Regulation of Termination Charges for Non-Dominant Networks

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Executive Summary

This paper presents new research into the regulation of termination services to non-dominant networks. We study an environment where one or more dominant networks (i.e., those with the greatest market shares) have regulated termination charges. We then consider the merits of regulating other networks. Specifically, we find that:

- If a single dominant network's termination charges are regulated, then this will tend to lower the average price of calls. It is likely to also lead to other networks raising their termination charges.
- Unregulated termination charges will be set above the marginal cost of providing those services regardless of the regulated termination charge on the dominant network.
- If networks sell differentiated products, both termination charges and call prices will tend to rise if there are more relatively small networks.
- If networks' customer bases are distinct, then regulating all networks termination charges is unambiguously welfare improving.
- Optimal termination prices would be set below the marginal cost of termination. In fact, a 'bill and keep' system will satisfy this and be easiest to operationalise.
- Regulating non-dominant networks termination charges will lower call prices by increase competition between them. The optimal regulated charge lies below marginal termination cost.
- When a non-dominant network has a sizeable market share, regulation of their termination charge to the dominant network may reduce call prices overall. However, if a non-dominant network has a very low market share relative to the dominant network, regulating their termination charge to the dominant network may increase call prices.

These findings suggest that termination services of non-dominant networks should be regulated on similar terms to those of dominant networks; particularly as the latter become more established. This will result in more competitive call pricing.

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1 Background[1]

This is an economic investigation of the determinants of inter-network pricing in the context of competition between alternative public switched telephone networks. In particular, as part of general principles of interconnection or any-to-any connectivity, telecommunications carriers offer terminating services for calls originating off their own networks. These services ensure that callers from other networks can reach those on a given telecommunication network and hence, are an essential ingredient in ensuring that telecommunications networks remain compatible. Given the convention that the caller pay the originating network directly, the terminating service involves the originating carrier paying the terminating carrier for that service. It is the determination of such inter-network (termination) charges that is the focus of this paper.

A terminating service is essentially the carriage of a call from a point of interconnection between two networks to the consumer for whom the call is intended. Thus, the terminating network bears the trunk and connection costs from that point of interconnect to the consumer while the originating network bears the costs from the caller to the point of interconnect. Under the caller-pays principle of charging, however, the caller is charged for both the originating and terminating services. The originating network collects the call charge and that network and the terminating network must, in turn, transact for the terminating service. It is the price that the terminating network charges the originating one that is the focus of the present analysis. Not surprisingly, as that price becomes part of the marginal cost of the call service, it also an important factor in the overall price of the call.

[1] We thank the Australian Competition and Consumer Commission (ACCC) for providing funds for this project. The views expressed are solely those of the authors and do not reflect those of the ACCC.

In this report, we focus on termination charges that arise for calls made from one fixed line network to another fixed line network. Each fixed line network will have an associated termination charge for calls and the originating network pays this charge. The originating network then recovers this charge together with its own costs by charging the calling party who is a subscriber to their network. The setting of these terminating charges raises a number of regulatory concerns. First, if one party wishes to call another specific person who is connected to a different fixed network, then the terminating network has an effective monopoly on incoming calls for that particular customer. The network that has attracted a customer, as a subscriber for outgoing calls, effectively 'owns' the termination revenues associated with that customer. The ability to exercise market power over termination charges might give rise to socially inefficient outcomes that are not in the long-term interest of network customers. Secondly, a dominant fixed line network owner might be able to use termination charges to limit the growth of competitors. Consumers value their ability to ring any customer connected to a fixed line network. By setting a high termination charges a dominant network might be able to undermine the ability of its competitors to attract customers. At the same time, asymmetric regulation that is limited to a dominant carrier might not lead to socially optimal outcomes.

Our analysis focuses on these regulatory concerns. In particular, we examine two broad questions:

- What pricing outcomes for terminating services arise when telecommunications prices are not regulated?
- Where these outcomes differ from a socially optimal outcome, what is the effect of alternative regulatory rules on prices and competition?

In addressing the former question, it is important to note the interaction between termination revenues and charges for network subscribers. To the degree that gaining subscribers raises the profits that a network can make from terminating calls to those subscribers, high termination charges can be associated with low origination charges. When considering the latter question, we note the differences that arise when only a dominant network is regulated rather than regulation that effects all networks.

The paper is organised as follows. In Section 2, we describe in more detail the economic forces that underlie the setting of termination charges and the reasons why regulation may be required. Section 3 then states and explains intuitively our modelling results concerning unregulated outcomes and the impact of alternative regulatory rules. Sections 4 and 5 provide a detailed technical analysis that underlay the results explained in section 3. Section 6 concludes; identifying key directions for future research.

2 Economic Characteristics of Termination

Before beginning the formal technical analysis, it is useful to summarise the economic factors that determine how fixed network owners will set termination charges. There are five key characteristics of terminating services that drive their value and use. These are: (1) market power over access to a consumer; (2) consumer ignorance regarding the network called; (3) horizontal separation; (4) vertical separation; and (5) tariff-mediated network externalities. We briefly summarise these below.[2]

Telecommunications involves a two-way network, where the party that makes and pays for the call is not the same as the party that chooses which company will terminate the call. Consequently, if one customer wants to contact another specific customer then they have no alternative but to buy terminating services from the network who has the B-party as a subscriber. This means that all fixed line networks have some degree of market power when setting termination charges.

This market power over call termination will be exacerbated if the A-party cannot easily identify which network is terminating their call. In such a situation, the A-party's decisions over whether or not to make the call, and over the length of the call, will be based on an average call price relating to all networks. This customer ignorance means that networks have an increased ability to raise termination prices without facing an adverse customer reaction.

Customer ignorance means creates a horizontal externality between the potential terminating networks. One network can raise its termination price and this only affects the average call price form the consumer's perspective. All terminating networks share any reduction in call numbers or length. This provides each network with an incentive to inflate its termination charges as it

[2] A more detailed discussion is found in our companion paper, Gans and King (1999).

shares any customer response with its competitors. We refer to this as the problem of *horizontal separation*.

An end-to-end PSTN service is constructed by using inputs from one network (termination) that is purchased by another network (the originating network) and sold to the consumer. This *vertical separation* can lead to well-known problems of double marginalisation where call prices can exceed the integrated monopoly price.

Finally, differential termination charges can create *network externalities* between PSTN customers. If it is less expensive to make intra-network calls rather than inter-network calls, and all consumers potentially make calls to any other consumers, then it is cheaper for all consumers if they all belong to a single network. A carrier might be able to artificially create these externalities, particularly if it is dominant. For example, suppose one carrier initially has almost all customers. Entry by competing carriers will be unlikely if the dominant carrier sets very high termination charges for these new entrants. No customer will join the entrant if this means that they face a higher expected price when they ring other customers.

Termination charges are an issue for all carriers, not just for a dominant carrier. Termination to a particular customer is a 'bottle-neck' to reach that customer. Because the customer receiving the call does not pay for incoming calls, termination charges will not be fully constrained by competition, even for small PSTN networks. This is reflected in the issue of customer ignorance and horizontal separation. In this sense, call termination differs from a standard access problem. Instead of having a single 'essential' facility that requires regulated access, termination creates competitive problems even with relatively small networks or where networks are of comparable size. In fact, some problems created by termination are exacerbated when there are more competing networks. As a result, it will often be expected that regulation of termination charges would apply to all carriers, not just to say a single dominant carrier.

The anti-competitive effects that characterise termination charges are built into the models presented in this paper. In section 4 we begin with a model of exogenous network shares that captures customer ignorance and both vertical and horizontal separation. We then extend this model to allow for endogenous market shares. This allows us to focus on the interaction between termination charges and originating charges.

3 Key Results

In this section we summarise our key results and the intuition behind them. The technical details are left to the next two sections. We begin first by considering the outcome that results when a dominant network is regulated and non-dominant ones are left unregulated. A network is considered to be dominant when it has a larger pre-regulation market share.

3.1 Unregulated Non-Dominant Networks

Suppose that the termination charge of one network, with the largest market share, is regulated while other termination charges remain unregulated. In this case, all other things being equal, the regulated network faces higher costs than the unregulated one. This is because the termination charge it pays to other networks is higher than the charge they pay to the regulated network and to each other. If because of consumer ignorance, networks charge the same price for on and off network calls, then the regulated network will face high relative costs than unregulated networks. Hence, it will find it more difficult to compete aggressively on price. The end result of this is to releve competitive pressure on other networks. Consequently, the lower regulated charge will not be fully passed on to consumers.

In addition, the unregulated networks are likely to raise termination charges to the regulated network and exacerbate this effect. This is our first result:

Result 1: *If a single dominant network's termination charges are regulated, then this will tend to lower the average price of calls. It is likely to also lead to other networks raising their termination charges.*

This follows from a number of effects. First, with fixed market shares, lowering one network's termination charges will flow through into the prices charged by other networks. The double marginalisation effect is reduced and average prices fall. But at the same time, non-dominant networks have an incentive to partially undermine this flow through and seize some of the benefits for themselves by raising their termination charges. Second, the reduction in termination charges will tend to alter the way each network, including the dominant carrier, sets its prices and attracts subscribers. With uniform prices, reducing a dominant firm's termination prices tends to lower non-dominant firms' prices, as noted above, and this leads to a competitive response from the dominant carrier. But this is partially offset by the reduction in the dominant network's termination revenues. Carriers use these revenues to compete more vigorously for subscribers, and reducing these for one carrier reduces that network's competitive position. As we show below, if the regulated carrier is dominant, the overall effect is lower call prices.

Related to this is our second result:

Result 2: *Unregulated termination charges will be set above the marginal cost of providing those services regardless of the regulated termination charge on the dominant network.*

This result reflects the market power that each network has over call termination to its subscribers. The pricing of termination charges above marginal cost will lead to prices for calls that strictly exceed the monopoly price. This follows directly from the effects of vertical and horizontal separation.

Greater network competition may encourage greater retail price competition. However, it will also exacerbate incentives to raise termination charges.

Result 3*: If networks sell differentiated products, both termination charges and call prices will tend to rise if there are more relatively small networks.*

This follows from the effect of consumer ignorance and horizontal separation. A small network has a relatively small effect on the average price of calls and so has a greater incentive to raise termination charges relative to a larger network. Overall, a system with many small networks will have higher average termination charges than a system with fewer large networks.

3.2 Regulatory Options

There are several possible regulatory options. We discuss many of these in our companion paper (Gans and King, 1999); including enhancing network identification in order to alleviate the problems caused by horizontal separation, and mandated negotiations to alleviate vertical problems. Here we confine our non-technical discussion to issues of regulated pricing outcomes.

The first key issue is whether non-dominant networks' termination charges should be regulated at all. When those networks offer products that are highly differentiated or operate in different markets, then the need for regulation is clear.

Result 4: *If networks' customer bases are distinct, then regulating all networks termination charges is unambiguously welfare improving.*

The regulation in this situation simply eliminates the anti-competitive effects of horizontal and vertical separation. That is, unregulated termination charges were set above marginal cost. This leads to call prices above their monopoly levels, reducing both consumer and producer surplus. When a single dominant network was regulated, this problem was alleviated to some degree but did not necessarily mean lower call prices passed through to consumers. Instead, it had the main effect of helping competitors rather than helping competition. However, when each networks' charge is reduced, this has a positive external effect on other producers and, by lowering their costs, allows a flow through to consumers in terms of lower call prices.

This brings us to a second question: at what level should regulated termination charges be set?

Result 5: *Optimal termination prices would be set below the marginal cost of termination. In fact, a 'bill and keep' system will satisfy this and be easiest to operationalise.*

If regulated termination charges are set at marginal termination cost, with highly differentiated products, call prices will be at their monopoly level. The social goal should be to reduce them to competitive levels; consistent say with average cost pricing.[3] A simple way of achieving this would be to institute a 'bill and keep' system of termination pricing. In this system, termination charges are, in fact, set at zero. It is well known that asymmetries in network market shares would not mean that this caused an undue burden to small or larger networks. Instead, it is likely that flows to and from networks will be roughly symmetric regardless of size.[4] This is because, from a large network's perspective, it has more customers who could make calls off net but there are fewer consumers who could receive them. As such, the savings they would realise by not having to pay another network for termination would offset any losses networks would incur.

If networks sell products that are closer substitutes then the case for regulating non-dominant networks' termination charges is more difficult. We have to distinguish between the termination charges non-dominant networks set for each other and the charge they would set for termination of calls from the dominant (regulated) network. Certainly, between two non-dominant networks, a regulated termination charge can increase competition and lead to lower prices.

Result 6: *Regulating non-dominant networks termination charges will lower call prices by increase competition between them. The optimal regulated charge lies below marginal termination cost.*

The reason call prices are reduced is that in the absence of regulation, termination charges are set too high – once again due to the problems of horizontal and vertical separation – and competition between networks only partly alleviates the consequent double marginalisation effect. Regulating non-dominant networks in this way will reduce their profits but only to the extent

[3] This is sometimes referred to as TSLRIC in telecommunications regulation. However, note here that this is the goal for call prices. The prices for the termination service itself should lie below marginal (and hence, average) cost to achieve this. In this respect, the benchmarks of TSLRIC are far too relaxed a standard for termination or interconnect charges. Only when regulated prices and call prices are a two-part tariff could this perhaps be used (see Gans and Williams, 1999b).

[4] See Williams (1995).

that they were earning monopoly rents. It will, therefore, have the effect of securing lower call prices without the additional costs of over-investment in duplicate networks.

Turning now to the termination charges that non-dominant networks set for the regulated carrier, the effect of regulation is ambiguous. On the one hand, regulation will lower the overall costs of the dominant network and enable it to profitably lower call prices. However, regulation will reduce the non-dominant network's benefits from attracting customers away from the dominant network. Without regulation, if a customer switched to its network, it would receive the termination revenues from calls made to that customer. However, with regulation, those revenues are reduced and hence, so are the potential benefits from attracting marginal customers. This will tend to put upward pressure on call prices. What we can say is this:

Result 7: *When a non-dominant network has a sizeable market share, regulation of their termination charge to the dominant network may reduce call prices overall. However, if a non-dominant network has a very low market share relative to the dominant network, regulating their termination charge to the dominant network may increase call prices.*

When the non-dominant network has a sizeable market share, regulating its termination charge will put upward pressure on its call price but it will put downward pressure on the dominant network's call prices. This may lower prices on average. In contrast, when the non-dominant network is relatively small, the dominant network may actually raise its call price in response to the higher price by the non-dominant network.

While it is socially desirable to regulate termination charges below marginal termination cost, precisely how far below is an open issue. As mentioned above, there are reasons to favour a 'bill and keep' rule for its simplicity and neutrality. Otherwise, what can definitely be said is that the upper bound for termination charges should be marginal termination cost. This, however, invites the question as to how to measure such costs. In our companion paper, we postulate using existing call prices to do this. While appropriate for established networks, this is difficult for newer entrants.

Nonetheless, as those entrants are often likely to have invested in newer technologies, their marginal termination costs will consequently be lower. In this situation, utilising the marginal termination cost of the dominant regulated network would probably be appropriate; also, enhancing incentives for newer entrants to invest in more cost efficient technologies.

4 Unregulated Outcomes

In this section and the next we provide a detailed, technical analysis of the results and conclusions discussed above. We begin by considering the outcome when only the dominant network is regulated. By dominant, we mean the network with the largest historic market share. In Section 5, we then turn to consider the implications of regulation of non-dominant networks and derive socially optimal regulatory prices.

4.1 Model Set-Up and Assumptions

Suppose there are n telecommunications networks with each owned by a separate firm, and each interconnected to one another. Let s_i be the market share of network i. We will assume that each network employs a similar technology and hence, has equivalent termination costs. Let c_T be the marginal cost of terminating a call on each network. Finally, let the remaining originating and trunk costs from network i be c_i.

Let P_{ij} be the price of a call charged by network i for a call from i to network j. There is a question regarding whether a network can price discriminate between calls that terminate on alternative networks – including its own. In particular, consumers may not be able to distinguish between alternative networks. This means that even though a network may set different inter-network call prices, these prices would only influence consumers' decisions to the extent that they influence the average price of inter-network calls. This average price determines demand and is given by $P_i = \sum_i s_i P_{ij}$.

This type of consumer ignorance is likely to be more salient where there is number portability between networks. Even where calls are made between different telecommunications modes – e.g., fixed to mobile and vice versa – consumers may not be able to distinguish between what network in that sub-class they are calling. We will, therefore, retain the assumption of consumer ignorance throughout this analysis.

A consumer's demand for calls is given by $q(P_i)$ where i is the network that consumer subscribes to. We can write demand this way because the consumer either explicitly or effectively faces a single (average) price for all calls from their network. We will assume that this demand is linear with $q(P_i) = 2 - P_i$ (which can be derived from a utility, u_i, and indirect utility function, v, satisfying $u_i = v(P_i) = \frac{1}{2}(2 - P_i)^2$). The linear demand assumption allows us to explicitly calculate prices and charges and to compare these charges over different regimes. We assume that $2 > c_i + c_T$ for all i.

Each network sets its own call price, P_i. In so doing it will take into account the origination and trunk costs from its network, c_i, and also the costs of termination it faces. For calls to its own network, the marginal termination cost is c_T. For inter-network calls, however, this will be the marginal termination charge set by a rival network j, T_{ji} per call (or call minute).

A useful benchmark price for our analysis is the uniform monopoly price for calls. This is the profit maximising price that would be set by a single firm that owned all networks. We denote this price by P^m, where this price is implicitly defined for a general demand function by $q'(P^m)\left(P - c_i - c_T\right) + q(P^m) = 0$. For the case of a linear demand, $P^m = \frac{1}{2}(2 + c_i + c_T)$ and the associated monopoly quantity is $q^m = \frac{1}{2}(2 - c_i - c_T)$. Monopoly profits from the sale of fixed-to-mobile call services in this situation is denoted by $\Pi^m = \frac{1}{4}(a - c_i - c_T)^2$

4.2 Exogenous Market Shares

We begin our analysis utilising a simple assumption that the market shares of respective networks are fixed or exogenous. This allows us to consider the issues of termination free of any effects on competition for subscribers to each network. However, this may also be a more realistic assumption where alternative networks' products are not close substitutes (e.g., one may a fixed and the other a mobile network). Below we will consider the effect of network competition in more detail.

Suppose that the n networks independently and simultaneously set their linear termination charges, T_{ij}. Each network then sets its call price P_i. Given this (average) price, customers decide how many calls they will make, taking into account their own ignorance of the identity of the terminating network for any specific call. With each decision, the relevant firm seeks to maximise its profits and all networks take the market shares of each other as given. Given the termination charges, the network i will set P_i to solve:

$$\max_{P_i}\left(P_i - c_i - s_i c_T - \sum_{j\neq i} s_j T_{ji}\right) q(P_i)\,.$$

The solution to this problem is given by $P_i = \frac{1}{2}\left(2 + c_i + s_i c_T + \sum_{j\neq i} s_j T_{ji}\right)$ with associated quantity $q(P_i) = \frac{1}{2}(2 - c_i - s_i c_T - \sum_{j\neq i} s_j T_{ji})$. Taking this into account, each network will simultaneously set its termination charges to solve:

$$\max_{\{T_{ij}\}_{j\neq i}} s_i \sum_{j\neq i} s_j (T_{ij} - c_T) q(P_j)\,.$$

The first order conditions for each network's optimisation problem is given by:

$$(T_{ij}) : 2 - \sum_{m\neq i,j} s_m T_{mj} - 2 s_i T_{ij} - c_j + (s_i - s_j) c_T = 0$$

Solving these first order conditions simultaneously for all termination charges to all networks gives the Nash equilibrium termination charges.

There are two cases worth more detailed consideration. First, suppose that there are only two networks. Solving the first order conditions for these two networks gives the termination charges as $T_{ij} = \frac{1}{2s_i}\left(2 - c_j + (s_i - s_j) c_T\right)$ for each network i. i's call price is given by $P_i = \frac{1}{4}(6 + c_i + c_T)$ with associated quantity $q = \frac{1}{4}(2 - c_i - c_T)$. Note that in this situation call prices are higher than if there were a single network. This is due to the effect of horizontal separation. Each network has an incentive to unilaterally raise its termination charge relative to the monopoly case as it gains the full price benefit of such a rise but shares any related loss in sales. This effect tends to be larger for small networks. Note that, as the market share of any network decreases, its (equilibrium) termination charge increases. In particular,

$$\frac{\partial T_{ij}}{\partial s_i} = -\frac{1}{2s_i^2}(2 - c_j - c_T) < 0 .$$

At the same time, the share of the other network must increase and its termination charge will fall. In the linear demand case considered here, the changes in termination charges that result from changes in market shares exactly offset each other. In other words, for the case of two networks, call prices are independent of the shares of the individual networks even though the specific termination charges do depend on these shares.

The second case of interest allows for competition between an arbitrary number of symmetric networks with identical originating and trunk costs, c. From the first order conditions, with n mobile carriers each of whom has a market share of $1/n$, each carrier will independently set its termination charge in equilibrium at $T_i = 2 - c$. The equilibrium call price is $P_i = \frac{1}{2n}\left(2(2n-1) + c_T + c\right)$. We can see that this price increases as the number of networks increases. Differentiating the call price with respect to n gives:

$$\frac{dP_i}{dn} = -\frac{c_T + c - 2}{2n^2} > 0 .$$

This reflects that, in terms of call prices, there is not really any competition between networks. Because the person making the call is ignorant of the specific carrier they are calling, networks have no incentive to compete by offering a lower termination price. But as the number of networks increases, the effect of horizontal separation rises and this pushes up the termination charges and call prices.

4.3 Regulation of the Dominant Network

The previous section set out the basics forces at work in charging for termination services. Here we consider the outcome when a single network's termination charge is regulated while others' remain free to choose their charges.

Let $s_D > s_i$ for all firms $i \neq D$ so that firm D is the 'dominant' network. The regulator directly sets its termination charge for inter-network calls at t. All other networks then simultaneously set their termination charges. Given these termination charges, all networks set their call prices.

Using the first order conditions presented in the previous section, replacing T_{Di} with t, we see that network i will set its termination charge so that:

$$(T_{ij}): 2 - \sum_{m \neq i, j, D} s_m T_{mj} - s_D t - 2 s_i T_{ij} - c_j + (s_i - s_j) c_T = 0$$

$$(T_{iD}): 2 - \sum_{m \neq i, D} s_m T_{mj} - 2 s_i T_{iD} - c_D + (s_i - s_D) c_T = 0 .$$

To simplify, assume that all non-dominant (and non-regulated) mobile networks are symmetric with market shares $s_i = \frac{1}{n-1}(1 - s_D)$ and costs $c_i = c$. From the first order condition for profit maximisation for each non-regulated mobile carrier,

$$T_{ij} = \frac{1}{(1 - s_D)}\left(2 - c - s_D t\right) \text{ and } T_{iD} = \frac{(2 - c_D)(n-1) + (1 - n s_D) c_T}{n(1 - s_D)} .$$

Notice that each unregulated network charges different termination charges to each other and to the regulated network. This is because the regulated network does not have the benefit of a regulated termination charge when setting its call price. Indeed, $T_{ij} < T_{iD}$ whenever $t < T_{ij}$.[5] This means that D faces strictly higher termination charges than do the unregulated firms.

Solving for the call prices:

$$P_i = \tfrac{1}{2(n-1)}\left(2\left(2n-3\right)+c+(1-s_D)c_T+s_D t\right)$$

$$P_D = \tfrac{1}{2n}\left(2(2n-1)+c_D+c_T\right).$$

Note that $P_D > P^m$ even if $t = c_T$ so long as $n \geq 2$. In other words, even if the regulator requires the dominant carrier to set its termination price at marginal cost, the resultant call price will always exceed the monopoly price whenever there is at least one other network.

It is worth considering the case of two firms in more detail. In this situation, the dominant firm D is regulated but the other network remains unregulated. Solving for the termination charge of the unregulated firm we find that $T_{iD} = \tfrac{1}{1-s_D}\left(2-c_D+(1-2s_D)c_T\right)$. Note that this termination is twice the termination charge when both networks are unregulated. The dominant network will then set the price of calls so that $P_D = \tfrac{1}{4}\left(6+c_D+c_T\right)$ while $P_i = \tfrac{1}{2}\left(2+c+(1-s_D)c_T+s_D t\right)$. Notice that the dominant firm's price still equals the double marginalisation price while the unregulated network sets its price above the monopoly price whenever $t - c_T^M$ is positive. So regulation assists in lowering the call prices of the unregulated network, however, they still remain inefficiently high.

4.4 Network Competition

We now turn to consider the effect of network competition. Here the regulated network, D, competes for market share with a single unregulated

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[5] Assume that $c = c_D$. Note that $T_{ij} < T_{iD} \Rightarrow 2-c-c_T < ns_D(t-c_T)$ and that $T_{ij} > t \Rightarrow 2-c > t$. Combining the two proves the result.

network, U. Hence s_D is endogenous and depends on the nature of price competition. We will see that the inefficiencies noted in the previous section remain to some degree and the need for regulation of the non-regulated network is, in many respects, more compelling.

4.4.1 Technological Assumptions

We maintain our notation from the previous section but add some new definitions. In particular, f is the cost of connecting a consumer to a network.

4.4.2 Customer Preferences

We suppose that the two networks – D and U – sell a differentiated but substitutable product. We model this by assuming that each network is located at either end of a line of length 1 with D located at 0 and U located at 1. Consumers are located uniformly over the line. Given income y and outgoing calls q, a consumer located at x and joining network i has utility:

$$y + v_0 - t\left|x - x_i\right| + u(q_i)$$

where v_0 represents a consumer's intrinsic value of subscribing to a network and $t\left|x - x_i\right|$ denotes the cost of being to a network with 'address' x_i (i = A, B).[6] Recall that $u_i = v(P_i) = \frac{1}{2}(2 - P_i)^2$. We assume that v_0 is sufficiently high that both networks have full coverage over all consumers.

4.4.3 Pricing and the Determination of Market Shares

We are now in a position to consider the determinants of consumer choice between networks. We will first assume that networks offer consumers a simple per call price, P_i. The case of non-linear tariffs will be considered in a later sub-section.

The market share of network D, s, is determined by the point of indifference between D and U. That is,

6 This is essentially the model structure of Laffont, Rey and Tirole (1998a, 1998b).

$$v(P_D) - ts = v(P_U) - t(1-s)$$
$$\Rightarrow s = \tfrac{1}{2} + s\,(v(P_D) - v(P_U))$$

where $s = 1/(2t)$ is the degree of substitutability between the two networks. Finally, note that $\partial s/\partial P_D = -s\, q_D$ and $\partial s/\partial P_U = s\, q_U$.

4.4.4 Social Efficiency

A convenient social optimum is to assume, as do Laffont, Rey and Tirole (1998a), that consumer welfare is maximised subject to a break even constraint on the firms. Average consumer welfare is:

$$W(P_D, P_U) = s(P_D, P_U)v(P_D) + \left(1 - s(P_D, P_U)\right)v(P_U) - \Phi(s(P_D, P_U)) \qquad (1)$$

where $\Phi(s)$ denotes the disutility the average consumers suffers from not being able to subscribe to their closest network.[7] This disutility is minimised with s = ½. The break even constraint for the two networks is:

$$s(P_D, P_U)\left(P_D - c - c_T\right)q(P_D) + \left(1 - s(P_D, P_U)\right)\left(P_U - c - c_T\right)q(P_U) = f \qquad (2)$$

Maximising (1) subject to (2), gives a symmetric solution $P_D = P_U = P^R$ which is a Ramsey price that is the lowest price that satisfies the industry break even constraint. That is, P^R is defined by:

$$\left(P^R - c - c_T\right)q(P^R) = f$$

To make the analysis meaningful, we assume that f is low enough that $P^R < P^m$, as defined before.

4.4.5 Price Competition for Given Termination Charges

Suppose that D's termination charge is regulated at t and U's is currently, T. Then the profits of each network are:

$$p_D = s\left(\left(P_D - c - sc_T - (1-s)T\right)q(P_D) - f + (1-s)(t - c_T)q(P_U)\right) \qquad (3)$$

[7] That is, $\Phi(s) = \frac{t}{2}\left(s^2 + (1-s)^2\right)$.

$$\pi_U = (1-s)\left(\left(P_U - c - st - (1-s)c_T\right)q(P_U) - f + s(T - c_T)q(P_D)\right) \quad (4)$$

Note that each network earns profits from all calls made from its network as well as termination profits from inter-network calls made to its network. Each firm will choose its price to maximise its profits. Notice that increasing price has two effects. First, it increases infra-marginal revenue. Second, it causes a reduction in the network's market share and demand. The former is particularly costly as the firm will lose termination revenue as well as retail call revenue from its consumers. Hence, the existence of termination revenues makes networks tough price competitors than might otherwise be the case.

It is interesting to consider the effect of a change in termination charges on the degree of price competition. For this we have the following proposition.

Proposition 1. *Suppose that s > ½, then an increase in t will result in increases in both P_D and P_U. For s < ½, an increase in T will cause P_D and P_U to rise.*

PROOF: Observe that $\frac{\partial^2 \pi_D}{\partial P_D \partial P_U}, \frac{\partial^2 \pi_U}{\partial P_D \partial P_U} \geq 0$ and

$$\frac{\partial^2 \pi_D}{\partial P_D \partial t} = -s\, q(P_D)q(P_U)\left(1-2s\right) > (<) 0 \text{ for } s > (<) \tfrac{1}{2}$$

$$\frac{\partial^2 \pi_U}{\partial P_U \partial t} = -s(1-s)\, q'(P_U) - (1-2s)s\, q(P_U)^2$$

which is also positive for s > ½. This proves to comparative static result (Milgrom and Roberts, 1990). For T, the proof is symmetric.

Thus, if for some reason, one network is larger than the other, then an increase in that network's termination charge will soften price competition between the networks. In particular, if s > ½, then reducing t will reduce call prices. Of course, given our previous analysis, this reduction will be in part offset by an increase in the unregulated network's termination charge T.

4.4.6 Termination Charges

When the unregulated network sets its termination charge, it will continue to ignore the effect on the other firm's profits. Consequently, it will set its termination charge above marginal cost and, moreover, call prices would be higher than they would be if termination charges equalled c_T. In general, higher termination charges soften price competition; so networks may wish to agree to these as an instrument of price collusion (see Armstrong, 1998).

4.4.7 Competition in Two-Part Tariffs

If networks offer two part tariffs to consumers, each will have an incentive to set it's per call price, P_i, equal to its marginal cost. Because, in general, $T > t$, this means that $P_U < P_D$. It will also mean that $s < ½$, so we will implicitly assume D has some market share advantage (such as coverage or historical inertia).

Networks will compete for subscribers through fixed charges that are not based on actual usage. Each will consider the overall attractiveness of a customer in setting these charges. As networks earn termination revenues by attracting subscribers, the network that earns a higher termination charge will be a more aggressive price competitor. In this case, this advantage would rest with U in this case. It would, therefore, have an incentive to set $T > t$.

4.5 Originating charges

Origination charges are relevant for services such as 1-800 numbers, where the B-party pays for the call. In these circumstances, the originating network has an incentive to raise the amount that it charges the terminating network for originating the call. The originating network's subscribers do not directly care about this charge as the call is (mostly) paid for by the receiving party.

If we assume that the number of subscribers who wish to offer 1800 or similar B-party call services are relatively small compared to the total number of subscribers, then the fixed market share analysis provides an appropriate model of origination charges. Altering these charges will have little effect on competition for more general subscribers. The fixed share model shows that origination charges will be set at a high level, and that these charges will be socially inefficient. Further, relatively small networks will have a greater incentive to raise origination charges. Increasing the number of networks will tend to exacerbate rather than reduce this problem.

If just the dominant network has origination charges regulated, then this will tend to reduce the price of these B-party calls. However, the unregulated networks will still have an incentive to set high origination charges. In fact, they will tend to raise these charges when regulation forces the dominant carrier to lower its charges. Because of this, regulation of just the dominant carrier will have limited effect and it will generally be desirable to regulate all carriers. Further, so long as the share of B-party pays calls is relatively small, the caveats raised in the next section regarding the regulation of smaller networks are not relevant, so that regulating all networks will unambiguously lower prices.

The optimal regulated price for origination charges will depend on the degree of competition for the subscribers that wish to establish B-party pays numbers. At one extreme, suppose this competition was relatively low. This would be the situation if the subscribers that wanted to offer a B-party pays service were locked in to a specific PSTN network due to, say, the purchase of other services. In this case, both the originating and the terminating network have market power and the optimal originating charge will be below marginal cost. This low originating charge will help offset the market power of the terminating network.

Alternatively, suppose that competition to gain subscribers who wish to offer B-party pays calls is fierce. Then in this situation, the market power of the terminating network is reduced. If will offer the subscriber B-party pays services at cost. But the cost to the terminating network includes the (average) origination charge. So competition reduces the terminating networks market power but has no effect on the originating networks market power. The optimal regulation for all originating charges in this situation would be to set the price equal to the marginal cost of call origination.

4.6 Conclusion

The broad conclusion here is that, in general, in the absence of regulation, termination charges are set above marginal cost in a way that leads to call prices above their monopoly level. Regulation of a single network will reduce call prices but it also creates an incentive for unregulated networks to raise their termination charges to each other and the regulated network. However, the unregulated networks' termination charges to each other will be lower than their charges to the regulated network. Consequently, the regulated network will be at a competitive disadvantage relative to the unregulated ones; they face higher costs and lower termination revenues from their customers. This will reduce the market share of the regulated network and consumers more reliant on that network will be worse off.

5 Regulation of Non-Dominant Networks

We now are in a position to turn to the issue of the regulation of termination on non-dominant networks. We will deal with the exogenous market share case first before turning to the issue of network competition.

5.1 Highly Differentiated Products

Suppose networks sell highly differentiated products. Under consumer ignorance we saw that termination charges were set too high although regulation of the dominant carrier tended to reduce call prices. In this environment, regulating all carriers can reduce call prices further. Indeed, if termination charges equal marginal cost, the resulting call prices will reduce to their monopoly level.

In order to obtain more efficient call prices, closer to true marginal cost, termination charges would have to be reduced below marginal termination cost. Indeed, given the symmetry in calling patterns, a 'bill and keep' regime could be implemented without a disproportionate burden falling on networks of different sizes (Williams, 1995).[8]

5.2 Substitute Products

If networks' products are closer substitutes, so that they compete with one another, the effects of regulation of non-dominant networks are more complex. Take, for example, our previous situation with only two networks. If the dominant network (that with the highest market share) has its termination

[8] See also Carter and Wright (1999).

price regulated at t, what is the effect of regulating the termination charge of the non-dominant network?

Such regulation will have the effect of reducing *T*. For the non-dominant network, this will weaken its incentives to build market share as:

$$\frac{\partial^2 p_U}{\partial P_U \partial T} = p_U = s(1-2s)q(P_D)q(P_U) < 0.$$

Thus, all other things being equal, a reduction in *T* will put upward pressure on P_U. This, however, will be mitigated, if a reduction in *T* creates incentives for *D* to lower P_D. If this mitigating effect is strong, P_U may fall as a result of a reduction in *T*.

Turning then to *D*, the effect of a reduction in *T* is more complex. A reduction in *T* will strengthen *D*'s incentives to offer low prices if:

$$\frac{\partial^2 p_D}{\partial P_D \partial T} = -s(2-P_D)^2(2s-1) + s(1-s) > 0$$
$$\Rightarrow \frac{s(1-s)}{2s-1} > s(2-P_D)^2$$

which only holds for *s* close to ½. Basically, a lower *T*, reduces *D*'s costs; encouraging it to lower price. However, it also makes *D* less concerned about market share; weakening its incentive to use price to build this. The former effect dominates the latter only when *D*'s market share is relatively bw. If it is high, *D* faces much larger consequences from a high termination charge paid to *U*. A reduction in this charge will, therefore, cause it to soften its price competition. Therefore, when *D* is very dominant (high *s*), a reduction in *T* will unambiguously raise call prices.

Nonetheless, when there are other small networks, it may become important to regulate those non-dominant networks that have a substantial market share; at least in their termination charges to smaller networks. The results here are preliminary, however. A more complex analysis would also have to consider more carefully the sources of high market share and their welfare implications.

5.3 Network Identification

Network identification encompasses the range of policies that may relieve consumer ignorance. As noted earlier, this is difficult to do when there is number portability. Nonetheless, education campaigns and more information on customers' bills (including the network of regulator numbers called) could assist in this. Network identific ation only matters to the degree that the consumer faces different prices for intra-network and inter-network calls. Consider that market shares are given and suppose that there is no substitution in calling patterns; so that a consumer demands a call to a particular person who is connected to a specific network and no other call is a relevant substitute. The relevant quantity is then the length of the call. With network identification each terminating carrier and each originating carrier are like a pair of sequential monopolists. The inter-network call price would be set at the 'double marginalisation' price $\frac{1}{4}(6+c_i+c_T)$. In contrast, the price of an intra-network call would be the monopoly price. Network identification will have reduced the price of inter-network calls whenever there are more than two networks, by eliminating the horizontal externality between different networks.

As different calls become more substitutable, then carrier identification will tend to further reduce inter-network call charges. In the extreme, suppose that each customer has a variety of potential calls that are perfect substitutes. The customer always has the option of calling alternative parties that are on different networks. Then termination charges will be forced to marginal cost. Any network that sets a higher termination charge will have a higher price from the customer's perspective and the customer will substitute to another call. Note, however, that this leads to the price of both intra-network and inter-network calls being identical, and set to the monopoly price.

Allowing discriminatory pricing and network identification with endogenous market shares and uniform pricing is more problematic. If the networks were close substitutes (so that s was large), then each network would have an incentive to increase inter-network call charges and create a network externality that benefited itself. In particular, if there were a 'dominant' network that had an advantage in gaining (or retaining) customers, then this network would have an advantage in using discriminatory pricing based on customer identification to prevent significant competition.

6 Future Directions

This paper has taken a preliminary look at the principles and issues behind the setting of termination charges for non-dominant networks. However, in many respects the analysis here is static. There are issues of investment (particularly in network coverage) and the question of entry itself that would require more analysis. Also, the model of competition is based on simple linear pricing. In many areas, telecommunications pricing is involving more non-linear pricing forms; such as two-part tariffs.[9] In this environment, the principles governing the regulation of termination charges are likely to be different. Hence, the ultimate application of regulatory rules to termination charges will need to be considered on a case-by-case basis with regard to the maturity of the telecommunications industry and the market environment.

[9] Such a model is analysed in Gans and King (1999).

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