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OPTIMAL TELECOMMUNICATIONS TARIFFS AND THE CCITT

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Abstract

International telephone service providers must decide how to apportion their call revenue between the orginating and receiving networks. The CCITT makes detailed recommendations as to how this should be done. However it is not merely a matter of accounting. Tariffs also create incentives for the administrations own pricing behaviour. Creating the right incentives through appropriate tariffs is crucial to inducing an efficient outcome. This article characterizes optimal tariffs and compares them with the recommendations of the CCITT.

Briefly the optimal tariff consists of a flat-rate price per circuit plus a traffic-unit price plus a fixed component transfer. Optimal tariffs are time-dependent, depending upon whether demand is peak or off-peak. This characterization enables an assessment of the extent to which current procedures may be inefficient. With appropriate interpretation, our results are applicable to a wide range of telecommunication services.

1 Introduction

In a previous paper (Carter and Wright, 1991) we developed a general model of *Symbiotic Production* in which all firms trade necessary intermediate goods. An important application of such a model involves international telecommunications services. For example, an international telephone call utilizes the facilities of a telephone network at each end. Normally, the revenue for the call is collected by the originating Administration [1] from the party who initiates the call. The destination Administration looks to the originating Administration for reimbursement for the services which it provides. These charges for network services between telephone Administrations are called tariffs or accounting rates. Amongst other things, we showed:

- By cooperating over the tariffs charged, Administrations can raise industry profits and lower consumer prices.
- Regulations on the output markets may be undone by Administrations, by appropriate setting of tariffs on their input markets.

These results were particularly interesting in light of the recommendations of the International Telegraph and Telephone Consultative Committee (CCITT), a voluntary cartel of telephone administrations which regulates international trade in telecommunications services. "The recommendations of the CCITT are in effect the real international telecommunication rules of today for, although they are not legally binding, they are nevertheless adhered to by most member nations." (Cullen, 1987)

In this paper we carefully examine the appropriate form of tariffs between Administrations on the basis of our model of symbiotic production and the special features of international telecommunication services. The rest of the paper is organized as follows. Section 2 considers the optimal tariff while section 3 compares it with each of the tariffs recommended by the CCITT. Conclusions are presented in Section 4.

2 Optimal Tariffs

A tariff serves two purposes. Firstly it transmits economic information (e.g. costs) between Administrations, thus decentralizing decision making. Secondly it leads to a redistribution of profits between Administrations. We define an optimal tariff to be one which simultaneously satisfies the following criteria:

1. It transmits the "appropriate" economic information, in the sense that each Administration pricing independently will be lead to choose the prices which maximize its contribution to industry profit.

[1] We follow the CCITT practice in using "Administration" to include both public telecommunications utilities and recognized private operating agencies.

2. It leads to that redistribution of profits among Administrations which is agreed to after bilateral or multilateral bargaining between the parties concerned.

Thus an optimal tariff maximizes total industry profits and then splits these profits according to the bargaining strengths of the parties concerned.

Our analysis is based on a sequential model in which Administrations first choose tariffs and then consumer prices, which are called collection charges [2]. This is implicit in the recommendations of the CCITT as can be seen from the following extract:

> The accounting rate [is] regarded as a matter to be settled between Administrations, each Administration being reimbursed according to the cost of the equipment it made available. The fixing of collection charges [is], within certain limits, a national matter. Each terminal Administration [is] expected to fix a collection charge in such a way that it covered at least the average of the accounting rates applicable to the various routes used. (CCITT, 1988, p.309)

The choice of tariffs is not merely an accounting issue. Its affects final consumer prices and thus industry profits.

To determine the optimal tariff we need to consider the special features of telecommunication demand and costs. Demand is typically time dependent, while costs are largely capacity related. These features give rise to the well known theory of peak load pricing which we utilise to determine the optimal tariff.

The cost of providing a certain level of capacity, K, is assumed to be a stepwise continuous function of the form illustrated in Figure 1. This formulation of costs is a result of the indivisibility of the Administration's plant. In other words, investment opportunities are discrete. If this were not the case the analysis would be substantially simplified. This turns out to be crucial in understanding the appropriateness of various tariffs.

To simplify the arguments we assume

1. Demand is independent, that is the price of a call from country 1 to country 2 does not affect the demand from 2 to 1.

2. Demand can be divided into just two periods, peak and off-peak.

3. The capacity required to supply peak demand is sufficient to supply off-peak demand at the optimal collection charges. Thus peak demand is capacity constrained while off-peak demand is not. Later we relax this assumption and reconsider our results.

[2] The collection charge is the charge established and collected by an Administration from its customers for the use of an international telecommunication service

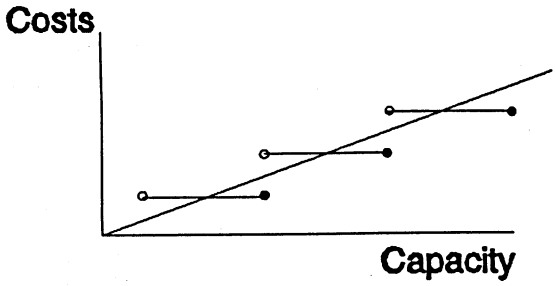

Figure 1: Capacity cost

Consider first the case of off-peak demand. The optimal tariff is a two part one, comprising of a traffic-unit price and a fixed component transfer. The traffic-unit price is set to transmit the appropriate economic information and the fixed component transfer is set to give the appropriate redistribution of profits. Regardless of the number of Administrations or the form of inter-dependencies among their costs, it is easy to show that the traffic-unit price charged from Administration 1 to Administration 2 should be set to the non-capacity marginal cost in country 1 of incoming calls from country 2.[3] Given that typically this cost is very close to zero, it is clear that traffic-unit prices should be negligible.

How is the fixed component transfer determined? If the Administrations take part in bilateral or multilateral bargaining their share of the industry profits will be higher the greater is their bargaining power. Their bargaining power, in turn, depends upon what they can obtain if the parties cannot agree. The opportunities available to Administrations acting independently will thus constrain the levels of the fixed component transfers. This suggests that, other things equal, the fixed component transfer should be set so as to transfer profits from countries with relatively large demand levels to countries with relatively small demand levels. This is because countries with small demand levels can do relatively better acting on their own, exploiting the other countries' larger demand levels, compared with achieving the industry profit maximizing outcome with no fixed component transfers (Carter and Wright, 1991).

Now consider the peak demand period. When Administration 2 sets its collection charges for the peak period, it should take into account the effect of its prices on capacity costs incurred by Administration 1. However, unless the cost of this capacity is reflected in the tariffs charged by Administration 1 to Administration 2, it will not choose its price so as to maximize industry profit. During peak demand periods, therefore, the optimal tariff is a three-part tariff consisting of the two-part tariff previously defined plus a flat-rate price per circuit, reflecting the marginal cost of additional capacity.

Throughout the above analysis we assumed the demand difference between peak and off-peak periods was sufficient to ensure off-peak demand was not capacity constrained at the optimal prices. We now relax that assumption. For large off-peak demand the distinction between off-peak and peak is somewhat blurred, because both types of demand are capacity constrained. This could occur if, for instance, off-peak and peak demand periods were largely off-setting in two countries. That is, one country's peak time was another's off-peak time and vice versa. In this case the difference in total demand levels between the two times could be sufficiently small so that demand was capacity constrained, in both periods, at the optimal prices. Thus the optimal tariff now involves the flat-rate price per circuit applying in both periods; the flat-rate price in each

[3]Recall that we are assuming independent demands. If the demands are in fact gross substitutes then it can be shown that the optimal tariff requires traffic-unit prices which exceed marginal cost.

period being such that demands are capacity constrained in each period.

Finally we suggest a procedure by which the optimal tariff could be implemented. Firstly the CCITT would ask individual Administrations to reveal their appropriate cost information, on the basis that the information will only be used to calculate tariffs which maximize industry profits and will not affect their individual profit shares. Each Administration has an incentive to reveal their true information. Given this information the CCITT can then calculate the optimal tariffs (up to the fixed component transfer) which become their recommendations. If the Administrations can agree on the levels of the fixed component transfers then this agreement is implemented along with the CCITT recommendations on traffic-unit and flat-rate prices. If they cannot agree they revert to non-cooperative behaviour, each charging one another the most they can achieve individually, which generally results in lower profits for all Administrations (Carter and Wright, 1991). Thus there is an incentive for the Administrations to reach some agreement over profit sharing.

We now examine the specific recommendations of the CCITT in light of the above results.

3 The CCITT Recommendations

The CCITT recommendations on the appropriate form of tariffs (or remuneration of the Administration of the country of destination) are essentially contained in recommendation D.150.2 (CCITT, 1988, p.155). These are summarized below.

1. *Flat-rate price procedure*

   Under this procedure the Administration of the country of destination receives payments for the facilities made available by a flat-rate price fixed by it as a price per circuit.

2. *Traffic-unit price procedure*

   Under this procedure, the country of destination receives payment on the basis of the price fixed by it per tariff unit.

3. *Accounting revenue division procedure*

   Under this procedure the accounting revenue from the traffic exchanged in their relationship is divided between the Administrations of the terminal countries, in principle on a 50/50 basis. Proportions other than 50/50 may be used when the facilities made available by each of the Administrations of the terminal countries are not approximately equivalent, or if Administrations reach agreement on a different proportion when, for example, the costs differ greatly.

In comparing the above recommendations with the optimal tariff we are interested in their ability to satisfy both the efficiency and distributional objectives outlined in section 2. We initially ignore the distributional goal and determine whether each is capable of transmitting the 'appropriate' information. That is, are firms pricing independently led to maximize their contribution to industry profits.

Consider first the flat-rate price procedure. Assuming negligible non-capacity marginal costs we know from section 2 that zero tariffs should be charged during off-peak periods, while a fixed price per circuit is optimal during peak demand periods provided the flat-rate prices are chosen to reflect capacity costs appropriately. Thus, ignoring the peak/off-peak distinction and the distributional requirements, this recommendation is appropriate to the extent to which the non-capacity marginal cost of incoming calls to each Administration is negligible.

Next consider the traffic-unit procedure. The basic recommendation of the CCITT is that traffic-unit prices be set at the average cost of incoming calls. Ignoring non-capacity costs we show that this leads to a sub-optimal outcome by way of a simple diagrammatic example. Figure 2 considers the case of Administration 1 charging Administration 2 for the cost of incoming calls. The top panel depicts Administration 1's capacity cost. The traffic-unit tariff is denoted by the line, T(K), the slope of which is the marginal cost faced by Administration 2. Thus Administration 2 maximizes profits at q_{21}^0 where the slope of line A (= the slope of line T(K) = marginal cost) equals the slope of the revenue function (= marginal revenue). However it is clear that the contribution to industry profits is in fact maximized at q_{21}^*. Using an average cost traffic-unit price means that Administration 2 undervalues the true cost of capacity imposed on Administration 1. It does not correctly internalize capacity cost.

There are two cases in which the use of a traffic-unit price is optimal. Firstly it is clear from Figure 2 that if the CCITT has information on the Administration's demand functions as well as costs, it can determined traffic-unit prices which would lead to each Administration choosing collection charges which maximize their contribution to industry profits. The CCITT could in effect work backwards. Firstly with all information on demands and costs it could calculate the traffic-unit prices which if charged would lead Administrations to price at the industry profit- maximizing levels. Thus in the simple example of Figure 2 the traffic-unit price for 2 would be the slope of the revenue function at q_{21}^*, that is, the slope of line B. Administration 2 taking this as its marginal cost will equate marginal cost and marginal revenue at the output level q_{21}^*, as required.

Secondly, if in fact the costs (capacity and non-capacity) could be represented by a continuous, smooth function then ignoring distributional requirements, the traffic-unit price procedure would be optimal. In this case the traffic-unit prices would simply be set to the marginal cost of incoming calls during peak and off-peak demand periods.

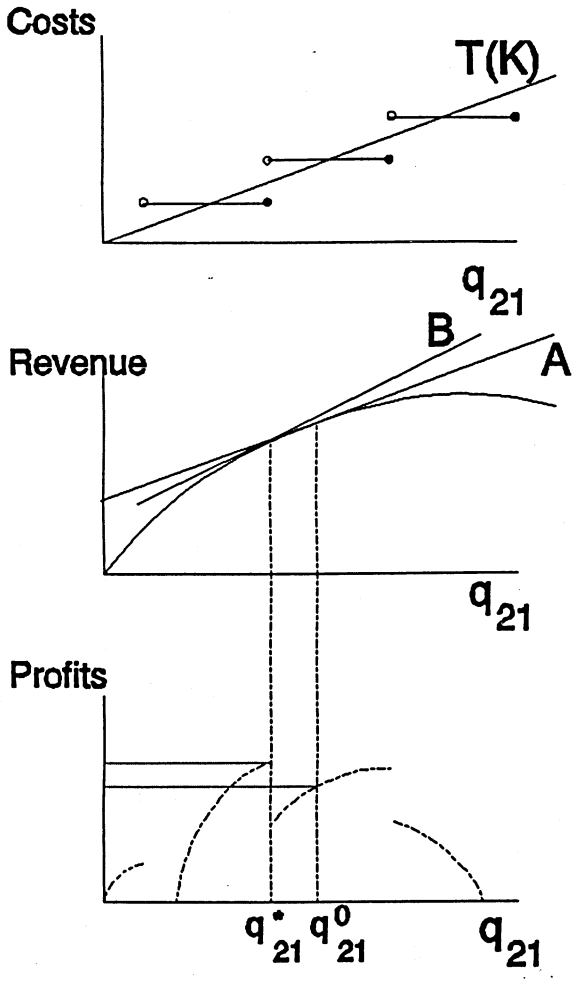

Figure 2: Illustrating the sub-optimality of the traffic-unit price

Finally we consider the accounting revenue division procedure. With no explicit tariffs between Administrations the accounting revenue division procedure relies on Administrations to price cooperatively in order to take into account the costs (particular capacity costs) of each other's action. Thus it fails to decentralize the pricing decisions and therefore does not meet optimality criterion (1). If Administrations priced independently under the accounting revenue division procedure, each Administration would fail to take into account the true cost of its outgoing calls, and thus price inefficiently.

In each of the above cases the efficiency goal could be satisfied approximately given suitable qualifications. However in each case, in the absence of a fixed component transfer, the outcome determined not only the total level of profits but also their distribution. That is, the satisfaction of the efficiency goal in each case lead to a particular distribution of profits. Given asymmetries in demand or costs between Administrations this would not necessarily be the distribution of profits arrived at after bargaining. Thus without a fixed component transfer, bargaining will in general lead to an inefficient outcome in the sense that industry profits will not be maximized. This is since the tariffs or collection charges will be used partly as a way of redistributing profits. Hence in each procedure we still require a fixed component transfer which allows for the appropriate redistribution of profits.

A fixed component transfer is also necessary to provide appropriate incentives for participating in the CCITT's procedure for determining recommended tariffs. This procedure requires that Administrations should reveal their costs to the CCITT, under confidentiality, to be analyzed and presented anonymously in the form of numerical tables. These are then averaged over a particular region and used to calculate the appropriate tariffs. Thus the CCITT states:

> To carry out a detailed tariff study in international telecommunication services, a Tariff Group must know the cost of the services supplied by the Administrations and the factors affecting the provisions of these services. The Tariff Group must therefore collect the detailed data from the Administrations in its region, synthesize them, calculate the average costs of the various factors and determine the standards to be adopted in remunerating the facilities made available by Administrations in providing a service in the international telecommunications services. Administrations must, of course, be assured that the data collected are treated absolutely confidentially. (CCITT, 1988, p.310)

Consider two countries with asymmetric demand functions. It can be shown that the small demand country prefers a higher accounting rate in order to exploit the other country's larger demand. Thus the small demand country has an incentive to reveal higher costs in order to raise the average costs and thus accounting rate in a particular region. By similar reasoning, the large demand country has an incentive to reveal lower costs. Thus the actual tariffs set under

such a scheme may bear little relation to the true cost, despite anonymity. If, on the other hand, the information revealed is only used to work out tariffs which determine industry profit and not individual profit shares then Administrations have every incentive to reveal their true costs. Any fight over profits is then directed at the setting of the fixed component transfer.

As Turan (1989) correctly says, "However, the success of the method... (the analytic method) ... hinges on the reliability of the replies to the questionnaires used to collect the basic data required for cost studies of telecommunication facilities". Under the heading, *Difficulties to be overcome and problems to be solved before undertaking a cost price study*, the CCITT concludes:

> The Administrations belonging to a Tariff Group have to be convinced that it is in their own interest to undertake cost price studies and apply recommended standard rates, as such standards lead to harmonized tariff structures for the different telecommunication services and guarantee the most equitable remuneration of the various facilities made available by the Administrations. (CCITT, 1988, p.327)

A useful way of seeing the contrast between economic and accounting objectives, emphasized in the above analysis, is to examine the following CCITT recommendation. "In certain conditions, the Administration of terminal countries may agree not to exchange international accounts when, for example:

1. the balance of settlement of their accounts is normally negligible;
2. the terminal countries' traffic levels in both directions are more or less equal;
3. there is approximate equivalent as regards their national extension." (CCITT, 1988, 156)

Clearly from an accounting point of view the above recommendation makes sense. However, by not exchanging accounts the Administrations are effectively setting zero tariffs. As we have seen, this is only appropriate if prices are set cooperatively.

4 Conclusions

In this article we attempted to answer the question: What tariffs should Administrations set for international accounting? However in a world where tariffs are chosen first, then collection charges, the choice of tariffs is far from just a matter of accounting. Changes in tariffs lead to not only a redistribution of industry profits but changes in the actual level of industry profits to be distributed. Our objective was to find a tariff which would lead Administrations pricing independently to choose the prices which maximized their contribution to industry

profits while still allowing any redistribution of profits, as determined by bilateral or multilateral bargaining between the Administrations concerned.

In determining the optimal tariff we allows for both the indivisibility of the Administration's plant, and the time dependent nature of demand. The characterization of the optimal tariff depended on, among other things, whether there was a 'large' or 'small' difference in demands between peak and off-peak periods.

In the 'large' case the optimal tariff is

during peak demand periods: a flat-rate price per circuit (reflecting the cost of additional circuits provided) plus a traffic-unit price (set to the non-capacity marginal cost of incoming calls) plus a fixed component transfer (set by bilateral or multilateral bargaining).

during off-peak demand periods: a traffic-unit price (set to the non-capacity marginal cost of incoming calls) plus a fixed component transfer (set by bilateral or multilateral bargaining).

In the 'small' case, the optimal tariff is

during peak and off-peak demand periods: a flat-rate price per circuit (set such that the demands are capacity constrained in each period) plus a traffic-unit price (set to the non-capacity marginal cost of incoming calls) plus a fixed component transfer (set by bilateral or multilateral bargaining).

Each of the CCITT recommendations, namely

1. Flat-rate price procedure
2. Traffic-unit price procedure
3. Accounting revenue division procedure

can be viewed as an approximation to the above optimal tariff given suitable qualifications. Abstracting from the important issues of distributional requirements and peak load pricing we have that

- the flat-rate price procedure is optimal to the extent to which non- capacity marginal costs of incoming calls are negligible.
- the traffic-unit price procedure is optimal to the extent to which the CCITT can obtain demand information and use it to work out the appropriate traffic-unit prices as described in section 3 or to the extent a continuous, smooth cost function can be used as a reasonable approximation of the true cost function and traffic-unit prices are set to the marginal cost of incoming calls.
- the accounting revenue division procedure is optimal to the extent to which the Administrations cooperative over their choices of collection charges.

Moreover, allowing for peak-load pricing in line with the optimal tariff outlined above, may lead to substantial improvements in industry profitability as well as lower collection charges.

In each case above the necessity for a fixed component transfer is twofold. Firstly it is needed to ensure the 'appropriate' redistribution of profits. That is, one which occurs after bilateral or multilateral bargaining of the parties concerned, not one which is an ad hoc result of the particular international accounting procedure chosen. Secondly unless the efficiency and distributional goals are separated through a fixed component transfer, Administrations will have an incentive to misrepresent their true costs when these costs are being used to determine the tariffs applicable between Administrations.

A general theme in the above analysis is the contrast between economic and accounting objectives. We have emphasized the economic effects of changing international accounting procedures. Giving Administrations the right incentives is crucial to an efficient outcome.

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