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How to Make Cost-Axiomatic Pricing Work in the Real World of Transport Management

Hema de Silva
Centre for Transport Policy Analysis
Wollongong

Abstract:

Cost axiomatic pricing is a full cost recovery pricing mechanism which adheres to given cost allocation restrictions or axioms. This pricing mechanism can simultaneously accommodate most of the important objectives that are widely pursued by many public sector transport authorities in Australia, their clients, the governments overseeing these authorities and the community in general. In setting prices, a transport authority may not accommodate all objectives of these different players, it certainly may strive to find the equitable 'user-pays' type of prices that are payable by its various client groups. It is argued that such information is essential for efficient planning, investment and management of transport authorities. This paper develops a pricing methodology based on cost axiomatic allocation principles and illustrations how the information on user-pays type costs that are recoverable from different user-groups can be estimated while overcoming data problems that frequently inhibit public enterprise pricing.

Contact Author:

Dr Hema de Silva
Centre for Transport Policy Analysis
PO Box 2112
WOLLONGONG NSW 2500

Telephone: (042) 213 225 Fax: (042) 264 257

Introduction

Transport management is a multidimensional concept, in which pricing is an important element. The emphasis on pricing as an aid to management has lacked due recognition in most publicly managed transport organisations thus resulting in augmented management problems. Such problems of the magnitude and nature as present in the public sector are rather rare in privately managed transport organisations. This paper concentrates only on the publicly managed transport organisations.

Current pricing policies of most publicly managed transport authorities owe more to history and tradition than they do to commercial management concepts. A common characteristic of much of these inherent tariff structures is that they have been formulated by matching costs and revenues at global level. As a consequence, it is commonplace in public enterprises to be marred by a mix of financial and economic management problems like cross-subsidies, cost penalties, underrecovery of costs and even a considerable degree of distortions in modal choice.

Recent studies of the management and performance of a number of public sector transport authorities have aptly perceived the role that appropriate pricing could contribute in transforming the existing public sector transport authorities to more commercially oriented operations. Most of these studies have proposed pricing guidelines to overcome the prevailing pricing anomalies and in general fulfil salient objectives of transport authorities, transport users and the governments overlooking them. Translating these pricing guidelines to workable pricing structures has proved to be a demanding task primarily because of the complexities involved in attributing major cost components of public sector transport organisations to their multi users and other empirical difficulties stemming from information deficiencies. These factors have often frustrated attempts by authorities to formulate appropriate pricing regimes and have also contributed to the arbitrary nature in the relationship between the costs and the prices that are levied on users. The purpose of this paper is to suggest a cost-axiomatic approach to formulate pricing policies so as to meaningfully relate identifiable cost elements to prices payable by various multi-users of public transport establishments, to contribute to the efforts of the authorities in their transition of public sector transport enterprises to commercially oriented operations and in general provide solutions to some of the key management problems of users and other players in public sector transport enterprises.

The next section discusses the role of pricing in public sector management reforms. It is followed by a discussion of cost-axiomatic pricing, the data problem facing price formulators and an illustration of the cost axiomatic concepts. The illustration utilises published aggregate data for a port authority in Australia. Some concluding comments are given in the final section.

Role of pricing in public sector management reforms

Irrespective of whether an enterprise is privately or a publicly owned and operated, its management essentially involves conversion of inputs into outputs. These two sectors differ however, in the nature of inputs or resources utilised, the management process involved and the outcomes of activities there.

Substantial changes have occurred in Australia in the management of public sector's resources in recent years due mainly to considerable pressure to operate in a more 'commercial manner'. This has necessitated in bringing about reforms requiring specific examination of needs for public sector activity and effective ways to meet those needs. Often equity has been regarded as an essential principle underlying the necessary public sector reform (Labour Research Centre Inc., 1990). In the public sector context the concept of equity refers to fairness and equality in the provision and outcome of services as well as to fairness in the distribution of benefits from society and economy (Labour Research Centre Inc., 1990). How influential is pricing in attaining equity or fairness goals in the delivery of goods and services and in the distribution of benefits? In other words, can equity oriented pricing be a major instrument of public sector reform? The potentials of pricing in general and equity based or user-pays pricing in particular as reform instruments are widely acknowledged (c.f., Inter-State Commission, 1988; Royal Commission into Grain Storage, Handling and Transport, 1988).

The operating costs of public enterprises can be classified into two types (a) separable costs and (b) non-separable costs. The former are a relatively small portion of the total operating costs and can be easily separated and allocated to the respective users. They can be avoided by reducing the level of goods or services demanded. The latter on the other hand cannot be varied with the level of goods or services. It constitutes a large component of the operating costs. In a sea port context for instance, costs such as those incurred in providing port infrastructure and administration, navigational channels and breakwaters belong to this category. In road transport, these costs include maintenance costs due to weathering, initial purchase of right of way and the costs of the minimum quality of road necessary before any traffic is able to use it.

As indicated in the introduction, much of the management problems stemming from inappropriate pricing is centered around the manner in which non-separable costs are apportioned among users. Achieving equity or fairness in the allocation of this cost component has always posed problems. Furthermore, owing to its large magnitude any errors in the allocation of it among the multi-users of any publicly managed transport body result in one user category gaining significant benefits at the expense of others. Assuming that a given public enterprise caters to only two user-groups, Figure 1 illustrates three likely points of dividing non-separable costs between these two groups. Similar to these, there are several other points of demarcation. Only one of those is equitable. The aim is to find that.

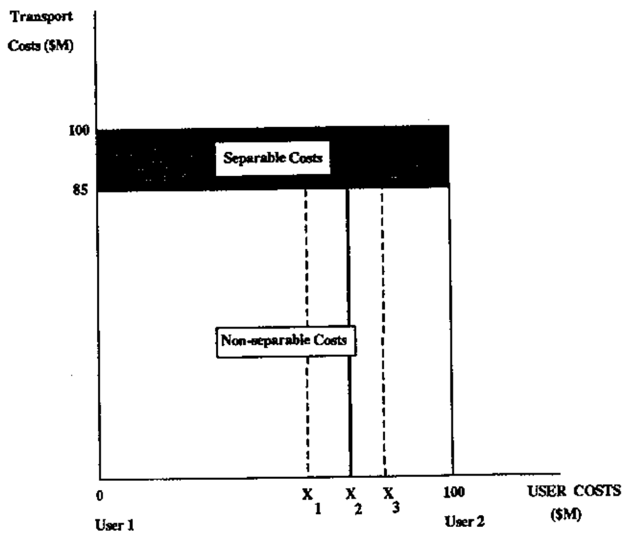

Figure 1. Relative proportions of separable and non-separable costs of transport and three likely approaches (X_1, X_2 and X_3) of apportioning the non-separable costs between users.

There are several approaches to allocate non-separable costs. These approaches are primarily based on equity and/or efficiency.

Recent public sector pricing literature convincingly argues that it is equity in the allocation of non-separable costs, and not efficient pricing (as in a market based approach

to efficiency assessment), that is capable of alleviating pricing related management problems and contribute to public sector reforms. It points out that revenue raised under efficient pricing regimes like marginal cost pricing would not suffice to cover costs, -a problem that public sector reforms strive to rectify. Many economists have found non-adherence to marginal cost pricing objectionable on equity grounds; others have objected on the grounds of allocative efficiency. More recent discussions of this issue with particular reference to port pricing are contained in Meyrick (1989) and Talley (1989). ISC (1986) and Bureau of Transport Economics (1987) carry discussions of this issue in relation to roads.

Equity approach to pricing essentially involves allocation of expenditure in excess of avoidable costs by matching costs and revenues at user level rather than at global level. Unlike efficient pricing where production resources are utilized in the most efficient manner to maximize net benefits to the community, an equity approach to pricing results in a loss in net benefits to the community as it does not set charges of products or services equal to short run marginal cost (SRMC). A pricing strategy which provides equity as well as effective in minimizing efficiency losses therefore is ideally suited as a public sector pricing strategy. Ramsey pricing is one such strategy. Its adoption however is hampered by inadequacy of or difficulties in obtaining information on demand functions for authorities engaged in the provision of transport services and facilities. There are several other approaches to public sector pricing -mostly those based on cost allocation formulae. But on equity grounds the suitability of these other approaches as public sector pricing tools seem dubious (Breautigam, 1980). As Bos, (1986), Brown and Sibley, (1986) and Samet, Tauman and Zang, (1983) note, cost axiomatic pricing has attracted considerable attention recently as a practical solution to the public sector pricing problem because of its outstanding ability that none of the other formula approaches possess.

A cost-axiomatic solution

Achieving equity in both *cost recovery* and the *distribution of gains from productivity reforms* is only a part of the solution to current management problems of many of the public sector transport organisations. This section shows that by adopting cost axiomatic pricing, the equity objectives can be achieved while solving other management problems as well.

Cost axiomatic pricing is a full cost recovery pricing mechanism, where prices must adhere to stated cost axioms. A cost axiom is a condition that must be satisfied relative to costs in the determination of prices and the choice of an axiom is an act of value judgement.

Cost axioms are usually equity or fairness oriented (Talley, 1989). Talley notes that unlike in traditional pricing theory, cost axiomatic pricing does not necessarily assume cost efficiency. Furthermore, unlike in traditional pricing theory, demand information such as demand price elasticities is not required for cost axiomatic pricing. It requires only cost and associated output information.

The cost axioms as stated by Mirman, Samet and Taumann (1983) are presented and discussed below illustrating how these axioms can be captured meaningfully in formulating port prices.

Axiom 1: Cost sharing. This axiom requires complete allocation of all costs so that the prices levied on users of services and facilities of an enterprise cover its total cost. For example, if a transport authority spends $100 million per year to provide services to two user categories, then it must recover this cost through prices levied on the users, so that no outside subsidy is necessary to cater to these two user groups.

Axiom 2: Rescaling. If the scale of measurement of the commodity or the service is changed, then a sensible allocation mechanism should result in the prices which change accordingly. For example, price of a unit of freight task when measured in tonne-miles is higher than the price of a unit measured in tonne-kilometres.

Axiom 3: Consistency. That all services and facilities provided by a transport enterprise with the same marginal costs should be priced the same. That is, if the costs of providing services to individual users in a group are the same, then, each user of this user-group should be charged the same price irrespective of their price elasticities of demand. This assumption differs from the theoretical principles governing Ramsey pricing. According to Ramsey pricing, a service with low price elasticity is charged a higher price than a service with a higher price elasticity even if their marginal costs are the same.

Axiom 4: Positivity. If a transport enterprise has to incur higher costs in serving one group of users than another, then the group which causes higher costs should be charged a higher price than the other. This means, if the cost of providing services to users of group A is higher than the cost of providing services to users of group B, then, the users in group A should be charged a higher price than the users in the latter group.

Axiom 5: Additivity. Shared (common) costs should be allocated as add-ons to the separable cost so that the allocation to any user-category correlates with its relative cost. This simply means that the ratio of separable costs of the two user-groups A and B is equal to the ratio of the total costs associated with services rendered to the two user-groups.

Assume that there are only two groups of users in a port, -the cargo owners and shipowners and that all costs incurred by the port are to serve these two user-groups. If the costs involved in serving the two groups of users or the port's total cost is TC, and the avoidable or separable costs associated with services provided to cargo owners and shipowners are Ac and As respectively, then, the port's total cost is:

$$TC = FC + Ac + As \quad (1)$$

In equation 1, FC is the fixed or the common cost associated with the provision of services to cargo owners and shipowners.

Equations 1 accords with the notion of 'sharing' the total cost of serving users or the notion underlying the first axiom.

If it is assumed that the scale of measurement of any of the costs mentioned here are not subject to change, then the need for following the axiom on 'rescaling' (that is the second axiom) does not arise. Therefore the formulation of port prices presented here are not affected by the second axiom.

Axioms three and four are about user-prices. More precisely these axioms are about charging users according to the costs of providing services to them. Assuming that the per unit cost axiomatic prices paid by the cargo owners and shipowners are Pc and Ps respectively, then, the information given in equation 1 translates as follows:

$$Pc \text{ is proportional to } Ac/Xc \quad (2)$$

$$Ps \text{ is proportional to } As/Xs \quad (3)$$

where, Xc and Xs are the quantities of services utilised by the cargo owners and shipowners respectively.

Let r be the fraction of fixed cost utilised by the cargo owners. Accordingly, the cargo owners' share of the fixed cost is rFC and the total costs of utilising Xc units of services by the cargo owners are, (Ac + rFC). Similarly, shipowners' fraction of the fixed cost is [1-r]FC and the total costs of Xs units of services to them are (As + [1-r]FC). Utilising these results and heeding axioms 1, 3 and 4, the port's total costs can be restated as the sum of total costs of the two user-groups as shown below:

$$TC = (Ac + rFC)+(As + [1-r]FC) \quad (4)$$

According to the 'additivity' axiom or the fifth axiom, the total costs allocated to cargo owners and the shipowners correlate with their relative variable costs. That is,

$$\frac{Ac}{As} = \frac{(Ac + rFC)}{(As + [1-r]FC)} \quad (5)$$

From equation 5 we know that

$$r = \frac{Ac}{As + Ac} \quad (6)$$

Substituting for r in the term (Ac + rFC) by the value for it given in equation 6 and dividing the whole term by Xc, we can obtain the cost axiomatic price payable by cargo owners. This is shown in equation 7.

$$Pc = \{Ac + AcFC/(Ac+As)\}/Xc \quad (7)$$

We can derive the cost axiomatic price payable by shipowners (Ps) in a similar manner. This is shown in equation 8.

$$Ps = \{As + AsFC/(Ac+As)\}/Xs \quad (8)$$

Data requirements and the availability

According to equation 1, the type of data required for cost axiomatic pricing are:

(a) port's total annual operating costs and
(b) the costs that can be avoided or saved (avoidable costs) by withdrawing services to cargo owners and shipowners.

Obtaining these and other data suitable for public sector pricing have always been difficult. Because of the commercially sensitive nature, public authorities are extremely reluctant to release detailed costs and other relevant information. Even when available, such data need to be treated cautiously as the underlying objectives of maintaining cost records by public authorities have often been to serve accounting purposes. For instance, virtually all data recorded by ports characteristically contain fixed and variable costs combined with the costs for common and jointly used resources which are allocated on an *a priori* basis (Bureau of Transport and Communications Economics 1989).

Because of the data problems noted above, this study, of necessity utilises only the published aggregate data and other information to estimate parameters of the conceptual pricing models in equations 7 and 8. As such data cannot be directly used for establishing mathematical cost-output relationships for the port, appropriate econometric procedures need to be applied (c.f. Arnold, 1985; Waters and Woodland, 1986; Talley, 1988). To illustrate the econometric procedure for the estimation of model parameters, we utilise time series cost and output data for the 21 year period from 1969 to 1989 obtained from the Annual Reports, Trade and Transport Reviews and Port Gazettes of the Port of Melbourne Authority (PMA).

Parameter estimates

Annual variability of a port's total operating cost (TC) is influenced by a variety of factors. Fluctuations in port's throughput of cargo, the number and the size of vessels calling at the port are all factors having an important, direct and a significant bearing on the variability of port's operating costs. Loading and unloading of cargo are services rendered to cargo owners or shippers. Therefore it is assumed here, that the variability in cost of serving cargo owners can be proxied by the variability in cargo throughput. Similarly it is assumed, that variability in the cost of serving vessel operators can be proxied by the variability in annual ship calls, gross registered tonnage (GRT) or by an appropriate form of interaction between ship calls and GRT. Correlation of TC with cargo throughput, ship calls, gross registered tonnage and various interactions between ship calls and GRT showed that the total operating cost of the Port of Melbourne bears a statistically significant functional relationship with the annual throughput and the annual gross registered tonnes per ship visit. Assuming that the cost of serving cargo owners or its proxy, -the throughput is Xc; and the cost of serving shipowners or its proxy, -the GRT per ship visit is Xs; the Port's cost-output relationship can be modelled as:

$$TC = f(Xc,Xs) \quad (9)$$

A more explicit form of the port's cost function is:

$$TC = FC + \alpha Xc + \beta Xs \quad (10)$$

In this simple cost function, α and β are the coefficients of the variables Xc and Xs respectively. The terms αXc and βXs are the variable costs due to the two users. The other variables are as defined earlier.

This simple cost function can be used as illustrated below to estimate the costs that can be avoided or saved by withdrawing services to the two user-groups or their avoidable costs or separable costs.

Assume that TC' is the port's total cost after withdrawing services to cargo owners in a given year. Accordingly, the costs that can be avoided or saved by the port authority by withdrawing services to cargo owners in that year is,

$$Ac = TC - TC' \quad (11)$$

Since TC' = FC + 0 + ßXs, cargo owners' avoidable cost is simply the product of the variable Xc and its coefficient (α). That is, by setting Xc in equation 10 to zero, αXc or the cargo owners' avoidable costs can be estimated. Similarly shipowners' avoidable costs (ßXs) are obtained by setting Xs in equation to zero.

Accordingly, the avoidable cost of cargo owners is,

$$Ac = \alpha Xc \qquad (12)$$

and the avoidable cost of shipowners is,

$$As = \beta Xs \qquad (13)$$

Empirical results

The empirical estimate of the Port's cost function is shown in equation 14. The binary dummy variable (D) included in equation 14 is intended to account for any drastic fluctuations of the model variables about the trend. Such fluctuations may have occurred in the trade through the Port in 1978, 1979, 1984 and 1989. Events like the decline in overseas imports, significant slump in wool exports, the depressed level of coastal trade, disruptions to trade because of major industrial disputes may have affected the normal trade and shipping trends in 1977/78 and 1978/79. Easing of recessionary economic conditions in Australia and overseas, the end of drought in Eastern Australia may have had similar disruptions to normal trends in 1983/84. Significant influences on the growth in domestic demand in 1988/89 may have markedly affected the trade and shipping trends in that year. D is set to zero for 1978, 1979, 1984 and 1989. It's value is 1 for the remaining years.

$$TC = 34185552 + \underset{(2.9772)}{1.2319\,Xc} + \underset{(2.2101)}{1215.85\,Xs} + \underset{(4.4950)}{6013375\,D} \qquad (14)$$

The values in parentheses are t-statistics and the R^2 is 0.8257.

The signs of the estimated model-coefficients accord with *a priori* expectations. The fitted model has an explanatory power of over 82 percent and its coefficients are significant at the 5 percent level of probability. The statistical significance of the coefficient of D indicates that external forces have had a marked effect on the general trend of the Port's trade activities.

Applying the results of equation 14 in equation 11, the avoidable costs for cargo owners and shipowners were estimated. The estimated avoidable costs together with the appropriate parameters of equation 14 were then substituted in equations 7 and 8 to apportion Port's annual operating costs between the cargo owners (see equation 15) and shipowners (equation 16). As defined earlier, Pc and Ps respectively are the cost axiomatic prices of cargo owners and shipowners.

$$Pc = (1.2319Xc)\,[1 + \{34185552/(1.2319Xc + 1215.8Xs)\}] \qquad (15)$$

$$Ps = (1215.8Xs)\,[1 + \{34185552/(1.2319Xc + 1215.8Xs)\}] \qquad (16)$$

To estimate the average annual cost axiomatic charges payable by cargo owners and shipowners, Xc and Xs in equations 15 and 16 were replaced by port's average throughput (18272200 revenue tonnes) and its average GRT per visit (10172.30) for the 21 years.

The above estimates of cost axiomatic charges or the 'user-pays' charges for cargo owners and shipowners differ from that of PMA charges both prior to the introduction of their new pricing structure and after. This study shows that costs to cargo owners amount to about 65 percent of the aggregate user costs (i.e., the sum of costs to cargo owners and shipowners) and those due to shipowners is about 35 percent. These estimates assume that the shipowners' costs include tonnage charges, birth and area hire and any other charges that the port incurs due to them. In their pricing structure prior to 1.2.89, PMA collected berth hire charges from shipowners. Under the new pricing structure, shipowners' charges exclude berth hire and this is expected to be collected from stevedores or terminal operators.

According to the analysis presented here, to achieve equity and satisfy other management objectives, there appear to be a need for transferring to shipowners some of the costs that the cargo owners were made to bear before the new pricing structure was launched. Results from this study show that the cost transfer to shipowners should only be about 151 percent and not as high as 377 percent as claimed by the PMA.

This same procedure of cost allocation can be used to further apportion cargo owners' and shipowners' costs. For example, cargo owners' costs that are estimated in the above manner can be further apportioned between (i) imports and exports or (ii) between imports and exports of containers, general cargo and bulk cargo. Such estimates require time-series information on the volumes of aggregate imports and exports (for the first set) and the volumes of imports and exports of containers, general cargo and bulk cargo (for the second set).

The analysis presented here demonstrates the potential that exists in overcoming data problems. It showed the use of a simple econometric technique to successfully generate the parameters needed to apply the cost-axiomatic pricing model. The use of aggregate data as illustrated here is a considerably inexpensive approach to have meaningful insights into the magnitudes of gains from pricing and operational reforms. But estimate of gains from reforms can be further improved and prices can be formulated more accurately if transport authorities endeavour to collect cost data suitable to quantify avoidable costs associated with each user category.

Concluding comments

Setting prices in public enterprises is often a cost allocation exercise. In particular, it is an exercise in 'appropriate' allocation of non-separable costs. If non-separable costs can be allocated to fulfil equity or fairness objectives, then it automatically satisfies an important central consideration needed to set in motion public sector management reforms.

A major hindrance to achieve this end has constantly been the lack of meaningful cost allocation procedures. This paper demonstrates that cost-axiomatic pricing helps to achieve equity objectives while not violating other public sector management goals such as total cost recovery.

For them to be progressively less dependent on government subsidies and hence pave way for transition to commercial orientation, the managers of public transport authorities must have greater accountability of inputs and outputs with a view to fully recover costs. This paper illustrates that cost-axiomatic pricing can effectively aid the public sector authorities in achieving the commercial objectives.

Achieving equity objectives also contribute to the task of eliminating distortions in modal choice. As subsidies of all forms are eliminated, transport prices will not be artificially lowered or raised. Accordingly, the demand for transport services and capital investment in transport systems will not be distorted.

Equity or fairness objectives are incompatible with community services or development objectives. Public enterprises such as transport authorities have traditionally been the instruments for achieving such objectives. Equity or fairness objective has greater merit than development and community service objectives. Given the ethos of the present economic climate, the governments have to opt for equity objectives, rather than others and give the public sector reform process the impetus it needs.

Finally it must be noted, that "the equity issue ...may have little effect ....despite the heated debate which may take place" (Bureau of Transport and Communications Economics 1989:p63), for it is beyond the powers of public sector authorities to prevent any cost transfers either (a) between user groups of a transport service as can occur from shipowners to cargo owners when costs to the former increase under new pricing policies of certain city ports of Australia or (b) to the community as may occur from truck owners

and operators to those who use road transport services if pricing policies affecting the heavy vehicles change in future.

Acknowledgements

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A Method for Scoring Urban Freeway Performance

Kim Hassall
Transport Economist
Australia Post

Abstract:

The freeway will always command a prime focal position with regards road budgets at any level of government because of the large sunk cost involved. The U score has been designed to bring together the concepts of road design, capacity flow and user utility. Through empirically derived coefficients for a capacity flow relationship combined with a deterministic utility equation, this U performance score can be derived. The score may well be used in the freeway planning, or performance evaluation, process or for examining the behaviour of different freeways within the same city or in different cities.

Contact Author:

Kim Hassall
Investment and Economic Analysis Unit
Australia Post
GPO Box 1777Q
MELBOURNE VIC 3001

Telephone: (03) 204 7366 Fax: (03) 204 7230