Network Competition with Price Discrimination: Revisited—Once Again

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Abstract

This paper shows that, with destination-based price discrimination, when networks commit to utilities instead of fixed fees, they choose an efficient access charge. This result contrasts with the literature on network competition, which usually stresses the collusive nature of the access charges. When firms commit to fixed fees, access charges become an instrument to reduce the sensitivity of the residual subscription demand implying higher markups. In contrast, when firms commit to utilities, the utility sensitivity of the residual subscription demand is independent

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of the access charge and is higher. This implies that firms choose efficient access charges and provide higher surplus in equilibrium.

Introduction

The telecommunications markets across the globe have been going through a major structural change in last decade. Technological developments such as the introduction of fiber optic lines, developments in the mobile telephony, convergence of the cable and telephone networking technologies, and finally the tremendous growth of the Internet made the definition of natural boundaries between various services obsolete. Therefore, many countries have started to liberalize their telecommunications markets, and introduce competition against the traditionally state-owned or regulated incumbent operators. Interconnection between different operators has emerged as the single most important policy issue in this new era. As a consequence, the pricing of interconnection has received ample interest.

Interconnection price or access charge[1] is the payment from one network to another, in order to compensate the originating or terminating network for delivering the call to the receiver. Each country which has gone through the liberalization process has introduced legislation governing the interconnection of networks. Common features, with regard to pricing, are that access charges should be cost based, just, and non-discriminatory. The mechanism envisioned by many policy makers requires firms to negotiate terms of interconnection before engaging in product market competition. These negotiated interconnection arrangements are operationalized subject to approval by regulatory bodies. This mechanism is clearly vague enough to allow a wide range of negotiated interconnection arrangements. Nevertheless, practice, without clear justification, has selected one particular pricing mechanism: linear access prices. That is, firms negotiate per minute(unit) access charges.

Not surprisingly, the interconnection issue has led to a vast number of papers in the nineties. The framework to study access pricing is introduced by Laffont, Rey and Tirole

[1] We will use both terms interchangeably throughout the text.

(1998 a,b)—henceforth LRTa,b—and Armstrong (1998). These papers first show the collusive role access charges might play with linear retail prices and no price discrimination.

This result however does not seem to hold when two-part tariffs are employed. This is a practice commonly observed in telecommunication markets where tariffs mainly consist of a flat fee to be paid monthly and per-unit prices. LRTa shows that industry profits are independent of the access charge with homogeneous consumers when non-linear tariffs are employed.[2] Hence the collusive nature of the access charge vanishes.

Another viable business model mostly employed by cellular phone networks—and increasingly by the fixed line operators—is the use of on- and off-net price discrimination, which is considered in LRTb. If firms use two part-tariffs and access charges are not allowed to be below cost, they show that profits are maximized at and access charge is set at its marginal cost. Gans and King (2001), using the same model, show that if access prices could be set below the marginal cost of transport, firms would do so in order to maximise profits.[3] The intuition is that by pricing inter-network calls below intra-network calls, consumers are given incentives to belong to the smaller network. This, in turn, softens price competition and relieves the pressure to reduce the subscription fee.

Let us briefly summarize the results of the literature. With linear prices access charges play a collusive role. With two part tariffs and no destination based price discrimination, usage prices are set at the perceived marginal cost, and competition then takes place in setting the corresponding fixed fees. Particularly, in the Hotelling model of subscriptions, the profits of the firms turn out to be independent of the level of access charges. When firms are allowed to use different prices depending on where the call is terminated, the usage prices are once again set at perceived marginal costs, and firms use the subscription fees as the main instrument to compete with rivals. In this setting, firms prefer interconnection to be priced below cost inducing consumers to prefer smaller networks. This, in

[2] Dessein (2003) extends this conclusion to a model with heterogeneous consumers. However, as noted by Dessein (2003) this profit neutrality result holds under very specific conditions.

[3] Dessein finds a similar result when allowing for elastic subcription demand. He additionally states, that the socially optimal access charge will be above marginal cost.

turn, allows firms to inflate their subscription fees.

In this paper, we will use the model introduced in LRTb and analyzed further in Gans and King (2001). That is we consider competition between two facilities based networks which are horizontally differentiated á la Hotelling. Our point of digression is the pricing mechanism we analyze. Namely, firms will announce their on-net and off-net usage prices as well as an overall utility level.[4] Then, competition takes place and demands are resolved. At this point, by means of a predetermined formula which uses the announced utility levels, usage prices and market shares, a subscription price is computed and paid by the consumers to the firms.[5] This formula is nothing but the inverse of the net surplus function which simply selects a price to equate realized and offered indirect utilities. Thus, information on the demand and indirect utility function is necessary to implement such a formula.

We study a two period game. We assume that in the first stage access prices are either set by negotiation[6] or by a regulator. Given access charges, firms compete in the tariffs described above, that is they announce on-and-off net prices as well as an overall utility level. Then, consumers make their subscription decisions and the subscription payments are computed using the predetermined formula.

Given access prices, firms select usage prices at perceived marginal cost as in other models in the literature. The utility levels which are offered in equilibrium are independent of access prices. The equilibrium utility levels are simply the indirect utility of making calls at marginal cost prices when all calls are on-net minus the sum of the fixed cost of providing service and the standard Hotelling mark-up. The implied subscription fees, however, vary with the access charges.

These utilities differ significantly from the utilities that would be obtained if firms competed with standard two part tariffs. The underlying mechanism leading to this

[4]Competition in utilities when there are no network effects has recently been analyzed in Armstrong and Vickers (2002) and Rochet and Stole (2002).

[5]We discuss further the applicability and relevance of such a pricing mechanism below.

[6]We abstract from potentially complex bargaining problem that may take place in these negotiations and assume firms agree on joint profit maximizing level of access charges.

difference could be explained as follows. Fix a subscription price for firm 2. Then, by using the definition of net surplus, a utility level for firm 2 could be computed as a function of the utility level offered by firm 1 and the fixed subscription price of firm 2. As will be clear once we introduce the model, the market share of firm 1 is simply a function of the utilities offered by both firms. Therefore, given the utility rule implied by the subscription price commitment of firm 2, firm 1 could simply act as a monopolist on the residual subscription demand and select a utility level to maximize its profits. Notice that the utility rule of firm 2 responds to a change in the utility offered by firm 1. This implies that the residual subscription demand faced by firm 1 would have a different utility sensitivity than it would if firm 2 were to commit to a utility level.

Given this difference in equilibrium utility levels, the joint profit maximizing level of access prices are also naturally different. In our model, firms set access prices at its cost to maximize their joint profits. This is simply due to the fact that the marginal increase in access revenues due to a marginal increase in access charges is completely offset by the reduction in the equilibrium subscription fee.

We show that, a social planner who just controls the access charge will set it at cost if firms compete in utilities in the next stage. Thus, the outcome of the negotiated-access charge and retail competition game coincides with the socially optimal one. In equilibrium, consumers receive a higher surplus in our model compared to the surplus implied by LRTb and Gans and King(2001) at the negotiated access price.

The paper is organised as follows. In section 1, we introduce the model and briefly review LRTb and Gans and King (2001). We derive the subgame perfect equilibrium outcome in Section 2. A comparison of our results with others is presented in section 3. Section 4 will conclude and discuss the relevance of the approach.

1 The Model

We use the framework of LRTb thus allow destination based price discrimination and non-linear tariffs.

☐ **Cost structure:** There are two networks A and B, located on each end of a unit line. Both firms incur the same fixed cost f of providing service to a consumer. Marginal cost of providing a call consists of the cost of physically transporting data (c_0) and the cost of switching/routing the call (c_1). c_0 is incurred twice, since the call is transported from the caller to the switch and from thereon to the receiver, hence marginal cost of providing a call amount to $c = 2c_0 + c_1$.

☐ **Demand structure:** In order to be as general as possible, we will not assume a specific model of demand formation. However, we will restrict our attention to settings where market will be covered. Let α_i denote the market share of (demand for) network i, then $\alpha_j = 1 - \alpha_i$. Empirically this assumption seems to be reasonably in the case of telecommunication industries. Nearly every household already has a telephone, if not also a mobile set. This naturally implies that a decrease in the demand of network i will be exactly offset by an increase in the demand of network j.

We will leave the market share function as general as possible by only assuming that

$$\frac{\partial \alpha_i(w_i, w_j)}{\partial w_i} = \gamma(w_i, w_j)$$

is negative. This derivative measures the mark up a firm is able to achieve because it exhibits market power. We will illustrate this assumption after the discussion of the model by using two particular examples, namely Hotelling models and the logit demand.

Apart from the preferences for the specific networks, i.e. their distance to each operator, consumers are homogeneous with respect to calling patterns. This implies that there are no different types of users such as heavy or low users. In line with LRTb the net utility of making calls is given by $v(p) = \max_q u(q) - pq$, i.e. given a price for an outgoing call, the consumer will pick the length of his call q in order to maximize her utility[7].

Furthermore, we assume balanced calling patterns, that is, every customer is equally likely to be called by everyone. This in turn implies that the probability of a call terminating at either of the two networks is equal to its market share. Price discrimination between

[7]We are not assuming any income effects. Observe that, because of Shepard's Lemma, this implies $v'(p) = -q(p)$ (see for instance Armstrong and Vickers (2002)

on-net and off-net calls and the behavioral assumptions imply net surplus functions for being attached to firm A and B given by

$$w_A = \alpha v(p_A) + (1-\alpha)v(p_{AB}) - F_A \tag{1}$$

$$w_B = (1-\alpha)v(p_B) + \alpha v(p_{BA}) - F_B \tag{2}$$

where F_A (F_B) denotes the subscription fee to be paid by consumers to firm A (B). α denotes the market share of firm A and, markets will be covered leaving firm B with market share of $1-\alpha$.

□ **Access pricing:** Like most of the literature on two-way access pricing, we will assume linear per-unit prices a. These are paid by the originating network to the terminating network. [8] Another convenient assumption which is often suggested by regulatory bodies is the reciprocity of access charge. This assures that both networks pay the same price for transporting the same amount of traffic.

□ **Retail market competition:** We consider a particular retail price mechanism. As opposed to a regular two-part tariff, where firms charge a subscription fee and per-unit-prices, we require firm i to announce a utility level w_i which they want to deliver to consumers and per-unit prices. Once these are announced and market shares are realized, subscription fees are determined. The formula is given by the inverse of the net surplus function which is simply

$$F_i = \alpha_i v(p_i) + \alpha_j v(p_{ij}) - w_i. \tag{3}$$

Just as LRTb we allow firms to price discriminate between on-net (p_i) and off-net (p_{ij}) calls. The profit function of firm i is given by

$$\begin{aligned}\Pi_i = {} & (F_i - f)\alpha_i + \alpha_i^2(p_i - c)q(p_i) + \alpha_i\alpha_j(p_{ij} - c)q(p_{ij}) \\ & + \alpha_i\alpha_j mc\big(q(p_{ji}) - q(p_{ij})\big),\end{aligned} \tag{4}$$

where $m = \frac{a-c_0}{c}$ is defined as the access mark up relative to total marginal cost. The first term represents the profits due to subscription fees, second and third terms represent

[8] Observe that a could be negative. In that case the direction of the payment changes.

profits from on-net and off-net calls, respectively. The fourth term is the access deficit which is negative for the firm with the lower off-net price.

□ **The timing of the game:** The strategic interaction is modelled as a two stage game. In stage 1, firms negotiate an interconnection price. Given this access charge, firms compete in stage two by offering the preferred level of overall utility and per-unit retail prices. Then consumers make subscription decisions after which the subscription fees are determined using (3).

2 Analysis

We are now ready to solve the model and present the optimal choices for both the retail market stage and the negotiation of the interconnection charge. We will solve the game through the standard backwards induction procedure. Section 3.1 will present the solution for the second stage of the game, followed by the optimal access prices of stage 1 which are derived in section 3.2.

2.1 Competition in utility space

In this section we will analyze the equilibrium outcome of the market game, given access charge a. That is, firms maximize their profits with respect to overall utilities provided and the per unit prices. It will be instructive to rewrite (4) using (1) and (2), yielding

$$\begin{aligned} \Pi_i &= (\alpha_i v(p_i) + \alpha_j v(p_{ij}) - w_i - f)\alpha_i + \alpha_i^2 (p_i - c) q(p_i) \\ &\quad + \alpha_i \alpha_j (p_{ij} - c) q(p_{ij}) + \alpha_i \alpha_j mc\big(q(p_{ji}) - q(p_{ij})\big), \end{aligned} \tag{5}$$

Using the literature on two part tariffs, we can see that calls are priced at marginal cost. Assuming that a symmetric equilibrium is characterized by the first order condition of the profit function with respect to w_i we will be left with

$$\frac{d\Pi_i}{dw_i} = \frac{\partial\alpha_i(w_i,w_j)}{\partial w_i}(mc\alpha_i(w_i,w_j)q((1+m)c) + \alpha_i(w_i,w_j)v(c) + \alpha_j(w_i,w_j)v((1+m)c) - w1 - f)$$
$$+\alpha_i(w_i,w_j)(mc\frac{\partial\alpha_i(w_i,w_j)}{w_i}q((1+m)c) + \frac{\partial\alpha_i(w_i,w_j)}{\partial w_i}v(c) + \frac{\partial\alpha_j(w_i,w_j)}{\partial w_i}v((1+m)c) - 1) \quad (6)$$

This rather complicated expression reduces considerably once we impose the assumption of market coverage ($\frac{\partial\alpha_i(w_i,w_j)}{\partial w_i} = -\frac{\partial\alpha_j(w_i,w_j)}{\partial w_i}$) and symmetry ($\alpha_i(w_i,w_j) = \alpha_j(w_i,w_j) = \frac{1}{2}$) to the following term

$$\frac{d\Pi_i}{dw_i} = \frac{\partial\alpha_i(w_i,w_j)}{\partial w_i}(v(c) - w_i - f) - \frac{1}{2} \quad (7)$$

We can now state the following Proposition:

Proposition 1. *Suppose two networks A and B offer a tariff which consists of two prices for on-net and off-net traffic (p_i and p_{ij} respectively) and an overall utility level w_i. Additionally an ex post payment F_i from consumers to firm i is determined by (3). If an equilibrium is characterized by the first order conditions, this will be given by*

i. per-unit prices that are determined by

$$p_i^* = c,$$
$$p_{ij}^* = (1+m)c.$$

ii. an overall utility level given by $w^* = v(c) - f - \frac{1}{2\gamma(w^*,w^*)}$

iii. the corresponding subscription fee for consumers is given by

$$F_i^* = \frac{1}{2}(v((1+m)c) - v(c)) + f + \frac{1}{2\gamma(w^*,w^*)}.$$

Proof: See appendix.

Part [i.] of Proposition 1 is the well known result which is common to most of the two-part tariff literature and it holds in our case as well. It simply states that usage prices are set equal to the perceived marginal cost of the operator. Part [ii.] states the equilibrium utility level that is announced by the firms. As can be seen, it is exactly equal to the gross surplus if all calls of the consumers were made on-net, net of the fixed cost incurred by the firm for connecting a single consumer and the mark-up that results from the sensitivity of market share with respect to net utility levels. The assumption that γ, the sensitivity of own market share with respect to the offered net utility level is independent of w_i in a symmetric equilibrium drives this result. It is easy to see in the appendix, that this allows us to solve for the symmetric equilibrium net utility. Part [iii.] of proposition 1 gives the subscription fee that is determined after the market shares are resolved. Its components are the fix cost of connection, the mark-up, and half of the loss (gain) of gross consumer surplus due to an access charge above (below) marginal cost.

There are two things to recognize in this proposition: first of all agreed upon access charges do not enter the announced utility levels. Losses or gains in consumer surpluses due to above or below marginal cost pricing are fully incorporated by the firms through the adjustment of the subscription fee after the game has been played. It only enters the firms' offers via the prices charged for off-net traffic. Secondly, the firm is offering utility as if all calls of the consumers were on-net. In that sense, the distribution of calls that one subscriber makes, hence the market share that a network has, does not effect the equilibrium choice of the firm. That means all asymmetries due to access charges and size differences are accounted for ex post via the subscription fee determined by the inverse net surplus formula.

In order to compare our fairly general result with the existing literature, we will now specify the market share function by using two popular models of demand, namely the Logit approach and the competition *à* la Hotelling. The latter is frequently used in models of two-way interconnection.

Starting with the Logit formulation[9]we have a market share function given by

$$\alpha_i = \frac{e^{w_i/\eta}}{e^{w_i/\eta} + e^{w_j/\eta}}$$

[9]The derivation of market shares and the corresponding derivatives can be found in Anderson, de Palma and Thiesse (1992)

where the derivative with respect to w_i is given by

$$\frac{d\alpha_i}{dw_i} = \frac{\alpha_i(1-\alpha_i)}{\eta} = \frac{1}{4\eta}. \tag{8}$$

The latter equality follows because of the symmetric equilibrium we are assuming. The latter term represents $\gamma(w^*, w^*)$ in Proposition 1.

Corollary 1. *If market shares result from a Logit model, then if η is sufficiently large, the equilibrium net utility level is given by*

$$w^* = v(c) - f - 2\eta \tag{9}$$

where per-unit prices remain as in Proposition 1. The ex post subscription fee is given by

$$F_i^* = \frac{1}{2}(v((1+m)c) - v(c)) + f + 2\eta.$$

We proof in the appendix, that this is indeed an equilibrium for η sufficiently small.

If we adopt the Hotelling formulation applied in LRTb and Gans and King (2001), the market share function is given by

$$\alpha_i(w_i, w_j) = \frac{1}{2} + \sigma(w_i - w_j)$$

and the derivative thereof reduces to

$$\frac{d\alpha_i}{dw_i} = \sigma \tag{10}$$

Hence we can state the following:

Corollary 2. *If market share result from a Hotelling model, then if either σ is sufficiently small or a is close to c_0, the equilibrium net utility level is given by*

$$w^* = v(c) - f - \frac{1}{2\sigma} \tag{11}$$

where per-unit prices remain as in Proposition 1. The ex post subscription fee is given by

$$F_i^* = \frac{1}{2}(v((1+m)c) - v(c)) + f + \frac{1}{2\sigma}.$$

Again, it is shown in the appendix that this is an equilibrium for the correct choice of parameters.

2.2 Determination of the access charge

In this subsection, we will analyze the first stage of the game, and derive the optimal access charge, i.e. joint profit maximizing level of access charge, given the retail market outcome. The interconnection price will be negotiated cooperatively. The previous literature suggested that the access charge would be such that it boosts the profits of both operators, i.e. it acts as a collusive device. We now show that this will not be the case if firms compete in overall utilities and prices. In order to do so, we will rewrite the profit function taking into account the symmetric equilibrium of the second stage given the access charge. This is given by

$$\Pi_i = \frac{1}{4}\left[\frac{1}{\frac{\partial \alpha_i(w_i,w_j)}{\partial w_i}} - (v(c) - v((1+m)c)) + mcq((1+m)c)\right]. \qquad (12)$$

Proposition 2. *Suppose that firms offer a tariff consisting of different off-net and on-net per-unit prices p_i^* and p_{ij}^* and an overall utility level w^*. Then, if market is covered and $\frac{\partial \alpha_i(w_i,w_j)}{\partial w_i}$ is independent of the access charge, the unique equilibrium access charge is chosen such that $a = c_0$, hence $m = 0$.*

Proof: See appendix

First notice that, in equilibrium firms offer marginal cost prices for both on-and off-net calls. By doing so, they fully "insure" the consumers against price distortions caused by an access charge above or below cost. Hence the firm internalizes positive as well as negative effects due to distorting the off-net prices. Examining (12) one can see the mechanism at work. Increasing m by an infinitesimal amount has three distinct effects on the profit function. First of all it decreases the utility consumers derive from off-net calls. Because we assume away income effects, this is exactly equal to the negative of the demand. This comes into the profit function because of the subscription fee paid ex-post. Secondly, there are two different effects on revenue generated from calls directly. There is a direct change in revenues due to the access price increase. This is nothing but the demand for calls. At the same time, there is an indirect effect on quantity demanded through the increase in price which would be negative for downward sloping demand. Now observe that the first two effects are exactly equal in absolute terms, but have different signs, hence they cancel out. The reason for this is that firms fully incorporate the effects of changing the access mark up whereas the overall utility supplied to the consumers is not affected by it. Thus, the only term we are left with is the change in profits due to the demand response to an increase in access charges. Marginal profits in this case can be set to zero by setting access price at cost of providing access. . There are no incentives to distort the off-net cost prices, by taking away consumers' net utility.

Observing corollary 1 and 2, it is easy to see, that the independence of $\frac{\partial \alpha_i(w_i,w_j)}{\partial w_i}$ with respect to access charge is clearly fulfilled in equilibrium. Furthermore in these cases the derivatives boils down to a constant in equilibrium. Nevertheless, the results suggest that the general mechanism at work holds for a large class of demand specifications.

This is a very appealing result, since it suggests an efficient market outcome in the sense that firms price at marginal cost. It is resulting from the fact that firms are the only market agents who exhibit gains and losses from varying the access charge. This is a crucial difference to the models introduced by LRTb and Gans and King (2001). In the next section we want to provide an intuition for that difference.

3 Discussion

In this section we compare our results from section 2 to those of LRTb and Gans and King (2001). It is therefore instructive to use the results obtained in corollary 2, since this is the same formulation used in the aforementioned papers. There are three major differences that we want to explore, namely differences in subscription fees/utility provided, access charges and the welfare analysis.

3.1 Differences in competition with utilities and flat fees

In comparing our results to the ones obtained by the previous literature we will again start from the end, by looking at the retail market. As stated in proposition 1, per-unit prices do not differ, it is the subscription fees/net utility levels which are different. LRTb obtain

$$F_F^* = f + \frac{1}{2\sigma} - \Big(v(c) - v((1+m)c)\Big) \tag{13}$$

$$w_F^* = \frac{3}{2}v(c) - \frac{1}{2}v((1+m)c) - f - \frac{1}{2\sigma} \tag{14}$$

where the subscript F denotes the solutions in the case of competition in subscription fees. Taking differences between the results from proposition 2 we obtain

$$F^* - F_F^* = \frac{1}{2}(v(c) - v((1+m)c) = -(w^* - w_F^*). \tag{15}$$

This will be zero, if $m = 0$,[10] i.e. both results coincide for $m = 0$. For $m < 0$ —the equilibrium access markup obtained in Gans and King (2001)—the net utility supplied to the consumers is higher in the case of utility based competition. The reverse result hold true for subscription fees. It is apparent from (14) that the net utility is not independent of the access charge. As we shall see, this has immediate implications on the welfare comparison of both mechanisms.

We now offer an explanation of the forces that lead to these differences. Independent of whether firms compete in prices or utilities, marginal prices are the same across both approaches. Thus, let us first fix the marginal prices p_i and p_{ij} at their equilibrium values. Recall that the profit of firm i is given by

$$\Pi_i = \alpha_i(F_i - f) + \alpha_i(\alpha_j)mcq((1+m)c) \tag{16}$$

where α_i denotes the market share of network i and

$$F_i = \alpha_i v(c) + \alpha_j v((1+m)c) - w_i.$$

Once firm j commits to a strategic variable, firm i essentially acts as a monopolist over the residual subscription demand. Therefore, it could either choose utilities or fix prices. Ultimately all choices of the monopolist will lead to the same outcome. Therefore, we will assume that in solving its best response problem firm i selects a utility level, i.e.

[10] We are assuming identical access markups in both cases for this comparison.

w_i. The first order condition of firm i with respect to w_i, after simplifications, can be written as

$$\Big(2\alpha_i v(c) + (1-2\alpha_i)\big(v((1+m)c) + cmq((1+m)c)\big) - w_i - f\Big)\frac{d\alpha_i}{dw_i} - \alpha_i = 0. \qquad (17)$$

Notice here that we have the total differential of α_i since depending on the strategic variable, w_j could be a function of w_i. In a symmetric solution, i.e. $\alpha_i = 1/2$, the differences across models is only due to the $\frac{d\alpha_i}{dw_i}$. Solving (17) for w_i at $\alpha_i = 1/2$ yields

$$w_i = v(c) - f - \frac{1}{2\frac{d\alpha_i}{dw_i}}. \qquad (18)$$

Thus, the difference between the equilibrium values between our model and that of LRTb or Gans and King (2001) is due to the last term which determines the equilibrium markup.

Now consider, the pricing mechanism used in LRTb and Gans and King (2001) where firms compete in fixed fees. If firm j commits to a fixed fee F_j, one could equivalently say that firm j commits to a utility rule $\bar{w}_j(F_j, w_i)$. Since, given F_j and the definition of α_i and α_j, w_j could be computed by solving

$$F_j = (\frac{1}{2} + \sigma(w_j - w_i))v(c) + (\frac{1}{2} - \sigma(w_j - w_i))v((1+m)c) - w_j,$$

yielding

$$\bar{w}_j(F_j, w_i) = \frac{1}{\Delta}\Big((\Delta - 1)w_i - F_j + \frac{1}{2}(v(c) + v((1+m)c))\Big). \qquad (19)$$

with $\Delta = 1 - \sigma(v(c) - v((1+m)c))$. Therefore,

$$\begin{aligned} \frac{d}{dw_i}\alpha_i(w_i, \bar{w}_j(F_j, w_i)) &= \sigma - \sigma\frac{\partial}{\partial w_i}\bar{w}_j(F_j, w_i) \\ &= \Big(1 - \frac{\Delta - 1}{\Delta}\Big)\sigma \\ &= \frac{\sigma}{1 - \sigma(v(c) - v((1+m)c))}. \qquad (20) \end{aligned}$$

Substituting (20) in (18) leads to the expression provided in (14). Now notice that (20) equals σ when $m = 0$, smaller than σ if $m < 0$ and larger otherwise. Thus, when firms compete with fixed fees, they are able to increase their markups by selecting $m < 0$ which decreases the utility sensitivity of the subscription demand. That is at the optimal access charge, characterized in Gans and King (2001), each firm faces a less elastic residual subscription demand.

As explained above, when firms commit to utility levels, the equilibrium values will not be dependent on the access charge. In case of fix price competition, however, the residual subscription demand faced by firm j will be dependent on the interconnection price. By decreasing the access charge, firms reduce the sensitivity of the subscription demand to utility levels. In doing so, they offer higher value for off-net calls, however this increase in value is more than off-set by a larger increase in the subscription fee. If consumers' net utility depends on the access charge, firms have an instrument for extracting surplus from the consumers. Overall welfare effect, at first glance, is ambiguous however, since below cost pricing of off-net calls leads to losses. However, consumption of on-and-off-net calls are unambiguously distorted. at the level of access charges characterized in Gans and King (2001).

3.2 Welfare Analysis

In this subsection we will analyze the welfare implications of either mode of competition and compare the results with the solution that would be obtained if a social planner had regulated the market in order to maximize total surplus. In our analysis the benevolent dictator simply picks an access charge in the first stage and competition takes place in the second stage. Therefore there are two different situations, one where there will be utility based competition and one with fixed fee competition in stage two. Hence, we can make use of the results obtained in the analysis before. consumer surplus is given by

$$CS = \alpha_i w_i + \alpha_j w_j - T$$

where T denotes the average disutility of not being subscribed to his preferred network with $T = t(\alpha^2 + (1-\alpha)^2)/2$. Total surplus to be maximized is then given by

$$W = CS + \Pi_i + \Pi_j \tag{21}$$

Let us first observe the case of utility based competition. Given the equilibrium of the retail market game, we have

$$
\begin{aligned}
W_{util} &= CS + \Pi_i + \Pi_j \\
&= w^* - \frac{1}{4\sigma} + \frac{1}{2\sigma}\big[1 - \sigma(v(c) - v((1+m)c))\big] + \frac{1}{2}mcq((1+m)c) \\
&= \frac{1}{2}\Big[v(c) + v(1+m)c) + mcq((1+m)c)\Big] - f - \frac{1}{4\sigma}. \qquad (22)
\end{aligned}
$$

Notice that we already already made use of the fact that the equilibrium is symmetric. w^* is given by Proposition 1. The task for the social planner will be to pick the access charge in order to maximize (22). Notice, however, that this is nothing but the firms problem if they choose the profit maximizing access charge, since neither w^* nor $\frac{1}{4\sigma}$ is a function of the access charge. We can therefore state the following Proposition

Proposition 3. *Suppose firms are offering tariffs consisting of an overall utility level and per-unit charges. Then the profit maximizing access charge chosen by the firms is also socially efficient.*

We will now turn to the case of LRTb and Gans and King (2001), where firms compete in regular two-part tariffs. Taking into account (14), (13), (5) and the symmetry of the equilibrium, we can rewrite (3) as

$$
\begin{aligned}
W_{fix} &= CS + \Pi_i + \Pi_j \\
&= \frac{3}{2}v(c) - \frac{1}{2}v((1+m)c) - f - \frac{1}{2\sigma} - \frac{1}{4\sigma} + \\
&\quad \frac{1}{2\sigma} - \frac{1}{2}\left[2\Big((v(c) - v((1+m)c)\Big) - mcq((1+m)c)\right] \\
&= \frac{1}{2}\Big[v(c) + v(1+m)c) + mcq((1+m)c)\Big] - f - \frac{1}{4\sigma}. \qquad (23)
\end{aligned}
$$

Observe that (22) and (23) are equal for the same m. That in turn means that they will have the same optimum, namely at $m = 0$, hence for any value of m social welfare will be lower than at $m = 0$. However, as Gans and King (2001) show, firms will choose $m < 0$ in equilibrium where fix prices are selected. An unregulated industry where firms are competing in utilities is always at least as desirable as an industry where firms are offering per-unit prices and a subscription fee.

Consider again an infinitesimal change of m. In the case of utility based competition, we obtain the following reactions by the consumer side

$$\frac{\partial w^*}{\partial m} = \frac{1}{2}\frac{\partial v((1+m)c)}{\partial m} - \frac{\partial F^*}{\partial m}$$

with the term on the l.h.s. being zero. Hence

$$\frac{1}{2}\frac{\partial v((1+m)c)}{\partial m} = \frac{\partial F^*}{\partial m}.$$

We now look at the changes in profit due to the change in m. Here we have

$$\begin{aligned}\frac{\partial \Pi^*}{\partial m} &= \frac{\partial}{\partial m}\left(\frac{1}{2}(F^* - f) + \frac{1}{4}mcq((1+m)c)\right) \\ &= \frac{1}{2}\frac{\partial F^*}{\partial m} + \frac{1}{4}cq((1+m)c) + \frac{1}{4}mc\frac{\partial q((1+m)c)}{\partial m} \\ &= \frac{1}{4}\frac{\partial v((1+m)c)}{\partial m} + \frac{1}{4}cq((1+m)c) + \frac{1}{4}mc\frac{\partial q((1+m)c)}{\partial m}\end{aligned}$$

Note that the first two terms of the last equality cancel out because of Shepard's Lemma. We see that there is no distortion because the change in gross consumer surplus due to a change in access charge is fully absorbed by the change in the ex-post subscription fee. Now let us conduct the same analysis with the case of subscription fee based competition. First consider the change in net consumer surplus due to a change in m, it is given by

$$\frac{\partial w_F^*}{\partial m} = \frac{1}{2}\frac{\partial v((1+m)c)}{\partial m} - \frac{\partial F_F^*}{\partial m}.$$

By inspecting the equilibrium value w_F^* it is easy to see that this results in

$$\frac{\partial F_F^*}{\partial m} = \frac{1}{2}\frac{\partial v((1+m)c)}{\partial m} + \frac{1}{2}\frac{\partial v((1+m)c)}{\partial m}.$$

Hence the change in the profit due to a change in m is given by

$$\begin{aligned}\frac{\partial \Pi_F^*}{\partial m} &= \frac{1}{2}\frac{\partial F^*}{\partial m} + \frac{1}{4}cq((1+m)c) + \frac{1}{4}mc\frac{\partial q((1+m)c)}{\partial m} \\ &= \frac{1}{2}\frac{\partial v((1+m)c)}{\partial m} + \frac{1}{4}cq((1+m)c) + \frac{1}{4}mc\frac{\partial q((1+m)c)}{\partial m}.\end{aligned}$$

In this situation, the two terms result in a difference of $-\frac{1}{4}q((1+m)c)$. Hence at a level $m=0$ the reduction of revenue due to the reduction of demand for calls is more than offset by the increase of revenue that results from an increase in the subscription charge. The firm has therefore an incentive to distort the prices for off-net calls. This net differences is shifted over to the consumer. They gain from decreasing off-net prices, but the fixed fee increases by even more.

Summing up, we have seen that for both modes of competition, the welfare maximizing access charge is the same. However, in an unregulated environment the utility based mechanism is clearly superior since it implements the first best, which is not true in the case of ordinary two-part tariffs. The utility based mechanism is so powerful, because it forces the firms to include all the effects on welfare due to a change of the access charge, profit boosting as well as utility reducing effects. By offering an overall utility level which is independent of the gross surplus generated via off-net calls, it guarantees the consumer a certain level of utility. Therefore the firm bears all the risk that might arise because of size differences of the networks and adjusts only the subscription fee accordingly ex-post. If consumers were to pay an upfront flat payment, they would have to adjust their level of utility accordingly.

4 Conclusion

This paper proposes a mechanism, which vaporizes the collusive nature of the access charge in the presence of on and off-net price discrimination by using a special form of a nonlinear tariff. The two major findings of the paper are:

i. By committing to utilities instead of prices, the sensitivity of the residual subscription demand is altered as compared to the case of committing to subscription fees. This affects the equilibrium values of net utility/subscription fees. Hence, in the presence of network effects, price and utility competition are not equivalent.[11]

[11] This has been realized by Armstrong (2002) in the context of two-sided markets.

ii. The equilibrium net utility level offered to consumers is independent of the access charge when firms commit to utilities. Hence, the access charge chosen by profit maximizing firms and the socially optimal level coincide. This is not the case in models of network competition with price discrimination and two-part tariffs.

Even though these results are very intriguing, the mechanism which leads to that outcome is not used in practice. The paper suggests that the regulator should simply force networks to offer net utilities instead of subscription fees. If they do so, there will be an equilibrium which will immediately result in the socially optimal outcome. Therefore, the implementability of such a mechanism emerges as an important question. The first issue is the fact consumers are not familiar with such mechanisms. The proposed mechanism should simplify the subscription choice problem, as consumers can look at the offered utilities and consider their tastes and select the network offering highest utility. However, the fact that the subscription price they will have to pay is not known ex ante may complicate the thought process. Notice that the knowledge of the subscription fee plays a role only if consumers have budget constraints which we have assumed away in this paper similar to other models in the literature. Therefore, even though in practice this may be an important problem, we cannot resolve this issue in the present context. However, consumers who are able to form rational expectations should be able to anticipate the equilibrium level of subscription fees.

The second issue is related to the construction of the subscription fee formula. In order to impose such a rule on the firms, the regulator needs to know indirect utility functions. Once these functions are known, the subscription price depends on the observables such as prices, utility levels and market shares. We claim that the proposed mechanism might enjoy an advantage from an empirical point of view. If the regulator were to implement the socially optimal access charge in the case of LRTb, information on the costs of the firm is required. If that was available, he could simply impose an access charge at marginal cost. In this case both competition in utilities and fixed fees yield the same outcome. However, obtaining cost information from the firms involves moral hazard problems as well as rather strong assumptions in order to allocate costs across services. On the other hand, demand information could be obtained from the observed consumption behavior of a sample of consumers. There are various marketing research firms who already compiled data sets, such as Bill Harvesting® in the U.S., where this kind of information is available. Given the appropriate data, econometric methodology to infer indirect utility functions is well developed and easy to apply.

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Appendix

Proof of proposition 1:

Differentiating (5) with respect to p_i and p_{ij} and taking into account that $v'(p) = -q(p)$ yields first order conditions given by

$$\begin{aligned} \alpha_i^2(p_i - c)q'(p_i) &= 0, \\ \alpha_i\alpha_j(p_{ij} - (1+m)c)q'(p_{ij}) &= 0, \end{aligned}$$

implying the per unit retail price given in part [i.].

Differentiating (5) with respect to w_i, and substituting the retail prices from part [i.], and imposing symmetry, the first order condition of firm i determining w_i can be written as

$$\gamma(w_i, w_j)v(c) - \gamma(w_i, w_j)w_i - \gamma(w_i, w_j)f - \frac{1}{2} = 0.$$

Solving this equation for w_i yields the expression given in part [ii.].

In order to compute the subscription fee, one has to plug in w^* into (3). solving for F_i leads to [iii.] in proposition 1. ■

Proof of Corollary 1:

The net utility level in (9) follows immediately by plugging in (8) Proposition 1. The second order condition is given by

$$\frac{1}{8}\left(\frac{-\frac{mcq((1+m)c)}{\eta} + \frac{v(c)}{\eta} - \frac{v(a+c-c0)}{\eta} - 4}{\eta}\right)$$

This second order condition is indeed negative, if η goes to zero. ■

Proof Corollary 2:

The net utility level in (11) follows immediately by plugging in (10) Proposition 1. The second order condition is given by

$$2\sigma)(-mcq((1+m)c) + \sigma\left(v(c) - v((1+m)c)\right) - 1)$$

which proofs the corollary. ■

Proof of proposition 2:

In order to proof that $m = 0$ is indeed optimal, we have to differentiate (12) with respect to m. Again, taking into account that $v'(p) = -q(p)$ gives the following first order condition

$$\frac{1}{4} mc \frac{\partial q((1+m)c)}{\partial m} = 0$$

observing that $\partial q((1+m)c)/\partial m < 0$ and $c > 0$ we have $m = 0$ as the unique solution, which is stated in proposition 2.

Furthermore observe that the second derivative of (12) is given by

$$\frac{1}{4} c \frac{\partial q((1+m)c)}{\partial m} + \frac{1}{4} mc \frac{\partial^2 q((1+m)c)}{\partial m^2}.$$

This is always smaller then zero if

$$mc \lesseqgtr - \frac{\partial q((1+m)c)/\partial m}{\partial^2 q((1+m)c)/\partial m^2}$$

depending on whether $\partial^2 q((1+m)c)/\partial m^2 \gtreqless 0$. For $m = 0$ this is always true. ■