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PORT PRICING POLICY WITH SEPCIAL REFERENCE TO THE PORT OF GERALDTON (WESTERN AUSTRALIA)

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Abstract:

Deficits incurred by regional ports in Western Australia resulted in across-the-board revisions. However, this policy tends to perpetuate distortions in the charging system. Hence, it is necessary to develop a more systematic basis for decision-making, especially in view of the recent recommendation that these ports should seek to achieve a specific financial objective.

The consensus of opinion among economists is that ports should base charges on marginal cost pricing principals. This paper reviews recent developments in this theory and examines its applicability to a regional port such as Geraldton.

PORT PRICING POLICY

INTRODUCTION

The deficits incurred by Regional Port Authorities in Western Australia, due both to increasing costs of operation as well as to the high interest burden they have had to bear, resulted in a number of tariff revisions. However, a study carried out in 1978[1] showed that serious shortcomings existed in current charging practices, particularly the fact that charges were not related to costs. Therefore, the policy of making across-the-board changes will result in the perpetuation of inherent distortions in the pricing system. The present study is an attempt to examine the problems involved in introducing a cost-based tariff in these ports to provide a more systematic basis for decision-making.

Geraldton, which was selected for a pilot study, is predominantly an export port handling bulk commodities, mainly grain and mineral sands. It also handles petroleum (from Kwinana) and the import of fertiliser inputs. The port is also a centre for the servicing of oil rig tenders. Grain, mineral sands and petroleum account for over 90 per cent of the total tonnage handled.

The Geraldton Port Authority (GPA) performs rather limited functions and acts more in the capacity of a landlord. The Harbour and Light Department provides navigational aids and pilotage and charges shipowners directly for these services. Towage is provided by a private company which also makes a direct charge. With regard to cargo handling, the main users themselves own and operate the equipment for bulk loading and discharging. The warehouses and storage areas available are not used. The GPA only undertakes the discharging of fertiliser inputs from bulk hoppers and the handling of general cargo with labour provided by a stevedoring contractor. Any equipment needed is hired as the GPA owns only one fork lift truck.

The pricing policy followed by the GPA at present is broadly one of charging "what the traffic will bear" subject to certain constraints. However, the basis of the charging system reveals many of the shortcomings noted by scholars. The most significant defect is the fact that the GPA, like many other port authorities throughout the world, does not base its charges on costs. The charging structure that existed when the GPA took over control in 1969 has not been changed. This feature is also common to many ports in other parts of the world where autonomous port authorities have taken over control from Government or Municipal authorities.[2]

Port pricing policy has been the subject of considerable discussion among scholars during the past decade and the consensus of opinion appears to be that ports, like other public utilities, should adopt some form of marginal cost pricing. The objective of this study is to examine the applicability of this theory to a port such as Geraldton.

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1. I. Ker (1978).

2. UNCTAD (1973).

MARGINAL COST PRICING

Marginal cost (MC) pricing was advocated for public enterprises on the principle that their prices should be set in a manner that would maximise social welfare and result in an efficient allocation of resources. This theory was built upon the ideas originally expressed by Dupuit (1844) and later developed by Hotelling (1939) and by Lerner (1947). Hotelling put forward his case for MC pricing in relation to railway rates. Since then there has been general agreement that public sector transport undertakings should adopt this pricing rule. (1)

The adoption of MC pricing involves a decision as to whether it should be based on short run or long run costs (SRMC or LRMC). If we assume perfect competition, firms will be forced by the competitive conditions to produce a level of output such that SRMC is equal to the price determined on the market. Then the ratio of the marginal cost of production of any two goods will be equal to the marginal rate of substitution between the two goods for every individual. Thus, a Pareto optimum is achieved where it is impossible to increase the output of any product without reducing that of another. In these conditions, the public utility, by fixing its price at SRMC ensures that its plant is used most efficiently and that the distribution of resources is optimised. However, since perfect conditions do not prevail in an economy, it becomes necessary to diverge from the SRMC pricing rule. (2)

The use of the SRMC pricing rule also creates a difficulty as it does not provide a direct criterion to determine whether a given investment was worthwhile. For this purpose it is necessary to base price on LRMC, i.e. to include investment cost as part of the price. However, Walters (1965) argued that once an investment had been completed, the objective should be to maximise the use of the asset and, therefore, the 'investment test' argument for LRMC pricing was a "bad one". Instead he based his case for LRMC pricing on the argument that, in the case of administered prices - whether by monopoly or nationalised industry - there can be considerable changes in the conditions of demand and supply without any change in the price charged. Traditional theory assumed that price adjusted immediately and costlessly to a new equilibrium situation. Walters argued that this assumption was normally not valid with regard to administered prices. This arose from the 'stickiness' introduced by the framework of regulation and control in all organisations with centralised decision-making systems. In the case of public utilities there is also the need to convince political authorities that price revisions were necessary and this would take a considerable length of time. Therefore, Walters concluded that, "both in rail transport and road pricing there seems to be a case for taking account of a period much longer than the traditional short run in measuring marginal costs for pricing purposes".

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1. See, for example, Allais Report (1965); Walters (1968).

2. See, for example, Baumol and Bradford (1970).

The adoption of LRMC pricing was recommended by the (UK) White Paper on Nationalised Industries (1967). It was, however, recognised that this pricing rule would need to be departed from in situations where either spare capacity or excess demand existed when prices would have to be lowered to SRMC or increased as a rationing device. However, a NEDO study (1976) showed that none of the four nationalised industries examined, including British Rail, based their pricing policies on LRMC or SRMC. British Rail prices were determined primarily by market factors as it operated in a competitive market for most of its business. Some services which were planned to be phased out, however, were priced on a basis which reflected their SRMC.

However, the indivisible nature of most investments and the economies of scale inherent in many operations mean that the adoption of MC pricing (whether LRMC or SRMC) will result in deficits and the non-recovery of capital costs. Thus, as Turvey (1971) observed, if a new system is built with capacity in excess of the probable initial level of demand (due to indivisibilities) MC will be confined to running costs until demand has grown. This will clearly result in a deficit. Therefore, the major problem is to devise a method by which capital costs are recovered. One way of dealing with this problem is to subsidise the enterprises directly. But it has been shown that distributional and allocational distortions result from subsidisation in any form.(1)

Two policies, which are modified versions of the MC pricing rule, are usually adopted by public utilities to recoup capital expenditure. Firstly, the policy of discriminate pricing in which the minimum charge is based on immediately escapable costs and capital costs are recovered by charging "what the traffic will bear". Secondly, a two-part tariff based on the 'club principle' where a charge for usage is levied on SRMC while capital costs are recovered by means of a fixed admission or membership fee.(2) Thus, the recovery of capital under these pricing rules requires an annual charge or amortization payment based on the replacement cost of the asset.

AMORTIZATION - ANNUAL CAPITAL CHARGE

It has been argued, for example, by Merrett and Sykes (1969), that the constant annuity method is an appropriate way to determine the annual capital charge in public utilities which provide for the redemption of capital by way of sinking funds. It was considered particularly appropriate for pricing purposes because it provided a constant annual figure for depreciation and interest. However, the factors taken into account in this approach are not sufficient conditions to make the annual charge consistent with the principles of MC pricing.

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1. See, for example, Wiseman (1957).

2. Buchanan (1965); Littlechild and Thomson (1977); Anderson and Bonsor (1978).

Marginal cost is a more complex concept than merely the change in total cost resulting from a given change in output, as noted by Turvey (1969, 1971). He showed that both cost and output have time dimensions and both may be subject to uncertainty. He argued that marginal cost should be considered as being equal to first year running costs of new capacity plus its first year amortization per unit of output and that forecasts of economic life and the specification of a discount rate were not sufficient to determine the appropriate amortization when technical progress and/or running costs which rise with age were expected. Thus, he noted that, in the context of technical progress, "the correct amortization of plant in the first year of its life will be greater than the constant annuity whose present value equals capital costs, while in the last year it will be less than this value".

Therefore, in Turvey's approach first year amortization, "epitomised the complex of expectations and calculations about the future which (were) central to the notion of marginal cost". He rejected accounting rules of depreciation which, he maintained, involved conservative estimates of economic life and an arbitrary choice between devices such as straight line and diminishing balance. He argued that rules for amortization could not be derived without a proper calculation of marginal cost and proposed the following programming analysis.

The enterprise considered was assumed to produce only one non-storable output and have a given amount of inherited capacity Q^0. The demands to be met were given; thus, the amount to be produced in period t is X_t and this was decided in advance from t=0 to infinity. (An infinite horizon was chosen to simplify the exposition.) Output is produced by only one kind of 'capacity' which incurs running costs. The cost of new capacity is expected to change through time and so may the running costs per unit of new capacity which may rise as capacity gets older.

The present worth of the total lifetime cost of acquiring and using Q^ν, i.e. the number of units of vintage, ν, is

$$c^\nu . Q^\nu + \sum_{t \geq \nu} r_t^\nu . O_t^\nu .$$

Summing over all vintages gives the present worth of the total costs of the enterprise from now, t=0, to infinity.

$$\sum_{\nu \geq 0} \left(c^\nu . Q^\nu + \sum_{t \geq \nu} r_t^\nu . O_t^\nu \right) \qquad (1)$$

The objective function (1), is the present worth of system costs, which is to be minimised by choosing the best time-paths of capacity acquisition Q^ν and of operation O_t^ν to provide the given time-path of output X_0, X_1, X_2 ..... This minimisation is subject to various constraints. Thus

$$Q_t^\nu \leq Q^\nu \quad \text{for all } \nu \text{ and all } t \geq \nu \qquad (2)$$

$$X_t \leq \sum_{\nu=0}^{t} O_t^\nu \quad \text{for all } t \qquad (3)$$

$$Q^0 \leq \bar{Q}^0 \qquad (4)$$

$$Q^\nu, O_t^\nu \geq 0 \qquad (5)$$

where Q^ν = number of units of capacity of vintage ν installed; once installed in t=0 this capacity is available in all subsequent years.

c^ν = the present worth now of the capital cost of a unit of new capacity which becomes operational in $t=\nu$.

O_t^ν = output produced in period t by capacity of vintage ν.

r_t^ν = the present worth now of the period t unit running cost of capacity which became operational in $t=\nu$.

X_t = forecast output in year t.

Q^0 = given amount of capacity inherited from the past, $\bar{Q}^0$, and available free now at the beginning of period 0 so that $c^0=0$.

It was argued that the solution to this problem would give estimates of MC as the dual of the output constraint (3).

However, Parmenter and Webb (1976) argued that Turvey's approach to the determination of MC and the optimal first year amortization involved data requirements which were "quite severe". They suggested instead that an attempt be made to derive rules of thumb to give estimates of amortization embodying the essence of the theory put forward by Turvey but which required less data inputs. It was argued that the calculation of the first year amortization charge for new plant to be added to unit running costs to give a measure of MC appropriate for pricing decisions depended on the same considerations as did the operation of discounted cash flow investment decision rules and that the appropriate discount rate was the marginal cost of funds to the enterprise. They noted the Desrousseaux rule which suggested that optimal first year amortization allowance can be measured as twice the amortization allowance produced by a constant annuity.

Thus, what was required was an amortization stream for a unit of capacity of vintage $\nu=0$ such that

$$c^{\nu=0} = \sum_{t=0}^{T^*} \frac{A}{(1+r)^t}$$

where $c^{\nu=0}$ = present value of the cost of installing a unit of capacity in year 0,

A = the annual unit amortization charge for vintage ν plant defined to be constant with respect to t,

r = rate of discount (assumed constant),

T* = economic life of the vintage,

and discrete, annual discounting is assumed.

$$A = \frac{c^{\nu=0}.r(1+r)^{T^*}}{(1+r)^{T^*} - 1}$$

which is the standard fixed term annuity formula.

The information required for this approach consists of the cost of installing new capacity, the rate of discount and an estimate of the economic life of the asset. A considerable weight is placed on estimates of economic life, which was the key data to be obtained from the enterprises. However, Parmenter and Webb noted that, "firms may employ truncated estimates of economic life in their investment and pricing decisions as a method of accounting for risk". They argued that the risk factor could be taken into account by adding a risk premium to the discount rate.

The Desrousseaux rule was rationalised on the basis of the following assumptions. Firstly, that marginal cost, in real terms, of the product will decline over time at a linear rate (because of the effects of technical progress); secondly, that the unit operating cost of a unit of any given vintage of plant would rise over time at a linear rate, and thirdly, that the discount rate was zero. Then if an accurate estimate of economic life was available, the optimal first year amortization, $k_{t=0}^{\nu=0}$, could be measured as twice A, the constant annuity.

It was further argued that similar linearity assumptions could be made for the case of a positive discount rate and combined with an estimate of the economic life of the asset in order to estimate the optimal amortization streams. But here the choice was available to impose the linearity on discounted or undiscounted values. One of the ways in which the problem was formulated was the following (upper case letters are used for undiscounted values): Given a rate of discount, r, and an estimate of the economic life of the asset, T*, what stream of amortization allowances, declining linearly to zero at T*, has a present value equal to the supply price of the asset? It was maintained that the answer to this question could be calculated using the same information as was required to calculate A. Thus, it was shown that, using discrete annual discounting, the required time stream of linearly declining undiscounted allowances was given by the formula:

$$K_t^{\nu=0} = \frac{C^{V=0}(1-R)^2}{T^* R(1-R) - R(1-R^{T^*})} \cdot (T^* + t)$$

where $R = \frac{1}{(1+r)}$.

It was noted that the introduction of a positive rate of discount breaks the simple relationship between first year optimal amortization and the constant annuity. Instead, the relationship depended on both the rate of discount and the estimated economic life of the asset. It was shown that the ratio $K_{t=0}^{v=0}/A$, declined as the rate of discount increased and as T* increased.

Parmenter and Webb also noted that, even if reasonably accurate estimates of economic life were obtained, the usefulness of this approach depended on how accurately the optimal amortization streams implied by the modern theory of marginal cost were approximated by the key linearity assumptions in real world cases. However, they argued that where the economic life of a vintage of durable capital equipment was determined by the gradual increase over time of its escapable cost per unit of output relative to the marginal cost of the system as a whole, rather than by a sudden physical collapse, the optimal allocation of the associated capital cost should be on a declining rather than on a constant basis. Therefore, they noted that a first year amortization allowance in excess of that produced by the constant annuity rule would always be an appropriate basis for pricing decisions when combined with best practice running costs.

CURRENT PORT CHARGING PRACTICES[1]

Since a port provides facilities of a general and specific nature it is possible to make a broad distinction between general port dues and specific tariffs. The latter category of charges are levied for clearly defined services - pilotage, towage, storage and warehousing and cargo handling. General charges are levied for the use of port facilities as a whole and consist of conservancy dues, dock (or berthing) dues and wharfage.

The (UK) Dock and Harbour Authorities Association (DHAA) (1968) defined the conservancy due as the levy on shipowners for the facilities and services provided to enable a ship to enter the port from the open sea. UNCTAD (1973) showed that ports used net register tonnage (nrt) to charge for navigational aids which form part of conservancy facilities and services. The dock due (or berthage) was defined as the levy on shipowners for the facilities and services provided to enable a ship to dock at a berth. In most ports this due was also based on nrt with the time for which the facilities were used also taken into account. Wharfage is a due charged to the cargo owner for the use of the general port infra-structure and superstructure on the landward side. It was usually calculated on volume or weight of cargo. The DHAA noted that there was no need to standardise the method by which this due should be levied as it was charged against a few cargo handling firms and not against a large number of port users. It could, therefore, be settled by negotiation and may be levied by way of a fixed rent based on the time for which the facilities were used or which varied with throughput or one which combined both these factors.

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1. A more detailed discussion of port charging practices is contained in my "Review of Port Pricing Policy" (mimeo) Department of Economics, University of Western Australia (1980).

The basis on which port charges are levied is also an important factor to be considered in developing a charging system. This is so particularly in regard to dues on vessels because it has been noted that ship operators make false declarations or misdeclarations concerning ship's characteristics.(1) Dues on vessels are based on either size determined by gross register tonnage (grt), length and breadth of the vessel, or on the ability to pay which is usually determined on the basis of net register tonnage (nrt) which measures cargo carrying spaces. Heggie (1974) noted that the number of tonnes of cargo worked in port was also a suitable measure of ability to pay.

Both grt and nrt, which are the most widely used measures, have been subject to considerable criticism.(2) For example, Bennathan and Walters (1979) maintained that the nrt of ships can be varied by small changes in ship design and in deadweight tonnage without affecting the port's cost of servicing the ship. With regard to grt it was noted that though, "this was less open to abuse .... the correlation with cost (was) not high (nor was there) a good correlation with cargo carrying capacity". Wilson and Hunter (1972) showed that the major problem arose as a result of the different interpretations put upon these units by different authorities which resulted in anomalies between identical vessels due to the different treatment of water ballast spaces or common passenger spaces.

The Universal Measurement System (UMS) was proposed in 1969 as a means of overcoming these problems. However, Wilson and Hunter noted the shortcomings in this system which related to the measurement of vessels as well as to the definition of cargo spaces. The Working Group of the Association of Australian Ports and Marine Authorities (AAPMA) (1978) also did not favour UMS and recommended that port charges be based upon a formula derived from length, breadth and maximum draft of all vessels. This system, it was argued, would cover all deck cargo and also have the advantage that the factors used were readily ascertained and checked.

APPLICATION OF MARGINAL COST PRICING TO PORTS

Indivisibilities and economies of scale are inherent features of most port investments and operations. Therefore, as Bromwich (1978) showed, the short run costs of handling a trade in a port are very small and of little use in pricing decisions because the greater proportion of costs is fixed. Similarly, the indivisibility of most investments means that LRMC pricing would not be feasible except in a situation of optimum capacity utilisation. However, the objective of allocational efficiency requires the use of MC pricing. As Heggie (1974) showed, port pricing objectives could be achieved, without administrative direction of traffic, by relating charges to the marginal social opportunity cost (MSOC) of the resources used to provide services. Furthermore, as Button (1979) noted,

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1. See Sainsbury (1971); UNCTAD (1973), Bennathan and Walters (1979).

2. Ports and Harbours (1972).

if port charges were set either below or above MSOC, it would result in either excess or sub-optimally limited port capacity, both of which result in a waste of resources.

We noted that the use of strict MC pricing will mean that capital expenditure will not be recovered. However, the recovery of capital costs is important because most countries treat ports as commercial undertakings which have to achieve a financial objective. This attitude which was first given expression to by the Rochdale Committee now appears to have been accepted in Western Australia. However, it must be noted that in some European countries, capital costs of the port are written off on the grounds that it is an essential infrastructure facility.(1)

Two pricing policies which provide for the recovery of capital costs have been suggested for ports. Firstly, charging on the basis of "what the traffic will bear". UNCTAD (1973) noted that this was the policy followed in most ports at present but Button (1979) showed that the actual policies were not consistent across ports and were seldom based on MSOC principles. Secondly, Walters (1976) suggested the use of two-part tariffs where a low charge equal to SRMC is combined with a fixed charge, sufficient to recoup capital costs, for annual access to facilities.

However, several writers have noted that the introduction of MC pricing in ports involves considerable difficulties. These arose mainly from the fact that ports rarely classified expenditure under the kind of functional headings required for efficient cost accounting. Thus, Heggie (1974) showed that the introduction of a cost-based tariff would require a complete overhaul of the costing procedures. Walters (1976) noted that there would be "difficulties of detail and administration" and observed that MC pricing "does not provide a panacea for ailing or congested ports".

Port costs are incurred for two main activities. By definition a port has to provide facilities for a ship to enter the harbour and dock at a berth as well as for cargo to be moved from ship's hold to inland transport or storage and vice versa. The costs involved in the first category (such as dredging) are basically fixed costs and inescapable in all senses and the assets created do not have alternative uses. The escapable costs involved are relatively insignificant. The costs in the second category are those of durable assets which are subject to depreciation and have opportunity costs.

Heggie (1974) argued that all past capital dredging and all existing quays could be treated as sunk costs. He maintained that while these costs were a function of ship size, once the facilities had been created port costs were virtually unaffected by the size of the vessels using them. Therefore, he argued that these costs should be recovered in relation to

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1. National Ports Council (1970); Heggie (1974).

ship's ability to pay as measured by its nrt and not in relation to its size. This is basically a policy of "charging what the traffic will bear".

The same argument was used in the case of new capital dredging. Heggie argued that this cost should be recovered from the larger vessels that required the extra water. It was suggested that, "beyond a certain size, a due should be collected which in total equalled the cost of providing the extra water and that this should also be based on the ship's ability to pay. Therefore, Heggie argued that the charge be based on nrt and, in addition, be scaled by actual draft since this was the most important factor affecting dredging costs. He showed that this could be done by covering the current maximum permissible draft and then dealing with any future dredging, or that carried out in the recent past, in intervals of say 2 metres. The task of the pilot would be to record into which range of draft a particular vessel falls.

Heggie maintained that discriminating by draft was necessary even though capital dredging, when completed, is inescapable in all senses and could easily be recovered by a standard tonnage due on all vessels using the port. However, it was shown that this argument would overlook the fact that new dredging had only been undertaken (or should only be undertaken) for the benefit of deep draft vessels willing to meet this cost. It was maintained that a uniform due would charge part of the of dredging to the shallower draft vessels that derived no specific benefit from it, and that this may discourage some of them from using the port or force them to raise their charges. He also showed that quay or berth dues should be related to the size of the ship and suggested that the cost of longer quays be recovered from the ships that required this extra length by means of a "jumbo length surcharge". The relevant length would be the length between the perpendiculars which is readily available from the ship's International Tonnage Certificate.

Walters (1976) who recommended that ports should adopt a two-part tariff to obtain the benefits of MC pricing without the disadvantages of losses and subsidies maintained that it "seemed silly" to dredge a deep channel and charge high fees from the very vessels it was designed to accommodate. He noted that the "willingness to pay" criterion was required before the decision to dredge was made and that evidence *ex post* was of little use. Therefore, he argued, charges had to be designed to encourage utilisation by large ships so that the port and the country could benefit from the economies that the construction of the deeper channel made possible. He recommended a low charge for the use of the channel (SRMC) combined with a fixed charge for annual access and argued that conference vessels be charged more than vessels operated by competitive organisations. The basis for this argument was the fact, noted by Heggie (1974) that the conference charging system did not allow any advantage in the freight rate to a port which effected improvements. Therefore, Walters argued that ports should load as much as possible of the unallocated port costs onto the conference operators. This was possible, he said, because the conference faced a kinked demand curve and an increase in costs did not, for a considerable range, have an effect on freight rates.

Another area in which this two-part tariff could be adopted is in container handling. Here the economies of scale made it necessary to impose a low charge for usage combined with an annual rent, to recoup capital costs, for the right to operate a container service to the port. He argued that this would encourage container firms to bid vigourously for additional traffic and so realise the economies of scale. However, Wilson (1979) noted that the appropriate level for the variable portion of the charge would be the price which maximised net annual domestic benefits resulting from the investment rather than marginal cost as suggested by Walters.

The cost of durable assets is an avoidable cost. UNCTAD (1973) noted that most ports treated all assets, except land, as renewable. Thus, the basic problem is to determine the amortization payment, based on marginal cost principles, for the recovery of capital costs. For this purpose it is necessary to determine a basis of valuation and an estimate of the economic life of the assets. The current practice among ports is to provide for depreciation on the basis of historic costs using mainly the straight line method over periods of life (which varied widely among ports) which UNCTAD (1973) noted was, "too optimistic". It was suggested that, "it would be more prudent to err on the side of short depreciation periods". Thomas (1978) showed that in the UK too the schedule of assumed lives adopted for depreciation purposes was too "excessive" in most ports.

With regard to the basis of valuation, it has generally been recommended that estimated replacement cost be used. However, Heggie (1974) showed that this would result in users being penalised during the early years of the asset's life as they would be required to contribute towards an estimated rate of inflation at a future point in time. He suggested instead that current replacement cost be used for this purpose and that cargo dues (wharfage) should be based on the cost of a new alongside quay. This could be valued on the basis of either net replacement cost or resale value (opportunity cost). The opportunity cost of the quay is an important factor in long term decisions. This is determined on the basis of the alternative uses of the quay which would be to reclaim the land and sell it or lease it for a variety of uses. This value has to be estimated in relation to market prices in the port neighbourhood.

The determination of replacement cost could, however, present some difficulty. Thomas (1976) showed that an attempt to estimate the current replacement cost of fork lift trucks in a British port by using a mechanical equipment index provided estimates greatly in excess of current market prices. Johnson (1971) noted that the British Transport Docks Board used a different approach which avoided this problem. It provided for depreciation on the straight line method on the revalued cost to the Board of the assets vested in 1963, with subsequent additions at cost together with an additional amount based on an index of the general price level. UNCTAD (1973) recommended that ports should adopt the constant annuity method to recover capital costs. However, these methods are not based on MC pricing principles.

A method of determining amortization allowances based on these principles was suggested by Heggie (1974). He showed that, instead of a linearly declining stream of allowances, it would be "simpler, in real terms, to require each unit of service provided by an asset to make an equal contribution (in each year) towards its net replacement cost". He also noted that the economic life of assets could be based on their expected physical life and that the charge should reflect the marginal social opportunity cost of the resources used to provide port facilities.

Thus, the due would be determined by

$$d = \frac{R_0}{V_0}\left[\frac{1-(1+r)/(1+R)}{1-\{(1+r)/(1+R)\}^T}\right]\frac{1}{(1+r)/(1+R)}$$

where d = the due,

R_0 = the real replacement cost of the asset in year 0

V_0 = the volume of traffic serviced in year 0 (measured in nrt or tonnes),

r = the rate of growth of the service provided by the asset,

R = the discount rate,

T = the physical life of the asset.

Heggie also suggested that, to take account of inflation, the due should be increased by the average rate of inflation over the previous year. Thus, $d(1+i)^x$, where i is the estimated annual rate of inflation. The real replacement cost of the asset in year x will then be $R(1+i)^x$. Though this would still leave a shortfall when replacement actually fell due, it will be less than that incurred by historical cost depreciation.

FACTORS AFFECTING GERALDTON PRICING POLICY

Two main factors affect pricing decisions at Geraldton.[1] Firstly, like other regional ports in the State, there are no clearly defined objectives it is expected to achieve. Ker (1978) described the system within which these ports operated as a, "mixture of commercial and public service requirements" and recommended that a financial objective be specified requiring them to cover operating costs and capital servicing charges taking one year with another.

Secondly, the nature of the commodities handled. Both mineral sands and grain have to be charged low rates: in the case of mineral sands this is due to the problems the industry is

1. A more detailed discussion is contained in my "The Port of Geraldton: A Review of Operations" (mimeo) Department of Economics, University of Western Australia (1980)

currently facing while the rate for grain is kept low by government direction. It has also been shown that an increase in port charges for the latter commodity may result in the centralisation of grain shipments with adverse effects on regional ports. This would, however, depend on the elasticity of demand for the services of the port. Heggie (1974) noted that the short run price elasticity of demand for port services is low but that the usage of individual facilities within the port complex was far more sensitive. Goss (1979), on the other hand, argued that there was a high cross-elasticity of demand between ports and a significant elasticity of demand for any given port.(1) However, in the case of Geraldton since it is the only port between Fremantle and Port Hedland (a distance of nearly one thousand nautical miles) with the capacity to handle a variety of cargoes it does not face any serious competition.

A charging system for Geraldton has also to take account of the recent investment of approximately $10 million in harbour deepening, construction of No.5 berth and other capital works.' Heggie (1974) argued that one of the functions of a port tariff is to "tax" benefits of port investment so that the country recovers as much as possible from its investments. UNCTAD (1973) has also referred to this aspect of port pricing policy.

CONCLUSION

The GPA charges both berthage and wharfage on the number of tonnes of cargo worked. Capital costs are taken account of by way of straight line depreciation on book values. It is suggested that, in the context of the established theory and taking the specific features of the port into consideration, Geraldton should develop a cost-based tariff incorporating marginal cost pricing principles so that the recommended financial objective could be achieved.

Berthage

The berthage due levied by the GPA is intended to recover not only the cost of the facilities provided to enable a ship to dock at a berth but also the cost of capital and maintenance dredging. It is, therefore, necessary to ensure that the cost of the recent harbour deepening project which increased the maximum permissable draft from 8.6 metres to 9.1 metres is recovered by means of this charge. Since these costs are best treated as sunk costs, the most appropriate method of cost recovery would be by way of a charge based on ship's ability to pay scaled by actual draft as suggested by Heggie. It is generally accepted that ability to pay is best measured by the ship's nrt.

Wharfage

A number of factors have to be taken account of in determining the wharfage due. Firstly, the functions of the GPA

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1. See also Wilder and Pender (1979)

as a landlord help to simplify the charging structure. Secondly, the fact that each main commodity is handled at a specific berth which simplifies, to some extent, the problem of cost allocation. Thirdly, the irregular pattern of ship arrivals resulting from the fact that grain accounts for a significant part of total tonnage. This could cause congestion although it is not a problem at present.(1)

These considerations suggest that an appropriate way to levy wharfage would be by means of a fixed charge based on current replacement cost of the asset, discounted at the marginal cost of funds to the port over its physical life. The charge could be levied as an annual rent because the port has only a few main users. This has an advantage in that it permits a degree of flexibility to take account of any change in economic lives and/or interest rates. A variable charge could be levied to recover the cost of specific services provided to vessels on each visit. This would, therefore, be a two-part tariff on the lines suggested by Professor Walters with the amortization allowance based on the Parmenter and Webb model but with a constant annual charge as suggested by Heggie.

1. Harding and Ryder (1978) showed that a way of reducing the variation in the demand for port facilities caused by irregular ship arrivals would be to require shipping lines to pay a premium for a guaranteed berth on arrival.

REFERENCES

Anderson, F.J. and Bonsor, N.C. (1978). "Optimality and incentives in public utility pricing", International Journal of Transport Economics, Vol. 5 No. 1.

Association of Australian Ports and Maritime Authorities, "Report of the committee on ship's tonnage in relation to port charges", 1978 (mimeo).

Baumol, W.J. and Bradford, D.F. (1970). "Optimal departures from marginal cost pricing", American Economic Review, Vol. 60.

Bennathan, E. and Walters, A.A. "Port pricing and investment policy for developing countries", New York, Oxford University Press, 1979.

Bromwich, M. (1978). "Port costs - and an alternative approach", International Journal of Transport Economics, Vol. 5 No. 3.

Buchanan, J.M. (1965). "An economic theory of clubs", Economica, Vol. 32.

Button, K.J. (1979). "The economics of port pricing", Maritime Policy and Management, Vol. 6 No. 3.

Dock and Harbour Authorities Association (London), "Report of the port charges sub-committee", 1968.

Dupuit, J. (1844). "On the measurement of the utility of public works" in D. Munby (ed.) Transport: Selected Readings, Penguin, 1968.

EEC Transport Study Series (1965). "Options in transport tariff policy" (Allais Report) Brussels.

Goss, R.O. (1979). "A comparative study of seaport management and administration", Vol. 1, Government Economic Service, London.

Harding, A.S. and Ryder, S.C. (1978). "The impact of irregular ship arrivals on liner terminals with high fixed costs", Marine Transport Centre, University of Liverpool.

Heggie, I.G. (1974). "Charging for port facilities", Journal of Transport Economics and Policy, Vol. VIII No. 1.

Hotelling, H. (1938). "The general welfare in relation to problems of taxation and of railway and utility rates", Econometrica, Vol. 6.

Johnson, S. (1971). "Financial policies for ports", International Association of Ports and Harbours, Montreal Conference.

Ker, I. (1978). "A review of Regional Port Authority finances", Director General of Transport, Perth, Report 188.

Lerner, A.P. Economics of Control, New York, Macmillan, 1947.

Littlechild, S.C. and Thompson, G.F. (1977). "Aircraft landing fees: a game theory approach", Bell Journal of Economics, Vol. 8 No. 1.

Merrett, A.J. and Sykes, A. The Finance and Analysis of Capital Projects, London, Longmans, 1969.

National Ports Council (London) (1970). "A comparison of the costs of Continental and United Kingdom ports."

National Economic Development Office (NEDO) (1976). "A study of UK nationalised industries", HMSO, London.

"Nationalised industries: a review of economic and financial objectives" (1967), Cmnd. 3437, HMSO, London.

Parmenter, B.R. and Webb, L.R. (1976). "Amortization and public pricing policies", Australian Economic Papers, Vol. 15.

Ports and Harbours (1972), Vol. 17 No. 9.

Report of the Committee of Inquiry into the major port of Great Britain (1962), Cmnd. 1824, HMSO, London.

Sainsbury, J.R. (1971). "The simplification of port charges", International Association of Ports and Harbours, Montreal Conference.

Thomas, B.J. (1976). "Port pricing" in UNCTAD Manual on Port Management, Part 4.

Thomas, B.J. (1978). "Port charging practices", Maritime Policy and Management, Vol. 5 No. 2.

Turvey, R. (1969). "Marginal costs", Economic Journal, Vol. 79.

Turvey, R. Economic Analysis and Public Enterprises, London, Allen and Unwin, 1971.

United Nations Conference on Trade and Development (UNCTAD) (1973). "Port pricing", Report by the Secretariat, TD/B/C.4/110.

Walters, A.A. (1965). "The long and short of transport", Bulletin of the Oxford Institute of Economics and Statistics, Vol. 27 No. 2.

Walters, A.A. Economics of Road User Charges, Baltimore, Johns Hopkins, 1968.

Walters, A.A. (1976). "Marginal cost pricing in ports", The Logistics and Transportation Review, Vol. 12 No. 3.

Wilder, R.P. and Pender, D.R. (1979). "The economic behaviour of public ports in the United States", Journal of Transport Economics and Policy, Vol. XIII.

Wilson, B. and Hunter, T. (1972). "Alternative measurements of the types of vessels calling in British ports in relation to port charges", National Ports Council, London.

Wilson, H.G. (1979). "Port pricing and investment planning", The Logistics and Transportation Review, Vol. 15 No. 3.

Wiseman, J. (1957). "The theory of public utility price - an empty box", Oxford Economic Papers (new series), Vol. 9.