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SECOND BEST PRICING FOR COMPETING MODES OF TRANSPORT

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Abstract:

A well known second best pricing rule for a decreasing cost public enterprise subject to a budget constraint (e.g. being required to break even) is that the revenue required over and above marginal cost should be obtained by allocating the additional charges in inverse proportion to demand elasticities. This rule, which is essentially traditional value-of-service discriminatory pricing, breaks down when there are significant cross-elasticities. Thus, in some important transport cases a better rule is needed. This paper shows how the appropriate second best pricing rule can be applied to specific transport situations and demonstrates that the resulting prices can differ substantially from the simple elasticity rule. The extreme case of closely competing modes such as rail and road general freight are given particular attention, and it is shown that improved cost data together with better estimates of demand elasticities make rational public enterprise pricing a feasible policy.

SECOND-BEST PRICING FOR COMPETING MODES OF TRANSPORT

As we all know from the success of aviation de-regulation in the United States, cases of natural monopoly in transport are fewer than was once thought. Government intervention in naturally competitive industries is not only unnecessary but will do a great deal of harm. Of course, getting rid of it may be painful for operators, as some American airlines are finding.

Nevertheless, railways and the provision of roads (not road operations) do appear to be natural monopolies and consequently need careful regulation. To these can be added airports and seaports. All exhibit increasing returns, so that marginal costs are less than average costs and marginal cost pricing, the optimal policy, would send the railways, for example, even more broke than they are. Consequently, the operators must resort to some form of second-best pricing in order to break even or to keep the loss within bounds.

In the past, railways have done this fairly well: value-of-service pricing or charging what the traffic will bear is a reasonable approximation to the correct second-best rule when there is no serious competition from another mode also exhibiting increasing returns. The rule is[1]:

$$\frac{p - MC}{p} = \frac{\beta}{E}$$

where p is the freight rate
MC is long-run marginal cost
E is the price (freight rate) elasticity of demand for the service
and β is a constant across all railway business which is set to achieve the required revenue.

At one extreme, $\beta = 0$, we would have marginal cost pricing. At the other extreme, $\beta = -1$, we would have profit maximising monopoly behaviour, charging to get as much as possible out of the traffic. One way of looking at an intermediate value of β, necessary to achieve break-even or some other goal, is that it is a scalar used to increase all the demand elasticities, so that the operators can then apply the simple 'profit maximising' rule with the scaled elasticities.

This rule breaks down when the various demands are not independent, i.e. there are appreciable cross-elasticities. Nevertheless, the second-best rule which does take into account cross-elasticities still results in discriminatory pricing not unlike traditional value-of-service pricing.

In reality, there are not many cases where the demands for two services performed by a railway are non-independent. It is hard to think of such pairs - fast and slow services for a particular class of goods on a particular route would be one. The important cases arise when two decreasing cost industries compete. This includes those cases where increasing or constant cost industries use facilities provided by decreasing cost industries: trucks (and buses) using roads, aeroplanes using airports and navigation aids, ships using seaports and navigation aids. Perhaps the crucial point

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1 The rule has been similarly stated by Baumol and Bradford (1970) except that β is expressed as $-(1 + \lambda)/\lambda$ and also by Rees (1976, p.106) except that β is expressed as $-\lambda/(1 - \lambda)$.

in all this was made by Boiteux (1956, 1971) when he showed that the optimizing (i.e. second-best) procedure should be applied across all these enterprises simultaneously. In the French context, he spoke of using the one rule for all 'nationalized firms'.

Although the great merit of Boiteux's work is its generality, his result still has a lot to offer when we narrow it for application to two competing modes and ignore the refinements with respect to factor prices. Adapting from Drèze's (1964) summary of Boiteux, one has the following conditions for achieving the second-best :

$$\sum_i (p_i - MC_i)\left(\frac{\partial x_i}{\partial p_j}\right)^* = \beta x_j$$

where $\left(\frac{\partial x_i}{\partial p_j}\right)^*$ is the partial derivative with respect to the price on the jth mode of the income-compensated demand function for transport by the ith mode.

Thus, for the first of the two modes (i.e. j = 1) :

$$(p_1 - MC_1)\left(\frac{\partial x_1}{\partial p_1}\right)^* + (p_2 - MC_2)\left(\frac{\partial x_2}{\partial p_1}\right)^* = \beta x_1$$

But $(\partial x_2/\partial p_1)^*$ can be replaced by $(\partial x_1/\partial p_2)^*$ because they are identically equal. When the equation is also divided through by x_1 and the terms on the left are multiplied appropriately top and bottom by p_1 and p_2, an expression in compensated elasticities is obtained, and similarly for the second mode :

$$\frac{p_1 - MC_1}{p_1} E^*_{11} + \frac{p_2 - MC_2}{p_2} E^*_{12} = \beta$$

$$\frac{p_1 - MC_1}{p_1} E^*_{21} + \frac{p_2 - MC_2}{p_2} E^*_{22} = \beta$$

This derivation has followed Train (1977)[1].

In matrix form :

$$\begin{bmatrix} E^*_{11} & E^*_{12} \\ E^*_{21} & E^*_{22} \end{bmatrix} \begin{bmatrix} \frac{p_1 - MC_1}{p_1} \\ \frac{p_2 - MC_2}{p_2} \end{bmatrix} = \begin{bmatrix} \beta \\ \beta \end{bmatrix}$$

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1 In his examination of second-best pricing for BART and A.C. buses in the San Francisco area, Train (1977) used average total cost to arrive at the constrained optimum. This does not appear to be as sound as setting β to achieve a fixed sum in excess of marginal costs.

For virtually all transport situations, the difference between income-compensated elasticities and ordinary elasticities is negligible, so that ordinary elasticity estimates can be used. However, for the usual reasons, mode-split elasticities cannot be used.(1)

To see that the pricing rule can give an appreciably different result from the simple one shown earlier, consider the following hypothetical system, where marginal cost is the same in each case ($MC_1 = MC_2 = \$10$) :

$$\begin{bmatrix} -1 & 0.5 \\ 0.8 & -1 \end{bmatrix} \begin{bmatrix} \dfrac{p_1 - 10}{p_1} \\ \dfrac{p_2 - 10}{p_2} \end{bmatrix} = \begin{bmatrix} \beta \\ \beta \end{bmatrix}$$

Because the own-price elasticities are equal ($E_{11} = E_{22} = -1$) and the marginal costs are equal, the simple rule would imply that the two prices should also be equal. This is not correct. Suppose that $\beta = -0.2$, then the correct prices are obtained by solving the system, to give :

$$p_1 = \$20$$

$$p_2 = \$25$$

In arriving at these results, the following expressions were obtained :

$$\frac{p_1 - MC_1}{p_1} = -2.5\beta \qquad \frac{p_2 - MC_2}{p_2} = -3.0\beta$$

These look very similar to the simple optimising rule, and can be changed into exactly the same form :

$$\frac{p_1 - MC_1}{p_1} = \frac{\beta}{-0.4} \qquad \frac{p_2 - MC_2}{p_2} = \frac{\beta}{-0.333}$$

It may be useful to regard the reciprocal values, -0.4 and -0.333, as 'pseudo own-price elasticities' which, after scaling by the system-wide β, could be used by operators to set the particular fares or freight rates.

Second-Best Pricing for a Mixture of Independent and Non-Independent Demands

The more usual situation is that the enterprise meets some transport demands which are non-independent, having significant cross-elasticities of demand, and some which are independent. In this situation the second-best pricing procedure is to use a mixture of the two pricing rules. We take

1 See Taplin (1980)

the previous example but add a third class of trips having no significant cross-elasticities with the other two classes. Again it is illuminating, if somewhat artificial, to assume the same long-run marginal cost ($MC_3 = MC_2 = MC_1 = \$10$) and the same own-price elasticity ($E_{33} = E_{22} = E_{11} = -1$). Thus, the second-best conditions are :

$$\begin{bmatrix} -1 & 0.5 & 0 \\ 0.8 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} \dfrac{p_1 - 10}{p_1} \\ \dfrac{p_2 - 10}{p_2} \\ \dfrac{p_3 - 10}{p_3} \end{bmatrix} = \begin{bmatrix} \beta \\ \beta \\ \beta \end{bmatrix}$$

If we again set $\beta = -0.2$ in order to satisfy the budget constraint (say break-even) then the solutions for p_1 and p_2 are the same as before ($p_1 = \$20$, $p_2 = \$25$) while p_3 is, in effect, found by the simple elasticity rule :

$$\frac{p_3 - 10}{p_3} = \frac{\beta}{-1} = \frac{-0.2}{-1}$$

$$p_3 = \$12.50$$

Even more than before, this extended example shows how much the existence of some appreciable cross-elasticities cause prices under constrained optimum (second-best) conditions to depart from the uniform prices that would be implied by the simple rule alone in a case of uniform marginal costs and own-price elasticities.

If the number of daily travellers at these prices were 1000 in group 1, 500 in group 2 and 1,200 in group 3 then daily costs and revenue, assuming that the enterprise breaks even, would be :

long-run marginal costs (MC)	27,000
other costs	20,500
total costs (= total revenue)	47,500

In reality the problem would start with the question how to cover the \$20,500 of other costs in an optimal fashion. The actual exercise would be to find a β that would do it, and the solution would be $\beta = -0.2$.

Competition for Freight : the Road-Rail Case

The foregoing discussion has deliberately been in terms of passenger transport because the points being made are likely to be most relevant in that context. For many classes of travel (not urban commuting) the income elasticity is substantial and the (positive) cross-elasticities with respect to the prices of other consumer goods can also be appreciable. It therefore follows from the homogeneity condition (the elasticities sum to zero) that the difference between the absolute values of the own-price elasticity and the cross-elasticity with respect to the fare on a competing service can be fairly large. To put it another way, such differences represent the price responsiveness of the general class of travel, which may be fairly high.

In contrast, the price responsiveness of the demand for freight transport is low. Consequently, in the case of competing modes, the absolute values of the own-price elasticity and the cross-elasticity with respect to the rate on the competing mode will differ very little. Fitzpatrick and Taplin (1972) made a rough estimate that demand for general freight transport between Australian cities is less elastic than -0.1, and there seems to have been no disagreement with this general order of magnitude. It follows that where road and rail compete for general freight the difference between the absolute values of the own-price elasticity and the cross-elasticit in each demand function will be in the vicinity of 0.1 or less.

A report by the BTE (1979) provides data which makes it possible to indicate how second-best pricing could be used operationally for competing road and rail. They estimated a (long-run) own-price elasticity for road between Melbourne and Sydney of -0.7. One can infer from this a cross-elasticity of approximately 0.6, assuming an absolute difference of 0.1. Now the cross-elasticity of demand for rail transport with respect to road rates can be derived by symmetry. This is done on the basis of the estimated 1975-76 non-bulk freight quantities given by the BTE (1978)(1):

	Road	Rail
Sydney to Melbourne non-bulk ('000 tonnes)	2120	322
Melbourne to Sydney " " "	1870	471
Total	3990	793

Because road is estimated to carry five times as much as rail the cross-elasticity in the rail demand equation is five times the cross-elasticity in the road demand equation.

Finally the own-price elasticity in the rail equation is inferred from the cross-elasticity. An arbitrary difference of 0.05 is assumed. The resulting system is :

$$\begin{bmatrix} -0.7 & 0.6 \\ 3.0 & -3.05 \end{bmatrix} \begin{bmatrix} \dfrac{P_1 - MC_1}{P_1} \\ \dfrac{P_2 - MC_2}{P_2} \end{bmatrix} = \begin{bmatrix} \beta \\ \beta \end{bmatrix}$$

1 This is an example of the importance of having reasonable estimates of how much freight is moving where and by what modes. The significance for rational policy development of the estimates made by Dr H. Quinlan of BTE cannot be over-emphasised.

The solutions are :

$$\frac{p_1 - MC_1}{p_1} = -10.896\ \beta \qquad \text{i.e.} \quad \frac{p_1}{MC_1} = \frac{1}{1 + 10.896\ \beta}$$

$$\frac{p_2 - MC_2}{p_2} = -11.045\ \beta \qquad \text{i.e.} \quad \frac{p_2}{MC_2} = \frac{1}{1 + 11.045\ \beta}$$

The significance of this result is that to achieve the optimum (i.e. second-best) the ratios of the freight rates to the marginal costs must be approximately the same.

When both elasticity differences are the same then this constancy of p/MC result can be shown to be an exact one. This is an interesting special case because it holds even for large (equal) elasticity differences, but would be of limited value in applications because there is no reason to believe that equal elasticity differences is a common phenomenon. Thus the approximate result for small but unequal differences is the more useful

The view that for second-best pricing of competing modes the p/MC ratios should be equal has been held by a number of writers, but the grounds have been somewhat different. Kolsen (1968, p.36) argued that the ratio must be the same in the two competing modes because the substitutability at the margin of road transport outputs for rail transport outputs is likely to be much greater than the substitutability of either for non-transport outputs. However, in the example earlier in this paper the cross-elasticities between the modes would be much larger than any other cross-elasticities in either equation. Yet second-best pricing resulted in a substantial difference between the p/MC ratios.

What the result in the latter part of this paper suggests is that if income elasticities and other cross-elasticities are all very small then equality of p/MC ratios is the correct second-best rule for competing modes.

The curious thing about these results is that knowledge about elasticities is more or less redundant for second-best pricing of competing modes under the conditions just indicated. Road, rail and sea transport competing for freight can all be appropriately regulated with reference primarily to marginal costs. Nevertheless, the general problem remains of optimising across the whole system, including parts which are non-competitive.

Although the p/MC rule is relatively simple, systematic application of it is still to come. The difficulty has been knowing the specific costs; these are now becoming much better known and so one can expect considerable advances in socially acceptable pricing.

<u>Summary</u>

(1) Charging what the traffic will bear - the simple elasticity rule - in order to break even or to meet some other budget constraint is appropriate so long as there are no significant cross-elasticities.

(2) Where there are significant cross-elasticities the more complex second-best pricing rule should be used.

(3) In the usual case where some traffics are competitive and others are not then a mixture of the two rules should be used, with a common β.

(4) In the case of competition for freight, the more complex rule is still correct but equality of price to marginal cost ratios is a satisfactory approximation.

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