METERED BILLING IN TELEPHONE RATES

G.D. QUIRIN

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TABLE OF CONTENTS

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(1) Introduction

Metered billing, or the charging for consumption on a basis related to the amount consumed, is the most common basis on which public utility services are sold, not only in Canada but elsewhere in the world. Flat-rate charges are found in the rate structures of gas and electric utilities, where they are typically restricted to hot water heater installations, and are often used for residential water supply, but their most important area of application appears to be in local-exchange telephone service. The survival of flat-rate billing in the latter area, indeed its expansion as local toll-free dialling areas are extended, appears to be particularly anomalous in view of the decline in its use by other types of utilities. Even municipal water systems, whose pricing policies are subjected to rather extraordinary political pressures, have moved gradually in the direction of metered billing. This paper examines the case for and against metered billing for local telephone services and examines their possible application in Canadian circumstances.

(2) Some Basic Considerations

Rationalization for the use of usage-related charges may be provided under rate structures based on almost any conceivable criterion, under so-called "value-of-service" criteria as well as under cost-related pricing systems. In the former, they may be justified as permitting a more precise relationship between the charge and the value of the service received by the individual consumer. In cost-related systems, their use may be justified as permitting charges to approximate more closely the costs imposed on the system by the individual consumer. We believe that any move to adopt metered billing for the local telephone service should be predicated upon its ability to bring prices into closer conformity with costs rather than upon value-of-service considerations, though we are not prepared to see the latter abandoned entirely.

Value-of-service ratemaking for public utilities has received rather short shrift from economists, who have tended to favour marginal-cost pricing rules of one type or another. Economists' basic objection to the "value-of-service" criterion is that it is no criterion at all. Any arbitrarily-selected price which someone is willing to pay is prima facie justified on value-of-service grounds; if the service were not worth the price asked, to those customers who subscribe, they wouldn't. There is thus a large element of circularity involved. A second source of objection is that value-of-service pricing usually involves price discrimination, which is widely regarded as having undesirable consequences for the distribution of real incomes, and, unless the price structure is so arranged that marginal units are available to all customers at marginal cost, adverse consequences from an allocative efficiency point of view as well.

We do not believe value-of-service considerations can be dismissed quite so easily. Even in a system in which marginal cost pricing is employed, value-of-service considerations must be taken into account in decision-making; as pointed out in Ruggles' basic contribution to the theory of marginal cost pricing,[1] capacity should not be provided unless a perfectly-discriminating monopolist would be capable of covering costs (including the opportunity cost of capital) through discriminatory charges. This constraint is necessary to ensure that the aggregate social utility of the facilities provided is in excess of the aggregate social cost. Arriving at this determination requires an evaluation of the area under the demand curve in comparison with the area under the cost curve. Despite the undoubted progress of econometrics, our knowledge of the shape of demand curves for individual commodities is sketchy indeed; particularly with respect to portions at prices significantly different from those being charged. As a practical matter the only available means of applying Ruggles' total benefits-total cost criterion may be to permit (or even require) the utility to impose rate structures involving some degree of discrimination and see whether it can capture a share of benefits at least equal to costs. The alternative may be to abandon the only practical basis available for deciding whether to expand capacity. It is true, as Samuelson[2] and others have pointed out, that once the capacity has been installed, its cost has been sunk, and that departures from a strict short-run marginal cost pricing rule may impose an arbitrary restriction on utilization. This criterion is valid, in our view,

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[1]N. Ruggles, "Recent Developments in the Theory of Marginal Cost Pricing," Review of Economic Studies, vol. 17, (1949-50), pp. 107-26.

[2]P.A. Samuelson, Foundations of Economic Analysis, (Cambridge: Harvard University Press, 1947), pp. 214-3.

only in a static context where no expansion in investment is under consideration. The alternative to continuously testing the social profitability of expanded facilities, via price discrimination if necessary, is to expand them willy-nilly without regard to their total social utility. We do not regard this as an adequate basis on which to allocate scarce resources.

While the above argument suggests grounds for the consideration of value-of-service criteria even in a utility where there are no external benefits nor costs (spillovers), their consideration is even more important when the possible existence of such externalities is taken into account. In the case of telephone service, there are at least two types of externality of some significance which should be taken into account in attempting to specify an optimal rate structure. Those are the external benefits conferred on present subscribers by the addition of new subscribers to the system, and the congestion costs imposed on other subscribers by utilization of the system. Because an additional subscriber increases the value of the system to existing subscribers, it will be argued below that a subscription charge which reflects the marginal cost of service will result in an output level which is inefficiently low; output should be expanded to the point where the marginal utility of the service to the subscriber, plus the marginal utility, to other subscribers, of his addition to the system is equal to the marginal cost of serving him. The price to the subscriber should be less than marginal cost by an amount reflecting the value to other subscribers of his addition to the system. To evaluate this externality, value-of-service considerations must be applied; to ensure some degree of correspondence between such evaluations and reality, it is desirable that they be incorporated in the rate structure.

Congestion costs are similar in nature. By using a system which is operating near capacity, a subscriber imposes delays or frustration on other would-be users. If the charge to him does not reflect these costs which he imposes on others, he will tend to overutilize the system. Capacity in the system should be expanded to the point where the reduction in congestion costs exceeds the cost of capacity expansion. The evaluation of congestion costs requires, once again, the application of value-of-service criteria.

Thus, in our view, the application of an "ideal" pricing system, even one which is basically consistent with marginal cost pricing principles, requires the use of value-of-service criteria and their application within the rate structure.

(3) Where Metered Billing is Used

Flat-rate billing, in which a monthly subscription charge is levied against the customer and entitles him to unlimited access to the local system, is the normal basis on which residential telephone company rate structures have been based in Canada

Business customers, on the other hand, have the option of flat-rate service or billing on a metered rate basis. Bell Canada's Tariff item 70.5 provides, for example, to business subscribers in Rate Group 10, the choice between a flat-rate of $ 16.35 per month or a two-part tariff which includes a monthly charge of $ 9.35 plus .05 per call.

Free calling privileges under Canadian rate structures are restricted to the local calling area. Calls to areas outside the local calling area are metered and billed accordingly. There has been a marked tendency, in the postwar period at least, to increase the local calling area in growing urban markets to make it roughly coincident with the metropolitan area, and to restrict metered billing to long distance or interurban calls. The charge for service outside the calling area typically covers not only the short-run marginal cost of effecting the connection, but a share of the fixed costs of providing the connection facilities.

It would appear to be impractical to offer long distance service to most customers on a two-part tariff or on a flat rate basis, e.g., by levying a higher rental charge for instruments capable of providing access to the interurban system, or by imposing a two-part tariff involving a flat connection charge plus an additional message charge reflecting short-run marginal costs. Most subscribers use the long distance service sufficiently infrequengly that they would hesitate to pay much for such access. For those customers we do make sufficiently frequent use of the long distance system to warrant such refinements in the pricing system, special arrangements are available (e.g., Zenith numbers, leased lines, etc.). The extent to which ordinary subscribers' telephones, which do provide immediate access to the long distance system, should be charged for on a basis which reflects the costs of providing such access and/or the benefit that they derive from the fact that it is available, even if they don't use it from one month to the next, is an interesting question which requires further research; it cannot be answered here.

The two U.S. cities in which metered billing is compulsory are both large metropolitan areas, comes larger than any in Canada. One consideration which is apparently relevant in explaining the choice of a two-part rate with metered billing by larger systems is that the cost of providing and operating exchange facilities permitting the inter-connection of local telephone rises at a rate which is more than proportional to the number of telephones provided with such access - the functional form suggested by one student of telephone system economics is quadratic.[1] It is also inversely related to the intensity of use, if service standards are to be maintained at a fixed level. It would appear to follow that, other things being equal, the capital and operating cost savings which result from the curtailment of use caused by the imposition of a message charge are greater in a large system than in a small, and sufficiently greater to justify the extra costs incurred in metering consumption.

This rationalization, while plausible, is to some degree speculative. The basic explanation may be nothing more than the force of custom. An

[1] A. Hazelwood, "Optimum Pricing as Applied to Telephone Service," Review of Economic Studies, vol. 18 (1950-51), pp. 67-78.

examination of rate structures in force in the U.S. in the 1920's suggests that the bulk of the markets in which metered billing is now used were already using metered billing half a century ago, although the relevant systems were much smaller at that time. Cities with flat rate billing in the 1920's have tended to retain it, (e.g., St. Louis, Cleveland, Philadelphia, Atlanta) although many of these markets now surpass in size those where metered billing was employed 50 years ago.[1] It should be noted, however, that very substantial capital costs are involved in the installation of metering deviced on electromagnetic switching system, and that hesitation to incur these costs may have been a factor.

Outside North America, the pattern is different. Two-part tariffs incorporating a standing charge either for the connection alone or for the connection plus some limited number of "free" calls, plus a message charge for all calls or for calls above the "free call" limit are the rule, rather than the exception. Once again custom may be a factor; the form of the rate structure has been unchanged in most areas since very soon after the introduction of telephone service. Manual systems remained in use in many of these centres for a much longer period than in North America, lower wage rates were undoubtedly a contributing factor, and recording of charges in a manual system may be quite inexpensive if labour is cheap. Most of the systems are small by North American standards, e.g., Paris has only slightly more phones than Montreal. However, there are perhaps more compelling economic reasons which tend to explain why metered billing may be more appropriate under typical European, Asiatic, or Latin American conditions. A separate message

[1]See W.E. Mosher and F.G. Crawford, Public Utility Regulation (New York, Harper) 1933, for rates schedules in the 1920's. There are apparently some doubt as to whether flat rate systems met legal requirements that rates by just, reasonable, and non-discriminatory. But see Rochester v. Rochester Telephone Corp., P.U.R. 1924 A 714.

charge permits the standing charge to be set lower than it would have to be under a flat rate system, and may therefore be viewed as promotional with respect to connections. As noted below, in an undersaturated market, additional subscribers create particularly substantial external benefits for existing subscribers and should be charged less than marginal costs for a connection. At the same time, message charges discourage utilization; most systems outside North America are underdesigned, at least by North American standards; significant congestion diseconomies are evident in the time taken to obtain a dial tone, the frequency with which busy signals and/or wrong numbers are obtained, etc. In these circumstances, the combination of a promotional connection charge to encourage long-run market saturation and a significant message charge to discourage short-run congestion is probably quite appropriate, and is more clearly so in these circumstances than it is under North American conditions.[1]

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[1] To some extent, the promotional effect of the limited standing charge in many overseas systems is vitiated by apparently high installation charges; these are apparently related to the financing problems of state-owned systems. If viewed as additional capitalized monthly standing charges, the contention that the basic rates are promotional still holds. For example, the installation charge in London, England is about $85, but the monthly rental is only some $1.25. Capitalizing the former at 12% over 10 years increases the effective monthly charge to $1.96. In Tokyo, installation costs about $200, monthly rentals are $3.50. Applying the same procedure produces an effective monthly charge of $5.18. Even with capitalization over 5 years, the equivalent monthly rentals are only $2.67 and $6.84, respectively.

(4) Appropriateness for Canada - Some Basic Issues

The question of whether metered billing is appropriate under Canadian conditions does not appear to have been seriously raised in recent years. Nor has the issue been considered in the U.S., although the N.A.R.U.C. has recently decided to investigate the matter in some depth.

The basic case for metered billing is that customers who use their phones a lot impose higher costs on the system and presumably derive more benefits from it than do customers who use their phones rarely. Thus, it can be argued, they should pay a higher price, either on cost-of-service or value-of-service grounds, and charging a flat rate is discriminatory.[1] Another argument asserts that connection to and use of the system are separate commodities (a view with which we partially concur) and that flat rate pricing enables the companies to overcharge for the one and undercharge for the other, effectively exploiting different elasticities in the two parts of the market and practising a sophisticated version of "gold-plating" along the lines suggested by Averch and Johnson.[2] A final objection is that the continued growth in telephone utility plant is absorbing capital on a scale that creates concern for the state of the capital market, and that flat-rate pricing is one of the causes of this inefficient growth.

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[1] See, e.g., Re Wisconsin Telephone Co., P.U.R, 1920 C 116.

[2] H. Averch & L. Johnson, "The Behaviour of the Firm Under Regulatory Constraint," American Economic Review, vol. 52 (December, 1962) pp. 1062-69. The form of "gold-plating" alleged is the second type described by Averch and Johnson, and does not necessarily involve the adoption of an inefficient capital-labour ratio.

Opponents of metered billing would meet these criticisms by arguing -

(a) With respect to discrimination: that a perfectly non-discriminatory system of pricing is an unattainable ideal in any event, and that the costs of eliminating the discrimination, in this case by metering calls, are probably inordinate in relation to the benefits in terms of equity or improved resource allocation which would result. More assertive critics would claim that adoption of metered billing could easily represent a greater departure from an ideal pricing system than that which now exists, if the costs of metering are taken into account.

(b) With respect to the Averch-Johnson Argument

There is no evidence to show that the present pricing system is a greater departure from an idealized marginal-cost pricing system than is warranted by the costs of metering under present technology. There is no convincing evidence of behaviour of this or any other type conforming to the Averch-Johnson conjectures. In any event, the introduction of metered billing *per se* would not prevent such behaviour but would, in fact, present the companies with an additional degree of freedom (the per-call charge) which would enable such opportunities as exist in this direction to be exploited more fully.

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[1] Cf. G.F. Mathewson and G.D. Quirin, "Metering Costs and Marginal Cost Pricing in Public Utilities," *Bell Journal of Economics and Management Science*, Vol. III (Spring 1972), pp. 335-339.

(c) <u>With respect to excessive growth and capital requirements</u>

The question here is one of excessive growth in relation to what. The fact that growth has been fairly continuous and at a fairly high rate says nothing about whether the growth is too fast, too slow, or just right. In the long-run, growth is primarily linked to the number of phones in use, and if growth is excessive it must be blamed on the likelihood that regulation has held the connection charge (the only charge in most cases) below a level which would permit an appropriate allocation of resources between telephones and competing commodities. The prevalence of market prices below book values for telephone securities suggest that in fact regulation has in recent years held rates of return below the cost of capital and encouaged just such possibly excessive growth. The long-run problem would be exacerbated, rather than helped, by the introduction of metered billing that was not part of a general rate increase.

On the other hand, it is true that metered billing would encourage more economical utilization of the existing system and would permit the number of services to be expanded with a below-normal increase in capital employed. This would be largely a once-for-all gain (entirely, except that a slightly lower investment per added phone would be required once the slack created by the reduced utilization rate had been absorbed.) The once-for-all saving would be in substantial measure offset by the capital cost of installing metering equipment, and it is not at all clear that the result would be to lower the capital requirements of the telephone system.

Capital requirements of the Canadian telephone systems have been substantial, though it is difficult to determine precisely at what point funds requirements of any given sector would become "excessive". The net increase in debt and preferred stock capitalization of the private sector telephone companies (Bell, B.C. Telephone and Maritime Telephone and Telegraph) is shown as a percentage of that corporate financing in the following table.

Year	Total Telephone Companies ($ Million)	Total Private Sector Net New Issues ($ Million)	%
1969	168.9	1,290	13
1970	206.1	1,523	14
1971	300.8	2,132	14
1972	201.9	2,079	10

Source: Moody's Public Utility Manual: Bank of Canada, Statistical Summary

These percentages indicate that a fairly significant fraction of capital earned by corporate issuers is accounted for by telephone utilities. It should be noted that in the period subsequent to 1972, the telephone utilities have been complaining about inability to adequate financing.

It is true that capital requirements per telephone have tended to grow. In part this reflects increasing utilization, which is to be expected as more potential call-recipients are added to the system. The growth in utilization could be deterred by a message charge, although it has yet to be shown that it would be desirable to do so. By far the greater part of the increase, however, is to be accounted for by the substitution of capital for labour in response to charges in their relative prices; this has produced significant productivity gains, whether measured on an output-per-man-hour basis or on a total-factor-productivity basis, and it is far from clear that any attempts to discourage such investment would yield any social benefits whatever.

The question of whether metered billing should be introduced, or not, cannot be easily answered on the basis of general arguments of the type presented above. It can only be answered in terms of whether it is required in a price system which is designed to maximize social welfare, taking account of any peculiar characteristics of the telephone system and of the costs of metering.

(5) The General Principles of Optimum Pricing

There is a vast (and some would argue, even excessively vast) literature on optimum pricing systems for commodities, including utility services, which it would be pointless to review here[1] except to indicate certain conclusions, which are summarized below.

(a) General Principle

An optimal price system will ordinarily involve marginal cost pricing for each distinghishable product, if

(i) there are no externalities or spillovers,

(ii) information and transaction costs involved in operating the price system are zero,

(iii) there are no economies of scale which preclude such a system from generating sufficient revenues to cover these costs,

(iv) other products are priced in accordance with a similar rule,

(v) the distribution of incomes is equitable.

This basic principle is discussed at length in the literature on welfare economics and its validity is sufficiently well established that we see no point in commenting on it here. The basic justification is that it enables every individual to adjust his purchases so that the marginal utility or value to him, of the last unit of each product consumed, is equal to the marginal cost to society of producing that unit.

In application to the telephone system, before making allowance for the adjustments in the price structure needed to adjust for departures from conditions (i) to (v), it implies that there should be a separate price,

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[1]But see E.J. Mishan, "A Survey of Welfare Economics 1939-1954," Economic Journal (Juhe, 1960), pp. 197-265 for a discussion and a fairly complete bibliography.

equal to marginal cost for every distinguishable product. This means a separate price for connection to the system and for use of it; within the latter category, we may distinguish a multiplicity of products, for a call at 9:30 a.m. Monday is not the same as one at 4:30 a.m. Sunday, nor even one at 10:30 Monday. These calls are not perfect substitutes for every consumer, though they may be for some, and the costs of providing them also differs. This principle implies not only that there should be metered billing, but that the rate-structure should embrace a different tariff for each time of day as well as distinguishing between calls placed within a single exchange and those which involve a second exchange. The result would be highly complex, but the implication of the general principle for the nature of an ideal rate structure should be kept in mind.

The type of metered billing system usually suggested, and that which is actually applied in jurisdictions using metered billing involves a two-part tariff with a fixed standing charge for connection to the system and a per call charge for each message originated. The flat rate system may be viewed as a special case of the two-part tariff in which the message charge is zero. The flat rate system of necessity involves a standing charge which is above the average cost of providing the connection to the system, since it must cover the average costs associated with the use of the system to carry messages. The former may, or may not, be above marginal cost as well, if it is assumed that the provision of service within a community is an increasing cost activity as certain physical characteristics of the system suggest it is. The zero message charge of the flat rate system is almost certainly below marginal cost, at least in the case of calls made at the system peak.

Casual consideration might suggest that systems with a non-zero calling charge (i.e., metered billing) offer a closer approximation to the ideal established above, but if the connection charge is set equal to average costs as distributed between providing the system and operating it, it may represent an even greater departure from marginal cost pricing for this component, if increasing costs are operative. At the same time, it is highly probable that many calls, made off peak, impose a marginal cost which is virtually zero, and that a zero message charge (i.e., flat rate billing) represents a closer approximation to marginal cost pricing on the utilization component of the service. Both systems in reality represent significant departures from the marginal-cost pricing ideal, some of which may be justified in terms of conditions (i) to (v).

(b) Treatment of Externalities or Spillovers

The general principle must be modified in the light of external benefits or diseconomies, sometimes referred to as positive or negative spillovers. The general principle is that if consumption or production of the product creates benefits to members of the community other than the individual who makes the decision to purchase, and thereby causes production to take place, the price should be set below marginal cost to the point where the sum of the price plus the value of the benefits thus generated for other members of the community, is equal to marginal cost. Conversely, where production or consumption of the product create a nuisance, price should be set above marginal cost to the point where price minus the value of the burden imposed on the rest of the community is just equal to marginal cost. These conditions ensure that production and consumption is carried to the point where the aggregate marginal social benefits, enjoyed by all members of the community, are just equal to the aggregate marginal costs imposed on them. A greater volume of production would involve a net loss to the community, less would mean potential gains foregone.

The telephone system may not be unique among utility services in the extent to which its existence and use creates external economies and diseconomies. However, most analysis of public utility pricing problems has proceeded on the premise that there are neither economies nor diseconomies, and its conclusions require substantial modification in the light of their undoubted existence.

(c) Treatment of Information and Transaction Costs

The usual assumption in economic theorizing is that information is perfect and that it costs nothing, and that transactions costs are also zero. While there are many areas of application where such assumptions are warranted, there are many where they are not. When ignored, they can lead to what has been termed "an irrational passion for impassionate calculation". It is possible to start with the concept of a "perfect" pricing system and work backwards to an admittedly imperfect one, scrapping some of the more elegant features of the ideal in exchange for savings in information or transaction costs. Since the cost of perfect information is probably infinite, and the costs of many components of nearly perfect information largely conjectural, it is probably more practical to start with a simplistic system with recognizable imperfections and to introduce complications only to the extent that it can be shown that the improvements in resource allocation or equity which can be obtained thereby are worth the added cost of implementation.

In the present context, flat rate pricing is, presumably, the most simplistic pricing system available. The general nature of its imperfections is well-known. Introduction of metered billing, in any of several forms, represents a move to a slightly more complex system which may or may not improve resource allocation and/or increase equity. What is certain is that it will cost more to gather and process the information required to make it work. No move to a metered billing system should be undertaken unless it is clear that the system has a high probability of producing social benefits in excess of the cost of installing and operating it.

(d) Economies of Scale

Departures from the strict marginal cost pricing rule, usually involving price discrimination in some form, may be required to make the operation of a utility financially viable and to ensure that aggregate benefits are at least equal to aggregate costs. We have reviewed the available evidence on economies of scale in the telephone industry and are unable to suggest, on the basis of our findings, whether this creates a serious problem or not. There is some evidence that there are economies of scale at the level of the firm. The "plant" concept as used in most industrial applications is difficult to apply in the telephone industry, since all of a firm's production facilities are interconnected; indeed for some purposes it might be appropriate to regard the entire North American telephone system as a single plant on these grounds. There is evidence, however, that the system in a single city can be expanded only under conditions of increasing cost. The observed decreasing cost of larger companies is apparently due to administrative economies. There seems to be ample evidence that increased utilization in a given system generates to short-run increasing costs.

If a piecemeal approach toward the introduction of added complexity into the tariff structure is introduced, as we suggest, it should be possible to ensure that solvency constraints are met at each step of the way.

(e) Second-Best Problems

It has been noted that, where prices of other commodities in the economy do not conform to the marginal cost pricing rule, as modified to allow for externalities, the imposition of marginal cost pricing in a single industry will ordinarily not produce a social welfare maximum, nor even the highest welfare level that can be attained by varying nothing but the prices and outputs of the industry in question. To attain even this "second-best" optimum requires systematic adjustment of prices and output in the industry in order to offset the effects of marginal cost-price discrepancies elsewhere. In general, the nature of these adjustments cannot be specified in advance. This theorem, due to Meade[1] as elaborated by Lipsey and Lancaster, is mentioned primarily to indicate that we are aware of its existence. We do not believe it is generally appropriate for administrators concerned with one segment of the economy to assume that those with similar responsibilities for other segments are not also attempting to secure optimum pricing and output in those segments, nor is it desirable that they attempt, in the present instance, to correct all of the inefficiencies or inequities which may exist elsewhere in the economy by fiddling with the price of telephone services.

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[1] J.E. Meade, Trade and Welfare, (London: Oxford, 1955) pp. 102 ff.

(f) Income Distribution

The basic presumption in our analysis is that this condition is fulfilled, and that the existing income distribution is either regarded as equitable by those who have the power to do something about it, or that it is being adjusted by other means. Even if it is not, the alteration of the incidence of telephone rates between different categories of customers on the basis of extent of use is perhaps one of the most inefficient re-distribution schemes imaginable.

(6) Externalities in the Production and Consumption of Telephone Service

(a) Externalities owing from connections

In some recent contributions to the literature on telephone rates, stress has been laid on the so-called "public good" character of telephone service.[1] This is little more than a formal expression of the fact, unrecognized long ago, that a given subscriber's connection to the telephone system is of value not only to him, but to other subscribers as well, who are thereby enabled to call him. In other words, his connection creates external economies or spillover benefits for existing subscribers. In this respect, telephone service differs from other utility services which are of no observable value to anyone but the consumer.[2] This brings the telephone service within at least one definition of a public good, that of Samuelson, who defines a public good as one in which "each individual's consumption of such a good leads to no subtraction from any other individual's consumption of that good".[3]

The Samuelson definition is so broad as to include almost every commodity which generates spillovers. While uncompensated spillovers are an important cause of potential market failure,[4] we do not believe that

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[1] R. Artle and C. Averous, "The Telephone System as a Public Good; Static and Dynamic Aspects." Bell Journal of Economics and Management Science, vol. 4 (Spring, 1973) pp. 89-100.

[2] Use of natural gas offers an apparent exception since consumption of gas may result in reduced emission of air pollutants. In this case, the spillover is due to a lack of controls on the emission of pollutants or to the failure of the legal system to impose any liability for emissions on the polluter. It is thus not intrinsic in the technology of the utility as in the case of the telephone.

[3] P.A. Samuelson, "The Pure Theory of Public Expenditure", Rev. of Economics and Statistics (November 1954), p. 387.

[4] F.M. Bator, "The Anatomy of Market Failure", Quarterly Journal of Economics, Volume 72 (August 1958): 351-79.

their existence is sufficient to convert the commodities into items which must be consumed collectively, i.e., provided as a free good by government outside the market mechanism. The problem of ensuring optimum output can be resolved in many instances by suitable pricing arrangements within the market sector under private or public ownership.[1] We would prefer to see the term "public good" reserved for commodities where it is impossible to effect such arrangements.

The essence of the public good argument is that the marginal social benefit of telephone service to a given subscriber i is equal to the sum of the marginal utilities of the subscriber A and of those other members of the community who might wish to call him.

Denoting the marginal utility of i's telephone to the jth individual in the community as MU_{ij}, marginal social benefit from the ith telephone is given by

$$MSB_i = MU_{ii} + \sum_{j \neq i} MU_{ij} \qquad (1)$$

It is the existence of the second term which creates the alleged difficulty. The individual i will become a subscriber only if price, here assumed to be equal to marginal cost, does not exceed his own utility. The conventional marginal conditions require that he be connected if price does not exceed MSB. Because the individual does not take into account the value of his connection to others, it is argued, some individuals will abstain from consumption even if the $MSB \geq MC$ relationship holds, and there will be underconsumption of the commodity. The argument is valid so far as it goes. Whether it constitutes a serious criticism of existing rate structures is another matter.

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[1] R.H. Coase, "The Problem of Social Costs," Journal of Law and Economics, vol. 3 (October 1960) pp. 1-44.

First of all, it should be noted that telephone service is, for reasons indicated above, an increasing cost industry in at least one important sense. This is a basic characteristic which has remained and seems likely to remain despite technical advances. This being the case, the additional subscriber imposes additional costs (via the complexity of the system) on existing subscribers. The additional subscriber for whom personal benefits just equal price should not be connected unless the spillover benefits he creates for other subscribers exceed the additional costs he imposes on them. If prices were set to equal marginal costs, this condition would automatically be fulfilled, and market failure could result. But existing rate structures do not reflect marginal costs; insofar as they are cost-related they reflect average costs, which in the circumstances are less than marginal costs.

The individual will therefore be induced to subscribe even if his own marginal utility is less than the marginal cost of serving him. Market failure may still result, depending on the extent to which the implicit price subsidy MC-AC is greater or less than the spillover benefits $\sum_{j \neq i} MU_{ij}$. While there is no guarantee that there will be a precise balance, there is no longer any certainty that the service will be underconsumed.

Existing rate structures of telephone companies involve higher rates in service areas where there are larger numbers of subscribers. The practise has been justified both by reference to the increasing cost characteristics of local systems and a value-of-service grounds.[1] For practical reasons, rates are not varied continuously, but are in blocks reflecting community size, which may be regarded as approximating average

[1] Cf. Home Telephone & Telegraph Co. v. Public Service Commission, P.U.R. 1922B, 478.

costs. Ignoring these discontinuities, and treating the relationship as continuous, an additional consumer will generate marginal revenue for the system in excess of the amount he is charged, because everyone else's subscription charge will be increased.

As a consequence, of the increase in price, some subscribers (those for whom the utility obtained from the new connections exceeds the increase in price) will remain as subscribers, while others (for whom the increase in price more than offsets not only the gain in utility from the new connection but any consumers surplus previously enjoyed) will cancel, and cease to be subscribers.[1] It would appear, however, that as long as revenues of the system are expanding, the gains in welfare of the new subscribers and of those who remain as subscribers exceed the losses of those who withdraw.

The probable magnitude of the external utility gain which results from the addition of new subscribers to the system is likely to be a decreasing function of the fraction of the population covered. A single subscriber would have nobody to talk to, and would perhaps obtain substantial gains from the first few additions to the system. He might in fact obtain greater utility from the addition of these first few customers than from his own connection. Successive increments would, on the average, yield successively smaller gains; the gain to the rest of the community from the connection of the last household or business remaining in the community would be relatively trivial.

[1] Income effects are ignored in this discussion. Since the average telephone bill in Canada represents a small fraction of the typical family budget, it seems a safe assumption that any income effects will be of the second order of smalls, and that, by implication, the marginal utility of money can be assumed constant. The argument may not be applicable in other countries where telephone bills constitute a larger fraction of the typical consumer's budget. The Canadian system allows connection for a service charge which is relatively low in comparison with other systems and permits low-income customers, or at least those low-income customers with acceptable credit records, to finance their consumption of the service on a pay-as-you go basis. The high connection charges of many foreign systems, eg., the U.K., are a strong deterrent to low-income consumers, even if the equivalent cost is comparable.

This type of relationship seems to be implicitly accepted in existing block rate structures, which impose higher rates for subscribers in local systems of varying sizes.

The Bell Canada rate structure for systems of varying sizes is as follows:

Size of System	Annual Flat Rate - Individual Residence
1 - 2,000 phones	47.40
2,001 - 5,000 phones	51.00
5,001 - 10,000 phones	54.00
10,001 - 20,000 phones	57.60
20,001 - 50,000 phones	60.60
50,001 - 100,000 phones	64.80
100,001 - 250,000 phones	69.60
250,001 - 750,000 phones	73.20
750,001 - 1,750,000 phones	76.20
1,750,001 - 2,750,000 phones	83.40
2,750,001 - 3,750,000 phones	90.00

This structure implies a charge for access to additional telephones at the following annual rates:

For the first	2,000	telephones,	$ .0237	per telephone
for the next	3,000	telephones,	.0012	per telephone
for the next	5,000	telephones,	.0006	per telephone
for the next	10,000	telephones,	.00036	per telephone
for the next	30,000	telephones,	.00010	per telephone
for the next	50,000	telephones,	.00008	per telephone
for the next	150,000	telephones,	.00003	per telephone
for the next	500,000	telephones,	.00001	per telephone

etc.

The annual charges for the additional system connections are small; the utility of most of them to the average consumer is equally small. Most people could get along nicely with a system involving 2,000 phones, if they could determine who was to be connected to their personal system. The possibility of providing selective access so that the individual could determine how many others he was connected with is probably out of reach with today's technology.

Considerations along these lines suggest also that the subscription charge-marginal cost difference ought to be larger in communities where relatively low saturation exists than in communities where saturation is high, as is typically the case in Canada. To the extent that a message charge is a means of keeping the subscription charge low, it is apt to be more justified in overseas communities where the telephone market is underdeveloped than under typical Canadian conditions.

There is a second type of externality associated with increases in the number of connections to the system which is mentioned here only for the sake of completeness. Where above ground wires are used in the system, and are a source of disamenity or visual pollution, additional connections which increase the density of wires create a negative externality. If, however, they create a situation in which density is such that a change to underground wiring results, they may generate external benefits. This situation is probably not one which is appropriately handled by the choice of rate structures, what is required is a decision in particular situations to put wires underground and adjust rate levels accordingly. Such costs should be borne by all subscribers in the local system rather than by those who happen to be connected to underground cables, since the externalities are general in their incidence.

(b) Externalities Arising from Use

So far we have concentrated on externalities arising from connection to the system, which may yield benefits even if the connection is never used, as does a fire alarm system. Use of the system does, however, create benefits for, and impose costs on, individuals using the system in addition to the individual who places the call.

The most obvious of these external effects is that on the person called. While some calls, i.e., those from heavy breathers and bill collectors probably create negative benefits for the recipients, most calls involve an exchange of information which is beneficial to both parties. Appreciation of a call charge which reflected the marginal cost of the call would lead to an inappropriately restricted utilization of the system, since calls would be unlikely to be made unless the marginal utility to the caller exceeded the price. Optimum utilization, in general would seem to dictate that the call should be made if the sum of the marginal utilities of the sender and receiver of the call exceed or even equal the cost. This could be obtained under metered billing if both sender and receiver were billed; the latter could avoid the charge by refusing to answer. We are inclined to dismiss this solution out of hand, since any widespread reluctance to answer the telephone would decrease the value of the entire system. If a calling charge is to be adopted, it should be restricted to the caller, who is the maker of the decision to call or not to call. Some calls are primarily of benefit to the maker, some to the recipient. On the average, however, and ignoring nuisance calls, it seems plausible to argue that benefits are approximately equal. This implies that the price should be set equal to one half of the marginal cost of providing the call if an efficient use-pattern is to be established. The nuisance call problem remains, of course. It should be pointed out, however, that there is already, a special message charge for obsene calls, in the Criminal Code, though the collection machinery may be too inefficient to reduce the incidence of such calls to the optimum level. If other categories of nuisance calls pose a problem, they can be handled in a similar manner, e.g., by a special tariff for collection agencies (not necessarily under the Criminal Code).

Benefits to the recipient are not, however, the only form of externality created by use of the telephone system. At least at certain periods, use of the system may tie up lines or exchange facilities so that connection with a called number is delayed or a busy signal results, so that its value to other would-be users is reduced. These externalities may be termed congestion costs. These may be very significant indeed if they prevent emergency calls from reaching doctors, fire departments or police, or result in the frustration of an important business transaction. The frequency with which such costs are incurred in most Canadian systems is relatively slight, but they are incurred. In comparison, similar congestion costs on European systems are much higher, as anyone who has ever used phones in Britain or, more particularly, in Paris will testify.

Actual congestion costs may be measured as a product of the frequency with which calls are rendered incomplete by virtue of congestion, times the mean cost per call. for operations well below system capacity, they are apt to be very close to zero. As the call-handling capacity of the system is approached, the frequency of incomplete calls is increased and the cost mounts; it would become effectively infinite if no calls could be completed. These congestion costs will vary with time of day, and possibly from one day of the week to the next.

Optimum utilization of a system in which congestion costs are non zero requires that output be carried to the point where marginal utility to the caller, plus marginal utility to the recipient, minus congestion costs imposed on third parties, is just equal to the cost of providing the service. In terms of the approximation presented above, price should equal one half of marginal cost, plus any congestion cost imposed on other users.

Congestion cost is of course a short-run phenomenon; congestion costs incurred at the system peak will be reduced if the system is expanded in terms of its call-handling capacity. Receipts under a congestion toll provide a measure of the congestion costs inherent in a given capacity, and the system should be expanded whenever the costs of alleviating congestion are less than the costs of allowing it to continue to exist. This matter is discussed more fully in the mathematical appendix.

The Need for a Solvency Constraint

One of the conditions we impose on an optimal pricing system for a telephone service is that it should yield revenues which are sufficiently great to cover the costs (including the contractual and/or opportunity costs of capital employed) of the system. The requirement for such a condition in the case of a system operated under private ownership is obvious enough, unless it is met the system will eventually dissipate its capital and become a financial failure. This does not dispose of the matter, however; costs could be covered by a continuing subsidy to a private carrier. Alternatively the carrier could be transferred into public ownership and its deficits met out of general revenues. If there were no economic case for a solvency constraint on the pricing system, there would be an implicit case for such a subsidy or for public ownership.

Long run optimality conditions for resource allocation require that there be an excess of aggregate benefits over aggregate costs for any resource using activity. If not, it should not be undertaken at all, or if in existence, and costs are "sunk" it should be phased out at the point as soon as benefits fail to cover the out-of-pocket costs of its continuation. However, unless forced by the pricing system to reveal the amount they are willing to pay for the service, those who benefit from its existence have every incentive to exaggerate its value to them in order to encourage its continuation. The imposition of a pricing system which requires the benficiaries of a service to cover its full costs is one means of ensuring that the long-run optimality conditions are met; it is perhaps the most effective tool available for doing so.[1]

[1]N. Ruggles, op.cit.,
R.A. Coase, op.cit.,

R.N. McKean & J.R. Minasian, "On Achieving Pareto Optimality - Regardless of Cost" Western Economic Journal, vol. V (December 1966).

Where there are important external benefits extending to non-users of the service, who cannot be charged directly, there may/will be a case for removing such a constraint. We do not believe that the telephone system generates such externalities in most cases; there may be an exception in thinly populated Northern areas. We therefore conclude that telephone service, whether publicly or privately produced, should be sold on a basis whereby the full costs are recovered from the users of the service.

Conclusions and Recommendations

The analysis above suggests that, in the absence of metering costs, an ideal pricing system for a telephone utility might involve

(a) a standing charge, for connection with the system, in an amount sufficiently below the marginal cost of providing the connection to compensate for the external benefits created for other subscribers;

(b) A message charge, fixed at approximately one half of the marginal cost of "producing" the message (to allow for the positive spillover to the party called) plus a congestion charge that reflects the negative spillover imposed on other would-be users of the system,

with such appropriate modifications as might be necessary to ensure solvency of the carrier. The precise measurement of marginal costs is, of course, impractical. Approximate measurements are, however, relatively simple. Thus, for example, marginal cost of a call is less than \$.01 nor more than \$.04 in most Canadian systems, and the probable value lies between \$.01 and \$.02. These conclusions must be modified, however, in the light of the fact that metering calls, on that portion of the system using electromagnetic switching would require substantial investment and be relatively expensive to operate; the order of magnitude of metering cost would be approximately the same as the present marginal cost of making a call. Where electronic switching has been installed, metering could be applied at perhaps one tenth of this cost level.

In an earlier article, we examined the question of metering costs and rate structures in a context in which externalities were ignored.[1] Applying similar reasoning to the more comprehensive model developed here, similar conclusions emerge. Given a marginal cost per call of $.01 to $.02, the appropriate per call charge is likely to be $.01 or less, except when a congestion charge is added. Congestion costs are incurred only during the peak periods of operation; the optimal structure would by implication involve application of a time-of-day tariff with higher charges at peak hours to spread the peak more evenly. In the off-peak periods, no congestion charge would be added, and the ideal price is more closely approximated by a zero price than by a marginal cost price with present metering costs added.

The metering costs required to implement a time-of-day tariff would be even larger than those contemplated in our earlier study, and would impose a major burden on the off-peak uses with little or no offsetting benefit; there is no particular point in attempting to discourage off-peak use. It is doubtful whether the reduction in peak use such a tariff would lead to efficiency savings large enough to offset the metering cost.

If we move a step into the future, however, the picture changes. Electronic switching systems permit, as we have noted, cheaper metering than the systems which are currently in use in most parts of the system. The metering cost reduction is in the order of 80-90%, and time of day metering and billing can be added fairly simply.

Once electronic switching has taken over the bulk of the system, (present technology may linger on in other parts for years, as did the hand

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[1] G.D. Quirin and G.F. Mathewson, op.cit. See this article also for a discussion on costs of metering on electronic switching systems.

cranked phone in rural areas) the present case for not metering which is based on the need to cover metering costs, collapses. At this point, we believe, it will be desirable to consider the application of metered billing seriously. Such a tariff should, in our view, have at least two different and distinct message charges, one for off-peak calls and one or more for alternative peak hours. It may be desirable to leave the off-peak message rate at zero, and to charge only for calls made at the peak.

Our recommendations are therefore that

(a) no amendment in the structure of the tariff (opposed to its level) in a given market until the percentage of the market provided with electronic switching is large enough to permit the use of metering without altering the marginal cost of a call by a significant amount.

(b) When this point is reached, that a two part tariff be introduced which consists of

(i) a monthly connection charge

(ii) a per call charge on calls initiated during peak hours only.

Off-peak calls should continue to be charged at a zero rate.

Appendix

Introduction

A previous paper by Mathewson and Quirin[1] argued that metering costs would appear to be prohibitively expensive relative to the net potential gains in consumer surplus from lowering subscription rates and charging positive prices for local calls. The model developed in this appendix improves upon our previous analysis in two significant ways. First, our previous assumption of independent demand functions for subscriptions and calls made to facilitate the calculation of consumer surplus as the area under the demand curves seems unduly restrictive. Demand functions which depend solely on own-price are consistent only with additively separable utility functions, a very limiting assumption. Here this assumption is dropped in favour of a more general specification of consumer utility. In turn, alternative pricing schemes are analyzed in terms of a more general social welfare specification rather than consumer surplus calculations. This is accomplished through the extension of a public utility pricing model developed by H. Mohring.[2]

Secondly, as outlined in the text, our previous paper did not take into account the impact on pricing of the public good nature of the connection to the telephone system by a subscriber.

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[1] G.F. Mathewson and G.D. Quirin, "Metering and Marginal Cost Pricing in Public Utilities", Bell Journal of Economics and Management Science, Vol. 3 (1), Spring 1972, pp. 335-339.

[2] H. Mohring, "The Peak Load Problem with Increasing Returns and Pricing Constraints", AER, September 1970, pp. 693-705.

The model presented in this appendix represents a generalization of both the papers by Artle and Averous[1] and Squire.[2]

Model

There are two models presented in this appendix. First, a brief model of a typical consumer's decision process is presented; second, the resulting consumer behaviour feeds into a social welfare function where the public sector determines optimal prices so as to maximize this social welfare subject to resource and budget constraints.

Consider a society where there are I consumers each of whom set out to maximize a utility function of the type

$$U^i = U^i (y^i, z^i) \quad (1)$$

subject to $$z^i = F^i (X_1^i, X_2^i; X_3^i) \quad (2)$$

and $$y^i + p_1 X_1^i + p_2 X_3^i = r^i - h^i \quad (3)$$

y^i measures physical units of a numèraire good; z^i measures a characteristic of the communications system which in turn is generated through a consumer production function F^i which depends upon three variables, X_1^i, the number of accesses to the telephone system by consumer i, X_2^i, the number of calls in the system initiated by consumer i, and X_3^i, consumer i's perception of quality in the communication system.

As outlined in the text, the assumption is that the greater the number of accesses to the system by other consumers, the greater the quality

[1] R. Artle and C. Averous, "The Telephone System as a Public Good: Static and Dynamic Aspects", Bell Journal of Economics and Management Science, Vol. 4 (Spring 1973) pp. 89-100.

[2] L. Squire, "Some Aspects of Optimal Pricing for Telecommunications", Bell Journal of Economics and Management Science, Vol. 4 (2), (Autumn 1973) pp. 515-525.

of the system to each consumer. As well, the more calls there are in the system, the greater the likelihood that any one consumer will receive a call which increases his perception of quality. Finally, the greater the probability of completing a call through the system, the higher each consumer's perception of quality in the system. Specifically, if we assume that communications systems which are more capital intensive, i.e., have larger switching equipment, imply that the probability of completing calls is higher, we may specify the quality variable for consumer i as $X_3^i = X_3^i\ (X_1^j,\ X_2^j,\ K)\ j \neq i,$ where K represents units of physical capital used to operate the telephone system. Increased number of accesses by other consumers, increased number of calls in the system and increased capital intensity of a system yield higher levels of quality for the typical consumer. More formally, $\partial X_3^i/\partial X_1^j,\ \partial X_3^i/\partial X_2^j, \partial X_3^i\ /\ \partial K > 0$.

Finally, equation (3) for each consumer constitutes a budget equation where r^i is the value of the flow of basic resources held by consumer i and h^i measures a head tax levied by the public sector on consumer i.

For the typical consumer the decision variables are $(y^i,\ X_1^i,\ X_2^i)$ and the maximization exercise yields the demand equations

$$y^i = y^i\ (p_1,\ p_2,\ r^i,\ h^i\ ; X_3^i\ )$$

$$X_j^i = X_j^i\ (p_1,\ p_2,\ r^i,\ h^i\ ;\ X_3^i)\ ,\ j = 1,\ 2\ .$$

As a zero price on local calls is the covention in North America, i.e., $p_2 = 0$, we need to assume an upper bound on the number of calls made when p_2 is zero.

i.e., assume $\bar{X}_2^i = X_2^i\ (p_1,\ 0,\ r^i,\ h^i\ ; X_3^i) < \infty$

For the purposes of interpretation, we may view the typical consumer's decision process as a two-part process. First, as a producer of z^i, each consumer selects his input bundle (X_1^i, X_2^i) so as to minimize his expenditure on the inputs X_1^i, X_2^i for each desired level of z^i. This yields a cost function $C^i = C^i\,(z^i, p_1, p_2\,; X_3^i)$. Secondly, as a buyer of z^i and y^i, each consumer maximizes his welfare subject to $y^i + C^i\,(z^i, p_1, p_2\,; X_3^i) = m^i - h^i$. This yields the demand equations.

If we assume that the production function for z^i is concave (i.e., $F_1^i, F_2^i > 0$, $F_{11}^i \cdot F_{22}^i - (F_{12}^i)^2 > 0$) then C^i is convex in z^i, $C_z^i > 0$, $C_{zz}^i > 0$. Furthermore, $C_{p_1}^i = X_1$, $C_{p_2}^i = X_2$, $C_{3p'}^i, = \frac{1}{F_1^i}$, $C_{zp_2}^i = \frac{1}{F_2^i}$. These properties together with the assumption of the concavity of the utility function for each consumer guarantee that X_1^i and X_2^i are complements, i.e., $\partial X_j^i / \partial P_k < 0$, $j,k = 1,2$. This is the property we would expect for the goods, access to the system, and calls in the system.

Given these demand equations for phones, calls and all other goods, the appropriate setting is to permit the public sector to maximize a social welfare index defined over the welfare levels of all consumers by selecting p_1, p_2, K, h^i. Formally, this may be defined as

$$\max_{p_1, p_2, K, h^i} \quad W = W\,(U^1, \ldots, U^I) \tag{4}$$

There are a number of constraints imposed on the system.

(1) A resource constraint.

This constraint requires the resources used in the system to be equal to the resources available in the system. We make the assumption of no unemployed resources.

This constraint may be expressed as

$$R - Y - C\,(X_1, X_2, K) - K - mX_2 = 0 \tag{5}$$

Here, $R = \sum_i r^i$ represents the total resources available in the economy, $Y = \sum_i y^i$ represents the aggregate demand for the numèraire good, $X_1 = \Sigma X_1^i$ represents the aggregate demand for accesses to the system, $X_2 = \sum_i X_2^i$ represents the aggregate demand for calls in the system, C measures the variable costs of producing accesses and calls and metering accesses in the system, m measures the metering costs per call, K measures the cost of capital in the system.

(2) a non-deficit constraint.

Conventionally in North America, telephone systems are constrained to be self-supporting. In the absence of internal economies of scale, this constraint should not represent a problem. Formally, this constraint may be expressed as

$$p_1X_1 + p_2X_2 - C(X_1,X_2,K) - K - mX_2 \geq 0 \qquad (6)$$

Maximizing social welfare subject to the resource and non-deficit constraints for interior solutions is tantamount to setting the appropriate derivatives of the relevant Lagrangian expression to zero. The relevant Lagrangian expression may be written as:

$$L = W(U^1,\ldots, U^I) + \mu\,(R - Y - C(X_1,X_2,K) - K - wX_2) + \eta(p_1X_1 + p_2X_2 - C(X_1,X_2,K) - K - mX_2) \qquad (7)$$

For the optimal capital stock, the first-order condition is

$$\sum_i W_i \; U_z^i \, F_{X3}^i \, X_{3K} + (\mu+\eta)\,(-C_K - 1) = 0 \qquad (8)$$

This equation says that capital should be expanded until an additional dollar of capital expense is offset by a dollar of the sum of savings in variable costs plus the social welfare from an increment in quality weighted by the inverse of the sum of two shadow prices, the value of an additional unit of all purpose resource plus an additional dollar of profits. This determines the optimal capital stock and the optimal congestion in the system

The maximization of L with respect to p_1 and p_2 is simplified by the use of a duality theorem developed by E. Silberberg.[1] With the use of this theorem and by substitution of the first-order equation for the maximization of L with respect to h^i, without presenting the mechanics, the following optimal price equations are developed:

$$p_1 \leq C_1 - \frac{1}{\mu+\eta} \quad \frac{1}{S} \quad [\eta \; (S_{22}X_1 - S_{21}X_1) + (S_{22}\, Qp_1 - S_{21}Qp_2)] \qquad (9)$$

$$p_2 \leq C_2 + w_2 - \frac{1}{\mu+\eta} \quad \frac{1}{S} \quad [\eta \; (S_{11}X_2 - S_{12}X_1) + (S_{11}\, Qp_2 - S_{12}Qp_1)] \qquad (10)$$

S is the determinant of the matrix of pure substitution terms summed over consumers.

$S_{jk} = \sum_i S^i_{jk}$ where S^i_{jk} is the substitution term S_{jk} for individual i.

$$Q_{p_1} \equiv \sum_i W_i \, U^i_z \, F^i_{X_3} \; (X^i_{3p_1} - X^i_{3h} \, X^i_1);$$

$$Q_{p_2} \equiv \sum_i W_i \, U^i_z \, F^i_{X_3} \; (X^i_{3p_2} - X^i_{3h} \, X^i_2) .$$

Qp_1 and Qp_2 are respectively the weighted sums of the changes in social welfare through the effect on each consumer's utility of changes in other consumers' access and call decisions due to price changes on each individual's perception of quality in the phone system.

Equations (8), (9), (10) are analogues for this system of the corresponding first-order conditions developed by Mohring.

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[1]E. Silberberg, "Reciprocity and Duality", Western Economic Journal, March 1972, pp. 95-103.

Interpretation and Comparison with Other Studies

Our previous paper ignored any externality of effects, i.e., $Q_{p_1} = Q_{p_2} = 0$. We argued that based on estimates of m, plausible demand elasticities, the independence of the demand for accesses and calls ($S_{12} = S_{21} = 0$) and ignoring any distributional effects, a zero price on local calls with the subscription price set above marginal cost to satisfy the non-deficit constraint appeared to be socially optimal.

In terms of (9) and (10) this is tantamont to arguing that at $P_2 = 0$ the marginal social welfare from additional calls still exceeds the social opportunity costs of the resources.

$$\text{i.e.,} \quad p_2 < C_2 + m_2 - \frac{\eta}{\mu+\eta} \frac{1}{S} S_{11}X_2$$

However, p_1 admitted of an interior solution and as the non-negative profit constraint was binding (i.e., $\eta > 0$) p_1 should be set above marginal cost as $S > 0, \mu > 0, S_{11} < 0\ X_1 > 0$

$$\text{i.e.,} \quad p_1 = C_1 - \frac{\eta}{\mu+\eta} \frac{1}{S} (S_{22}X_1)$$

Additional Terms and Observations

The presence of non-zero S_{21}, S_{12} terms relax the demand conditions to permit complementarity (or substitutability) between the two goods. If the social welfare function with constraints admits of an internal maximum for the selection of p_1 and p_2 then (still ignoring spillovers),

$$p_1 = C_1 - \frac{\eta}{\mu+\eta} \frac{S_{22}X_1 - S_{21}X_2}{S_{11}S_{22} - S_{12}S_{21}}$$

$$p_2 = C_2 + m - \frac{\eta}{\mu+\eta} \frac{S_{11}X_2 - S_{12}X_1}{S_{11}S_{22} - S_{12}S_{21}}$$

These equations are identical to those appearing in Mohring p. 697. Only the accompanying story is slightly different. If calls and accesses are compliments then $S_{12} < 0$. Then it is plausible that values of S_{11}, X_1, S_{12}, X_2 are such that it would be optimal to set p_2 below marginal production and metering costs.

Squire's solution emerges from equations (9) and (10) by setting $S_{12} = 0$, i.e., holding system size or number of accesses to the system constant.

Then (10) for an internal maximum becomes

$$p_2 = C_2 + m - \frac{\eta}{\mu+\eta} \frac{1}{S} (S_{11}X_2) - \frac{1}{\mu+\eta} \frac{1}{S} (S_{11} Q_{p_2}) .$$

If Q_{p_2} reflects the marginal social welfare accruing to members of society, weighted by their marginal social welfare weights, from the increased perception of quality due to receiving a call then $Q_{p_2} < 0$.

If, as in Squire's analysis, there is no deficit constraint, then $\eta = 0$ and $p_2 = C_2 + w_2 - \frac{1}{\mu}\frac{1}{S} (S_{11} Q_{p_2})$.

Then we obtain the result that the price of a call should be set below the marginal cost of a call.

Squire's equation determining the optimal price for a phone in the presence of an internal maximum may be derived from (9) with a non-binding deficit constraint ($\eta = 0$).

$$P_1 = C_1 - \frac{1}{\mu}\frac{1}{S}(S_{22} Q_{p_1} - S_{21} Q_{p_2})$$

If $S_{22} < 0$, $S_{21} < 0$, $Q_{p_1} < 0$, $Q_{p_2} < 0$.

Then the sign of the expression $S_{22} Q_{p_1} - S_{21} Q_{p_2}$ is uncertain.

Squire's methodology requires a strange asymetry $S_{21} > 0$, yet $S_{12} = 0$. Equality of cross-substitution terms weakens Squire's conclusion for then the sign of $(S_{11} Q_{p_2} - S_{12} Q_{p_1})$, the net addition or substitution from the marginal cost of a call to determine optimal price, is also ambiguous.

If the profit constraint is binding as well then there is an additional expression in each of the first-order equations which has an ambiguous sign and consequently an ambiguous effect on the optimal deviation of price from marginal cost.

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Appendix A

Some U.S. Examples of Metered Billing

Rates cited are for individual residential use for the year 1970.

Business metered rates are available in most areas.

Source: Exchange Service Telephone Rates (in effect June 30, 1970). National Association of Regulatory Utility Commissioners, Washington, D.C.

Description of areas and exchanges where metered rates may be used	Minimum Monthly Charge (Min.)	Message Units Allowance (MUA)	Additional Message Unit (AMU)
California:			
Orange County	$3.30	60	$.0405
San Diego	3.10	60	.0405
Los Angeles	3.00	60	.0405
San Francisco Bay Area	3.00	60	.0405
Connecticut:			
Hartford (on experimental basis)	4.35	45	.075
Bridgeport	4.10	45	.075
Maryland:			
Exchanges with over 500,000 telephones	Rates vary depending on size from $6.40 (Min.) for 60 MUA to $9.10 (Min.) for 65 MUA. AMU for all sizes is $.05		
Massachusetts:			
Boston Metropolitan Area Exchange	Rates vary depending on size from $4.00 (Min.) for 50 MUA to $9.90 (Min.) for 90 MUA. AMU for all sizes is $.05.		
Pennsylvania:			
Pittsburgh -- Local calling area	4.40	65	.04
Philadelphia - primary calling area	4.65	70	.04

Appendix A (cont'd)

Description of areas and exchanges where metered rates <u>may</u> be used	Minimum Monthly Charge (Min.)	Message Units Allowance (MUA)	Additional Message Unit (AMU)
Rhode Island:			
Providence Zone	$5.45	30	$.05
Pawtucket Zone	5.20	30	.05
Warwick Zone (primary calling area)	5.20	30	.05
Virginia:			
Virginia Zones of the Washington Metropolitan Exchange Area	6.25	50	.05
Wisconsin			
Madison - exchanges over 100,000 telephones to 125,000 telephones	4.80	60	.06
All exchanges over 125,000 to 150,000 telephones	4.90	60	.06
Milwaukee Metropolitan Area	5.45	60	.06

Appendix B

Exceptions to Flat Rate Billing in U.S.

Source: Exchange Service Telephone Rates (in effect June 30, 1970). National Association of Regulatory Utility Commissioners, Washington, D.C.

	Min.	MUA	AMU
Illinois:			
Chicago - Primary Calling Area			
(1)	$ 5.60	80	1st 1125 @ $.0475
(2)	$ 7.85	140	remainder @ $.0425
(3)	$10.10	200	
New York:			
Bronx	5.80	75	.055
Brooklyn to Manhattan	6.08	75	.055
Queens			
(1)	6.08	75	.055
(2)	5.80	75	.055
White Plains, New Rochelle, Mount Vernon, Yonkers, and other suburbs	5.53	75	.055

QUIRIN, G.D.
Metered billing in telephone rates

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