The Economics of BOC Long Distance Entry when Access Rates are above Costs

Department of Economics Working Paper 99-08

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September, 1999

This paper was started while the ¯rst author was visiting the Federal Communications Commission. It does not necessarily re°ect the opinion of the FCC or any individual Commissioner.

Abstract

We examine a series of models in which an incumbent local phone carrier sells access to its network to long distance carriers at a regulated price above marginal costs. When the incumbent maximizes short run pro¯ts, consumers are always made better o® when the incumbent enters the long distance market and typically welfare increases. We also examine two dynamic games with demand uncertainty to see whether the BOC's incentive to prey is increasing or decreasing in the price of access. The incentive to prey is decreasing in the price of access in one of the games, and maybe either decreasing or increasing in the other. We discuss other network industries where this model may be appropriate.

1 Introduction

Section 271 of the 1996 Telecommunications Act outlines conditions under which Regional Bell Operating Companies (BOCS) may enter interLATA interexchange (long distance) voice markets. Many commentors representing non-BOCs argue that allowing the BOCs into long distance may be problematic as long as the BOCs are the monopoly provider of \access" services.[1] Access services refers to the provision of the connections between an individual end user and a long distance carrier's network on both the originating and terminating ends of a long distance call.[2]

There are two broad categories of arguments that address why such entry could be problematic. The ¯rst is that the BOCs would have an incentive to withhold or degrade the quality of access services available to competing long distance carriers. We label these activities non-price raising rivals' costs strategies.[3] The second category suggests that the BOCs will have an \arti¯cial cost" advantage over their rivals because the price of access that is set by regulators exceeds long run incremental

[1] See paragraph 126 of the Second Report and Order Regulatory Treatement of Local Exchange Carriers. Commentors include AT&T, MCI, and MFS.

[2] We use the term access in this paper as it is typically used in the US telecommunications industry, to refer to the interconnection between a long distance company and a Local Exchange Carrier. This di®ers from the use by La®ont, Rey and Tirole (1998) in which access refers to interconnection between two Local Exchange Carriers.

[3] Economides (1998) shows that a ¯rm will have an incentive to degrade its rivals input. Sibley and Weismann (1997) have suggested that the greater access rates are above the cost of access the less incentive a BOC has to engage in non-price raising rivals' cost activities. See also Riordan and Salop (1995).

costs (LRIC).[4] Thus, the BOCs can supply themselves access at a cost that is lower than its competitors' e®ective costs. The suggestion is that under such conditions the BOC can undertake strategies that will be harmful to the market. We label such strategies as \unfair cost advantage strategies."

In this paper, we formalize and examine the validity of the unfair cost advantage arguments. In particular, we compare the market equilibrium that occurs when the BOC is not allowed to o®er long distance services to the market equilibrium that occurs when the BOC can sell long distance services, while it sells access to its competitors at above cost prices. Within this framework we consider two major questions. Each question has been motivated by claims made in the record, not supported by formal analysis, regarding potential problems that can arise from allowing BOCs into long distance while they sell access at prices above cost.

The ¯rst question is: \Assuming that the BOC will enter and compete in a non-predatory way (i.e., not select strategies that are pro¯table only because they drive out competitors) will allowing them to enter the market increase or decrease welfare?" To answer this question, we examine a series of complete information models. We ¯nd that if the BOC maximizes short run pro¯ts, the e®ect of BOC entry will be the same as allowing a low cost ¯rm to enter the market; all consumers are better o® in

[4]At the time of the 1996 Act, access rates averaged 7 cents per conversation minute, where the cost of providing access was estimated to be about 2 cents per minute (Mitchell (1990)). The primary reason for pricing access in this way is to subsidize local residential telephone service which is provided below LRIC. This is to help ensure \universal service" to all consumers and take full advantage of network externalities.

the short run. Typically, welfare will also be higher.[5]

The second question is: \Does allowing the BOC into long distance while charging an above cost price for access increase its ability or incentive to engage in predatory pricing behavior relative to its incentives if access is priced at costs?"[6] It has been argued that the BOC can o®er long distance at a retail price just below the regulated price of access (plus any additional marginal cost a ¯rm would incur). This would make it impossible for other carriers to compete pro¯tably in the long distance market. The fear is that once competing ¯rms are driven from the market, the BOC could then increase the price it charges for long distance calling.[7]

While charging a price above cost for access makes it less costly for the BOC to engage in predatory behavior, (i.e., it reduces the size of the loss the ¯rm incurs during the predatory period) it also makes the bene¯ts from predation smaller. The bene¯t of predatory behavior is that once a ¯rm drives out it competitors, it is able to enjoy monopoly pro¯ts for some period of time. However, being able to capture monopoly pro¯ts may represent a small increase in pro¯ts for a ¯rm that is already extracting a great deal of the rents from a market through pricing an essential input

[5] We de¯ne welfare to include consumer surplus plus pro¯t, holding types of products and consumer tastes constant. There is a theoretical possibility in a di®erentiated product market that welfare will be lower if only linear pricing is allowed.

[6] Again, see paragraph 126 of the Second Report and Order Regulatory Treatement of Local Exchange Carriers.

[7] This predatory scenario is quite controversial. There is a large literature that suggests that such predation can never be pro¯table because once the BOC raises its price, either the ¯rm will re-enter the market or another ¯rm will use the assets of the non-BOC and do so. See Bolton, Broadley, and Riordan (1999).

above cost.

To determine the overall e®ect of increasing access rates on the BOC's incentive to prey, we examine two versions of a two-period model with demand uncertainty where the non-BOC must receive outside ¯nancing as in Bolton and Scharfstein (1990). In each version, the non-BOC must attain a pro¯t target in the ¯rst period in order to obtain ¯nancing necessary to continue production in the future. In Game 1, the non-BOC must receive ¯nancing before the access price is determined. We demonstrate that increasing the access rate decreases the BOC's overall incentive to engage in predation in this game. In Game 2, the non-BOC receives ¯nancing after the access rate is determined.

We show that the BOC's incentive to prey is decreasing less in the price of access in Game 2 than in Game 1. If the price of access is close to costs, then the incentive to prey is still decreasing in the access rate. On the other hand, if the access rate is close to the monopoly price, then the incentive to prey may be increasing in the access rate. In Game 2, raising the access rate increases the pro¯t hurdle that the non-BOC must clear to get future ¯nancing. This makes it cheaper for the BOC to prey and thus increases its incentive to prey. We also show that as the products become less di®erentiated, the BOC's incentive to prey shrinks.

This analysis addresses a very speci¯c policy issue: Given that access rates are above the (LRIC) of providing access, and given that BOCs are currently not allowed to provide long distance service, will allowing them into long distance while access rates are above cost incrementally increase or decrease welfare relative to keeping them out? We understand that lowering access rates will likely increase welfare, but we assume this is not possible, and look only at the e®ect of the incremental decision to allow BOC entry when access rates exceed cost.[8][9]

While we couch our analysis in terms of entry by the BOC into the long distance market, it is also useful in many other network industries where one ¯rm controls a bottleneck facility. For example, in our framework one can analyze whether ¯rms that own the transmission facilities in electricity should be allowed to also be suppliers in the electricity generation market. One can also analyze whether cable ¯rms should be allowed to be internet service providers given that they are the only provider of coaxil access to the home. Similarly, we can examine the issues of BOC entry into the high speed data (internet) market.

In section 2, we present a Cournot equilibrium where the BOC does not engage in predation. We present a model of product di®erentiation in the next section, that will be used to expand on the intuition generated in section 2. Section 4 examines two versions of a two period model with uncertainty to examine the incentives of a BOC to engage in predatory behavior. The ¯nal section provides concluding remarks.

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[8] In practice, the decision will be made independently of each other. The FCC is required to allow a Regional BOCS into long distance if it meets a 14 point checklist which does not include selling access at cost.

[9] An analysis dealing with optimal access rates in a dynamic model is in Biglaiser and Riordan (1999).

2 The Cournot Model

In this section, we treat long distance calling as a homogeneous good characterized by a linear market demand curve $P = z - bQ$, where P is the price and Q is the sum of the output produced by all of the firms. We consider a market in which there are n long distance carriers (firms) indexed by i. A firm must have one minute of access to produce one minute of long distance calling. All non-BOCs have the same cost structure. They incur a per period fixed cost F of operation per period, and produce a minute of calling at zero marginal cost, except for the per minute price they must pay for access. The BOC has the same cross structure as other firms except that it provides access to itself.

The BOC is the only seller of access and its costs are normalized to zero dollars per minute. The regulatory authorities allow the BOC to sell access to the n firms at a price of α dollars per minute, where $\alpha > 0$.

We compare the market equilibrium when n identical firms compete as Cournot competitors with the BOC excluded, to the market equilibrium in which the BOC replaces one of the n firms that competes in the provision of long distance.[10]

Proposition 1 *Allowing the BOC into long distance as a Cournot competitor increases welfare both in the short and long run in long distance.*

Proof. When n identical non-BOCs compete in the long distance market pur-

[10] We have the BOC replace a firm rather than enter as the $n+1$st firm to eliminate the obvious short run downward price effect of allowing an additional firm to enter the market.

chasing access from the BOC, they each have an objective function of

$$\pi_i = (z - bQ - \alpha)q_i$$

where q_i is the output of firm i.

In a short run equilibrium with n identical firms, the market output is $\frac{n}{n+1}\frac{(z-\alpha)}{b}$. In the long run, the equilibrium number of firms is $n^* = \frac{(z-\alpha)}{(bF)^{1/2}} - 1$, and output is $Q^* = \frac{z-a}{b} - (\frac{F}{b})^{1/2}$.

Now we replace one of these n^* firms with the BOC. The BOC purchases access from itself and collects access revenues from the other firms. Thus, its payoff function is

$$\pi_B = (z - bQ)q_b + \alpha \sum_{j \neq B} q_j$$

where $\sum_{j \neq B} q_j$ denotes the output of all firms other than the BOC.

When the BOC is one of the otherwise equivalent n competing firms, the short run market output is $\frac{nz-(n-1)\alpha}{(n+1)b}$ which, for $\alpha > 0$, is greater than $\frac{n(z-\alpha)}{(n+1)b}$. Thus, since the equilibrium price when the BOC is in the market is greater than marginal costs, the resulting higher output implies that welfare is higher with the BOC in the market.

A long run equilibrium occurs when non-BOC firms earns zero profit. Letting firm i's profit equal 0 yields an equilibrium number of firms equal to $n^{**} = \frac{z-2\alpha}{(bF)^{1/2}} - 1$ and an equilibrium market output of $Q^{**} = \frac{z-\alpha}{b} - (\frac{F}{b})^{1/2}$. Output is the same in the long run regardless of whether the BOC is in or out of the market. Thus, since fewer firms are in the market when the BOC is present than when it is not ($n^{**} < n^*$ for

® > 0), welfare is higher when the BOC is in the market, because the level of ¯xed costs is lower. ■

This proposition hinges on the fact that the BOC behaves as if costs are lower than its competitors. That is, while all other ¯rms view themselves as having a marginal cost equal to ®, the BOC behaves as if it marginal cost is 0. In the short run, replacing a high cost competitor with a low cost competitor will result in that ¯rm expanding output relative to the ¯rm it replaces and leads to a price closer to marginal cost and hence higher welfare. In the long run, the output expansion of the BOC reduces the number of ¯rms in the market, which reduces the overall level of ¯xed costs in the market, which increases welfare.

While the results of this model are fairly clear, they are based on some assumptions inherent in the Cournot model which may not be appropriate for the telecommunications market. First, the Cournot model treats quantity as the strategic variable. As such, when the BOC considers increasing output at the margin, it behaves as if this will not reduce the output of its competitors. This is important because the access revenue of the BOC depends on the output level of its competitors. Thus, if we believe that activities that expand the output of the BOC at the margin decreases the output of its competitors (i.e., the BOC wins some customers from its competitors), then the results of this model may not be appropriate for making policy decisions.

Second the long run welfare results depend on competitors being driven from the market (so that ¯xed costs are reduced). However, in a market where product di®erentiation is important, or in a market in which public policy favors increasing the number of competitors (to facilitate deregulation or innovation) one may not be happy with welfare results that rely only on a net reduction in the number of competitors. In the next section we introduce a more general model of product di®erentiation to examine these more complex relationships.

3 The Model of Product Di®erentiation

We now consider a di®erentiated product market for long distance calling. Each customer observes the prices set by all ¯rms and purchases from the ¯rm that gives him the highest net surplus. The quantity that a customer purchases depends only on the price set by the ¯rm from which he purchases. All customers have the same demand function for minutes of calling regardless of the ¯rm from which they purchase, denoted $q(p)$, where q is that quantity (number of minutes) purchased, and p is the price set by the ¯rm the customer chooses.

The structure of di®erentiation is symmetric. The number of customers served by ¯rm i, $s_i(p_1; p_2 \ldots p_n; n)$ is a function of the prices set by all of the ¯rms and the number of ¯rms. It is symmetric in the sense that if two ¯rms, say 1 and 2, were to set prices p_1 and p_2 respectively, then they would serve $s_1(p_1; p_2 \ldots p_n; n)$ and $s_2(p_1; p_2 \ldots p_n; n)$ customers. If ¯rm 1 were to change its price to p_2 and ¯rm 2 were to charge p_1, holding all other ¯rms' prices constant, then the two ¯rms would `exchange' the number of customers that they serve. Formally, this means $s_1(p_1; p_2 \ldots p_n; n) = s_2(p_2; p_1 \ldots p_n; n)$ and $s_2(p_1; p_2 \ldots p_n; n) = s_1(p_2; p_1 \ldots p_n; n)$. We normalize the mass of customers to 1 and assume that in equilibrium all consumers consume a positive amount. We also assume that $\frac{\partial s_i}{\partial p_i} < 0$, $\frac{\partial s_i}{\partial p_j} > 0$ for $j \neq i$ and $\frac{\partial s_i}{\partial n} < 0$ and symmetry implies that $\frac{\partial s_j}{\partial p_i} = \frac{\partial s_k}{\partial p_i}$ for all $j,k \neq i$. The structure of differentiation is suggestive of each customer having a one time "travel cost" associated with purchasing from each firm, and that once a customer has arrived at a firm, his purchase behavior at that firm is identical to what it would be if he arrived at any other firm.

In addition to the symmetry conditions outlined above, we impose the following two conditions:

1) No income effects. If all firms lower their prices by the same amount, no customer would change firms. This along with symmetry ensures that if all firms charge the same price they each serve $1/n$ customers.

2) Each firm has a non-decreasing best response function with respect to its competitors' prices. That is, prices are strategic complements. Strategic complementarity in prices is a characteristic of most common price setting games such as Hotelling line competition.

Given this structure, we assume that the firms compete in a Nash price setting game; all firms choose price simultaneously to maximize their profit taking as given the prices of the other competitors. In this setting we compare an equilibrium with n firms purchasing access from the BOC to an equilibrium in which the BOC competes with $(n - 1)$ other firms. As in the previous section, we model BOC entry as replacing one of the firms in order to eliminate the effects of adding one additional firm to the market. This allows us to isolate the effects of BOC entry when it sells access at a price above cost. The firms have the same cost structure as in the model of section

2. This is the most general form of our model. At certain parts of the analysis we will impose more structure on the model to obtain more tractable results.

3.1 Analysis of the General Model

We assume that firms can only set linear prices. We then ask if allowing the BOC to enter the long distance market will result in, first, a change in prices and, second, an increase or decrease in welfare.

Proposition 2 *If $q(p)$ is constant then allowing the BOC into long distance will have no affect on the price. If $q(p)$ is downward sloping, then allowing the BOC into long distance lowers all output prices.*

Proof. When n firms compete they each face a profit function of

$$\pi_i = (p_i - \alpha)s_i(p_1; p_2 \ldots p_n; n)q(p_i)$$

The first order condition for the firm is

$$\frac{\partial \pi_i}{\partial p_i} = s_i q(p_i) + (p_i - \alpha)[s_i \frac{\partial q}{\partial p_i} + q(p_i)\frac{\partial s_i}{\partial p_i}] = 0 \qquad (1)$$

Since the problem is symmetric there is a Nash equilibrium in which all firms charge the same price. Call that price p^* that satisfies (1). Now suppose that the BOC enters by replacing (purchasing) one of the n firms. The BOC's profit function is

$$\pi_B = p_B s_B q(p_B) + \sum_{i}^{n-1} \alpha s_i q(p_i) \qquad (2)$$

which can be rewritten as

$$\pi_B = (p_B - \alpha)s_B q(p_B) + \sum_i \alpha s_i q(p_i)$$

The first order condition of the BOC is

$$\frac{\partial \pi_B}{\partial p_B} = s_B q + (p_B - \alpha)[s_B \frac{\partial q}{\partial p_B} + q\frac{\partial s_B}{\partial p_B}] + \sum_i \alpha \left[\frac{\partial s_i}{\partial p_B} q_i + s_B \frac{\partial q}{\partial p_B} \right] = 0 \qquad (3)$$

Since $\sum_i^n s_i$ is constant, if $q(p_i)$ is also constant, then the last term in (2) is constant, and the BOC has the same first order condition as does any other competitor; equations (1) and (3) are exactly the same. Thus all firms charging p^* is a Nash equilibrium when the BOC enters.

When $q(p)$ is downward sloping, the derivative of the last term in (2) is negative. This means that if all of the firms charged p^* (3) would be negative. Due to the concavity of (2), the BOC will lower its price from p^*. Since this game has a supermodular structure, this implies there exists an equilibrium in which all firms set a price less than p^*.[11] In addition, since (3) is always less than (1), the BOC must set a price less than the other firms' prices in equilibrium. ■

The intuition behind this result is that when the quantity demanded by each customer is unaffected by price, the BOC treats the access revenue earned from a competitor's customer as the opportunity cost of winning that customer. Thus the BOC has the same incentives at the margin as its competitors to lower price

[11] See DeGraba (1995) or Milgrom and Roberts (1994).

marginally to win additional customers.

This may be viewed as the polar opposite of the result from the Cournot model. That is, in this model, when the total quantity demanded in the market is fixed, the BOC treats an additional minute of long distance calling it sells to end-users at the margin as reducing by one minute the amount of access it sells to competitors. In this case the appropriate marginal cost is the foregone revenue from selling that minute of access which is α. In the Cournot model the BOC views selling an additional minute at the margin as having no affect on the quantity of access it sells to its competitors and so treats the marginal cost of that minute as 0, the marginal production cost of an additional minute of access.

When q_i is price sensitive, we obtain a result between the two polar cases. The BOC views an additional minute as reducing the access sold to competitors by a fraction of a minute. In this case, the BOC will behave as if its marginal cost is lower than α but greater than 0. Because the BOC behaves as if it has a lower marginal cost than its otherwise equivalent competitors, it will set a lower price and sell to a higher market share than its competitors. This provides some validation for the claim that allowing the BOCs into long distance while access rates exceed costs will place competitors at a disadvantage relative to the BOC.

This also explains why the BOC sets a lower per minute price in equilibrium than its competitors. It is not true that the BOC has a greater incentive to steal customers from its competitors at the margin. Rather it is because the BOC receives a greater margin than its competitors on additional minutes its existing customers purchase (p as opposed to p ¡ ®) that the BOC has a greater incentive to lower price in order to expand output. The increase in market share is simply a by-product of the fact that the BOC has an incentive to set a lower price than its competitors.

Now, we examine the welfare consequences of the BOC entering the long distance market.

Proposition 3 In the short run all consumers are better o® with the BOC in the long distance market than when the BOC is not in the market.

Proof. In proposition 2, we showed that allowing the BOC into long distance reduces every ¯rm's price. Since all consumers have the same set of choices of ¯rms with and without the BOC, and all prices are lower with the BOC in the market, all customers must be better o®. ■

This proposition suggests that while a BOC entering the long distance market will reduce competitors' pro¯ts, customers, at least in the short run, will bene¯t from this entry. In the long run, some consumers may be worse o® since there will be fewer carriers to choose from because prices are lower with the BOC in the market.

In general, the overall welfare e®ects of allowing the BOC into long distance are ambiguous both in the short run and the long run. In the short run there are two opposing welfare e®ects of allowing the BOC into long distance. First, because the equilibrium with the BOC in the market is asymmetric, consumers distribute themselves less e±ciently across ¯rms than they would under the symmetric equilibrium that occurs when the BOC is not in the market. This reduces welfare. On the other hand, allowing the BOC into long distance lowers all prices in the short run, which increases output and therefore, welfare.

To calculate the magnitude of the welfare effects we need to define some notation. Let p^* be the Nash equilibrium prices when there are only non-BOCs in the market, and p_B^{**} and p^{**} be the BOC and the non-BOC prices when the BOC is in the market, respectively. Let q^*, q_B^{**} and q^{**} be the corresponding quantities purchased by customers. Also, define Δs to be the difference between the number of customers a firm serves in the symmetric equilibrium and the number of customers a BOC serves when it enters. For simplicity, we assume that each individual's demand curve is linear and that the distribution of consumer tastes is uniformly distributed across firms.

A customer that purchases from the BOC in the asymmetric equilibrium, but would not purchase from the firm the BOC replaced in the symmetric equilibrium, can impose a loss in welfare on society that is at most equal to the additional surplus he receives from purchasing from the BOC as opposed to the firm from which he would have purchased in the symmetric equilibrium. [12] The additional surplus received by a customers from switching to the BOC can be calculated as $(p^{**} - p_B^{**})(q^{**} + q_B^{**})/2$. Intuitively this is the increase in surplus customers receive because they purchase more units at a lower price from the BOC than from the firm it replaced.

The additional surplus generated by a customer that purchases a higher quantity in the asymmetric equilibrium than in the symmetric equilibrium from a non-BOC firm is $(p^{**} + p^*)(q^{**} - q^*)/2$. Similarly the increase in surplus from customers that purchase from the BOC is $(p_B^{**} + p^*)(q_B^{**} - q^*)/2$. These expressions represent the area

[12] In the context of the Hotelling line this would be an increase in "travel" cost incurred by a customer that does not choose the firm closest to his location.

under the demand curve corresponding to the additional units customers purchase because prices fall when the BOC enters.

The decrease in surplus is calculated as $\Delta s(p^{**} - p_B^{**})(q^{**} + q_B^{**})/2$; which is the sum of the additional cost incurred by customers that switch from a non-BOC to the BOC after entry. The increase in welfare is

$$\sum_{j \neq B} \frac{(p_B^{**} + p^{*} - c)(q_B^{**} - q^{*})}{2} + \frac{s_B(p_B^{**} + p^{*} - c)(q_B^{**} - q^{*})}{2}$$

While given the generality of the model we cannot calculate the equilibrium values and therefore the magnitude of these changes, we do note that the decrease in welfare accrues only to those customer that represent the increase in market share the BOC generates by entry relative to the firm it replaces, while the increase in welfare from an increase in individual's purchasing accrues to all customers. Thus, for example, if the BOC enters and increases its market share by 5% of the customers in the market, then the per customer reduction in welfare must be 20 times that of the per person increase in welfare in order for entry not to increase welfare overall.

Welfare analysis in the long run is similar to that of the short run. It is complicated by the exit of firms in the long run. This will increase welfare (as in the Cournot analysis) because it reduces the overall fixed cost in the industry. However, the exit will reduce the variety of differentiated products available to consumers which will reduce welfare. We now turn to a model that puts more structure on demand and gives firms more flexibility in terms of pricing allowing us to make more precise statements about welfare.

3.2 Hotelling Model

We now consider a special case of the general model. In particular we assume that there are only two firms in the market and that they are located on opposite ends of a Hotelling line with length l. Each customer has linear travel cost t per unit traveled, and a demand curve of the form $q = z - bp_i$ where as before p_i, is the per unit price charged by firm i. We also allow the firms to offer two part tariffs where E_i represents the fixed portion (entry fee) of the tariff. We impose two restrictions on the parameters:

(R1) $tl < b(z/b - \alpha)^2/3$

(R2) $\alpha < z/2b$

Noting that $b(z/b - \alpha)^2/2$ is the surplus generated when a customer purchases minutes while facing a usage charge of α, (R1) implies that the travel cost incurred by the customer that lives at one end of the line to purchase from a firm located at the other end of the line is 2/3 of the surplus he would get by purchasing from that firm. It ensures that all consumers will be served in equilibrium. (R2) says that the regulated price of access must be less than the monopoly price of access.

Following the analysis of the previous section, we compare an equilibrium in which two carriers purchase access from the BOC at α to an equilibrium in which the BOC competes against one carrier to whom it sells access at α. We start with a preliminary lemma.

Lemma 1 In any equilibrium, the non BOC sets $p_N = \alpha$, while the BOC sets $p_B = 0$.

This result stems from the fact that all customers have identical demand functions and the ¯rm must set the same two part tari® to all customers. Intuitively, if the ¯rm ever tried to set a usage fee above the marginal cost of access, it could always do better by lowering the fee to its marginal cost and raising the ¯xed charge by just enough to cover the loss in revenue from the usage rate reduction (Since all customers are identical except for transportation costs, lowering the usage rate results in the same loss of revenue from each customer, so the same increase in E will recover this loss from each customer). This repricing will make the marginal customer strictly better o® which will increase the number of customers to which the ¯rm sells without reducing the revenue it receives from its original customers.

Proposition 4 Entry by the BOC makes all customers better o® and increases overall social welfare in the short run.

Proof. See Appendix.

Routine calculations, which are relegated to the Appendix, shows that $E_B^{¤¤}$, the ¯xed fee set by the BOC, is $tl + \frac{b®^2}{6} + ®(z ¡ b®)$, $E_N^{¤¤}$, the non-BOC's ¯xed fee when the BOC is in the game is $tl ¡ \frac{b®^2}{6}$, and $E_N^{¤}$, the fee when two non-BOCs are in the game, is tl. Clearly, $E_B^{¤¤} > E_N^{¤} > E_N^{¤¤}$. Thus when the BOC enters, the customers that continue to purchase from the non-BOC see no change in their usage fee, but a decrease in their ¯xed fee, so they are better o®. Customers that purchase from the BOC that were originally purchasing from the ¯rm the BOC replaced see a reduction in their usage fee from ® to 0, but an increase in their ¯xed fee from $E_N^{¤}$ to $E_N^{¤¤}$. We show that the increase in the ¯xed fee when the BOC is in the market extracts only a fraction of the additional surplus generated by the increase in the quantity purchased by customers in response to the decrease in the usage fee. For customers who switch from the non-BOC to the BOC, they must be better off because they had the option of continuing to purchase from the non-BOC at the same usage fee but at a lower fixed fee. There is a positive and negative welfare effect for customers who buy from the BOC when it enters. Welfare is increased for all BOC customers because they purchase a higher quantity, as a result of the usage fee falling (the price effect). On the other hand, there is an increase in travel cost since more than half of the customers purchase from the BOC. As the proof demonstrates, the price effect outweighs the increase in travel cost. Finally, we note that the non-BOC is unambiguously worse off as a result of BOC entry. It sells to fewer customers and charges each of its customers a lower fixed fee while leaving its usage fee unchanged.

We now determines how long run welfare is affected by having the BOC in the market. Since entry by the BOC reduces the revenue of the non-BOC, it is possible that in the long run the non-BOC could be driven from the market, while it could have survived if it were competing with another non-BOC. This would occur if F, the fixed cost of operation, is in the interval $\left[\frac{[3tl-\alpha^2 b/2]^2}{18t}; \frac{l^2 t}{2}\right]$. If F is smaller than $\frac{[3tl-\alpha^2 b/2]^2}{18t}$ then it will not be driven from the market and welfare would be higher with the BOC in the market by Proposition 4. While if F is greater than $\frac{l^2 t}{2}$; then it is not possible for two non-BOC firms to be in the market; thus having the BOC in the market instead a single non-BOC improves welfare. We find that welfare is improved in the long run even if the fixed cost falls in the range where the BOC replaces both non-BOCs. This result is independent of whether the BOC serves the entire market when it is a monopolist. The benefit of allowing the BOC into the market is to have a lower usage fee. This positive welfare effect outweighs the loss in welfare from having less variety of goods due to the non-BOC leaving the market.

Proposition 5 Entry by the BOC increases welfare in the long run.

Proof. See Appendix.

4 Predatory Price Squeeze

We now present a two-period model of competition based on the model of section 3.2 to determine whether the BOC has more or less incentive to prey as a function of the price of access.

For predation to be credible, we need to add some uncertainty to the model. Ex-ante there is uncertainty about the BOC's relative advantage over its non-BOC rival. It is quite natural for there to be uncertainty about the relative ability of the non-BOC to compete in these markets where the BOC has not been in the market, or when it is a newly opened market such as the internet.[13] Let k be the term that captures this advantage. k is the same in both periods. In our Hotelling framework, a consumer receives k more units of surplus if she goes to the BOC instead of the non-BOC. It is common knowledge that k is equally likely to be 0 or $\overline{k} > 0$. We assume that this advantage is non-negative, since the customer will be able to obtain

[13] Demand uncertainty in newly deregulated markets has also been examined in Biglaiser and Ma (1995).

all their telecommunications services, both local and long distance, from one carrier if they go with the BOC; the one stop shopping effect. The analysis can be carried out when k is negative. Once the non-BOC enters the market, k is observed by both firms.

A non-BOC's fixed costs in each period are F. F represents the cost of installing new technology to deliver services, which could include services other than long distance such as internet services and cable television, and the cost of setting up billing systems. A firm must incur F in each period to stay competitive due to the tremendous technological advances that occur in the industry. Given its nature and size, we assume, following Bolton and Scharfstein (1990), that a non-BOC must receive outside financing to cover F and participate in the market. This makes sense even for a firm like AT&T, since it issues corporate bonds and is a publicly traded company. For simplicity we assume that the BOC internally finances its entry into the long distance market. Of course, they must also deal with their creditors and stockholders, but we assume that it is always profitable for the BOC to be in the long distance market.

The courts cannot observe k and cannot observe profits unless the firm files for bankruptcy. If the firm files for bankruptcy, the court can determine the firm's profits and requires it to pay its financier according to the contract; if it cannot fully abide by the contract, then it must pay any profit that it did make. We only allow contracts that state that the non-BOC can only obtain financing if it pays back π^C to the financier. Otherwise, it must file for bankruptcy. Thus, we are ruling out contracts in which the non-BOC receives financing in the second period that is strictly increasing probability in its first period profits. For simplicity, we assume that the investor can commit to a contract and do not allow renegotiation. We also assume no discounting of future profits.

If k is known, then in the static stage game equilibrium a non-BOC can make profits larger than F if $k = 0$, but cannot cover F if $k = \bar{k}$. Thus, due to the limited liability, there is some positive probability that the investors will not be paid back F. This implies that a non-BOC's cost of capital will be above the risk free rate. We assume a competitive capital market. We make the following assumption concerning $\bar{k}$:

(R3) $3tl - \alpha^2 b/2 - (18tF)^{1/2} < \bar{k} < 3tl - \alpha^2 b/2$

The first inequality is a sufficient condition for a type $\bar{k}$ firm not to be able to cover F in the stage game equilibrium. The second inequality is a sufficient condition for the non-BOC to get positive sales in the stage game equilibrium.

We focus our attention on whether the BOC will have an incentive to prey. Unlike Bolton and Scharfstein, we do not focus on the issue of strategic manipulation of π^C by investors. Furthermore, we assume that revenues from the first period are not large enough for the non-BOC to be able to self finance the second period fixed costs given that it must pay back π^C.

There are two different timings of the model that we analyze. They differ by whether the price of access is determined before or after the non-BOC receives financing. In Game 1, at stage 1, the non-BOC either does or does not receive financing.

In stage 2, the price of access is determined. In stage 3, the non-BOC enters if it receives financing. In stage 4, both firms learn k. The firms then compete by simultaneously choosing two-part tariffs. If the non-BOC pays π^C at the end of period 1, then it gets financing in period 2 and the firms again compete by simultaneously choosing two-part tariffs. If the non-BOC does not pay π^C it goes into bankruptcy and the BOC is a monopolist in period 2. Game 2 is the same as Game 1, except for switching stages 1 and 2.

In this setting we will define the incentive to engage in predatory pricing as the difference between the sum of the profits the BOC makes when engaging in predatory behavior and the sum of its profits from engaging in non-predatory pricing. If this difference is increasing in the price of access, α, then we say that increasing α increases the incentive for the BOC to engage in predatory pricing, and if this difference is decreasing in α then we say that the incentive to engage in predatory behavior is decreasing in α. We solve the game by working backward from the final stage in period 1.

The static duopoly Nash equilibrium payoffs for the BOC and non-BOC in a period are

$$\pi_B^D = \frac{[3tl + \alpha^2 b/2 + k]^2}{18t} + \alpha l(z - \alpha b)$$

$$\pi_N^D = \frac{[3tl - \alpha^2 b/2 - k]^2}{18t} - \pi^C$$

The monopoly profit of the BOC is

$$\pi_B^M = \frac{z^2 l}{2b} - tl^2 \tag{4}$$

if the BOC wants to serve the entire market, or is forced to by the regulatory authority, and

$$\pi_B^M = \frac{z^4}{16tb^2} \tag{5}$$

if does not. That is, π_B^M is (4) if $\frac{z^2}{4bt} > l$ and (5) otherwise.

We want to compare the profits of the BOC from predatory pricing with the profits from maximizing short run profits in each period. Clearly, we only need to examine the case when $k = 0$, since if $k = \bar{k}$ the non-BOC will always exit at the end of the first period, and thus the BOC will always maximize short run profits in this case. If the BOC maximizes short run profits, then its total profits are $2\pi_B^D$.

To obtain the BOC's profits from predatory pricing, we need to determine what tariffs it must use to force the non-BOC to exit the market. From Lemma 1, the non-BOC's optimal variable part of the tariff is equal to α. The first order condition for the non-BOC's optimal E_N, given the BOC's fixed tariff E_B, is

$$E_N = \frac{tl - \alpha z + \alpha^2 b/2 + E_B - k}{2}$$

This generates an indifferent consumer i^* of

$$i^* = \frac{[\alpha z - \alpha^2 b/2 - E_B + 3tl + k]}{4t}$$

Thus, the non-BOC's profits as a function of E_B are

$$\frac{(tl + E_B - k - \alpha z + \alpha^2 b/2)^2}{8t}$$

If π^C is the profit target that the non-BOC must meet to get funding for the next period, then if the BOC wants to prey it must set the fixed portion of the two-part tariff, E_B, so that the non-BOC can not meet the target. The highest E_B that induces the non-BOC to exit is

$$E_B^P = 2(2t\pi^C)^{1/2} - tl + \alpha z + k - \alpha^2 b/2$$

This generates an $E_N = (2t\pi^C)^{1/2}$.

The BOC's profit if it preys in period 1, and is a monopolist in period 2 is thus

$$\begin{aligned}\pi_B^P \;=\;& [2(2t\pi^C)^{1/2} - tl + \alpha z - \alpha^2 b/2]\left[l - \left(\frac{\pi^C}{2t}\right)^{1/2}\right] + \alpha(z - b\alpha)\left(\frac{\pi^C}{2t}\right)^{1/2} \\ &+ \max\left[\frac{z^4}{16b^2 t}, \frac{lz^2}{2b} - tl^2\right] \qquad (6)\end{aligned}$$

The first bracketed term in (6) is the tariff that the BOC charges. The second term is its market share. The final set of terms are its profits from access in period 1 and its monopoly profits in period 2, respectively.

The difference between the BOC's profits when it preys and does not prey is $H \equiv \pi_B^P - 2\pi_B^D$: We first examine the BOC's incentives in Game 1, when the price of access is determined after π^C; thus the price of access does not affect π^C. To determine the incentive of the non-BOC to prey as a function of the price of access, we look at the derivative of H with respect to α:

$$\frac{\partial H}{\partial \alpha} = \frac{7\alpha bl}{3} - zl - \frac{\alpha^3 b^2}{9t} - \alpha b\left(\frac{\pi^C}{2t}\right)^{1/2} \qquad (7)$$

Proposition 6 The BOC's incentive to prey in Game 1 is decreasing in the price of access.

Proof. We need to demonstrate that (7) is negative. Clearly, for $\alpha < 3z/7b$, the result holds. By Assumption R2, $\alpha < z/2b$; the price of access is below the monopoly price. For $3z/7b < \alpha < z/2b$; let $\alpha = \lambda z/b$ where λ is between $3/7$ and $1/2$. Substituting for α in the first three terms of (7) we get $(7\lambda/3 - 1)zl - \lambda^3 z^3/9tb$. This can be rewritten as

$$(7\lambda/3 - 1)\frac{z}{t}\left[tl - \frac{z^2}{(9b(7\lambda/3 - 1)}\right] \tag{8}$$

We can rewrite (R1) as $tl < \frac{z^2(1-\lambda)^2}{3b}$. Substituting $tl = \frac{z^2(1-\lambda)^2}{3b}$ into the bracketed term of (8) we obtain

$$(7\lambda/3 - 1)\frac{z^3}{t}\left[\frac{(1-\lambda)^2}{3b} - \frac{1}{(9b(7\lambda/3 - 1)}\right]$$

which is less than 0 for all $\lambda \in [3/7; 1/2]$. ■

It should be noted that this result holds for any positive π^C. Thus, no matter what beliefs the investors have regarding the determination of the price of access, the BOC's incentive to prey is always lower the higher the price of access.

The intuition behind this result is that the ability to charge an above cost price for access both reduces the cost of engaging in predatory pricing and decreases the benefits. The decrease in the cost of preying comes from the fact that the BOC need not set a predatory price as low as it would have if it sold access at a price equal to cost. The reduction in the benefit arises because the difference in profit from being a monopolist in period 2, or a duopolist in period 2 that also collects access charges, decreases as the level of access charges increases. In our model the reduction in benefits exceeds the reduction in costs. Thus increasing the access rate decreases the incentives for the BOC to engage in predatory pricing, which is contrary to what many commentors believed.

Now we examine the BOC's incentive to prey in Game 2, where the price of access is determined before the non-BOC receives funding; thus affecting π^C. In this game, if the BOC does not engage in predation, π^C is

$$\pi^C = 2F - \frac{[3tl - \alpha^2 b/2 - \bar{k}]^2}{18t}$$

Raising the price of access now increases the profit target that the non-BOC must meet since when the type $\bar{k}$ non-BOC goes into bankruptcy, the financier will get a lower profit. It is straighforward to show that raising π^C increases the BOC's profit from preying. In the next proposition, we show that for access rates levels close to the cost of access, then the incentive to prey is decreasing in the price of access. For access levels close to the monopoly price of access, the incentive to prey may be increasing in the access rate.

Proposition 7 The BOC's incentive to prey is decreasing less in the price of access in Game 2 than in Game 1. A sufficient condition for the incentive to prey to be decreasing is that $\alpha \quad \frac{z}{3b}$. For α close to $\frac{z}{2b}$ the incentive may be increasing.

Proof. The derivative of H with respect to α now becomes

$$\frac{\partial H}{\partial \alpha} = \frac{7\alpha b l}{3} - zl - \frac{\alpha^3 b^2}{9t} - \alpha b \left(\frac{\pi^C}{2t}\right)^{1/2}$$

$$+ \left[\frac{\alpha b(3tl - \alpha^2 b/2 - \bar{k})}{9t}\right]\left(\frac{2t}{\pi^C}\right)^{1/2}\left[\frac{5l}{4} - 2\left(\frac{\pi^C}{2t}\right)^{1/2} - \frac{\alpha^2 b}{8t}\right] \qquad (9)$$

The first line is precisely how the incentive to prey changes in game 1, equation (7). Expression (9) represents how the incentive to prey changes when π^C is a function of access. The first term is $\frac{\partial \pi^C}{\partial \alpha}$ which is positive; raising the price of access increases the profit hurdle that the non-BOC must meet. This is because the profits that the investors get from the unsuccessful non-BOC, type $\bar{k}$; are decreasing in the price of access. The remaining terms are $\frac{\partial H}{\partial \pi^C}$. It is straightforward to show that it is also positive by setting $\pi^C = \frac{[3tl - \alpha^2 b/2]^2}{9t}$, which is larger than π^C can actually be. Thus, as the profit target increases, the BOC has a larger incentive to prey. The fact that (9) is positive implies that the effect of the price of access on π^C increases the BOC's incentive to prey because now it lowers the foregone profit incurred by the BOC in period 1 when it preys.

The fact that (9) is positive provides the possibility that $\frac{\partial H}{\partial \alpha}$ is positive. To maximize $\frac{\partial H}{\partial \alpha}$, we set $F = \frac{[3tl - \alpha^2 b/2 - \bar{k}]^2}{18t}$ which is the lowest fixed cost consistent with our model; if F were smaller, then the non-BOC will always get funding in period 2, thus any preying would be irrational. This generates $\pi^C = \frac{[3tl - \alpha^2 b/2 - \bar{k}]^2}{18t}$. Plugging this π^C into (9) and simplifying we obtain

$$\frac{\partial H}{\partial \alpha} = \frac{11\alpha bl}{6} - zl - \frac{\alpha^3 b^2}{36t} + \alpha b\frac{\bar{k}}{6t}$$
$$+ \left[\frac{2\alpha b}{3}\right]\left[\frac{l}{4} + \frac{\bar{k}}{3t} + \frac{\alpha^2 b}{24t}\right] \tag{10}$$

which is equivalent to

$$\frac{\partial H}{\partial \alpha} = 2abl + \frac{7\alpha b\bar{k}}{18t} - zl \tag{11}$$

Expression (11) is negative if

$$\bar{k} < \frac{18tl}{7}\left(\frac{z}{\alpha b} - 2\right) \tag{12}$$

By restriction (R2), the right hand side of (12) is positive. Thus if $\bar{k} < \frac{18tl}{7}\left[\frac{z}{\alpha b} - 2\right]$, then the BOC's incentive to prey is decreasing in access. On the other hand, for the price of access sufficiently close the monopoly price $\frac{z}{2b}$, (12) is violated. Thus, for access levels close to the monopoly level, then incentive to prey may be increasing in the price of access.[14]

We now provide a sufficient condition for (12) to be satisfied. If $\bar{k} < 3tl - \alpha^2 b/2$; restriction (R3), then (12) holds if

$$3tl - \alpha^2 b/2 \quad \frac{18tl}{7}\left(\frac{z}{\alpha b} - 2\right) \tag{13}$$

[14]Recall, that the lowest possible fixed cost was used to derive (12). As the fixed costs increases, the incentive to prey will fall. Thus, it is not always the case that the incentive always increasing at rates close to the monopoly level.

Let $\alpha = \lambda z/b$, then (13) becomes

$$3tl - \lambda^2/2b \leq \frac{18tl}{7\lambda} - \frac{36tl}{7}$$

which is satisfied if $\lambda \leq 1/3$.[15] ■

We also have some comparative static results for the BOC's incentive to prey.

Corollary 1 The BOC's marginal incentive to prey is decreasing in F and $\overline{k}$. The incentive is increasing in t in Game 2; thus this marginal incentive to prey decreases as the goods become less differentiated.

Proof. It is straightforward to show that $\frac{\partial^2 H}{\partial\alpha\partial\pi^c} < 0$. Since π^c is increasing in F and $\overline{k}$, $\frac{\partial H}{\partial \alpha}$ is decreasing in both of these parameters. More interestingly, $\frac{\partial^2 H}{\partial\alpha\partial t} > 0$. Let $G \equiv \frac{\partial}{\partial\alpha}\left(\frac{\partial\pi^c}{\partial t}\right) = -\frac{F}{t^2} - \frac{[3tl - \alpha^2 b/2 - \overline{k}][\alpha^2 b/2 + \overline{k}]}{36t^3} < 0$. Then

$$\frac{\partial^2 H}{\partial\alpha\partial t} = \frac{\alpha^3 b^2}{9t^2} - \frac{\alpha b}{2}\left(\frac{2t}{\pi^c}\right)^{1/2} G + \frac{\alpha^2 b/2 + \overline{k}}{9t^2}\left[\frac{5l}{4} - 2\left(\frac{\pi^c}{2t}\right)^{1/2} - \frac{\alpha^2 b}{8t}\left(\frac{2t}{\pi^c}\right)^{1/2}\right]$$
$$- G\left[\frac{\alpha b(3tl - \alpha^2 b/2 - \overline{k})}{18t}\right]\left[\frac{5l}{4} - 2\left(\frac{\pi^c}{2t}\right)^{1/2} - \frac{\alpha^2 b}{8t} + \left(\frac{2t}{\pi^c}\right)^{3/2}\right]\left(\frac{\pi^c}{2t}\right)^{1/2}$$

which is strictly positive. ■

There are three main points that Proposition 7 and Corollary 1 bring out. First, decreasing π^c will increase the BOC's marginal incentive to prey as a function of access. Thus, even if it is more costly for the BOC to prey, this marginal incentive to prey shrinks. The reasoning for this is that as π^c drops, the BOC has to price more

[15] As the fixed cost increases, higher values of λ are possible.

aggressively, lower its ¯xed charge, E_B^p; in order to induce the non-BOC to exit the market. This will lower the non-BOC's market share and hence the BOC's revenues from access. The drop in potential access revenues gives the BOC more incentive to prey. Since ¼^c is increasing in ®, the BOC's marginal incentive to prey is larger in Game 2 than in Game 1. Second, while it may be possible that the incentive to prey is increasing in access, this could only occur if the regulated price of access was at least 2/3 of the monopoly price. that as the products become less di®erentiated. Finally, as t goes to zero, the marginal incentive to prey shrinks; that is, the BOC will behave less aggressively. The reason for this is that as t gets smaller, the BOC does not have to lower E_B^p in order to reduce the non-BOC's market share and pro¯ts. In other words, this di®ers from the traditional Hotelling analysis where the more di®erentiated the products, the less aggressive the pricing. In order to get the non-BOC out of the market, the BOC has to price aggressively and the more di®erentiated the products the more aggressive it must be to induce exit.

In either game, the ¯nancier will decide whether to ¯nance the non-BOC depending on whether the BOC will or will not prey. If H is positive, then the non-BOC will never receive ¯nancing, since the BOC will always prey. If H is negative, then the BOC will not prey, the non-BOC will receive ¯nancing, and there is a positive probability that there will be competition in period 2. Thus, we would never see preying in equilibrium.[16] Our analysis demonstrates that, typically, raising the price

[16] There are other models in the literature where preying does not occur in equilibrium, but the possibility of preying does deter entry (See Milgrom and Roberts (1982), for example). If k were a continuum, then preying could occur in equilibrium. It will in general still be the case that raising

of access will increase the likelihood that there will be two ¯rms in the second period, since raising ® reduces H. This contradicts many statements in the record. It is easy to construct examples where the BOC preys or does not prey on its rival.

5 Conclusion

We have shown that allowing a BOC into the long distance market when it receives a price for the bottleneck input above marginal cost will typically result in higher welfare when the BOC does not attempt to act preditorily. Furthermore, the higher the price of the input, typically the lower the incentive for the BOC to price preditorily. We recognize that the e®ects of entry encompass more welfare considerations than those examined in this paper. For example, allowing BOCs into long distance may change other long distance carriers' incentives to engage in R&D. In particular it may change the incentives of a non-BOC to build its own facilities. It may also a®ect the government's ability to deregulate the industry. Furthermore, if the market is expected to be much larger in the future, then the incentive to prey may be quite large especially if brand name is important. We also recognize that our results may di®er if customers purchase both long distance services and other services that do not require access as an input. We look to future research to consider such e®ects.

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the price of access will reduce the BOC's incentive to prey. Furthermore, if there is some positive probability that the anti-trust authorities could detect a BOC preying, with the BOC having to pay a ¯ne if caught, then this is equivalent to lowering H, and hence making less likely that the BOC will prey.

While we have cast our analysis in terms of telecommunications markets, our results may also apply to other markets. In particular the supplier of a good or line of goods that sells its goods through retail outlets, or a franchiser who sells through independently owned franchises may choose to enter the downstream directly. In such cases our analysis should shed some light on their incentives and there consequences.

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6 Appendix

Proof. Proposition 4. First, we derive the equilibrium when two non-BOC's are in the market. Using Lemma 1, the ¯rms only get revenues from the ¯xed portion of the two part tari®, E_i, since each charge the same variable price ®. The pro¯t function for the firms located at 0 and l,are

$$\pi_n^0 = \frac{E_0[tl - E_0 + E_l]}{2t} \quad \pi_n^l = \frac{E_l[tl - E_l + E_0]}{2t} \tag{14}$$

where the bracketed terms are the firms' market shares. Using symmetry, it is easy to see that $E_N^* = tl$.

Now, if the BOC is at location 0, the objective functions for the BOC and the non-BOC at location l are

$$\pi_B^0 = \frac{E_B[tl + E_l - E_0 + \alpha z - \alpha^2 b/2]}{2t} + \frac{\alpha(z - \alpha b)[tl - E_l + E_0 - \alpha z + \alpha^2 b/2]}{2t} \tag{15}$$

$$\pi_N^l = \frac{E_N[tl - E_l + E_0 - \alpha z + \alpha^2 b/2]}{2t} \tag{16}$$

Equation (14) differs from (16) because the BOC charges a variable fee of 0. Taking the first order conditions and solving for the equilibrium we obtain prices $E_B^* = tl + \frac{b\alpha^2}{6} + \alpha(z - b\alpha)$ and $E_N^* = tl - \frac{b\alpha^2}{6}$.

Ignoring transportation costs, the surplus that a buyer receives from buying from the BOC is $\frac{z^2}{2b}$: This gives the buyer a net surplus of $\frac{z^2}{2b} - tl - \frac{b\alpha^2}{6} - \alpha(z - b\alpha)$: The surplus that this buyer receives if she buys from a non- BOC is $\frac{b(z/b - \alpha)^2}{2}$; this gives a net surplus to the buyer when there is no BOC in the game of $\frac{b(z/b-\alpha)^2}{2} - tl$. If the buyer at location $\frac{l}{2}$ is better off with the BOC in the market, then all other buyers must be better off since buyers below $\frac{l}{2}$ will also do better from buying from the BOC, and buyers greater than $\frac{l}{2}$ could always remain purchasing from the non-BOC at a lower price. It is straightforward to show that buyer $\frac{l}{2}$ is better off with the BOC in the market.

The increase in social welfare from the BOC is the gain in the additional surplus generated by the variable charge dropping from α to 0 for all customers who buy from the BOC. This is equal to the BOC's share of the market, $\left[\frac{l}{2} + \frac{b\alpha^2}{12t}\right]$; times the gain due to the drop in price, $\frac{b\alpha^2}{2}$. The loss in welfare is the additional travel cost incurred by consumer between $\frac{l}{2}$ and $\frac{b\alpha^2}{12t}$ now going to the more distant firm, the BOC. This is equal to $\frac{lba^2}{24t} + \frac{b^2\alpha^4}{288t}$ which is clearly less than the gain in surplus. Thus, surplus is higher with the BOC in the market. ■

Proof. Proposition 5. There are two cases to consider: either the BOC serves the entire market or it does not. The BOC will serve the entire if $tl < \frac{z^2}{4bt}$ and will only serve a subset of the market, equal to $\frac{z^2}{4bt}$, otherwise. We examine each case in turn. If the market is served by two non-BOCs then the social surplus is $\frac{b(z/b-\alpha)^2 l}{2} - \frac{tl^2}{4} - 2F$; where F is at least $\frac{[3tl-\alpha^2 b/2]^2}{18t}$: Thus, welfare with two BOC's in the market is at most

$$\frac{z^2 l}{2b} - z\alpha l + \frac{2b\alpha^2 l}{3} - \frac{5tl^2}{4} - \frac{\alpha^4 b^2}{36t}$$

Case 1. $tl < \frac{z^2}{4bt}$. In this case, the monopoly social surplus is $\frac{z^2 l}{2b} - \frac{tl^2}{2}$. Welfare is higher with a monopoly BOC since $z\alpha l - \frac{2b\alpha^2 l}{3} + \frac{3tl^2}{4} + \frac{\alpha^4 b^2}{36t}$; the first term is bigger than the second term by (R2).

Case 2. $\frac{z^2}{4bt} < tl < \frac{b(z/b-\alpha)^2}{3}$. Now, social surplus when the BOC is a monopolist is $\frac{3z^4}{32b^2t}$. Welfare is higher under monopoly if

$$\frac{3z^4}{32b^2t} + \frac{5tl^2}{4} - \frac{z^2l}{2b} + z\alpha l - \frac{2b\alpha^2 l}{3} + \frac{\alpha^4b^2}{36t} \tag{17}$$

is positive. Since $\frac{z^2}{4bt} < tl$, (17) is less than

$$\frac{3z^4}{32b^2t} - \frac{3tl^2}{4} + \alpha l(z - \frac{2b\alpha}{3}) + \frac{\alpha^4b^2}{18t} \tag{18}$$

By restriction (R2), (18) is less than

$$\frac{3z^4}{32b^2t} - \frac{3tl^2}{4} + \frac{\alpha^4b^2}{18t} \tag{19}$$

To minimize (19), set $\alpha = 0$: This allows tl^2 to take on its maximal value and drops the positive last term. Since $tl < \frac{b(z/b - \alpha)^2}{3}$, the largest $\frac{3tl^2}{4}$ is $\frac{z^4}{12b^2t}$. Thus, since $\frac{3z^4}{32b^2t} - \frac{z^4}{12b^2t} > 0$, expression (17) is positive. ■

The welfare consequences of raising access? On the one hand, raising access, lowers welfare since consumers who buy from the non-BOC buy too few units. Furthermore, it is easy to see that the distribution of consumers becomes less efficient as the price of access increases(?). On the other hand, the BOC is less likely to prey since it gets more revenue from the non-BOC the higher the price of access. (NEEDS WORK)

We now determine what types of non-BOCs the BOC would want to prey against. To do this, we examine the derivative of H with respect to k, the BOC's advantage.

$$\frac{\partial H}{\partial k} = \frac{l}{3} - \frac{\alpha^2 b}{9t} - \frac{2k}{9t} - \frac{\pi^c}{(2t)^{1/2}}$$

Given that we impose no restrictions on the distribution of k and only assume that

$$\frac{[3tl - \alpha^2 b/2 - \bar{k}]^2}{18t} < F < \frac{[3tl - \alpha^2 b/2]^2}{18t}$$

we have a great deal of flexibility for what values π^C can take on. We develop different cases, depending on whether the BOC would want to prey on the toughest type of rival. It is useful to note that $\frac{\partial^2 H}{\partial k^2} < 0$.

Case 1. $H(k = 0) \geq 0$: In this case, the incumbent would not prey on the strongest rival. If $\frac{\partial H}{\partial k}|_{k=0} \geq 0$, then the BOC will never prey. This is because the marginal incentive to prey is decreasing in k:

If $\frac{\partial H}{\partial k}|_{k=0} < 0$, then there are two possibilities, which depend on whether $H(k)$ is ever less than 0. First, as above, the BOC may never prey since $H(k) \geq 0$ for all k. If

$H(k) = 0$ for some $k \in (0; \overline{k})$, then the BOC will prey. Let k^* be the smallest k that makes $H(k) = 0$. Then either the BOC preys on all k above k^* or it prey on some interval of non-BOC's $[k^*; k^{**}]$ and does not prey on the highest type of non-BOCS. Thus, the BOC either prey on all its weak rivals or it preys on some intermediate group of rivals.

Case 2. $H(k = 0) < 0$: Either the BOC always preys on the non-BOC, if $H(k = \overline{k}) < 0$, or it preys on all non-BOC $k \in [0; k^*]$ where $H(k = k^*) = 0$. Thus, the BOC only preys against its strongest rivals.

There is a possibility that the BOC may want to reduce competition to keep the non-BOC in the market in period 2. This can be the case when duopoly profits are larger than monopoly profits. NEEDS WORK