fee structure for interconnected networks. This case puts severe restrictions on the pricing policy of the incumbent, but does not force prices all the way to marginal cost. The incumbent gains some cost advantage over the entrant because the entrant must incur the cost of serving its particular set of customers and also must pay customer charges to the incumbent.

The incumbent gains greater pricing freedom by using a two part tariff than with a price only for subscription because it can then charge for all traffic coming from the entrant's network. With two part tariffs, the incumbent would lose the usage fees from calls among the set of customers that join the entrant, but continue to receive the usage fees from calls to the customers that remain with the incumbent as well as calls among the incumbent's customers.

The policy of treating competitive networks as ordinary customers greatly simplifies administrative arrangements, classification rules, and disputes over efforts to benefit from different prices for similar services. It allows some

freedom to develop innovative pricing plans and maintain contribution levels necessary to keep marginal customers on the network. However, it also creates a strong incentive to have usage prices even for services with costs that do not vary with usage in order to charge a large fee to a competitive network. If long distance companies had been allowed to connect as ordinary customers of the local companies, it would have led to a much more rapid introduction of local usage charges (local measured service).

D. Interconnection Fees Set by International Model

The treatment of entrants as customers of the incumbent produces an asymetry among the competitors because the entrants pay the incumbent for calls to the incumbent but the incumbent does not pay the entrant for calls from customers of the incumbent to customers of the entrant. A more symmetric treatment would occur by following the practice of international networks. Payments for international interconnection are based on a rate negotiated for each country pair known as the "accounting rate". Normally the originating country charges the customer for the call and pays the terminating country half the accounting rate for the terminating service. If traffic is exactly balanced (same number of calls in each direction) the accounting rate is irrelevant because all charges cancel out. Countries with a net surplus of incoming calls benefit

from high accounting rates while countries with a net surplus of outgoing calls benefit from low accounting rates.

Consider an accounting rate system for interconnection payments in which the incumbent has the power to specify the accounting rate. If the incumbent sets the accounting rate at the cost based rate of zero, then this case becomes the free interconnection case discussed above and there is no sustainable set of prices. If the incumbent sets a high accounting rate, it will benefit if its customers receive more calls from competitive systems than its customers make to customers of the competitive systems. If traffic is randomly and symmetrically distributed as in the numerical model, then the expected incoming calls equal the expected outgoing calls and the situation will resemble the case of free interconnection. Because the large customers are the most subject to competition, the incumbent can only benefit from its control over accounting rates if large customers make substantially more calls to small customers than small customers make to large customers.

So long as accounting rates are near cost, this case is worse for the incumbent than the treatment of competitors as customers because the incumbent must pay the competitors for traffic delivered to them. However, if the incumbent has complete control over the accounting rate level, it may be able to effectively prevent interconnection. A very high accounting rate eliminates demand for those calls and therefore the high price for calls across the boundary

effectively eliminates interconnection and creates two separate networks. This scenario places the accounting rate approach in the situation of no required interconnection and a wide range of sustainable discriminatory prices. An entrant could only succeed with a complete network that was viable without interconnection.

Thus an accounting rate structure can range from similar to zero price interconnection to similar to non-interconnection depending upon the details of how it is set up. The use of high accounting rates to eliminate interconnection and competition is dependent upon complete control of the rate level by the incumbent and upon the incumbent's ability to charge a different price for calls to a competitor than for calls to its own customers. If it were required to charge its customers the same rate per call regardless of the identity of the terminating customer, then it would charge a moderate rate for all calls and would incur accounting rate charges for calls delivered to the competitors, largely eliminating its benefit from setting a very high accounting rate.

V. Summary and Conclusion

Without interconnection, the requirement to gain a large number of customers in order to establish a viable network generates a wide variety of sustainable price structures even under contestable market conditions. Free interconnection eliminates all discrimination and forces

prices to marginal cost. Free interconnection creates the same effects in a communications network that mandated standards create in complementary products. With standards, a competitor can focus on any particular component that is priced above cost and need not be concerned with producing the entire package that is necessary for consumer utility. Similarly, with free interconnection, the competitor can serve any particular segment of the market that is priced above cost without attempting to supply the entire network that is necessary for consumer utility.

Required connection with an interconnection fee is an intermediate case between no required interconnection and required free interconnection. If the fee is completely under the control of the incumbents, then the interconnection requirement is irrelevant. If the interconnection fee is low, similar results to those for free interconnection are obtained.

Several conclusions can be drawn from the analysis:
(1) Contestability alone (no interconnection requirement) does not necessarily force prices to cost. Discriminatory prices can be sustained even in a contestable market so long as total revenue is equal to total cost.
(2) Contestability together with free interconnection does force prices equal to marginal cost. The free interconnection requirement allows competitors to serve only the customers who are charged above cost by the incumbent as in an ordinary market without externalities, and to still

gain the benefits of the entire network through interconnection.

(3) Contestability together with required interconnection does not necessarily bring prices to cost when interconnection fees are allowed. Interconnection fees can be designed to allow interconnection and still maintain any non-cost based pricing scheme that would be sustainable in a contestable market without interconnection. Such fees may not be simple to design or enforce, but they are theoretically possible.

(4) Cost based pricing is efficient despite the network externality if all potential customers privately value subscription above the cost of serving them.

(5) Cost based pricing is less efficient than discriminatory pricing when some customers whose subscription is socially beneficial have a private valuation of subscription below the cost of serving them.

(6) It is possible to have a network in which it is feasible and efficient to have 100 percent subscription with a discriminatory price structure sustainable under contestability, and still to have that network unravel completely to no subscribers under the cost based pricing created by free interconnection.