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EFFICIENCY VERSUS SOCIAL OPTIMALITY: THE CASE OF TELECOMMUNICATIONS PRICING

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Most policy analysis is based on the twin concepts of efficiency and equity. Of these twins, efficiency is undoubtedly the favourite child — analysis usually comprises a lengthy discussion of the efficiency consequences of the proposals under consideration, with some brief and informal remarks about equity.

The emphasis on the efficiency consequences of policy can be justified in two ways. First, it may be claimed that whatever its faults as a social objective function, efficiency can be defined precisely. Furthermore, under appropriate assumptions about aggregation, efficiency effects can be estimated on the basis of aggregate supply and demand data. A simple example is the estimation of the 'deadweight' efficiency costs of a tax (or more generally, a departure from competitive prices) using the Harberger triangle approach, which requires only an estimate of the elasticity of demand. Thus, under appropriate assumptions, efficiency effects can be estimated reasonably accurately on the basis of limited evidence.

It is not clear, however, that it is useful to obtain a precise measure of what is, at best, a partial indicator of the value of a proposal. The second argument in favour of the emphasis on efficiency is that equity problems should be dealt with through the tax and social security systems. All other policy decisions, it is claimed, should be based solely on efficiency considerations.

Informal support for this claim may be derived from a linear Tinbergen policy model, in which each instrument should be assigned to one, and only one, target. More formally, it may be argued that, assuming the availability of lump-sum transfers and taxes, the net surplus yielded by efficient policies can be redistributed to yield a social welfare improvement, which may be, but need not be, a Pareto-improvement. As the

Industry Commission (1991), puts it:

> ... the pursuit of economic efficiency is not an end in itself but a means to achieving a more productive economy. This means a greater capacity to do more about social justice, to alleviate poverty and disadvantage through income transfer payments and welfare services and to pursue other community objectives.

This argument breaks down once it is admitted that no lump-sum transfers and taxes are available (Quiggin (1995). The basic intuition is given by the comparison between a Harberger triangle and a transfer rectangle. For a small departure from competitive pricing, the efficiency cost is second-order, while the transfer is first-order. If the transfer substitutes for costly redistribution though tax and social security, a Pareto improvement may be achieved relative to the case where policy instruments are assigned separate efficiency and equity targets.

In this paper, these arguments are developed further with an application to utility pricing. In particular, the data used by Albon (1988) in his analysis of telecommunications pricing is re-analysed. Using the standard efficiency framework, Albon estimates that a doubling of access charges, with the proceeds being used to cut long-distance charges to marginal cost levels, would generate welfare gains of $212 million. Using an analysis that takes account of the cost of redistribution through the tax welfare system, it is argued that Albon's proposed policy would in fact reduce welfare. The optimal policy would involve a reduction in cross-subsidy, but not its elimination.

Given that nearly all households are connected to most utility services, a fixed access charge is approximately equivalent to a poll tax or a negative uniform payment to all individuals in the relevant jurisdiction, sometimes referred to as a demogrant. Hence, the impact of such a charge can, if desired, be cancelled out by an appropriate uniform payment to individuals or households.

Households using a utility service usually face a two-part pricing scheme, involving both a fixed access charge and a usage charge which varies with the amount used. If the usage charge is greater than the marginal cost of provision, a deadweight loss, analogous to the deadweight cost of a tax, will result. Consider a policy program in which the access charge for a utility is increased and the proceeds are used to reduce usage charges, making them equal to the marginal cost of provision. Simultaneously, an increase in taxation is used to finance a uniform payment exactly offsetting the increase in access charges. In terms of the efficiency–equity framework, the first part of this program, dealing with utility pricing is guided by the efficiency objective, while the second deals with the equity consequences

This combination of policies will be welfare-improving and, under ideal assumptions, Pareto-improving, if and only if the welfare benefit associated with the imposition of the access charge and the associated reduction in usage charges exceeds the deadweight cost of the taxation used to finance the uniform payment. Conversely, if this condition does not hold, a welfare gain may be made by reducing access charges and raising usage charges while reducing existing uniform payments and taxes.

In the present paper, this issue is addressed. Conditions are presented under which a socially optimal combination of access charges and usage charges may be determined. A simple approximate rule based on the elasticity of demand and the deadweight cost of taxation is also derived. The optimal usage charge will normally exceed marginal cost. The analysis is applied to data presented in an efficiency-based analysis of Australian telecommunications policy by Albon (). It is shown that the policy of setting prices equal to marginal cost, advocated by Albon, will result in significant reductions in welfare relative to the optimal pricing structure derived on the basis of the analysis presented here.[1] Finally, recent developments in telecommunications pricing policy and their impli-

[1] The main aim of this paper is to compare the efficiency-based approach and an approach based on welfare-maximisation, using the case of telecommunications as an illustrative example. The paper is not intended primarily as a critique of Albon's estimates.

cations for the analysis presented here are discussed.

1 The utility pricing problem

We consider a case where the government has two tax–transfer policy instruments: a proportional income tax, levied at a rate τ; and a uniform payment $\overline{w}$, ,expressed in terms of a Hicksian composite good. The government is subject to a balanced budget constraint. The per capita payment is assumed to be lump-sum, but the tax is associated with a proportional welfare loss $\phi(\tau)$, with $\phi'(\tau) \geq 0$, $\phi''(\tau) \geq 0$. Assuming that average gross income is y, the balanced budget constraint implies

(1) $$\overline{w} = (\tau - \phi(\tau))y - g$$

where e is per capita expenditure.

Suppose that a good x, which will be called phone calls is produced, using the Hicksian composite good as an input. Production is characterised by scale economies, so that the cost function, with per capita output as the independent variable and per capita input use as the dependent variable is a concave function $C(x)$.

The government also has two general policy instruments available in setting charges for phone users. Phone calls are supplied at a unit price p, with a per capita access charge a. The government pays any loss and receives any profit. We assume, for simplicity, that this is the only activity of government so that

(2) $$g = C(x) - px - a\ .$$

Individuals allocate their income between phone calls and the Hicksian composite good denoted z so as to maximize a utility function $u(x_i, z_i)$, where x_i is the number of phone calls consumed by individual i, and z_i is consumption of the Hicksian composite. We define income net of tax and transfers for an individual with pre-tax income y_i,

(3) $$m_i = (1- \tau)y_i + \overline{w}\ .$$

The budget constraint for individual i is

(4) $$m_i = z_i + px_i + a\ .$$

This implies the first-order condition

(5) $$u_x/u_z = p\ .$$

For simplicity we assume that u is homothetic, so that x_i/z_i depends only on p. Hence, per capita consumption is a function $x(p, m)$, which is linearly homogeneous in m and independent of the distribution of net income. Under the stated assumptions, $u(x^*_i, z^*_i)$ is monotonically increasing in m_i and hence in y_i. We define the indirect utility function

(6) $$u(m_i, p) = \text{argmax}\{u(x, z); m_i = z_i + px_i + a\},$$

and the expenditure function

(7) $$e(u, p).$$

Define $p^0 = C'(x)$. The equivalent variation for consumer i associated with a price p is

(8) $$EV_i = e(u(m_i, p), p^0) – m_i,$$

and the mean equivalent variation is EV(p). The change in per capita costs associated with p is

(9) $$\Delta(p, m) = C(x(p, m)) – C(x(p^0, m)).$$

Define the mean cost associated with a price p and average post-tax income m, expressed as a proportion of pretax income, as

(10) $$\Gamma(p, m) = [\Delta(p, m) - \mathrm{EV}(p, m)]/y.$$

It is easy to derive:

Lemma 1: $\Gamma(p)$ is non-negative and convex, taking the minimum value 0 at p^0.

We now consider the policy problem. We first rank the individuals in decreasing order of pre-tax income, so that $y_1 \geq y_2 \geq ... \geq y_N$. Observable demands define u only up to a monotone transformation, and we may therefore assume without loss of generality that u is linearly homogenous. The government's objective function is assumed to be of the form

(11) $$W = \sum_{i=1}^{n} a_i u_i,$$

with $a_1 \leq a_2 \leq ... \leq a_N$ and $\sum_{i=1}^{n} a_i = 1$.

This is the welfare function associated with measurement of inequality using the generalized Gini approach (Weymark 1981). If $a_1 = a_2 = ... = a_N$, the government is unconcerned with income distribution.[2]

Now observe that, in the absence of additional constraints, one of the pair of choice variables w, a is redundant. That is, for a universally consumed service, an access charge is equivalent to a poll tax or negative uniform payment. Hence, the government's unconstrained problem may be written as choosing $w - a$, τ and p to maximise

(12) $$W = \sum_{i=1}^{n} a_i u(m, p) = \sum_{i=1}^{n} a_i (m_i + \mathrm{EV}(m_i, p)),$$

subject to the constraints (1) to (4). When $a_i = 1/N$, $\forall$ i, Lemma 1 implies:

Lemma 2: For $a_i = 1/N$, $\forall$ i, the optimal policy has $t = 0$, $p = p_0$, $w - a = C(x(p_0)) - p_0$x.

[2] Under appropriate conditions, efficiency rules based on maximising a money metric utility function will yield the same recommendation.

When at least one $a_i < a_{i+1}$, we have an interior solution. The first-order conditions on τ and p are:

$$(1 - \sum_{i=1}^{n} a_i \; s^*i) - \phi'(\tau) = 0 \text{ ; and}$$

$$x(1 - \sum_{i=1}^{n} a_i \; s^*i) - y\Gamma(p) = 0.$$

This immediately yields:

Result 1 Assume that at least one $a_i < a_{i+1}$. Then the social optimum has

$$\Gamma(p)/\phi'(\tau) = x/y.$$

In the application presented in Section 3, it is assumed that the telecommunications sector is sufficiently small that $\phi'(\tau)$ may be regarded as constant. Using the standard Harberger triangle approximation for the welfare loss:

(13) $$\mathrm{EV}(m, p) = 0.5\varepsilon\,(p - p_0)^2\, x,$$

where ε denotes the elasticity of demand evaluated at (p, x), the condition of result 1 becomes

(14) $$(p - p_0)/p = \phi'(\tau) / \varepsilon.$$

That is, the markup over marginal cost, expressed as a proportion of the final price, should be equal to the marginal welfare cost of taxation divided by the elasticity of demand. For a linear demand curve $x = a - bp$, which is necessary if the Harberger triangle estimate of consumer surplus is to be exact, we have:

(15) $$\varepsilon(p, x) = bp/(a - bp),$$

and the condition on p becomes:

(16) $$(p - p_0)/p = (a/bp - 1)\phi,$$

or, after rearrangement:

(17) $$p = (p^0 + \phi a/b)/(1 + \phi).$$

With nonlinear (and strictly convex) demand, the Harberger triangle method applied using the final price, as above, will understate the welfare loss associated with above-marginal cost pricing, and hence will lead to an excessively high estimate of the optimal price. A lower bound estimate is:

(18) $$(p - p_0)/p^0 = \phi'(\tau) \, / \, \varepsilon^0,$$

where ε denotes the elasticity of demand evaluated at (p^0, x^0). For the constant elasticity case, the only difference is that the markup is now computed as a proportion of marginal cost rather than as a proportion of final price. An elementary geometrical exercise, demonstrates that this is, indeed, a lower bound.

The result derived here is consistent with the more general result derived by Quiggin (1995). Quiggin (1995) showed that, whenever the welfare cost of taxation is positive, any policy program in which general policies are chosen to maximise efficiency (in the present context, by choosing p to minimise Γ), while tax and welfare policies are used to redistribute income, can be Pareto-dominated by a program in which general policies are adjusted to take some account of distrbutional objectives. In the global optimum the marginal cost of achieving desired income redistribution through general policies must be set equal to the marginal cost of achieving the same redistribution through tax–welfare policies. For convenience, the argument of Quiggin (1995) is briefly restated in Appendix 1.

2 Efficiency-based pricing policies in telecommunications

To provide a baseline for assessment of the implications of the results derived above, it is useful to contrast them with the standard efficiency approach. The efficiency approach has been applied to Australian telecommunications pricing by Albon (1988), who concluded that access charges for residential users should be more than doubled, while usage charges for long-distance services should be cut. In the telecommunications context, the access charge for households is the cost of the first connection to the network, comprising the connection fee and the annual rental for the first telephone service. Charges for extra telephones, improved services and so on may be regarded as usage charges. Albon's analysis was presented in the context of policy formulation for a statutory public monopoly. Australia and many other countries have now abandoned this model in favor of competition in the provision of long-distance services. However, as will be argued below, many of the same issues arise in determining the appropriate charge to be paid by long-distance service providers for access to the local network. The move away from provision of services by statutory authorities, and the corporatisation or privatisation, of many public telecommunications enterprises has resulted in reduced availability of data on costs and revenue sources.[3] Hence, although Albon's data is a decade old, it is more complete than would be the case with more recent data.

Albon begins his analysis with the data in Table 1, concering costs and revenues associated with different parts of the service provided by Telecom Australia (now Telstra) in 1984-85. Albon shows that, under the pricing arrangements prevailing in 1984-85, charges for long distance services exceeded marginal costs, while local call charges and access charges were approximately equal to cost of provision. Because there is a gap between price and marginal cost for long distance services, but not for local services,

[3] The loss of transparency is a significant, but as yet little discussed, cost of recent moves towards private provision of goods and services in cases such as telecommunications where markets are far from perfectly competitive or where, for other reasons, regulation is required.

Albon concentrates on long distance services. To make his estimates more current, Albon updates the cost and revenue data to 1985-86 using proportional adjustments. He estimates that the total cost of providing long distance services calls in 1985-86 was $599 million, and that total revenue derived from long distance services was $1900 million. All subsequent discussion will refer to Albon's estimates for 1985-86.

		Earnings	Costs
Access Rental	Metro	551	517
	Non-metro	334	574
	Total	885	1091
Local calls	Metro	678	386
	Non-metro	295	286
	Total	973	672
Long-distance calls		1469	437
Other		1438	944
TOTAL		4765	2707

Table 1 : Telecom earnings and costs 1984-85

Source: Albon (1988), citing unpublished work by Telecom Australia

The next step is to compute the social welfare loss associated with the pricing of long-distance services in excess of marginal costs, using the consumer surplus approach.

To do this, it is necessary to specify a demand curve. Albon assumes a linear demand curve, such that the elasticity of demand at prevailing prices is -0.78 for domestic users (who made up 30 per cent of the market) and -0.33 for business users. The use of a linear demand curve simplifies the calculations and, as Albon observes, tends to produce a relatively conservative estimate of the welfare loss from prevailing pricing policies.

Albon’s elasticity estimates are derived from studies of United States telecommunications demand by Wenders and Egan (1986), and are supported by estimates reported by Beesley (1981, Appendix 4), Taylor (1980, Chapter 3) and Perl (1986). Broadly similar estimates have subsequently been reported by Chen and Watters (1992) who considered demand elasticities for calls at different times of day.

By contrast, Wolak (1996) estimates a mean own-price demand elasticity of -2.07 for long-distance calls for the United States. Acceptance of such a large elasticity estimate would radically change the analysis presented here. Indeed, in this case, the existing price for long-distance calls, which is more than twice the marginal cost, exceeds the monopoly profit-maximising price. Hence, it would be possible to achieve a Pareto-improvement by reducing the price of long-distance calls, and using the resulting increase in net profits to further subsidise local calls and network access. Since the issues raised by the present paper would therefore become moot, attention will be focused on cases where demand is sufficiently inelastic to permit significant cross-subsidisation.

On the basis of the Wenders and Egan elasticity parameters, Albon estimates that the total welfare loss from existing pricing policies in 1985-86 wwas $212 million of which $104 million was borne by domestic users and $108 million by business users. Albon suggests that this loss could be almost completely eliminated by reducing prices for long-distance services to the marginal cost price with the revenue loss being made up by increased access charges.

This estimate may be derived as follows. With a linear demand curve, the welfare loss associated with setting the price p above the marginal cost price p_0 is $0.5(p - p_0)(x_0 - x)$ where x is the quantity demanded at price p and x_0 is the quantity that would be demanded at the marginal cost price. Hereafter, prices will be expressed in cents, quantities in in millions of calls, and revenues in millions of dollars.

Albon makes the simplifying assumption that all calls have the same cost, and that 30 per cent of all calls are attributable to domestic users and 70 per cent to business users. Since there were a total of 1172 million calls supplied, this assumption yields values of $x = 352$ for households and $x = 820$ for business. Dividing the total revenue ($1900 million) by the total number of calls yields the average price in cents per call $p = 100*1900/1172 = 162$. Similarly dividing total cost by the the total number of calls yields the unit cost of supply $p_0 = 100*599/1172 = 51$.

The linear demand curves passing through the point (p, x) and having Albon's estimated demand elasticities are:

(19) $$x = 627 - 1.70\,p \qquad \text{(households);}$$

$$x = 1090 - 1.67p \qquad \text{(business); and}$$

$$x = 1717 - 3.37p \qquad \text{(total)}$$

where p is the price in cents and x is the quantity in millions of calls.

Substituting the marginal cost price p_0 in the demand equations (19) yields $x_0 = 541$ for households and $x_0 = 1003$ for business. Substituting these figures, and computing the welfare cost C, we obtain:

$$C = 0.5(p - p_0)(x_0 - x)/100 = 208$$

Thus, the total welfare loss associated with pricing in excess of marginal cost is estimated at $208 million, very close to Albon's estimate of $212 million. The small discrepancy, possibly due to rounding error or some similar factor, does not affect the results significantly.

3 Optimal cross-subsidy policies

When redistribution is costly, a policy of setting price equal to marginal cost will not, in general, be socially optimal. Income redistribution through pricing policies is a substitute for income redistribution through the tax system. Redistribution through pricing should be pursued up to the point where the marginal cost is equal to the marginal efficiency cost of pursuing redistribution through the tax–welfare system. Under the assumptions of Section 2, reductions in access pricing for telecommunications, financed by higher usage charges, are an exact substitute for redistribution through the tax system, using a proportional income tax to finance a uniform payment. Hence, the optimal pricing rule will have a markup equal to the marginal cost of raising revenue through the tax system divided by the elasticity of demand for the good in question.

A wide range of estimates have been offered for the marginal cost of raising revenue through the tax system. Estimates based on the observed elasticity of labour supply are very close to zero. Alternative estimation procedures yield values as high as 50 per cent. The most plausible range of values is around 20 per cent (Diewert and Lawrence 1994) and this value will be used here. In the notation of Section 1, $\phi = 0.2$.

A linear demand curve passing through the price-quantity pairs considered in Section 2, in the notation of Section 1, $a = 1717$, $b = 3.37$. As noted in Section 2, marginal cost estimate is $p_0 = 51$. Hence, the optimal pricing policy given in (17) is

$$p^* = (p^0 + \phi a/b)/(1 + \phi) = (51 + 0.2 * 1717/3.37)/1.2 = 127,$$

implying $x^* = 1289$.

To derive the welfare effects of any alternative pricing policy relative to the social optimum, it is necessary to take account of both the change in consumer surplus and the change in change in the welfare cost of taxation. Under the assumptions stated above, the an increase in revenue from usage charges will permit a corresponding reduction in revenue from access charges, and hence in uniform payments and tax revenue. Under the assumption $\phi = 0.2$, the corresponding welfare gain will be equal to 20 per cent of the increase in revenue.

This approach may be used to derive the welfare loss associated with the pricing structure actually prevailing in 1985/86 relative to the optimum $p = p^*$. Under the optimal pricing structure, the net revenue associated with pricing in excess of marginal cost would be $x^*p^* - x_0p_0$ = 1289*127 – 1554*51 = $845 million. Under the actual pricing structure, the net revenue associated with pricing in excess of marginal cost was xp - x_0p_0 = 1172*162 – 1554*51 = $1301 million.

The reduction in the deadweight burden of taxation associated with the additional revenue of $456 million is 0.2*$456 million = $91 million. The loss in consumer surplus associated with raising the price from 127 to 162 cents, given that $p_0 = 51$, is $110 million. The difference between the net loss of consumer surplus and the net reduction in deadweight burden yields the net welfare loss associated with the 1985/86 pricing structure relative to the socially optimal pricing structure. This is $110 million - $ 91 million = $19 million.

We may also compare the optimal policy to the alternative of reducing prices to marginal cost and recouping the lost revenue through higher access charges, or equivalently, by meeting the deficit from government revenue and reducing the uniform payment correspondingly. The deadweight burden of taxation associated with the additional access charges was 0.2*$845 million = $169 million. The increase in consumer surplus from marginal cost pricing, relative to a price of 127 cents, was approximately $97 million.

Thus the net loss associated with this policy is $72 million.

Relaxation of simplifying assumptions

The analysis above has used the simplifying assumptions that there are only two general policy instruments, a proportional tax and a lump-sum transfer, and that the impact of these instruments is approximately the same as that of an increase in usage charges for phone calss or a reduction in access charges to the phone network respectively. As a first approximation these assumptions appear reasonable.

Although the tax–transfer system is more complex than is supposed here, total tax payments are roughly proportional to income, and public expenditure, in total, benefits all income groups about equally. Lower income groups benefit more from social welfare payments and upper income groups from provision of higher education, but on average these differences cancel out (Travers and Richardson 1993).

Similarly the implied assumptions of universal access and a unit income elasticity of demand for telecommunications services are close to reality. For most public utilities, including telecommunications, universal access is an important goal. In Australia, nad most other developed countries, this goal has almost been reached. About 95 per cent of households have access to the telephone network.

If the analysis were expanded to include a larger set of tax–welfare policy instruments and pricing options, the simple equivalence used in the analysis presented above would disappear. It would become more difficult to identify Pareto-dominant and Pareto-dominated policy options. However, the basic argument would still apply.

As an example, consider the compensation proposals suggested by Albon (1988). These proposals involve compensating the worst-off 10 per cent of consumers for the losses associated with increased access charges. An obvious difficulty is that, even without considering deadweight costs of taxation, the combination of a move to marginal ost pricing with compensation to the worst-off 10 per cent of consumers will not represent a Pareto-improvement, since more than 10 per cent of consumers are likely to be made worse off by increases in access charges. The more fundamental problem is that proposals of this kind require the construction of what is, implicitly a nonlinear tax-subsidy instrument. Such an instrument is likely to involve high effective marginal tax rates and therefore, high efficiency costs. Thus, there is no general reason to suppose that a package based on tightly targeted compensation will generate a Pareto-improvement in a situation where a proportional tax combined with a uniform payment cannot.

More generally, whenever the social welfare function embodies some preference for equality, the adoption of pricing policies with regressive impacts will increase the demand for costly income redistribution through the tax–welfare system. Hence, the optimal policy is one which equates the marginal deadweight loss associated with redistribution and the marginal loss of consumer surplus associated with progressive pricing.

Finally, we may consider the implications of using a demand curve with constant elasticity, rather than a linear demand curve, and of estimates of marginal cost derived from alternative allocations of central operating costs. Results derived from these alternative estimates are presented in Appendix 2.

4 Recent developments in telecommunications pricing

An analysis of the kind presented in this paper

5 Concluding comments

An efficiency-based analysis yields the conclusion that access charges for telecommunications should be raised substantially in order to finance a reduction in long-distance call charges to marginal cost. The same conclusion will apply for many other utility services characterised by high fixed costs and excess capacity.

However, the critique of efficiency-based policy presented here and in Quiggin (1995) implies that distributional objectives should be taken into account in price setting. In the case of public utility pricing, this means that pricing policies should take into account the usage patterns of low-income households and should charge relatively low prices for those services which are relatively heavily used. In particular, access charges should not be used as the sole means of recovering fixed costs.

The extent to which a cross-subsidy of this kind can be socially beneficial depends on two factors. The first is the extent to which different income groups display different usage patterns. The more distinct are the usage patterns of high and low income households the greater the income distributional benefits of subsidising the services used more heavily by low income groups. The second factor is the extent to which prices can be varied without incurring large efficiency losses. In general, when prices are close to the efficient levels, small variations will have very small efficiency costs. However, the extent to which costs rise as prices are moved far from the efficient levels will depend on the pattern of demand and on the technology of production.

In the case of public utilities, any charge for initial access to the utility will be the same for all households whereas usage levels, and hence usage charges, will normally be lower for low-income households. For a utility where universal access is necessary, an access charge is equivalent to a poll tax or household tax. Some utilities such as water supply and garbage collection were, until recently, supplied without any access charge. Fixed costs were financed by rates, that is by taxes on the unimproved value of land. The recent shift from the use of rates to fixed access charges for the water supply and sewerage system are therefore equivalent to an increase in the regressivity of taxation.

The analysis presented in this paper is aimed at determining the optimal cross-subsidy between long-distance telecommunications services and access charges for all consumers.

There remains a case for additional access subsidies for disadvantaged consumers. Under current organisational arrangements these would be treated as a community service obligation (CSO) and accounted for separately.

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Appendix 1: Optimal policy with costly transfers

Following Quiggin (1995), we assume that governments have available two sets of policy instruments — general policies and tax policies including negative taxes and transfers). To every setting of general policies corresponds a vector $\boldsymbol{y} = (y_1, y_2 \ldots y_N)$ where y_i is the pre-tax income of individual i. The set of feasible general policies may be summarized by the set $Y \subseteq \Re^N$ of feasible pre-tax income vectors. We assume:

Assumption 1: Y is a smooth, compact, strictly convex set.

To every setting of tax–transfer policies, there corresponds a vector $\boldsymbol{t} = (t_1, t_2 \ldots t_N)$ of tax–transfer payments. Consumption for individual i is given by

$$x_i = y_i - t_i$$

Similarly, the set of feasible tax–transfer policies may be summarized by the set T of feasible net tax payment vectors. We assume that:

Assumption 2: T is a smooth, compact, strictly convex set such that $\mathbf{0} \in T$.

More significantly, we assume that redistribution through the tax–transfer system is always costly:

Assumption 3: If $\boldsymbol{t} \neq \mathbf{0} \in T$, $\sum_{i=1}^{N} t_i > 0$.

Let individual 1 be the numéraire individual, and let $\bar{y}_1$ be her base income. Then for any vector $(y_2, y_3 \ldots y_N) \in \Re^{N\text{-}1}$, we may define

$$C(y_2, y_3 \ldots y_N) = \inf\{\bar{y}_1 - \mathrm{y}\colon\ (y, y_2 \ldots y_N) \in Y\} \text{ if } \exists\, (y, y_2 \ldots y_N) \in Y$$

$$= \infty \text{ otherwise.}$$

Similarly for given $\boldsymbol{y}$ and $(t_2 \ldots t_N) \in \Re^{N-1}$, define

$$T(t_2 \ldots t_N) = \inf\{ t: (t, t_2 \ldots t_N) \in T\} \text{ if } \exists\, (t, t_2 \ldots t_N) \in T$$

$$= \infty \text{ otherwise}$$

A pair $(\boldsymbol{y}^0, \boldsymbol{t}^0)$ can maximize $V(\boldsymbol{x})$ only if $(y^0_2, y^0_3 \ldots y^0_N)$ and $(t^0_2 \ldots t^0_N)$ solve the cost-minimization problem:

$$\text{Min } C(y_2, y_3 \ldots y_N) + T(t_2 \ldots t_N)$$

$$\text{subject to } (y_2, y_3 \ldots y_N) - (t_2 \ldots t_N) = (y_2, y_3 \ldots y_N) - (t_2 \ldots t_N),$$

and the first-order conditions for this problem require $\partial C/\partial y_i = -\partial T/\partial t_i \ \forall\, i$. That is, the marginal rate of transformation between individual i consumption and individual j consumption must be the same whether tax policies or general policies are being considered.

In particular, this implies that whenever $\boldsymbol{t} \neq 0$, efficiency policies will be suboptimal. The first-order conditions for maximization of $\sum_{i=1}^{N} y_i$ imply that $\boldsymbol{y}$ satisfies the efficiency rule if and only if $\partial C/\partial y_i = 1,\ \forall\, i$. However, Assumption 3 and the convexity of T ensure that if $\boldsymbol{t} \neq 0$ is a boundary element of T, $\partial T/\partial t_i \neq -1$ for at least some i.

Given the result that $\partial C/\partial y_i = -\partial T/\partial t_i$ in the second-best equilibrium, it follows that the values $-\partial T/\partial t_i$ may be treated as welfare weights. In particular, consider a local adjustment to policy yielding gains in post-tax income of δ_i to individual i. For small δ, such a policy will be beneficial if and only if $\sum_{i=1}^{n} -\partial T/\partial t_i\, \delta_i \geq 0$.

Prima facie, it may appear that this criterion is informationally more demanding than the efficiency criterion, since we require knowledge of effects on every individual. In fact, the aggregation conditions required to justify the use of aggregate demand functions in welfare analysis are in many cases sufficient to permit the application of the results derived above. This may be illustrated for the case of a homothetic demand structure, where aggregation is particularly straightforward.

Appendix 2: Derivation under alternative assumptions

Some of Albon's procedures, notably the treatment of non-allocable costs and the use of a linear demand curve, are open to debate. However, since the treatment of non-allocable costs tends to increase estimates of welfare losses and the use of a linear demand curve tends to reduce these estimates, Albon's estimates appear to be reasonable, assuming that the efficiency-based framework is appropriate.

Albon's results must be qualified in view of the fact that total revenues greatly exceed measured total allocated costs, whereas, given that Telstra is making a normal return to capital, total costs, in an economic sense, should be equal to total revenues. The discrepancy between total costs and total revenues may be due to a number of factors. First, Telstra may be making supernormal profits. In this case, the optimal response is a reduction in prices. Since the access charge is determined as a residual in this analysis, the price reduction should fall entirely on usage charges. The only adjustment to Albon's analysis required here is that there should be no offsetting increase in access charges.

The remaining, and presumably most important source of discrepancy, is the existence of non-allocable central costs. Such costs may be separated into three categories:

(i) fixed costs, arising from the existence of the enterprise;

(ii) costs that are, in the long run, dependent on the number of subscribers; and

(iii) costs that are, in the long run, dependent on usage levels.

Costs in category (i) are clearly irrelevant to calculations of the welfare cost of pricing policies, assuming that the existence of the enterprise is socially beneficial. However, costs in category (ii) and (iii) are properly treated as part of the marginal cost of providing access and usage respectively. If such costs accrue in a 'lumpy' fashion, rising by discrete amounts when access (or usage) crosses particular threshold levels, it will be appropriate to distinguish between short run and long run marginal costs. Short run marginal costs will fluctuate, being sometimes below and sometimes above long run average costs. However, there is no evidence on which to make such a distinction in the present case.

In the light of the above analysis, Albon's approach may be treated as representing an assumption that the entire discrepancy between costs and revenues is due to the existence of fixed costs. We will explore the consequences of the assumption that the entire discrepancy is due to costs in categories (ii) and (iii). In the absence of more detailed information, a common proportional adjustment will be applied to access and usage costs. The ratio of revenue to total direct costs for 1984-85 was 1.76. Adjusting costs upward by this ratio implies the existence of a cross-subsidy in that access charges are below cost while long distance charges are well above cost.

Applying a similar adjustment to Albon's cost figures for 1985-86, we obtain a value of $p_0 = 90$. Applying the demand analysis as before, the estimated quantities become $x_0 = 472$ million for households and 939 million for business. The welfare loss is now $43 million for households and $42 million for business, for a total loss of $85 million, less than Albon's original estimate, but still substantial.

An intermediate estimate is obtained if the conservative assumption of a linear demand curve is replaced by a constant elasticity curve[4]. The constant elasticity demand curves passing through (p, x) and having the stated elasticities are

$$x = 18600p^{-0.78} \qquad \text{(households);}$$

$$x = 4390p^{-0.33} \qquad \text{(business);}$$

implying that, for $p_0 = 90$, we would have

$x_0 = 556$ (households); and

[4] Another possiblity is that of a linear curve passing through (p, x) but having the stated elasticities at $p^0 = 90$.

$x_0 = 996$ (business).

A straightforward consumer surplus calculation reveals that the welfare loss for households is $57 million and for business $54 million, yielding a total loss of $111 million.

The proportional markup estimated using the linear demand curve approach is very high. This reflects the fact that, with a linear demand curve, the elasticity of demand declines with price. In particular, at $p_0 = 0.51$, the implied elasticity of demand is 3.37*51/1717, or almost exactly 0.1. With this very low (indeed, implausibly low) elasticity, the welfare cost of moderate price increases is close to zero.

The assumption of a linear demand curve therefore seems inappropriate, especially given that the point elasticity estimate used in constructing it is derived from overseas evidence, so that there is no justification for applying it at the prevailing price in Australia. On the other hand, as has already been argued, Albon's treatment of non-allocable costs gives a lower bound estimate of the marginal cost p_0. The preferred approach adopted in this paper is therefore to assume a constant elasticity of demand, and to apply the conservative estimate but to scale costs up so that total economic costs are equal to total revenue, yielding $p_0 = 90$ cents.

Using Albon's estimate that the average elasticity of demand is around 0.5, we conclude that the optimal markup over marginal costs is about 40 per cent, implying an average charge per trunk call of 126 cents for 1985/86. By coincidence, this is almost exactly equal to the estimate obtained using the linear demand curve and the lower bound estimate of p_0. Thus, the modifications to Albon's approach cancel each other out. However, it is necessary to recalculate the various welfare estimates.

Alternative combinations of assumptions are possible. The lowest estimated optimal price is obtained using a constant elasticity demand curve in combination with $p_0 = 51$, yielding an optimal p of 75 cents. On the other hand, using a linear demand curve in combination with $p_0 = 90$ yields an optimal price of 159 cents, almost exactly equal to the actual price. Table 2 lists optimal prices and welfare costs of alternative policies for these different combinations.

	Linear demand		**Constant elasticity**	
	$p_0 = 51$	$p_0 = 90$	$p_0 = 51$	$p_0 = 90$
Optimal price	127	159	75	126
Welfare loss from current policy	\$19m	\$3m	\$72m	\$31m
Welfare loss with p=51	\$72m	\$205m	\$3m	\$199m

Table 2 Sensitivity analysis on optimal prices and welfare costs

Using a constant elasticity demand curve, in place of Albon's conservative assumption of a linear demand curve and retaining the assumption that $p_0 = 51$, it is apparent that marginal cost pricing would be preferable to the current policy. However, even in this case, once the welfare benefits associated with reduced access charges are taken into account, the net welfare cost of current policy is \$72m, about a third of the amount estimated by Albon.