Pricing Policy

Washington State Ferry System

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16. Abstract

This study considers how prices are first set in the private sector using simple, micro-economic models. Second, it considers how prices should be set in the public sector using the theoretical framework of user charges in public finances. Third, we look at how prices are established in the transportation literature, with the highway transportation literature being considered the more relevant. Then how prices are determined in Washington's transportation system, in general, and the ferry system in specific were analyzed. Empirical evidence on Washington's ferry system fares and subsidies were studied as was evidence on the price elasticity of demand for various transportation services. Finally, the impacts of changing the price level for ferry services was considered as were a number of recommendations for pricing policy changes.

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Pricing Policy for the Washington State Ferry System

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I. Executive Summary

The most important conclusion to come out of this study is that the pricing of the Washington State Ferry System has not been made following economic rationales. Data needed to price ferry services properly has in general not been collected. While system-wide cost data are available and ferry-class and route data are becoming available, cost and demand information on individual routes, during different times of the day and during different seasons of the year are not readily available. Thus estimates of a more efficient and equitable pricing scheme on each route cannot be made and compared to existing prices. (See Section X.)

Even with the existing data base a number of tentative recommendations on pricing policy changes can be made:

1. The system of fares should differentiate between users and the benefits they receive. (See Section IV.) At a minimum users during peak periods, when congestion occurs, should pay higher prices than users during off-peak periods. This price increase would be one way to raise total revenues which then could be used to reduce the state subsidy if that is desired. The price increase would also reduce congestions by spreading the traffic over a longer time period.

   Since congestion appears only with vehicles, further differentiation between vehicle and passenger fares should occur; that is, the relative price of vehicular traffic should increase. Using more technical languages, value of service or benefit theory pricing should be followed so price varies inversely with the elasticity of demand. (See Section V.)

2. Evidence in this study indicates the real price of ferry services has trended downward while the ratio of subsidies to operting costs have trended upward. (See Section VIII.) These increased subsidies are then capitalized into land values of the communities served by the ferry system, providing the individuals who live in these communities with an unexpected windfall. Because benefits from using the ferry system appear constant these trends would indicate that, in general, prices for ferry services are likely to increase and should probably go up to the point where price is equal to long-run marginal cost less any externalities. But any price increased (subsidy decreased) will be capitalized into losses in poverty values making the decision to raise prices politically sensitive.

These conclusions come from the following analysis developed in this study:

A. State government revenues appear to be inadequate to meet the needs of Washington's citizens. Hence the Governor has recommended a tax increase to support improvements in educational services. Under certain conditions (See Section II) user changes are a preferred way to raise revenues. This is so when the burdens of the changes fall on the primary beneficiary of the state government services, e.g., the user of the ferry system. When ferry system fares

approach the marginal cost of providing them allocative efficiency will be improved and the "visible hand" of government will closely approximate the "indivisible hand" of the private sector. While the goverment should not act like the private sector when the benefits of a program fall on all of its citizens, it should act like the private sector when the benefits primarily fall on specific individuals--the users of the ferry system.
Financing the ferry system with general taxes when the benefits of the system fall on just the user means that income transfers are occuring between the general population to the user of the ferry system. Such a redistribution could cause political problems unless a strong case can be made for subsidizing the ferry system. Subsidization levels are correct if they just equal the levels provided other kinds of transportation and the external benefits to the state of the ferry system.

B. If the Washington State Ferry Service was sold to a for-profit corporation, the new owner would attempt to maximize profits by trying to cut costs and by trying to manage the operation more efficiently. Being a monopolist, management would attempt to determine what were the marginal costs and marginal revenues for each product. Where MC equals MR, the optimal output of the particular ferry service would exist; while price would be determined by the demand curve of the users (P=MB>MC). Management would set higher fares on routes where there were not alternative highways or other forms of competition, during rush hour, during peak vacation periods and with other classes of users with inelastic demands. (See Section III.) If sufficient cost and revenue data were not readily available, management would experiment with raising prices to see if profits increased. They would continue to raise prices until profits on a particular route began to fall. They would then know that they were operating their business as efficiently as possible. (Note: The ferry system was in the private sector until 1951 and it was having financial problems. Thus, privatization is not necessarily a solution to existing problems.)

C. Assuming that the Washington State Ferry System will remain in the public sector, the managers have a more difficult task. They must be concerned with both efficiency and equity. (See Section IV.) They also must concern themselves with not only the direct cost and benefits of the ferry system, as in the private sector, but they also must consider the external costs and benefits. The pricing rule which is both efficient and equitable is that each type of ferry service should produce fares which are equal to MC for efficiency and equal to marginal benefits for equity (P=MC=MB) but these are marginal social costs and benefits, not the marginal private cost and benefits of the private sector. Where this set of equalities is not possible, and this study lists numerous cases where it is not, then a value-of-service pricing appears to be the best pricing policy. (See Section V.) Again this means that price will be inversely related to the elasticity of demand. But, as was mentioned at the beginning of the section, data on demand curves, the elasticities, and marginal benefits are not available.

II. Introduction

According to studies by the Advisory Commission on Intergovernment Relations (1986) user charges are growing more important in governmental finance. Property tax limits and limits to the growth of other revenue sources as well as cut backs in federal aid all have put pressure on using non-traditional revenue sources. As important as the revenue shortage is to raising and expanding the set of user charges, there is also an increasing acceptance of neo-classical economics by a growing number of politicians; that is, the decisions made in the private market place are more efficient than legislative decisions. Politically, it is becoming more acceptable to require that the user pay a price for government services which could be sold in the private sector because:

> There is a direct connection between the users of the service and the charge payer. In addition to sharing with taxes the basic purpose of raising revenue, charges have three distinguishing features:
>
> 1. Rationing of government output--charges allocate limited output to those individuals who are willing to pay for the service.
>
> 2. Allocation of burdens to beneficiaries--those individuals who are the recipients of government output assume such burdens in close relation to the quantity of output that they choose to take.
>
> 3. Provision of demand signals--charges yield information on consumer demand for government services or commodities.
>
> The rationale of Federal user charges has been summarized succinctly...Within the framework of economic theory, we think of user charges as being imposed either for reasons of equity or efficiency. User charges are levied on the basis of equity when a group of users of a program or facility can be clearly identified and a political judgment has been made that fairness requires that group to contribute some or all of the cost of the program or facility in question. Most federal user charges are of this type. Efficiency-based user charges are intended to optimize the use of a facility. Briefly put, the theory is that the price of using a facility should reflect the marginal (incremental) cost of the use of that facility. Generally speaking, the notion is that lightly used facility should carry low if not zero prices since there is no

> reason to discourage the use of such facilities. As the level of use increases the price should increase to reflect any increases in operating costs and to reflect the fact that the facility is becoming crowded. As volume approaches congestion levels, prices should rise high enough to discourage those users who do not realize the high benefit for the user of the facility at peak periods.[1]

Another advantage of user charges was made effectively by Criz at the last meeting of the National Tax Association.

> A distinction needs to be drawn between user charges and taxes. A charge is a voluntary payment for a unit of service or commodity sold by a government, similar to transactions of commercial firms. The benefit received by the purchaser determines whether he is willing to pay the price. A tax, on the other hand, is a compulsory contribution exacted by a government for public purposes usually without reference to any special benefits.[2]

The point being made is that voluntary charges tied to specific benefits are more acceptable politically than general revenue sources.

If we accept the growing importance of user charges, then we need to define what is the ideal user charge or price that government should establish for a particular commodity like a ride on the ferry system. Before we attempt to define an ideal price, it is important to establish the purpose of price in a free market decision.

One of the better descriptions of the purpose of price is found in the U.S. Department of Transportation Cost Allocation Study (1982).

> The purpose of an efficient price is to maximize net benefits to society. To achieve this, it is necessary to confront the individual consumer with the full social costs of his or her decision. The level of consumption is determined by users, weighing the costs to themselves against the benefits to themselves, and not by transportation planners or economists. No instrument is more neutral in this respect (less

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[1]Criz (1985) p. 90

[2]Criz (1985) p. 89

coercive) than a price. Because paying the price means the consumer must forego some other alternative, the benefits to the consumer will always be at least as great as the price paid. If the price also indicates the value of the resources society must give up in order to create the good or service consumed, the consumption decision that makes the individual better off will also be one which makes society better off.

For highway user charges to perform as efficient prices, it is desirable that:

1. Each vehicle pay the marginal cost of its usage, on each occasion of use;
2. The benefits from usage accrue directly to the user, whether or not they are eventually passed on to others (e.g., consumers of products shipped by highway); and
3. The user accurately perceives both the benefits and the price of each occasion of use, including the benefits and prices of substitute alternatives.

"Marginal" cost means that the relevant costs are those which would not be incurred if the vehicle did not make the trip. If the costs would be avoided by not making the trip, then these are the costs against which the user should weigh his or her benefits. Hence, only variable costs are of interest in determining efficient prices; fixed costs, by definition, are not affected by the passage of a particular vehicle and could not be avoided if the trip were not made.

Whether users reap the benefits, and whether users correctly perceive the benefits and the costs to themselves, are question for which there are no definitive answers. The preponderance of expert opinion probably lies on the side of saying that there are no external benefits of highway consumption beyond the benefits to users. Although the evidence suggests that users tend to be only partially aware of the prices they pay and the associated benefits of usage, users still appear to be in the best position to make the tradeoffs between the costs and benefits of usage.[3]

Thus, the purpose of price in economics is 1) to insure efficiency and 2) to maximize the net benefits to society. An efficient use of resources is one where no individual can be made better off without someone being made worse off (Pareto Optimum results). If markets are

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[3]US DOT (1982) p. E-9

properly functioning (competitive) then an efficient output will maximize the net benefits to society (Total internal and external benefits minus total internal and external costs).

III. Efficient Pricing Policy in the Private Sector

Monopoly Pricing

If the ferry system were owned by a private utility with monopoly rights and if they were allowed to set prices freely, micro-economic theory would predict that prices would be set at P* in Figure 3.1. The profit maximizing quantity (Q*) would be determined where marginal cost equals marginal revenue (MC=MR) (Profits are the cross-hatched area). Price would then be determined by the location of the demand curve, given Q*. The area under the demand curve measures the benefits to the user; thus, P* will also be equal to the marginal benefits of the user. Since P* is greater than cost (either marginal or average), monopoly pricing does not appear to be optimum (i.e., where marginal costs are equal marginal benefits).

Competitive Pricing

If one could visualize a ferry system that was perfectly competitive and in a long-run equilibrium the firm would still maximize profits where MC = MR and price as in Monopoly Pricing, but the results are quite different (see Figure 3.2).

Now Q* is being produced at its minimum cost and no profits beyond a normal return on capital are being made. Price just equals MC, which is what is necessary for economic efficiency, and all the cost of production (AC) are being covered. The benefits to the user (average and marginal) are just equal to the cost of the producers (average and marginal). Consequently, the pricing decision in the competitive model is considered optimal.

Figure 3.1

Monopoly Pricing Model

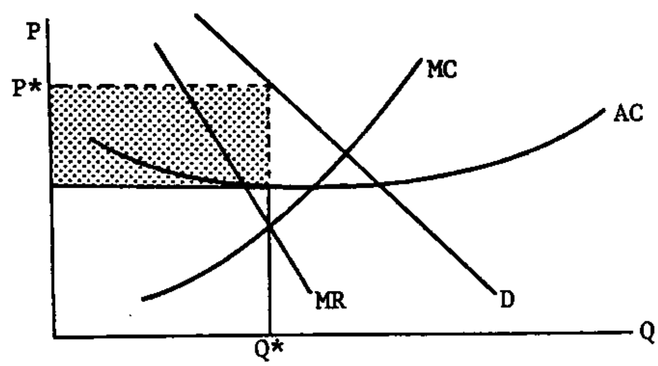
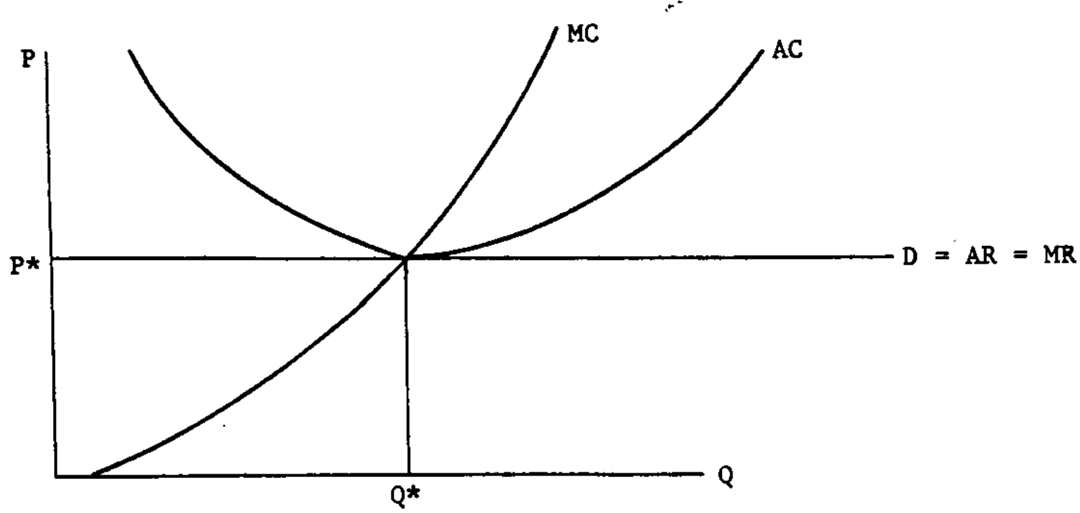


Figure 3.2

Competitive Pricing Model



IV. Efficiency Pricing Policy in the Public Sector

Public and Private Goods

Two types of goods are provided in the public sector: 1) public goods and 2) private goods. Private-type goods are goods which could be sold efficiently in the private sector. The benefits from the goods go solely to the person who receives them. Others are excluded from the benefits. Public goods are goods where everyone receives the same benefits from the good; exclusion is not possible (e.g., the benefits of a mosquito control program in a given area). Consequently, when benefits do not fall solely on the purchasers, when external benefits fall on others, the private market can not function efficiently (P to the user will not be equal to marginal cost or marginal benefits because of external costs and benefits.) In addition, the consumption of public goods by one person does not exhaust the benefits for other users. Consumption is said to be non-rival or joint. However, in the private sector when you buy an automobile, your enjoyment of driving the car prevents others from using it and enjoying the benefits. Thus for an efficiently operating private sector, benefits from the use of the purchased goods must be rival (not joint) and the benefits must restricted to the purchaser.

The public sector must provide public goods since the private sector cannot efficiently market them. Private goods are provided efficiently by the private sector and may be provided by the public sector, if the governmental unit or voters decide that the provision of the goods by government increases the net benefits to society. For example, if a natural monopoly exists in the provision of ferry services or any other public utility, the government can regulate the private firm with the goal of making it operate more efficiently or can operate the utility itself.

Public Sector Pricing

There is a general consensus on the principles of how the government should finance its operations. Revenue raising should be:

1) equitable,
2) efficient,
3) adequate.

Equity implies fairness in the raising of revenue. Three concepts of fairness have developed over time 1) Horizontal equity--this is a concept which is agreed to by almost everyone; that equals should be treated equally, that is tax payers with equal wealth or income should pay the same tax or price for government services. 2) Benefit Theory--another equity concept receiving nearly universal acceptance, if one can assume the federal government is meeting the desired income distributional goals, is the benefit theory of taxation: that is, the government should collect revenues which are equal to the benefits of government which are received by the user of government services. Richard Musgrave, one of the leading thinkers in public finance, in his Theory of Public Finance suggested that the benefit theory of taxation be used to finance all the traditional functions of government, like state highways, the ferry system, education, police and fire, in what he calls the Allocations Sector of Government.

The equity concept which has less universal acceptance is vertical equity; that is that those with more ability-to-pay should pay relatively more.

Efficiency is defined differently in different public finance texts but includes the following: other things being equal, a revenue raising device should be:

1) Simple,

2) Certain,

3) Convenient,

4) Neutral relative to private sector decision making;

that is, the tax or user charge should not effect decisions on work-effort, savings, levels and types of investments, and other market decisions like the selection of a mode of transportation.

Adequacy implies that the revenue source is adequate to cover current expenditure levels and that revenues are expected to grow at basically the same rate as expenditures.

Examples of the use of these concepts in highway transportation follows:

1) Ohio

In order to assess the appropriateness of Ohio's current approach to highway finance, the relevant taxes were evaluated against a number of criteria. The most important are:
ADEQUACY: Does the tax produce enough revenue for the intended purpose? This criterion is applied to Ohio highway taxes taken together, rather than individually.
EQUITY: Is the tax fair? In the tradition of highway finance, this usually is interpreted to mean that each highway user should pay in proportion to the costs he occasions (causes) on the system. Our analysis stresses this "cost-occasioned" approach over a "benefits-received" or ability-to-pay" approach to equity.
EFFICIENCY: Does the tax structure encourage efficient use of the highway system?

Other important criteria which are considered are perception, simplicity, legislative oversight, compliance/enforcement and administrative case.[4]

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[4]Curran, Stewart and Coughlin (1982) p. 5-6

Six criteria are used in the following pages to evaluate current Ohio taxes. Several of the criteria go back to Adam Smith, who developed a set of "canons" of taxation in his Wealth of Nations (1776). Smith did not discuss perception nor legislative oversight; both are relatively modern yardsticks growing out of concern with accountability in government. Neither was adequacy in the original canons: it evolved hand in hand with the increasing sophistication of the public budget process. The other three criteria go back to Smith and they have received extensive treatment in public finance literature. Originally, simplicity encompassed the two separate canons of the certainty and convenience. When all is said and done, however, the criteria of equity and efficiency are the critical ones. Indeed, H.B. No. 102 mentions them by name. Although there are a number of ways to define and apply equity, there is no ambiguity in the universal insistence that taxes be fair. It is not so very different with the criterion of efficiency. There may be varying levels of understanding about rules for resource allocation, but there is complete agreement that taxes should be carefully defined to achieve their announced purpose.[5]

2) Oregon

The State of Oregon during the past eighty years has tried to follow the "pay-as-you-go" philosophy. Its road user charges have evolved on the basis of three persistent principles: 1) that those who use the public roads should pay for them; 2) that road users should pay in proportion to the road costs for which they are responsible (the cost responsibility principle); and 3) that road user taxes should be utilized primarily for constructing, improving and maintaining highways.

The philosophical considerations underlying any tax structure are equity, efficiency, acceptability, and administrative ease. The latter includes compliance and economy. Oregon's three-tiered road user tax structure exhibits elements of all four factors.[6]

In this study, the concept of "efficiency" includes not only the efficient use of the ferry system (P = MC) but also the minimization of the collection costs in both the private and public sector so would include Ohio's simplicity, legislative oversight, compliance/enforcement

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[5]Ibid p. 103

[6]Oregon Department of Transportation (1981) p. 1-1 and 1-2

and "administrative ease" for both Oregon and Ohio. The concepts of "perception" and "acceptability" would fall in our equity concept. Summary: The financing or pricing of both public and private goods by government should be equitable, efficient and adequate.

The financing of private goods provided by government should also follow the optimum pricing rules of the private sector following the benefit theory of taxation. The ideal which is accepted at least at a theoretical level is $P^* = MB = MC$ so that the marginal benefits of the user is equal to the marginal cost of the producer. But in the public sector, the MC is marginal social cost of production rather than just the private costs; that is MSC includes the cost of pollution and other costs to society external to the production process as well as the private sector costs. Likewise, the MB is marginal social benefits which includes not only the internal benefits to the user but also the external benefits to society. (See Figure 4.1) Thus, $P^* = MSC = MSB$ not P_1 as would be optimum in the private sector. However, the price which the user should pay is P_2 which will cover the internal and external costs that the user causes and will be equal to his/her benefits. $P^* - P_2$ is the optimal subsidy payment by government; it covers the external benefits which society receives, but does not cover the users' benefits.

In a recent preliminary study on user fees, the Advisory Commission on Intergovernmental Relations (ACIR) stated the principles of pricing in a less technical fashion:

> Benefit-based taxes and user charges and fees can be viewed as public-sector counterparts of private-sector prices. The basic principle supporting user-charge financing is that recipients of government goods and services should pay taxes

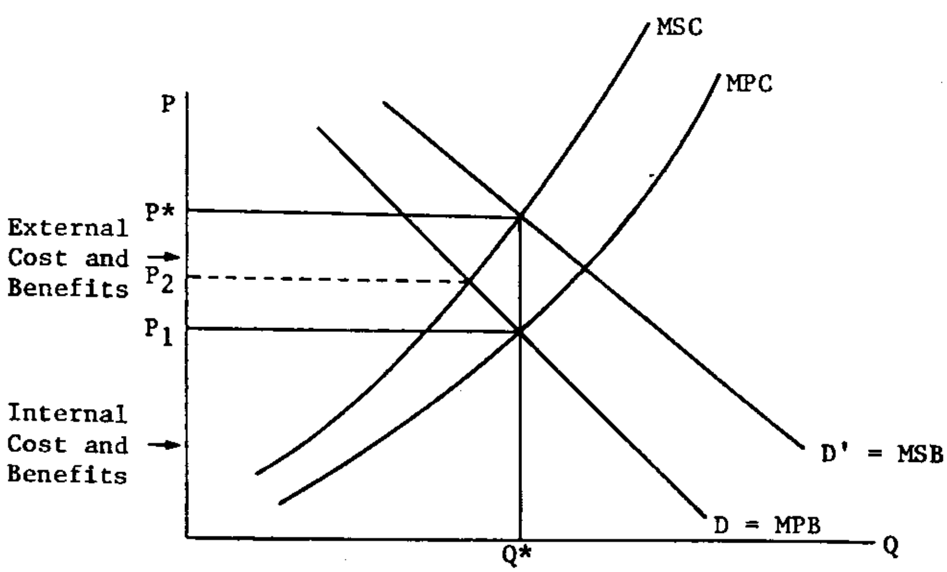
or charges that reflect the direct and identifiable benefits they receive. In effect, user charges establish a direct link between the revenue and expenditure sides of the budget for specific government services...

In the case of services provided by public utilities, user charges and fees are analogous to prices for private goods and services. Individuals voluntarily decide how much of a particular government good or service to buy and their payment to the government varies proportionately with their level of consumption. Those who do not consume the good do not have to pay for it. If there are no external benefits spilling over to the other taxpayers and there is no redistributive objective tied to the consumption of the good, the charge should reflect the full costs of providing to the consumer one more unit of output.[7]

Summary: A government pricing rule or a marginal cost pricing rule, P = MSC, will be both equitable and efficient.

Figure 4.1

Government Pricing Model



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[7]ACIR, p. 2,4

V. Problems with Marginal Cost Pricing

There are a number of conditions under which competitive markets and marginal cost pricing may fail to be economically efficient and, of course, there is no presumption that non-competitive, or monopolistic markets will be necessarily efficient. It is important to discuss these conditions because they commonly arise in transportation markets. Broadly speaking, marginal cost pricing rules fail because of technological requirements in production for some modes, externalities in the consumption or production of transportation outputs, difficulties in attributing costs to units of output, and problems inherent in pricing nonstorable output. The existence of these conditions leads to classes of cost functions in which the use of marginal cost pricing will lead to losses or excess profits and inefficiencies. The structure of transportation costs and cost functions is central to this discussion so a brief summary of key concepts is provided.

Review of Transportation Costs Categories

Functionally, transportation costs can be categorized in a number of ways and several accounting conventions have been established by the federal regulatory agencies. The cost categories presented here summarize the costs incurred by transportation producers.[8] For the purposes of discussion it will be assumed that all of the costs are borne by the transportation service provider although clearly in practice several of the following cost categories may be borne by

[8] See Mannheim, 1978; Harper, 1982

government agencies and paid for with user charges. The categorization draws heavily from Mannheim (1978) with a few modifications.

Cost Categories

A. Fixed Costs

1. Geographically fixed facilities (e.g. ferry terminals)

a. Cost to acquire (including construction):

-line haul facilities (waterway, etc.)

-port facilities (terminals and stations)

-maintenance and storage facilities

b. Maintenance of fixed facilities

c. Taxes on Fixed facilities

2. Vehicles or Vessels

a. Cost to acquire (purchase, lease, etc.)

b. Maintenance of vehicles:

-hull

-propulsion system (engines)

-control and navigation systems

-other

c. Taxes on vehicles (taxes foregone when owned by the state)

B. Variable Costs

3. Direct Variable Costs of Transportation

a. Labor:

-crews and other service personnel on vehicle

-operation of fixed facilities (dispatching, etc.)

-traffic servicing at terminals

b. Fuel

c. Insurance and compensation for damage and other claims

d. Taxes and other fees directly associated with transportation service

4. Indirect costs of transportation

a. Overhead costs associated with administration

b. Advertising

c. Reservations and sales

d. Other general administrative costs (phones, computer systems, etc.)

The costs of fixed facilities are those which the firm must cover whether or not the facilities are actually used to produce transportation services. The cost of vehicles also reflects costs which must be covered to assure the availability of vehicles in good operating condition, whether or not the vehicles are actually used to produce services. The direct variable costs arise only once transportation services are provided and for the most part these costs vary with the amount of transportation produced. It should be noted that some of these indirect costs may be fixed in the short or medium term due to long term labor or fuel contracts. The indirect costs reflect both fixed and variable costs.

One major problem in quantifying transportation cost functions is the difficulty in specifying the units of volume appropriate to each cost category. The question of transportation output measures has long been debated by transportation economists because there is rarely a single output and different units of output may be appropriate for each cost category[9]. For example, fuel and crew costs may depend most heavily on vehicle miles, shipboard crew on available passenger seat-miles, and maintenance costs on the fleet size, etc. Usually in practice, data are limited so it is impossible to relate each cost category to all the appropriate output measures. The most commonly used volume measures are ton-miles, vehicle-miles and passenger seat-miles or available passenger seat-miles.

As noted by Mannheim several "fundamental" observations can be made about transportation costs function. These are:

> Observation 1:
> The cost functions of most types of transportation systems have both fixed and variable cost components. However, the relative significance of fixed and variable components of the cost function varies widely from mode to mode, and is in fact a major aspect of the differences among modes.
> Observation 2:
> In most transport technologies, it is useful to consider the cost function as separable into three components, depending upon the ease with which the cost options can be varied... [These components are the long run, the short run, and the intermediate run.]
> Observation 3:
> Most types of transportation systems are characterized by "lumpiness," or indivisibilities. That is some options [cost categories] cannot be varied continuously over a range but must take discrete values.... . The indivisibility of transportation options is an important aspect of transport costs. The major implication is that for many transport technologies, the options [cost categories] cannot be varied so as to have precisely the amount of capacity to serve a particular volume of demand. Rather, there is usually either too much capacity or too little.[10]

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[9]See Griliches, 1968; Keeler, 1974; Wilson, 1982; Friedleander and Spady, 1982

[10]Mannheim, 1978, pp. 34-40

Quantifying the structure of transportation cost functions represents a significant portion of the recent research effort transportation economics.[11] With appropriate data for cost categories and output measures, statistical techniques exist to determine the proportion of costs that are variable in the short run for a firm or industry and the proportion of costs that are variable in the long run. Accurate measurement of the "percent variable" indicates whether marginal cost pricing will generate deficits or excess profits.[12]

As shown in Figure 5.1, in the short run some cost categories such as those associated with the fleet size or the maintenance facilities remain fixed. As more and more units of output, roundtrips or passenger/vehicle miles, are produced the unit costs initially fall due to efficiencies of increased use of existing capacity (returns to variable factors), reach a minimum at capacity of the existing facilities (where marginal costs equal average total costs) and then rise due to diminishing returns from using a fixed facility size more and more intensively. Each of the short run average total cost (SRATC) curves shown, therefore, reflects a different facility size. SRATC1 reflects the smallest capacity and the SRATC3 reflects the largest level of fixed capacity. Marginal costs equal SRATC at capacity, lie below SRATC while short run average total costs are falling, and lie above them when they are rising.

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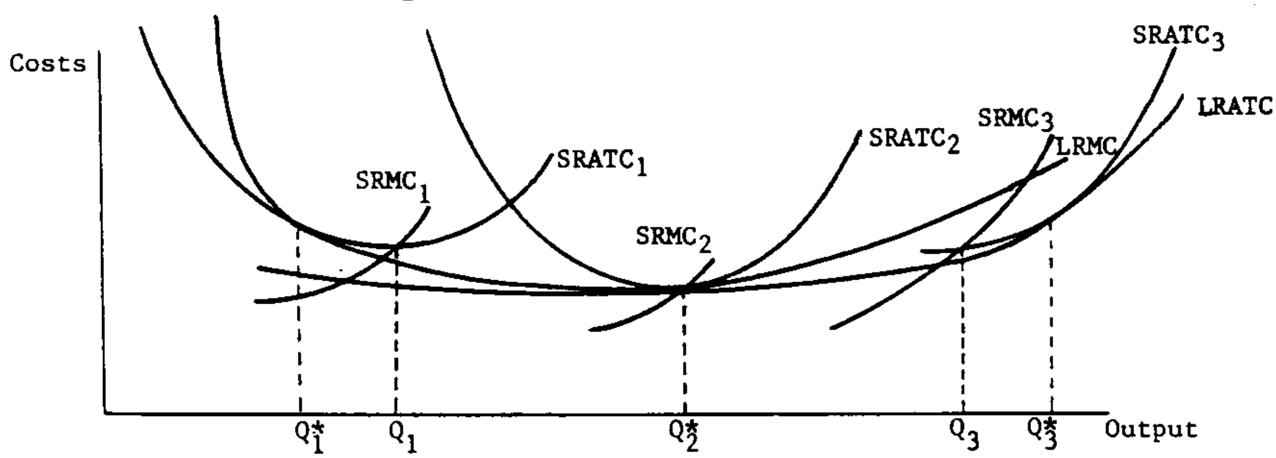
[11]For a good overview see Friedleander and Spady 1980; Wilson 1980

[12]Friedlaender, 1968; Friedleander and Spady, 1980, Wilson, 1980

The short run percent variable cost ratio SRVP (ratio of Marginal Cost/Average Total Cost) is therefore less than one hundred when the firm (or industry) is operating at less then capacity, equal to one hundred when the firm is operating at capacity, and greater then one hundred when the firm is operating over capacity (with diminishing returns).

Figure 5.1

Long-run and Short-run Cost Curves



The long run average total cost (LRATC) curve shown in Figure 5.1 is a planning horizon and reflects the cost effects of varying all the fixed factors, fleet size, terminal capacity, maintenance capacity, etc. It is thus the envelope of all the short run average total cost curves. The tangencies between the SRATC and the LRATC reflect the least cost means of producing any given output level. If the long run average total cost curve is falling, it implies that unit costs are falling as the firm increases its facility size. This is called increasing returns to scale and it is determined by technological factors in production. For example, when you expand the diameter of an oil pipeline the carrying capacity of the pipe increases exponentially, leading to increasing returns to scale.

Returns to scale or scale economies can be measured by the long run percent variable cost ratio (LRPV). LRPV less than one hundred implies there are increasing returns to scale and the marginal cost curve is below the LRATC, LRPV equal to one hundred implies that there are constant returns to scale, the marginal costs equal the SRATC, and LRPV greater then one hundred implies that there are decreasing returns to scale, the marginal cost is above the LRATC.

It is important to notice in Figure 5.1 that SRPV reflects the use of existing capacity and LRPV provides information on the structure of technology, (whether or not there are scale economies). Ideally, policymakers would want information for both the LRPV and the SRPV. For example, if demand levels lead the firm represented by Figure 5.1 to produce at Q_1 using a facility size reflected by SRATC1, the SRPV would equal one hundred whereas the LRPV would be less than one hundred. The policy implication would be that firm is operating at capacity; however, it is not taking advantage of potential cost savings possible with a larger capital structure. If demand levels are sufficient, the firm should expand its facility size.

At output level Q_3 the LRPV exceeds the SRPV. Although the firm is operating at capacity at Q_3, it would have lower unit costs if it decreased its facility size, due to the decreasing returns to scale in production. If the demand levels were at Q_2*, LRPV equals SRPV and the firm would have no incentive to change either its capacity structure or its output levels. Clearly the use of long-run marginal cost pricing will lead to deficits at Q_1, would just cover costs at Q_2, and excess profits at Q_3. Marginal cost pricing therefore will lead firms to earn a reasonable return on their capital investment only when firms are producing with constant returns to scale technologies at capacity.

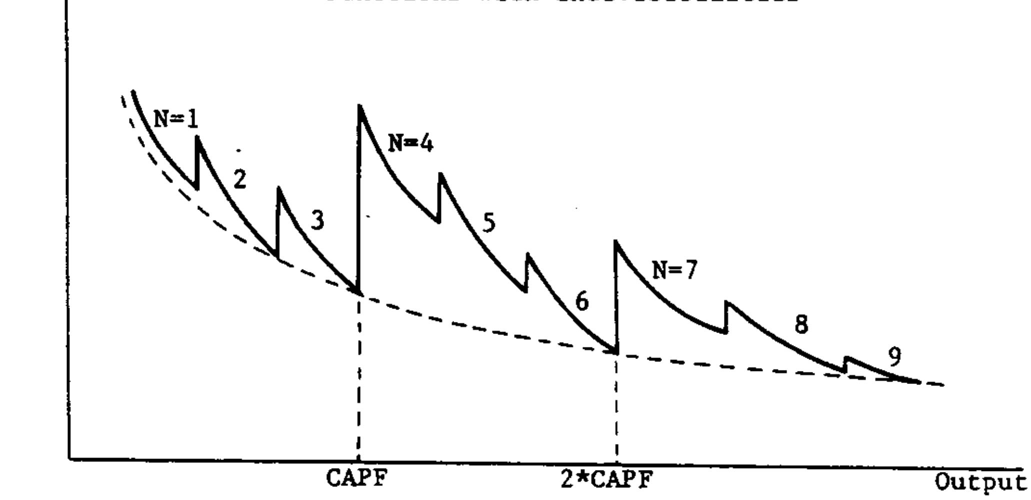
Modifying the diagrams to reflect Observation 3 above would lead to cost curves that have discontinuities as shown in Figure 5.2. The discontinuities would reflect the indivisibilities in capital structure acquisition. For example, one half a locomotive or a fraction of high speed ferry is not a purchase option. The substance of the arguments about the structure of transportation costs would remain unchanged.

As shown in Figure 5.2, the indivisibilities are reflected by discontinuities in the cost curves. The costs suddenly jump when an additional unit of fixed facility (CAPF) or fleet (N) is acquired. The magnitude of these discontinuities depends on modal technologies and cost characteristics. In some cases, the envelope of the cost curve (dashed line) is a satisfactory approximation to the true cost curve. If vehicle acquisition cost accounted for a large percentage of the total cost and were large compared to the unit cost of the fixed facility, then the jumps would be prominent, and the envelope would not be appropriate.

Marginal cost pricing is always economically efficient from the point of view of society; however, its use may lead firms with either excess capacity or increasing returns to scale to deficits and firms operating over capacity or with decreasing returns to scale to economic profits. Knowledge of the underlying cost structure of the industry is needed to determine whether marginal cost pricing will allow firms to cover their fully distributed costs. Cost functions can be estimated econometrically using either detailed cost data over time for a single firm (panel data), cost data for all, or a large number of, firms in the industry (cross-section data), or a combination of the two (a panel of cross-sections). Data availability and compatibility is often a difficult, though not insurmountable, problem.

Figure 5.2

Cost Functions with Indivisibilities



For example, we gathered the following data for eight different routes for the years 1979 to 1982:

Output Measures	Cost Measures
Passenger Miles	Labor
Auto miles	Fuel
Other Vehical Miles	Fleet Capital
	Terminal Capital
	Total

Unfortunately there is no direct way to allocate the measured costs to the different output measures. Allocation of these common costs to the different outputs and the joint costs inherent in a ferry trip make the marginal cost pricing of each trip also arbitrary. (These problems are discussed in a latter section of this report.) Consequently, value of service pricing, which is discussed in the next section, appears to be best pricing scheme available.

If a phase II proposal is funded, logical allocations will be made between passenger, auto and other vehicals, between peak and non-peak periods, as well as between front and back hauls so that more rational decisions can be made on appropriate prices. In addition, Phase II analysis would make calculations of the short-run percent variable cost ratio (SRPV) to determine how well existing capacity is used and of the long-run percent variable cost ratio (LRPV) to determine the presence of scale economies in the Washington State Ferry System.

Unfortunately there are no existing cost studies of ferry operation. There are several studies of inland waterway barge cost functions, but the results of these studies are contradictory. Two studies of the freight barge industry carried out in the 1970's indicated that there were increasing returns to scale in production in this industry (Case and Lave, 1970; Polak and Koshal, 1976). Other studies, however, have led Harper to conclude that the inland waterway freight industry is probably characterized by constant returns to scale but with relatively high variable cost (Harper, 1980). He argues that the

> ...high variable costs are due to the lack of large fixed costs associated with the way and to the fact that water carrier terminal costs are largely variable ...This, in turn, means that as a water carrier adds traffic, his costs also increase since variable costs are high and the water carrier does not have the railroad's advantage of sharply declining average costs per unit of traffic carried as traffic volume increases (Harper, 1982, pp. 273-274).

The apparent lack of consensus about the structure of costs for the barge industry and the total lack of information for the ferry industry suggests that a cost analysis of the ferry industry should be undertaken in Phase II.

Value of Service Pricing

The economic efficiency argument that price should be set equal to marginal cost has been questioned in recent years by a number of transportation economists[13] and convincing arguments have been presented

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[13] Brautigam, 1979; Levin, 1981; Phlips, 1983

to establish an efficiency basis for "value-of-service" or Ramsey Pricing. Value-of-service pricing is a form of price discrimination. In brief, it requires that the firm has some degree of monopoly power, that it has the ability to segregate markets at costs less than the increased revenues obtained from discriminating, and that there be differing elasticities of demand in each of the segregated submarkets. Thus the firm needs to be able to identify submarkets such as a peak and an off-peak user groups. The price discriminating firm's objective is to charge the maximum profit price in each submarket. Thus the profit maximizing firm would set Marginal Cost (MC) equal to Marginal Revenue (MR), as discussed above, in each submarket. Since marginal revenues are related to price elasticities (See Appendix II).

$$MR_i = P_i\ (1 - 1/e_i),$$

for each differing elasticity (e_i) there will be a different ratio of P_i to MC_i in each submarket.

As Wilson notes:

> In highly simplified form the basis for value-of-service pricing in transportation is: Transport suppliers seek to segregate markets in order to enhance their net profitability by charging the maximum profit rate in each submarket subject only to competitive pressures and legal constraints.[14]

Efficiency arguments supporting the use of value-or-service pricing arise under the conditions mentioned above where marginal cost pricing fails because there are returns to scale in production or costs cannot be traced directly to specific units of output. If, as shown in Figure 5.3, the short run average total cost curves are decreasing and demand levels are insufficient to allow the firm to take advantage of existing economies of scale, then three pricing options are available to the

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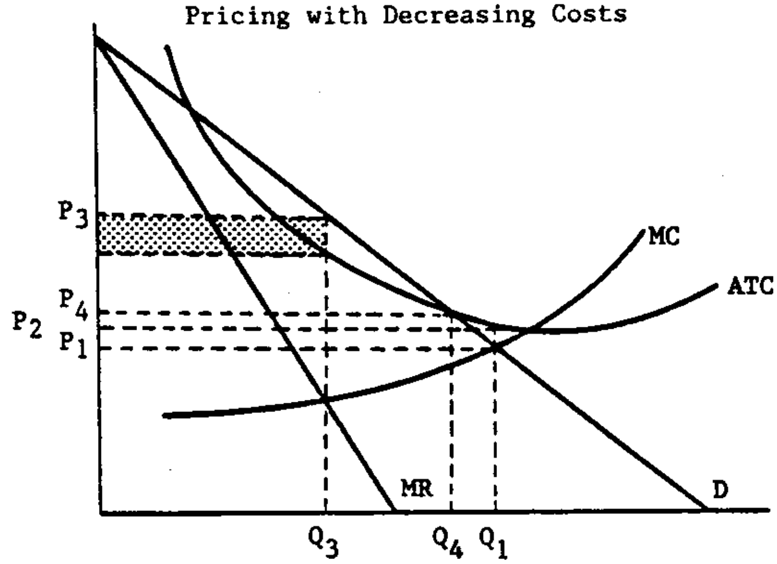
[14]Wilson, p. 141, 1980

firm. Marginal cost pricing could be used but the firm would have to be subsidized by the amount $P_2 - P_1$.

Figure 5.3

Pricing with Decreasing Costs



A second possible pricing strategy would be to allow the firm to maximize profits by equating marginal costs (MC) in Figure 5.3 with marginal revenues (MR), leading to a price of P_3 and an output of Q_3. In the case shown, this would lead to excess profits shown by the shaded area.

A final possible pricing strategy in the case of decreasing costs is to use some form of value-of-service pricing or pricing subject to a revenue constraint. This pricing strategy in the case of a single nonfluctuating demand structure, as shown in Figure 5.3, would lead to prices set equal to average total costs, or price P4.

More generally, society should seek to maximize the difference between the benefits (B) and costs (C) of producing any given output level. To find the maximum (B - C) with respect to price P_1 given certain regularity conditions about production and demand structure, take the partial derivative of (B - C) and set it equal to zero.

$$\frac{\partial(B - C)}{\partial Q1} = \frac{\partial B}{\partial Q1} - \frac{\partial C}{\partial Q1} = 0$$

If all publicly and privately provided goods are priced efficiently then $\partial B/\partial Q_i = P_i$. Similarly, $\partial C/\ \partial Q_i = MC_i$. Or as stated above optimality requires that $P_i = MC_i$.

If, as in the decreasing cost case, this pricing rule led to deficits, then the transportation firm or the transportation authority might be required to price such that total revenue ($R = P_iQ_i$) equals or exceeds total costs C. Again maximizing (B - C) but now with a revenue constraint $C = \Sigma_i P_i Q_i$ gives the following simple constrained maximization:

Max. (B - C) Subject to $C = \Sigma_i P_i Q_i$.

Setting up the Lagrangian function gives

Max. (Net Benefits) = $(B - C) + \lambda\ (\Sigma_i P_i Q_i - C)$

$$\frac{\partial(B - C)}{\partial Q_i} = \frac{\partial B}{\partial Q_i} + \frac{\partial C}{\partial Q_i} + (P_i + Q_i\ \frac{\partial P_i}{\partial Q_i} - \frac{\partial C}{\partial Q_i}) = 0$$

Since $\partial B/\partial Qi = Pi$, $\partial C/\partial Q_i = MC_i$, and $Q_i(\partial P_i/\partial Q_i) = -P_i/e_i$, the above can be written as

$$\frac{P_i - MC_i}{P_i} = \left(\frac{k}{1-k}\right)\frac{1}{e_i}$$

Therefore, for optimal pricing given a revenue constraint, price should not equal MC_i. Instead prices should systematically deviate from MC_i inversely and proportionately on the basis of price elasticity of demand. Such revenue constraints can be used either to prevent excess profits, in the case of monopoly, or if competitive pressures and cost indivisibilities make normal rates of return impossible, value-of-service pricing can assure normal rates of return. Under this pricing strategy submarkets that are very price sensitive (price elasticities that are substantially smaller than negative one), would be charged prices that are close to marginal cost. Vacation travellers would probably be in such a submarket since they would be able to plan trips sufficiently in advance that their choice of modes would be flexible and therefore very sensitive to price. Price insensitive or price inelastic submarkets should be charged prices that deviate more substantially from the marginal cost of service provision. Commuters would be an example of such a submarket since time constraints frequently make work trip decisions less sensitive to price changes.

Value-of-service pricing does lead to welfare loss since prices are higher and outputs lower than they would be at the efficient pricing level of $P_i = MC_i$. Whether deviation from marginal cost pricing is optimal depends on the magnitude of the welfare loss from the alternative strategies: direct subsidy or monopoly pricing. As mentioned above, whether income transfer from taxpayers to transportation service users is desirable is a judgment question. It is conceivable that such a transfer might lead to greater income equality if the users of the transportation services are concentrated in lower levels of the income distribution. If this is not the case then the subsidy of transportation services would increase inequality.

Subsidies also require either increases in tax rates or lower expenditures in government budgets. Tax increases can be shown to cause distortions in other sectors of the economy. If, for example, the income tax is used there will be distortions in the incentive to work and in the investment incentives of corporations. Sales tax increases would cause prices in the taxed sectors to deviate from marginal cost pricing and thus lead to welfare loss. These pressures could lead to income redistribution effects as well as cause a series of repercussions on the price/marginal cost relationship elsewhere in the economy. The result would again be welfare loss.

In summary, value-of-service pricing given a revenue constraint may turn out to be less undesirable than subsidy or monopoly pricing. Value-of-service pricing with a revenue constraint may increase output in instances where MC is declining since rates would be reduced in submarkets that were very price sensitive, very price elastic. This would increase output by an amount greater than an equivalent price increase in submarkets where demand is very price inelastic. This appears to be the situation in most transportation submarkets particularly if intermodal competition exists. There are now a number of transportation economists who would argue that a careful application of value-of-service pricing may be the main route to privately profitable operations for most transportation modes in either the public or private sectors.[15]

Efficient Pricing with Common or Joint Costs

Many cost categories in transportation production cannot be attributed to units of output. There are two types of these costs,

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[15] Wilson, 1980; Levin, 1981; Beilock, 1985

common and joint. Joint costs arise when the production of one output necessarily leads to the production of a fixed amount of some other output. The marginal costs of jointly produced outputs are inextricably tied. A classic example of joint production is transportation backhauls. If a firm owns terminals at a point A, then a trip from A to a point B automatically leads to a return trip from B to A. The firm produces roundtrips but its sales units are identical qualities of fronthauls and backhauls. Any allocation of costs to jointly produced goods is arbitrary.

In the case of ferry service provision the output of the ferry service is round trips (e.g., Seattle-Bremerton-Seattle) whereas the unit of sales is passenger seats or vehicle space. These user groups are likely to have different price elasticities of demand that vary over time of day and the seasons. The allocation of costs to these units of sales is arbitrary.

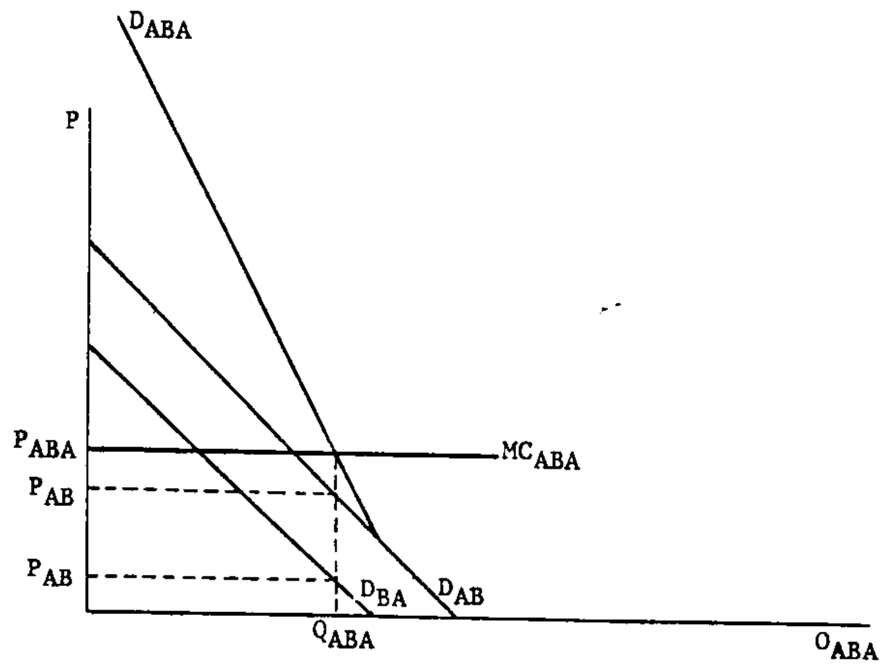
Common costs are similar to joint costs except that the magnitude of production for each output is not interdependent. For example, a single fronthaul trip may lead to the production of many different service outputs such as passenger-miles and ton-miles. In the case of ferries every crossing entails the production of passenger seat-miles and vehicular ton-miles. Many costs of the crossing, such as fuel and labor costs, are common costs and cannot be uniquely attributed to any particular unit of output. Common and joint costs may be either fixed or variable. Pricing strategies for such costs tends to be value-of-service.

Efficiency criteria for pricing with common or joint costs rely on a careful determination of the units of output that the firm actually produces, rather than the units it sells. The solution is efficient in that $P_i = MC_i$, however, it is also value-of-service because the allocation of costs is on the basis of price elasticity of demand.

Consider a transportation firm that produces units of service in round trips (Q_{ABA}) from point A to point B and back to A. The long run marginal costs of producing these roundtrips is MC_{ABA}. The firm sells the round trips in fronthaul (Q_{AB}) and backhaul (Q_{BA}) units and knows the nature of demand in submarket A and submarket B. As shown in Figure 5.4 the demand levels at point A are greater than those at point B.

Figure 5.4

Joint Cost Pricing



Joint production requires that the number of trips produced to A equal the number of trips produced to B. Since Q_{ABA} must be the same for both markets what is relevant to the firm is the total willingness-to-pay for fronthaul and backhaul trips for every roundtrip output level. The total willingness-to-pay can be found by summing the submarket demand curves vertically. Economic efficiency requires that price of roundtrips (P_{ABA}) equals the marginal costs (MC_{ABA}) of producing them. P_{ABA} is the sum of the willingness-to-pay in each submarket. The optimal output level is set where $P_{ABA} = MC_{ABA}$ and the prices that consumers will pay in each submarket can be obtained from the perspective submarket demand curves at Q_{ABA}. Thus the high demand market pays a higher price than the low demand market reflecting the value of the service to that consuming group.

The solution to the problem is similar for common cost pricing such as in airline or ferry pricing. In the common cost problem, the unit of production output is the fronthaul or the backhaul and the unit of sales over which costs must allocated is ton-miles of freight or passengers seat-miles. The solution to the problem again requires that the total willingness-to-pay be determined by vertical summation of the submarket demands.

Efficient Pricing with Nonstorable Outputs

In most other industries the commodities produced can be stored. Transportation services are by definition nonstorable and demand is known to fluctuate in a periodic way over the time of day and the seasons. Random fluctuations in demand are expected at any given point in time and in many instances the mean and the variance of the probability distribution for demand may also be periodic.

Optimal Peak-load Pricing

In the case of nonstorable commodities, firm capacity must correspond to peak demand whatever the behavior of aggregate sales. Clearly from the point of view of the firm, a smaller investment giving a higher profit is to be preferred. Optimal resource allocation, however, implies that prices fully reflect the cost of transportation over space and time. To meet this condition in the case of nonstorable commodities the marginal capacity costs (B) should be added to the marginal costs of production (b) to determine the marginal costs of the peak period. The peak-load problem is then to find the socially optimal peak and off-peak prices such that capacity is optimal. It should be noted in this discussion that the amount of capacity is determined with no given capacity assumed to start with.

The solution to this pricing problem was developed simultaneously by Boiteux (1949) and Houthakker (1951) with refinements by Steiner (1957). There are two cases for the solution: Case I in which peak and off-peak demand are fixed and Case II in which peak and off-peak demand shift or are interdependent. The pricing strategies are shown graphically in Figures 5.5 and 5.6 below.

Figure 5.5

Case I: Fixed Peak

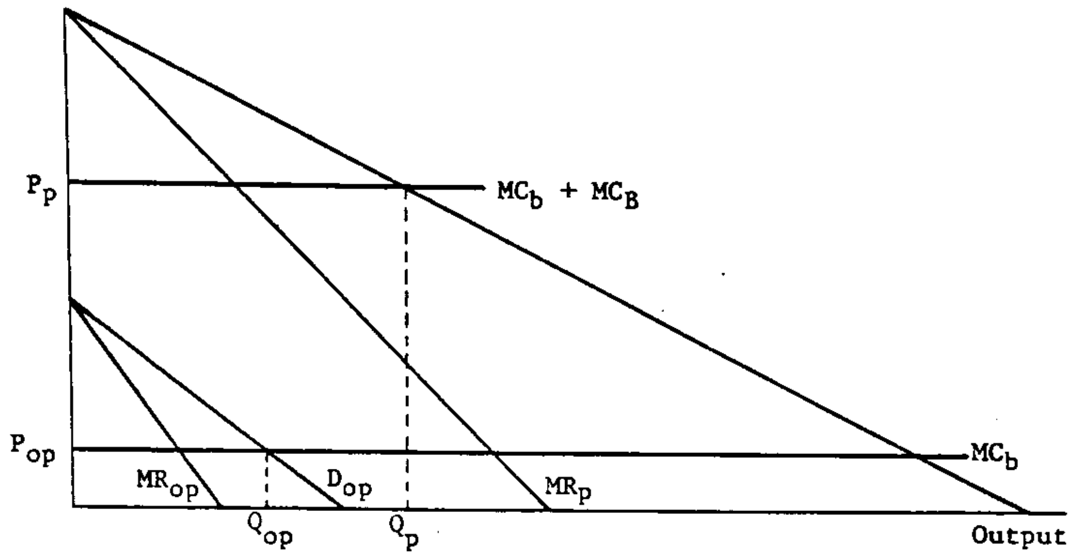
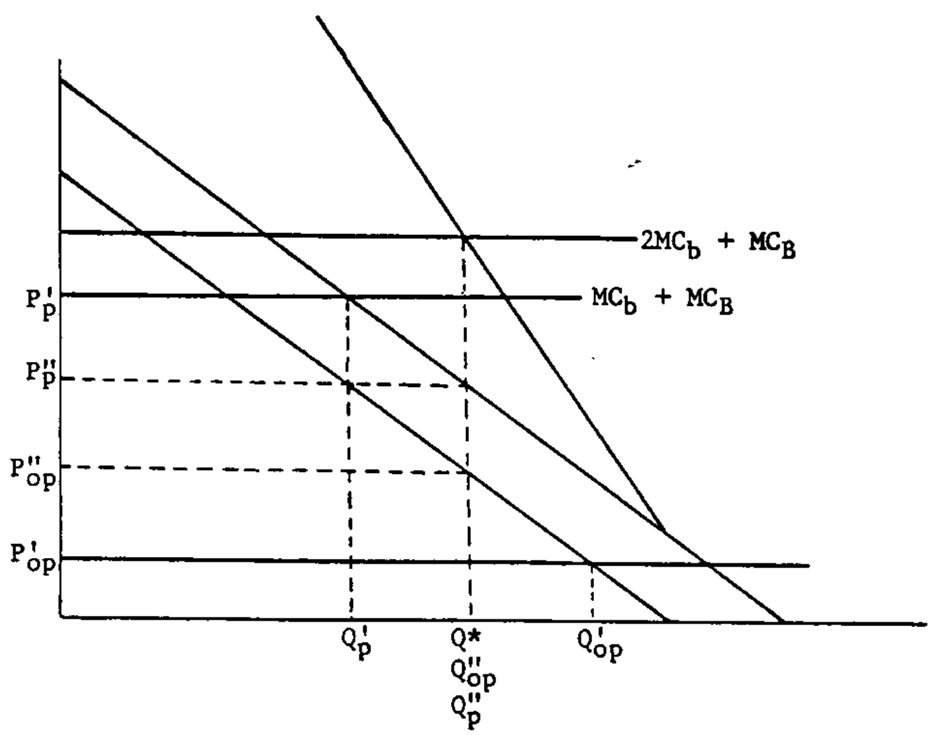


Figure 5.6

Case II: Shifting Peak (Steiner, 1957)



In the case of fixed peak, Figure 5.5, it is assumed either that the quantity demanded in one period is independent of the prices charged for output in the other period or that off-peak demand is small relative to peak demand. As shown the optimal solution (P_{OP}, P_P) is found where off-peak price equals the marginal costs of service provision ($P_{OP} = MC_b$) and the peak price equals the marginal costs of service provision plus the marginal costs of capacity ($P_P = MC_b + MC_B$). In this case the total costs would be covered and all units would be paying the full marginal costs of their production. Optimal capacity is determined by $P_P = MC_b + MC_B$, at Q_P.

In Case II, the off-peak demand is large relative to the peak demand as shown in Figure 5.6. Clearly, the solution used above no longer applies because at the price (P'_{OP}, P'_P) it is the off-peak demand levels that determine capacity Q^*_{OP}. Additionally, capacity cost of only Q'_P units would be recovered, whereas Q'_{OP} units of capacity are required. For this reason, the shifting peak problem solution can be determined by using the fact that demand for both periods combined can be satisfied at a cost of $2MC_b$ per combined unit up to the capacity limit, and ($2MC_b$ + MC_B) per combined unit beyond that limit. Summing the two demands vertically to determine the total willingness-to-pay and using the efficiency criteria P = MC, the optimal capacity is $Q^* = Q''_{OP} = Q_P$. At these prices total cost is covered.

Again the solution is a value-of-service pricing strategy with the peak consumers paying more per unit for use of the facility than the off-peak consumers. The solution involves discriminating between submarkets on the basis of price elasticity of demand and to some extent the off-peak consumers are paying for the peak customers. To assure that total marginal costs are covered, use is made of the fact that the smaller off-peak demand is more price inelastic than the peak demand at the same output levels. Thus, in keeping with the value-of-service strategy, the off-peak users are called upon to subsidize the peak users. The discriminatory policy is, however, the optimal strategy simply because differences in demand intensities are a fact of life and must be accounted for even in a socially optimum solution.

Random Demand Fluctuations

The above discussion relies on the assumption that demand levels are known with certainty at different periods of time. More usually, however, short-run demand fluctuations occur in random as well as periodic basis. There are two positions in the economics literature concerning pricing when demand is a random variable. One approach argues that randomness leads to excess capacity at certain time periods and that nonprice rationing mechanisms therefore become inevitable such as queuing, priorities, quality deterioration, etc.[16] Others argue that firms should be able to plan sufficient capacity to avoid rationing and should let highly variable random demand pay for the extra capacity cost due to the uncertainty the firm must face.

The basic argument for the second position (Boiteux, 1951; Phlips, 1983) is that the parameters of the probability distribution attached to

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[16] Brown and Johnson, 1969; Visscher, 1973; Panzar and Sibley, 1978

a random demand reflect characteristics of the good to be accounted for as product differentiation.[17]

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[17]Phlips argues the case as follows: "...each consumer i has a random demand (at a given time and price) qi = with known expected value $\bar{q}i$ and known variance σ_i^2. These demands are sufficiently analogous and independently distributed for aggregate demand to be approximately normally distributed with expected value $\bar{q}=\Sigma_i\bar{q}_i$ and vairance $\sigma^2=\Sigma_i\sigma_i^2$. We can then read the probability that aggregate demand will exceed a given level, say $(\bar{q} + k\sigma)$, from a table of the standardized normal density function. Conversely, to any probability ε there corresponds a level of aggregate demand $q(\varepsilon)$ that has probability $(1 - \varepsilon)$ of not being exceeded, namely $(\bar{q} + k(\varepsilon)\sigma)$. The number $k(\varepsilon)$ can be read from the same table (e.g., $k(.025) = 1.96$, $k(.005) = 2.58$).

The firms should build a plant of capacity $(q_c(\varepsilon) = \bar{q} + k(\varepsilon)\sigma)$. Let its short-run total cost function be

$$f(q_c=q) = \beta q_c(\varepsilon) + \gamma_q \qquad 0 \le q \le q_c$$
$$= \infty \qquad q < q_c$$

where β is marginal capacity cost and γ is short-term marginal cost of production. This cost function can be written as

$$F[\bar{q}_c(\varepsilon),q] = \beta[\bar{q} + k(\varepsilon)\sigma] + \gamma_q$$
$$= \beta[\Sigma_i\bar{q}_i + k(\varepsilon)(\Sigma_i\sigma_i^2)^{1/2}] + \gamma\Sigma_i q_i^*$$

where qi* is actual sales to consumer i (there being no shortage). We have thus expressed total cost as a function of individual sales qi, and of two parameters of the density functions of individual demands: their mean $\bar{q}i$ and their standard deviation σi.

To find the "marginal cost" of actual sales and of each parameter, it suffices to differentiate the total cost function with respect to qi*, $\bar{q}i$, and σi:

$$\frac{\partial F}{\partial \bar{q}i} = \beta$$

$$\frac{\partial F}{\partial \sigma i} = \partial\sigma_i\frac{\partial F}{\partial\sigma_i^2} = \beta k(\varepsilon)\ \frac{\sigma i}{\sigma} \text{ as } \frac{\partial/d}{\partial\sigma_i^2} = \frac{\beta}{2}\ \frac{k(\varepsilon)}{\sigma}$$

$$\frac{\partial F}{\partial q_i^*} = \gamma$$

Accordingly, pricing of all components (those that differentiate a good including the mean qi and the standard deviation σ_i) at marginal cost

(Footnote Continued)

The practical implications of this solution are that transportation consumers who are willing to purchase tickets well in advance and therefore reveal a zero valued σ_i^2 will have a lower fare than consumers of the same service who demand service with no advance reservations. The pricing strategy is efficient, however, the difficulties in determining the distributional characteristics of different consumer submarkets may be very great.

Efficient Pricing with Congestion Externalities

High demand levels or congestion is another common phenomenon in transportation service provision and pricing strategies for congestion are important in the study of transport pricing and in many other service areas such as telecommunications. Following the previous discussion about transportation cost functions, congestion occurs when the firm is operating above capacity where the marginal cost curve intersects the average total cost curve (See Figure 5.1). When there is congestion the marginal cost curve is everywhere above the average total cost curve. From the point of view of the transportation consumer, the marginal private costs of the transportation service reflect the

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(Footnote Continued)
implies in this context that consumer i should be charged a sum equal to

$$\gamma q_i^* + \beta \bar{q}_i + \beta k(\varepsilon) \frac{\sigma i^2}{\sigma}$$

Total revenue to the firm is then

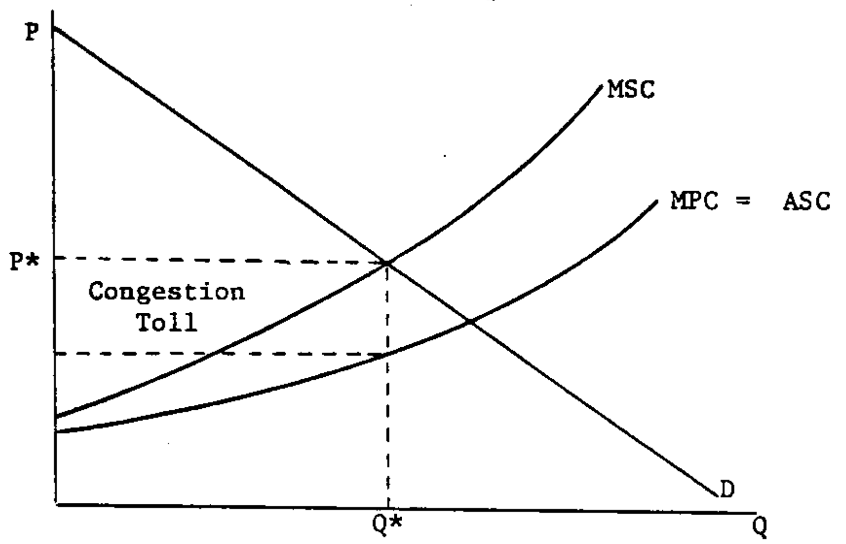
$$\gamma \sum_i q_i^* + \beta \sum_i \bar{q}_i + \beta \frac{k(\varepsilon)}{\sigma} \sum_i \sigma_i^2 = \gamma q + \beta[\bar{q} + k(\varepsilon)\sigma]$$

that is, equal to total cost, so that the firm breaks even" (Phlips, p. 142-143, 1983).

producer's marginal costs (as a user charge) plus the consumer's marginal time costs.

Figure 5.7

Pricing with Congestion



As shown in Figure 5.7, the Marginal Private Cost curve (MPC) is society's Average Social Cost curve (ASC), since the individual consumer only considers the costs that he incurs himself and does not take account of the fact that his consumption of the transportation service will affect all other consumers of the service. This is a clear example of an externality, in which the cost incurred by the individual vehicle mile will fall short of the total cost that it imposes on society. The Marginal Social Cost curve (MSC), as shown, will be strictly positive reflecting the time costs inflicted on other consumers.

Optimal pricing under congestion requires that Price be set equal to Marginal Social Cost to force all consumers to recognize the full social costs of their consumption. Since consumers already pay the price ASC in their time, the costs of operating their vehicles, and the user charge for service, the socially optimal pricing strategy requires that there be a toll reflecting the difference between the Average Social Costs and the Marginal Social costs at the marginal price traffic level of Q*. The magnitude of this toll will in general vary widely at different times of the day as demand fluctuates. An additional problem with a congestion toll pricing strategy is that in general it will generate excess profits for the service providers, the toll itself may impose additional costs and thus reduce volume levels from the optimal, and it may cause serious income distribution effects of those forced from the facility are lower income consumers. The advantage of the pricing strategy is that it provides the appropriate signal to consumers about the true resource costs of their consumption and is economically efficient.

The Total Social Cost functions can be estimated econometrically using flow and waiting time data for service provision and the MSC and the ASC can be determined from these estimates.[18] Electronic metering devices already are used in many other facets of transportation service provision so the technology certainly exists to institute a toll pricing strategy that is relatively low cost and does not invade personal privacy and traffic flow unduly.

Second-Best Conditions

Requiring all users of ferry services or any other government service to pay their marginal cost leads unambiguously to an increase in efficiency and net social benefits only if we assume that all prices

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[18] See Walters, 1961; Glaister, 1981

equal MSC. There is no necessary gain in efficiency if the pricing policy of other transportation modes are quite different. MC pricing of one mode, say ferry services, versus a subsidized policy on other highway transport will just shift traffic from the full cost ferry service to subsidized highway system. Thus, MC pricing is efficient only if other modes are similarly priced.

However, a working assumption often used is that if you move closer to MC pricing efficiency will be improved, but the theory of second-best does not allow one complete assurance that this is true. Consequently a cost-benefit analysis would be required to insure a net gain to society.

VI. Pricing of Highway Transportation

Since much of the work on pricing models for transportation services in the public sector has been done for highway services and since the ferry system in Washington is part of the Washington Department of Transportation, it is useful to consider the pricing models for highway services and see how they parallel to the pricing of ferry services.

Policy at the Federal Level

In 1981 Douglass Lee of the U.S. Department of Transportation in their Methods for Allocating Highway Costs stated the following:

> Parallels are becoming evident among many public services and regulated utilities, in regard to user charges. Electric power, railroads, inland waterways, telephones, postal services, airports, and highways, for example, are gradually being viewed with the same set of basic principles. The major objectives of user charges in these industries should be to:
>
> (1) Obtain efficient utilization of available resources by setting prices so that users pay in relation to (if not equal to) the marginal costs of their usage;

(2) Provide guidance for future investment by requiring higher (if not full) cost recovery from user charges in the long run.

Attention to the first objective has increased as it has become apparent that artificially low utility prices encourage overconsumption and waste. ...

Efficiency gains from better pricing of highway services might well be large. Maintenance expenditures alone amount to almost eleven billion dollars per year for the highway system as a whole. An improvement in efficiency might mean that fewer trips would be made for which the benefits were less than the social costs, and other trips could be made where the reverse was true. If increased highway prices enhance the efficient use of scarce resources, then the consequence could be lower overall inflation and lower local property taxes, despite higher prices for highway travel and perhaps for highway-dependent goods and services. Undermaintained roads mean higher costs for users, in vehicle wear, accidents, and increased travel time, and deferred maintenance may lead to higher total costs in the long run. Setting efficient user charges is an important step toward directing resources into their most productive uses, whether for highways or for other purposes.[19]

While the set of charges for highway transport should be "evaluated against their efficiency, equity and effectiveness"[20] the basic idea is a two stage user fee where:

1) The price of service would cover variable costs that were directly related to usage:

Optimal tolls would be set for each facility to vary with demand, typically peak and off-peak. On facilities where usage is fairly constant and time of travel would not be elastic to the variations in price that would be efficient, a uniform variable charge such as a fuel tax could be an adequate approximation. Where daily demand variations are great, as in urban areas, congestion tolls might be approximated through parking surcharges and bridge or other special tolls.

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[19] Lee (1981) pp. 1-2.

[20] Ibid p. 4.

> Capacity restrictions may substitute for tolls where other alternatives (e.g., exclusive bus lanes) are available.[21]
> 2) An access charge or other user fee would cover the residual of full long-run cost of the highway system. Full long-run costs would include the wearing out of the system (depreciation), interest forgone on the investment in highway facilities, external costs, and a charge for services of general government for which the highway sector is exempt from (opportunity costs).[22]

Equity means that the differential impacts on various groups should be considered.

> Potential groups include transportation disadvantaged, rich versus poor, competing transportation modes, capital versus labor, urban versus rural and any other demographic or economic subgroups that may be identified as important. Where impacts are adverse or unacceptable for whatever reasons, efficient user charges may need to be adjusted to correct for the impacts.[23]

The concept of "effectiveness" deals with the transaction costs of establishing and administering the user charge. For example, how expensive is it to get marginal cost data and to devise politically acceptable and administratively feasible user charges.

Second best compromises on efficiency, equity and efficiency and combining short-run pricing with optimal investment strategies have lead to a general acceptance of an incremental cost pricing scheme. The incremental cost concept includes short-run marginal cost (or the change in short-run variable cost) but it will also include user related fixed costs. A good descriptor is the long-run marginal cost of the user.

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[21]Ibid p. 8.

[22]Ibid p. 5.

[23]Ibid pp. 10-11.

The following extended quote from Lee's study for the Department of Transportation presents the basic arguments for long-run marginal cost pricing:

> The decision of whether to require user charges to cover full long run costs (including general government services and a rate of return on investment) is ultimately a political one, and there is no ironclad technical rationale that insists on such a standard. There are, however, quite a few arguments in favor of economically self-supporting highways.
>
> (1) The benefits of highway services are fully captured by users, and indirect benefits are passed on through normal market processes. There are no external (non-market) benefits, so there is no reason to ask non-users to help pay the costs. Non-users who reap windfall gains through market processes can be taxed for general purposes.
>
> (2) The market discipline of having to meet full long run costs forces highway authorities to allocate resources in a productive manner and recover costs from those receiving the benefits. This "bottom line" test encourages the entire enterprise to make only efficient investments.
>
> (3) Although the pure theory says that residual costs can be recovered from general taxpayers, and efficient investment in capacity is based on net benefits rather than user charge revenues, forcing users to pay the full costs ensures that these total benefits really exist. Access charges can be used to test willingness-to-pay without great distortions in efficient highway usage.
>
> (4) If other similar enterprises such as telephones, power companies, railroads, airlines, and intercity buses are required to meet the financial feasibility criterion, it seems fair to ask highways to adhere to the same standard. Local transit properties might also be asked to recover costs, but they will be unable to do so long as the highways are not recovering their costs.
>
> (5) In order to maintain policy neutrality between public sector and private sector investment, and between different transportation modes, the same pricing principles and investment criteria should be applied in all of these sectors. Otherwise, public policy is favoring those sectors not required to cover all of their real costs.

(6) Short run prices, while entirely defensible theoretically, may give misleading signals to consumers and investors even if accompanied by warnings that the prices are temporary. Informing users that prices will be higher in the future is not nearly so effective for encouraging efficient behavior as actually imposing the costs.

(7) As long as some of the costs can be passed on to the general taxpayer in some form, each political unit will strive to capture the largest possible share of the subsidy for itself. In practice, this is achieved by overstating the benefits of proposed highway projects in the expectation that someone else will help pay for them.

(8) Decreasing long run costs, which theoretically justify the use of general revenue for subsidies, may not be of great enough importance in the highway sector to warrant the abandonment of effective market discipline. If this is true, the practical gains of improved efficiency resulting from the full cost recovery constraint would outweigh the distortions potentially caused by overpricing.

(9) Accepting the reality that perfect pricing is not possible, placing the full cost burden on users will tend to confine the inequities and inefficiencies of imperfect prices to the class of highway users. Cross subsidies will be among highway users rather than from non-users to users.

(10) Voters predominantly oppose increase levels of highway user charges, and politicians reflect these preferences. The general sentiment seems to be that higher fuel taxes will be used to build more highways, and more highways are not needed. A rigorous break-even constraint would tie user charges much more closely to the extent and quality of the highway system, and users might view highway fees as prices for services received rather than as taxes extracted by government.

(11) Forcing each tub to stand on its own bottom means that pricing and investment decisions are made in private markets or in response to market signals. The alternative, for a firm or an industry, is national ownership and management. If the burden of full cost recovery is not imposed on the highway sector, similar considerations would call for the "nationalization" of many industries now in the private sector. At present,

> the highway system is not managed as a national resource nor does it meet the tests of private markets.[24]

Policy at the State Level - States tend to follow the Federal lead in the pricing of highway services and Washington is no exception. The most recent Washington State Cost Allocation Study continues the stress of allocating incremental costs. "Each vehicle type or class shall bear the cost it occasions in the construction, maintenance and operation of the highway system."[25]

> The total incremental cost component...was found to represent only 21 percent of total program cost. The balance, 79 percent, represents the non-incremental component of total program cost--i.e., the portion of cost which all vehicles regardless of size or weight share equally on a per-vehicle-miles of travel or pre-registered-vehicle basis depending upon type of expenditure. Nevertheless, while the "weight" share of overall program cost may not seem very large, it must be noted that much of this cost is born by a relatively small number of medium and heavy vehicles in the state's motor vehicle population (which includes allowance for interstate trucks and buses), and the manner of allocating this weight cost can have considerable impact upon tax equity for users of these vehicles.[26]

Non-incremental costs were defined to be expenditures on traffic signing, roadside maintenance, highway policing, and vehicle registration and are allocated to all vehicle classes on an equal per-mile-of-travel or per-registered vehicle basis depending on the cost element.

Policy on Toll Roads and Bridges Given Washington's laws the transportation service most closely comparable to Washington's Ferry System is the system of toll roads and bridges, particularly the toll

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[24]Ibid pp. 46-48.

[25]Transportation Development Associates, Inc. (1977) p. 78.

[26]Ibid pp. 4-5.

bridge. That is, the ferry can be considered to be a floating toll bridge. The primary difference is that toll bridges have low or zero marginal costs. The advantage of toll facilities was described in a paper by Smith and Wuestefeld:

> The benefits of toll facilities are many. Not only do toll facilities provide fiscal relief to the state from the burden of maintaining, operating, and reconstructing highway facilities, but they serve the motoring public and taxpayer in general. Toll facilities have the ability to match the cost of using such a facility with the benefits derived by each class of user. Separate toll classes are maintained for each vehicle class.
>
> Also, users pay for the facility, which lessens the financial burden on the taxpayer. Furthermore, toll rates can be charged to affect traffic flow, thereby smoothing movements during peak periods, and to encourage energy conservation by charging a separate ridesharing trip toll. In addition, toll facilities normally offer a greater degree of highway policing; a higher level of safety; on-the-road facilities, such as motor fuel stations and restaurants; and emergency highway services. Last, in the event that sufficient federal funds are not available for the construction of a travel facility in an area with a growing travel need, the toll-facility concept offers an effective alternative.[27]

The pricing of toll facilities was discussed explicitly by Claffey (1957) in regards to setting tolls for the Chesapeake Bay Bridge. He follows the two part pricing model of the federal and state highway system:

> The toll charge on publicly-owned bridges should equal the sum of (a) costs directly occasioned by a vehicle's passage (for pavement wear and toll collections), plus (b) a proportionate part of the fixed bridge costs (interest on the investment, insurance, etc). The costs included in the first group vary with use and may be assigned directly to each user, but are so small a part as to be unimportant. The second group makes up almost all the cost of providing bridge service, but being unaffected by use these costs cannot be attributed directly to individual users.

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[27] Smith and Wuestefeld (1983) p. 66.

Each of the type of groups of vehicles constituting the annual traffic volume that was in any way planned for by those responsible for the decision to build a bridge of given traffic capacity and strength should share in the payment of the resulting fixed costs in proportion to the extent that each contributed to the magnitude of these costs. The decision to construct a vehicular bridge capable of carrying some maximum hourly traffic volume is determined by peak-hour traffic. Since the hourly volume capacity necessary for peak-hour use is not required by the off-peak traffic, which could be accommodated by a smaller structure, all the fixed costs of a bridge of given capacity should be charged to the peak-hour traffic. Vehicles crossing during off-peak hours do not add to fixed costs, but only take advantage of capacity which otherwise would be unused. The increase in fixed costs resulting from building greater strength into the structure so as to accommodate heavier vehicles should be paid for by the truck traffic. To determine what part of the fixed cost should be assigned solely to trucks because of their weight, it is necessary to compute the saving in construction cost that could have been realized if the bridge had been designed only for passenger cars.

If trucks use the bridge during peak hours, their presence makes it necessary for the structure to have a greater volume capacity than would be required if all the vehicles were passenger cars. When the traffic volume using any roadway equals the maximum hourly capacity of the roadway, two passenger cars can be substituted for each truck without the capacity of the roadway being exceeded.

The toll charge is found as follows: First compute the user costs for pavement wear, toll collections, etc., which are chargeable to the non-peak-hour users and distribute this cost equally among all vehicles using the bridge during the non-peak hours. Distribute all other user costs, plus all fixed costs except those associated with incremental weight capacity, equally among the traffic units using the bridge during the peak hours, counting each passenger car as a unit and each truck as two units. Add to the charges thus computed for each truck an among to cover the fixed costs of the incremental weight capacity. The charge for the incremental weight capacity is assigned equally to all trucks whether they use the bridge peak or non-peak hours.[28]

The cost curves for a toll bridge will look as follows:

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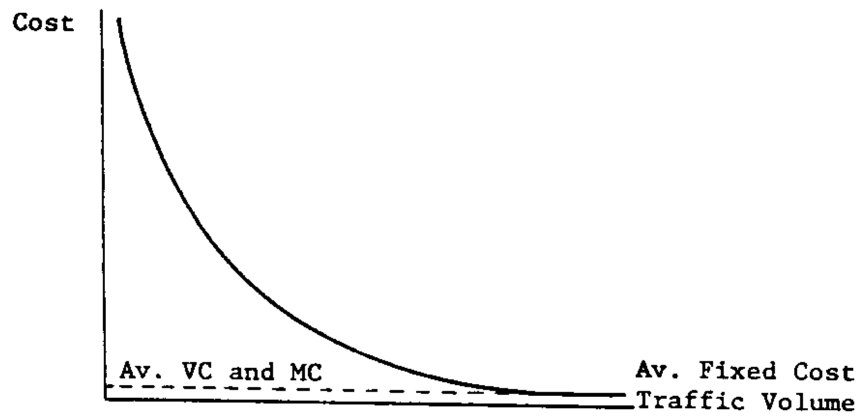
[28]Claffey (1957) p. 64.

Figure 6.1

Toll Bridge Cost Curves



Average fixed cost will fall until congestion costs occur as the fixed cost are spread over an increasing traffic volume. Variable costs are basically fixed once the decision is made to operate the system, until capacity of the system is reached. Seasonal or peak load costs will cause an upward step in Figure 6.1 when additional or larger units are added to the routes.

The market for many toll bridges tends to be monopolistic. Thus, the toll bridge authority can discriminate against various users. If its goal is to maximize profits, the toll bridge authority will price discriminate as follows:

1) Those groups with the more elastic demand (where use is price sensitive) will be charged lower rates;

2) Those groups with the more inelastic demand (where use is not price sensitive) will be charged higher rates.

The rule is the price will vary inversely with the price elasticity of demand when revenues are being maximized. This method of pricing will not likely meet the criteria of efficiency, equity and effectiveness but it does follow the benefit theory of taxation.

Peak-hour traffic patterns normally determine the size and location of the toll bridge (ferry route). Thus, "the marginal capacity cost of peak hour users is the total fixed cost of the plant, whereas for the non-peak users it is zero." The non-peak-hour user make use of capacity which would otherwise be idle. Price discrimination for peak and non-peak has the advantage of smoothing the flow of traffic over time and will reduce congestion costs.

Levinson, Regan and Lessieu (1980) in their paper "Estimating Behavior Response to Peak-Period Pricing" discuss congestion pricing in the toll bridges and tunnels of the Port Authority of New York and New Jersey.

> Peak-period pricing assumes that, as more vehicles use a roadway system during a given period, each additional vehicle will interfere with the free flow of others in the stream, which will cause them to reduce speed and lead to congestion. As additional vehicles try to enter the system, they further congest the total flow and impose additional costs and loss of time on vehicles that are already in the system. The total additional delay and discomfort forced on all vehicles generally exceeds the delay and discomfort to those marginal vehicles that enter a system that is approaching capacity.
>
> In economic terms, drivers who enter a congested traffic stream do not realize the total cost to society generated by their trips because they pay only the average cost of the trip. If these drivers actually paid the true cost, each would face an economic decision as to whether or not to make the trip at that time. A driver who values traveling during a peak period sufficiently would theoretically pay for these additional costs through a surcharge or, in the case of this study, a higher toll during the congested periods. A driver who did not so value his or her travel would change travel time or mode. In theory, the surcharge or toll should vary directly in proportion to the degree of congestion.[29]

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[29] Levinson, Regan and Lessiew (1980) p. 21.

User Charges versus Charges on Non-Users for Highway Externalities

Highways (and the ferry system) create access benefits to adjacent properties. If the net benefits are positive (negative) the benefits will be capitalized into increased (decreased) property values.

Access benefits from residential streets in a new development are often paid for through the creation of local improvement districts or the developer is required to put them in. In either case, the homeowner ultimately pays for the access benefits and will recapture the value of the access benefits when the home is sold. When a highway system is improved, the value of access benefits and therefore the property values will increase. An unearned increment of value is created for the homeowner that could be taxed away by a property tax which would equal the value of the change in access benefits.

Because of the capitalization process an equity problem may exist if the property tax increase does not occur simultaneously with the access benefit increase. If the property has been recently sold, the current owner of the property will have already paid for the capitalized value of the access benefits to the previous owner. The additional tax would be essentially paying for the benefits a second time. The original owner will be unjustly enriched by the increased sales price while the current owner is discriminated against.

The access benefits are not "external" in the normal use of that word since the benefits are capitalized, so these benefits should not be paid for by a general fund tax. The general consensus in the transportation literature is that the federal system access benefits are fully captured by the users so that it is not appropriate to use a non-user fee to pay for federal highway services.

Lee discusses this problem in the following quote:

> Non-users (or users in non-user roles such as consumers and property owners) benefit from the consumption of highway services, but this is not sufficient justification for asking non-users to pay for highways. Newspaper readers benefit from the manufacture of newsprint machines (that make the paper), but the rent on the machines is paid by the paper mill, who passes the cost on to the publisher and ultimately to the newspaper purchaser. There is no need to ask the reader or the general public to help pay for making newsprint machines just because the machines create indirect benefits. The key question is whether highways create external benefits, versus benefits that are internal to normal market processes. External benefits, if they exist, constitute a form of market failure because producers cannot get back in revenues the full value of the benefits they create. If highways create these kinds of benefits, then the general taxpayer may reasonably be asked to contribute toward their production.
>
> Highways generate, directly or indirectly, a large share of the jobs and income in the United States. Certainly the economy could not function if the highway system were removed, but removal is not an alternative being considered. The choice is between subsidized system and another, probably somewhat smaller, system that is fully supported by user fees. The investment not made in highways would be used for something else, which might create more or fewer jobs than the same investment in highways. If the social question is which use of general taxes will be most efficient, most equitable, and also create the most jobs, then highway investment would be simply one candidate among many. The manufacture of newsprint, for example, also creates jobs and income.[30]

Estimates have been made of the user and non-users share of revenues and cost responsibility in DOT's Final Report on The Federal Highway Cost Allocation Study for all levels of government. These estimates are shown in Table 6.1 and Table 6.2.

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[30] Lee (1981) P.49

Table 6.1

1977 Non-user Revenues for Highway Purposes Compared to
Cost Responsibilities Aggregated for All Levels of Government
(In Millions of Dollars)

	User Share		Non-user Share	
	$	(%)	$	(%)
Revenues contributed, as adjusted for cross subsidies	26,704	(76.0)	8,429	(24.0)
Cost responsibility, assuming property access costs are assigned to non-user	18,974	(61.3)	11,850	(38.7)
Cost responsibility, assuming property access costs are *not* assigned to non-users	28,399	(92.7)	2,245	(7.3)

Source: U.S. Department of Transportation, (1982) Final Report on the Federal Highway *Cost Allocation Study* p. I5.

Table 6.2

Estimate of Non-User Share of
Property Access Using the Earnings-Credit Method for 1977

Highway System	Net Highway Expenditure for 1977 by all Units of Government[1]	Percentage Distribution of Non-User Share From 1964 HCAS[2]	Non-User Share
Interstate	$4,724,400,000	1.78%	$84,094,320
Primary and Urban	4,964,800,000	1.78	106,173,440
Secondary	5,304,400,000	47.38	2,513,224,720
Non-Federal-aid	12,405,400,000	55.64	6,902,364,560
Total	$28,399,000,000		$9,605,857,040 (33.8% of net expenditures)

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[1]The estimate of Federal and State capital expenditures for the Interstate system was obtained from FHWA, Highway Statistics 1977, Table SF21, page 135. Interstate system maintenance expenditures were estimated from 1975 data in AASHTO, Maintenance Aid Digest, AASHTO Committee on Maintenance expenditures for 1975 and 1977 in Highway Statistics. The estimate of capital and maintenance expenditures for all highways by all units of government was obtained from Highway Statistics 1977, Table HF10, page 118. The distribution of capital and maintenance expenditures among highway systems other than Interstate was based on the percentage distribution of total highway needs reported in the 1961 Final Report of the Highway Cost Allocation Study, page 128. All additional expenditures were distributed among highway systems in proportion to the distribution of capital and maintenance expenditures.

[2]U.S. Secretary of Commerce, Final Report of the Highway Cost Allocation Study, 1961, Table III-G9, page 143.

Source: U.S. Department of Transportation, (1982) Final Report on the Federal Highway Cost Allocation Study p. F27.

Similar estimates were made in the Washington State Highway Cost Allocation Study and these are shown in Table 6.3.

Table 6.3

GENERAL COST RESPONSIBILITIES, FISCAL YEARS 1968-1973

Revenue sources	Percent of total financing	Percent of total user and non-user financing
A. State-administered system		
Highway users	89.3%	100.0%
Non-user	-	-
Bond issues	10.7	-
Total	100.0%	100.0%
B. County roads and city streets		
Highway users	27.0%	33.4%
Non-users	53.8	66.6
Bond issues	19.2	-
Total	100.0%	100.0%
C. All highway systems		
Highway users	61.3%	71.7%
Non-users	24.2	28.3
Bond issues	14.5	-
Total	100.0%	100.0%

Source: Transportation Development Associates, Inc., (1977) Washington State Highway Cost Allocation Study p. 12.

Institutional Framework for Setting Prices on Highway Services

The way user charges are established for highway services in the state of Washington is similar to that at the federal level. The Secretary of the Department of Transportation, who is the chief executive officer is responsible preparing biennial budgets for the highway division and the other divisions in DOT. When revenues are inadequate to cover the cost of desired new construction, maintenance and operations increases in user fees will be recommend to the State Transportation Commission. After public hearings, the State Transportation Commission will make recommendation for a change in user fee to the legislative transportation committee and the senate and house transportation committee. The transportation committees make recommendations to the legislature and if passed will go to the governor for his approval or veto.

The set of user fees established by the 18th Amendment to the State Constitution is the basic source of revenue for the highway system at the state and local levels. Motor vehicle license free and motor vehicle fuel taxes are deposited into the Motor Vehicle Fund. Operator's license fees, certificates of ownership, and excises in lieu of property taxes are allocated separately.

Figure 6.2 out of Financing Washington's Transportation System summarized the Motor Vehicle Fund's revenues and distributions.[31]

The motor vehicle license fee allocation is shown below in Figure 6.3.[32]

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[31]WSDOT (1983) p. 6

[32]Ibid p. 15

Figure 6.2

Motor Vehicle Fund State Revenue and Distribution

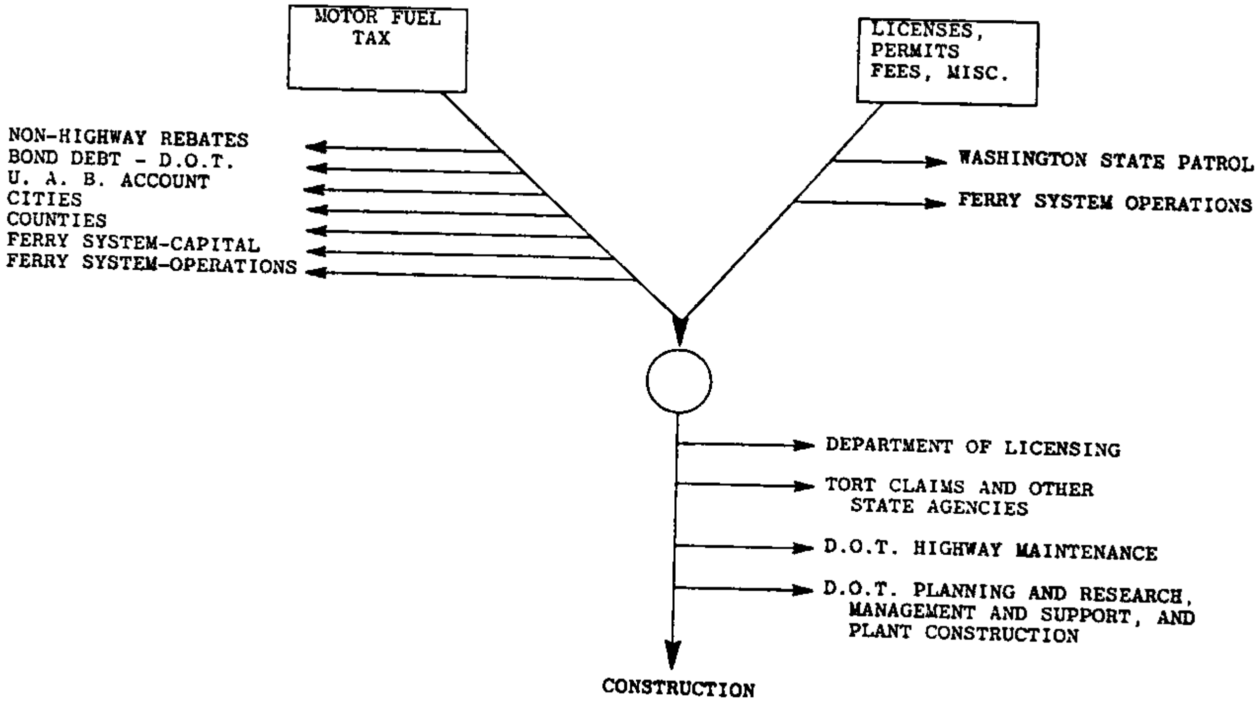
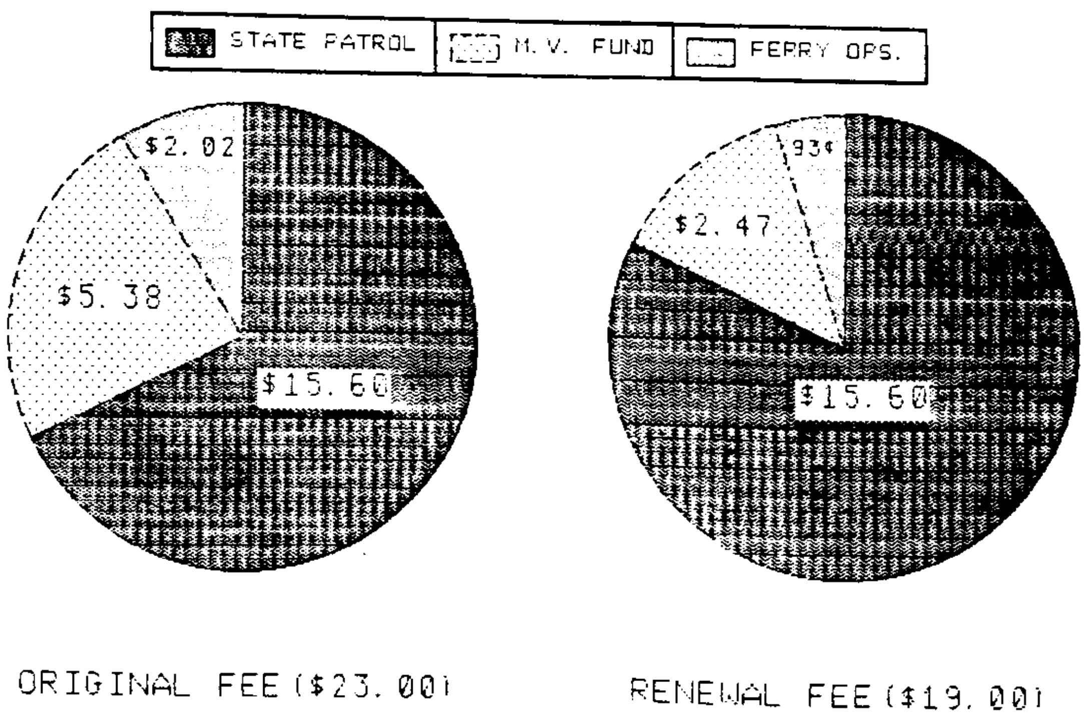


Figure 6.3

Basic Registration Fees

Current Distribution



While the user fees are clearly established by the political process Allocation Studies keep the decision makers informed as to the cost responsibilities and user fee payments of each vehicle class. Thus, the level of subsidy (ratio of user charge to cost) is common knowledge and can be adjusted when user charges are changed. A recent example of the adequacy of user charges by vehicle class is shown in Table 6.4.

Table 6.4

Summary: Annual Cost Responsibility vs. Tax Payment Comparisons By Vehicle-Type for Case3 (Average) Pavement Increments

Vehicle-Type	Cost Respon sibility	Tax Payment	Cost Less Tax	Ratio: Tax to Cost
Passenger Cars	$ 94	$ 64	$ 30	.68
Taxis	531	909	(378)	1.71
Stages:				
2-axle	2,200	706	1,494	.32
3-axle	4,798	1,283	3.515	.27
Private Buses	85	81	4	.95
Motorcycles	31	18	13	.58
Single-Unit Trucks				
2-axle/4-tire	69	63	6	.91
2-axle/6-tire				
Tractor/Semi-Trailers				
3-axle	1,172	695	478	.59
4-axle	1,095	875	221	.80
5-axle	2,805	1,862	943	.66
Truck/Trailers				
4-axle	3,016	1,725	1,291	.57
5-axle	4,467	2,083	2,381	.47
Tractor Trains	2,927	1,898	1.029	.65

( ) Indicates tax overpayment, i.e., tax payment exceeds cost responsibility.
Source: Transportation Development Associates, Inc., (1977) Washington State Highway Cost Allocation Study p. 108.

VII. Pricing of Ferry Services

Ferry Services

A review of the literature on ferry services and ferry prices indicated that:

> there are over 600 ferry operators in the US and Canada, ranging from small operations of 8 to 16-vehicle ferries across narrow waterways, to massive public operations, such as those in New York, Seattle, Vancouver, and others. Two hundred of these are in the United States, with 190 privately owned and operated. Twenty, including the Staten Island Ferry, however, carry almost 90% of the users of such services.[33]

The largest operations are as follows:[34]

1. Staten Island Ferry--over 20 million passengers and 600,000 vehicles per year between suburban Staten Island and the Manhattan central business district.
2. Washington State Ferries--over 18 million passengers and 7.3 million vehicles per year over 11 routes with 19 vessels.
3. British Columbia Ferries--over 11 million passengers and 4 million vehicles per year over 16 routes with 25 vessels.
4. Quebec Ferry Company--over 2.4 million passengers and 970,000 vehicles per year over 6 routes with 15 vessels.
5. Golden Gate Ferries--over 1 million passengers per year over 2 routes.
6. Cape May--Lewes Ferry--approximately 710,000 passengers and 236,000 vehicles per year with 4 vessels between southern New Jersey and Delaware.

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[33] Roess, Grealy and Berkowitz (1981), p. 1.3.

[34] Roess, Grealy and Berkowitz (1981), p. 2.4-2.5.

7. Alaska Marine Highway--over 294,000 passengers and 72,000 vehicles per year over 22 routes with 9 vessels.
8. Orient Point--New London--over 257,000 passengers and 103,000 vehicles per year on one route with 3 vessels as an alternative to a circuitous land route through New York City.
9. Port Jefferson--Bridgeport--over 112,000 passengers and 25,000 vehicles, as a seasonal operation between Bridgeport, Connecticut and Port Jefferson, New York.

All of these large operations are extensions of the regional highway system. Comparative cost data for these ferries are shown in Table 7.1. Washington ferries are neither the high or low cost ferries.

Operating revenue for selected ferry systems are shown in Table 7.2. For those services receiving government subsidies, the Washington State ferries appear to be the least subsidized.

A review of the literature on ferry services in the State of Washington indicated that besides the Washington State Ferry System there are:[35]

Three interstate systems

1. The Black Ball Transport, Inc. which operates on a route between Port Angeles and Victoria, B.C. and runs from March to November of each year.
2. The British Columbia Ferries which operate between Seattle and Victoria, B.C. on a seasonal basis.

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[35]WDOT (1983) p. 73

Table 7.1

SELECTED ANNUAL OPERATIONAL CHARACTERISTICS OF EXISTING FERRY SYSTEMS (1)

System Name	No. of Vehicles (in thousands)	No. of Vehicle--Miles (Millions)	Cost per passenger ($)	Cost per Vehicle ($)	Cost per passenger-Mile ($)	Cost per Vehicle-Mile ($)
1. Alaska Marine Highway	72.3	22.8	129.1	525.1	0.44	1.67
2. British Columbia Ferry	4,161.3	106.7	9.54	2.62	.035	1.02
3. Cape May-Lewes Ferry	236.0	4.0	4.82	14.5	0.28	0.85
4. Golden Gate Ferries	-	-	5.54	-	0.43	-
5. Orient Point - New London	103.8	1.7	7.05	17.46	0.44	1.09
6. Port Jefferson-Bridgeport	25.4	0.4	6.76	29.92	0.42	1.87
7. Quebec Ferry Company	971.0	3.6	5.50	13.61	1.37	3.67
8. Staten Island Ferry	574.0	2.9	1.27	39.86	0.25	7.97
9. Washington State Ferries	7,300.0	50.0	3.04	7.54	0.40	1.10
10. Jetfoil Test Service-Puget Sound	-	-	6.85	-	0.25	-

Source: Roess, R., P. Grealy, C. Berkowitz (1981), Some Critical Aspects of Ferry Planning, p. 2.9.

Table 7.2

FISCAL YEAR 1980 OPERATING REVENUES FOR SELECTED FERRY SYSTEMS

System	Revenue Sources	Fare Box ($) (millions)	Concessions ($) (millions)	% of Fares	Government Subsidies (millions)	% of Fares	Other ($) (millions)	% of Fares
1.	Golden Gate Ferries	1.118	0.121	10.8	1.611	144.1	0.008	0.7 (1)
2.	Alaska Marine Highway	21.165	-		24.629 (2)	116.4	-	
3.	Quebec Ferry Comapny	4.911	-		7.854 (3)	159.9	0.154	3.1
4.	British Columbia Ferry Corp.	60.378	17.933	29.7	49.447 (4)	81.9	4.556	7.5
5.	Washington State Ferries	29.982	-		11.000 (5)	49.7	2.968	9.9
6.	Staten Island Ferry	3.012	1.000	33.2	6.700	222.4	-	

NOTES:
(1) Revenue from feeder bus service
(2) G.F. Subsidy
(3) Government of Quebeck operating subsidy
(4) Province of British Columbia highway subsidy
(5) Subsidy from the state motor fuel tax revenue
(6) All amounts shown are based on rough estimates provided by operating authority.

Source: See Table 8.1

3. The Alaska Marine Highway System which operates between Seattle and Skagway, Alaska with various stops in between.

Six privately owned passenger-only systems operated in the state

1. The Lake Chelan Boat Company which ferries passengers from Chelan to Stekekin on Lake Chelan, a distance of approximately 50 miles.
2. The Horluck Transportation Company which operates between Bremerton and Port Orchard.
3. The Gray Line of Seattle which ferries passengers between Leschi Park and Elliott Bay, completely within the city limits of Seattle.
4. Hat Island Community, Inc., which ferries passengers between Everett and Hatt (Gedney) Island.
5. Island Mariner, Inc., which operates on a route which starts in Bellingham and includes many islands in the San Juans.
6. Exploration Cruise Lines which ferries passengers between several ports and the San Juan Islands. Routes start in Bellingham, Port Townsend, Seattle, Edmonds, Everett and La Conner.

Two ferry systems cross the Columbia River

1. Colville Confederated Tribes, which operates between Glifford and Inchelium.
2. WSDOT, which operates a free ferry on Highway 21 between Keller and Wilbur.

Five Counties operate ferry systems

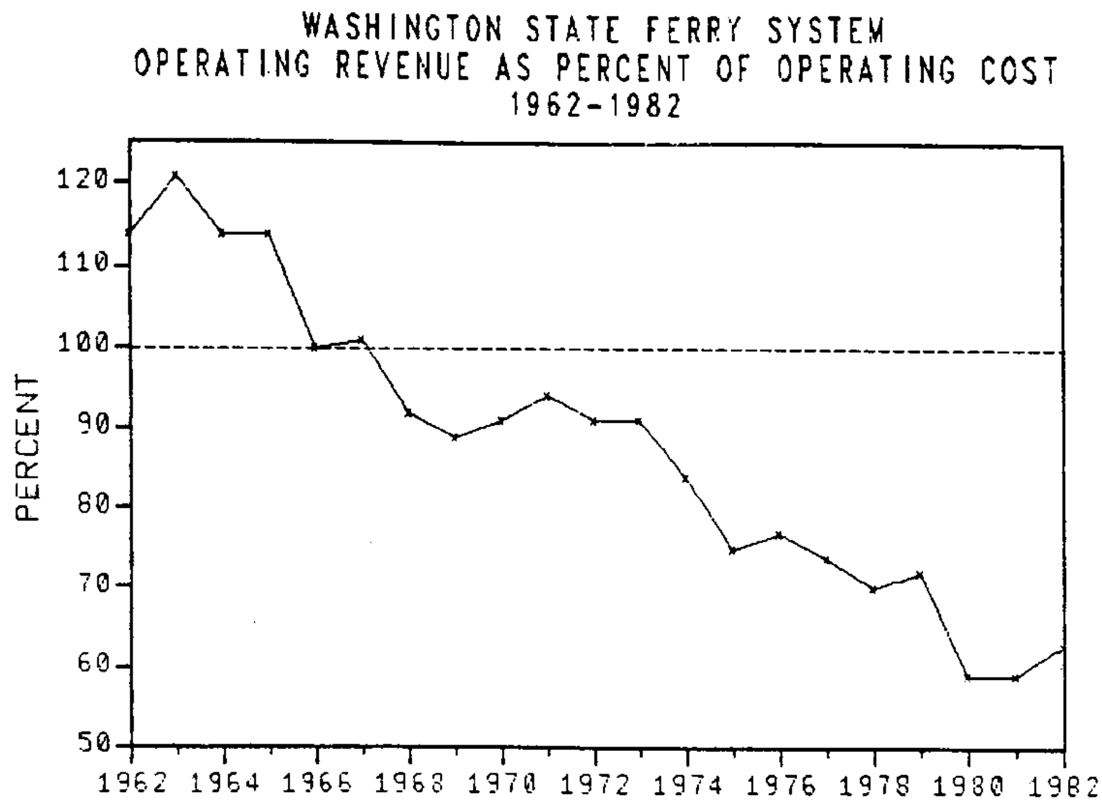
1. Grays Harbor Transit Authority, which operates a passenger only ferry between Westport and Ocean Shores. It operates daily in the summer and on weekends and remainder of the year. It is subsidized solely by county sales tax revenues. (RCW 82.14.04512)

2. Washington County, which operates a passenger-vehicle ferry between Puget Island and Westport, Oregon. It receives a subsidy form WSDOT under RCW 47.56.720.
3. Pierce County, which operates a passenger-vehicle ferry between Steilacoom, McNeil, Kentran and Anderson Island.
4. Skagit County, which operates a passenger-vehicle ferry between Anacortes and Guemes Island under RCM 47.56.725.
5. Whatcom County, which operates a passenger vehicle ferry between Gooseberry Point and Lummi Island under RCM 47.56.725.

The four county systems share in a state subsidy not to exceed $500,000 per biennium.

The Washington State Ferry Service was established in 1951 when the State of Washington purchased the majority of the financially troubled Black Ball Line's assets. Fares were originally set to cover all costs. Black Ball Line and its predecessors provided ferry services in the private sector since the 1930's. Subsidization of the system did not start until 1957 when ferry system employees were brought into the State Retirement Fund. The ratio of operating revenues to operating costs from 1962-82 are shown below in Figure 7.1.

FIGURE 7.1



Policy in the State of Washington

In general, the laws of the State of Washington link legislation dealing with toll bridges with the ferry system so the logic of comparing the two is sound. The pricing policy for both toll bridges and the ferry system is clearly established in RCW 47.60.150

> The schedule of charges for the services and facilities of the system shall be fixed and revised from time to time by the authority so that the tolls and revenues collected will yield annual revenue and income sufficient, after allowance for all operating, maintenance and repair expenses to pay the interest and principal and sinking fund charges for all outstanding revenue bonds, and to create and maintain a fund for ordinary renewals and replacements: Provided, That if provision is made by any resolution for the issuance of revenue bonds for the creation and maintenance of a special fund for

> rehabilitating, rebuilding, enlarging or improving all or any part of the ferry system then such schedule of tolls and rates of charges shall be fixed and revised so that the revenue and income will also be sufficient to comply with such provision.

The implication of this quote is that the Legislature is requiring a full incremental cost of a long-run marginal cost pricing scheme from tolls and revenues. Thus, the state legislature effectively determines the amount of the subsidy to the ferry system with three sets of revenues. First, the legislature determines the amount of revenue collected from the various tax sources by setting the tax rates and any tax credits as well as controlling the size of the tax base by setting deductions and/or exemptions. Once the revenue is collected from the motor fuel tax:

3.15% of it goes to the Puget Sound Operations Account.

3.21% of it goes to the Puget Sound Reserve Account.[36]

When the account is over $1 million, funds can be transferred to the Puget Sound Capital Construction Account or the Operations Account.

Similarly, the legislature controls the motor vehicle excise tax. The current rate is 2.2% of fair market value of which 0.2% goes to the Capital Construction Account. The revenues in this account are retiring $135 million in bonds sold in 1977 to finance the six Issaquah class ferries ($40 million of the authorized amount remains unsold.) As of March 31, 1983 $92.7 million was outstanding as was $2.2 million on a

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[36] RCW 46.68.100

1963 Ferry Bond Issue.[37] Again, revenues not needed for debt service or capital construction can be and is being transferred to the Operations Account.

Two modifications of this statute have been made. RCW 47.60.290 authorizes a review of the fare structure "for the purpose of establishing a more fair and equitable tariff to be charged passengers, vehicles, and commodities on the routes of the Washington state ferries."[38] RCW 47.60.450 appears to require prompt changes in tolls and charges to insure full incremental cost pricing except when such pricing would so "reduce traffic that no net gain in revenue would result." In economic terms, the legislature appears to require full incremental cost pricing as long as the demand curve for ferry services is inelastic.

The legislature also appears to require prices to be adjusted to types of traffic, volume discounts, time of travel, distance as well as operating costs, maintenance and repair expenses and debt services.[39]

Institutional Framework for Setting Ferry System Tolls

When revenues coming from the Motor Vehicle Fund and not sufficient to cover the cost of the ferry system, fares must be raised to cover long-term incremental costs. The procedures to raise fares is similar to that of a change in motor vehicle taxes except that legislative approval is not needed. Thus, if the traffic engineer's prediction of

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[37]WDOT (1983) p. 19, 77-79

[38]RCW 47.60.290

[39]RCW 47.60.300

fares does not cover the expected cost of the Ferry System after deducting expected funds from the Operating Account, the staff of the Ferry System would recommend a fare increase to the Washington State Transportation Commission. Once the Commission approves (RCW 47.60.290) it publishes a Notice of Intent to raise fares in the Washington State Register. Then a public hearing process is implemented. First, the Ferry System staff meets with Local Advisory Committees which represent each county where ferry terminals exist and would be effected by the fare increase (RCW 47.60.310). Second, the Washington Transportation Commission would hold public hearings on the fare increase. Once the Commission has finalized its recommendation the fare increase can take place.

As mentioned previously, RCW 47.60.450 states that fares shall not be increased if the traffic engineer feels that there would not be net gain in revenues from the fare increase.

VIII. Empirical Analysis of Ferry Service Pricing

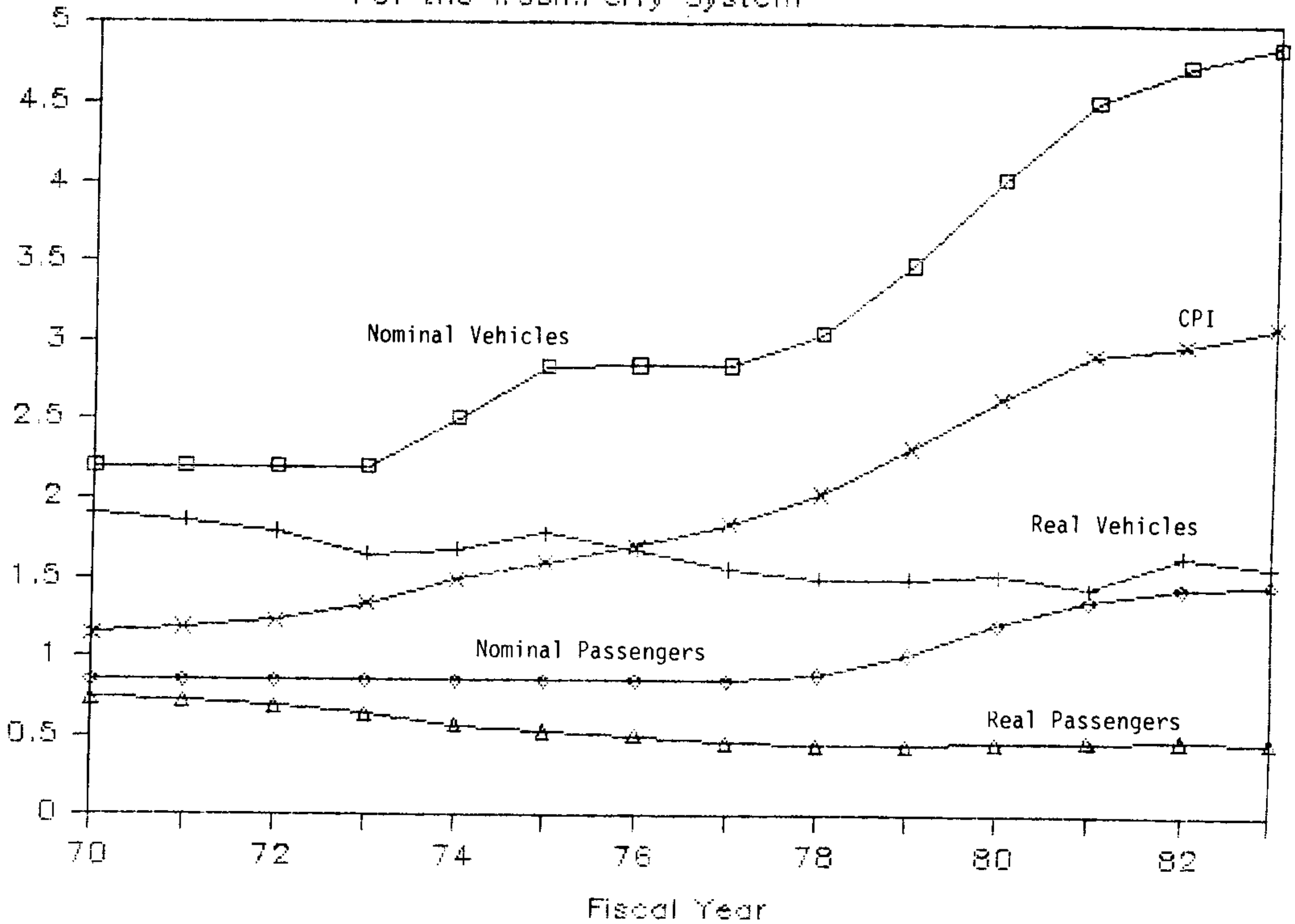
Nominal and Real Prices

What has been happening to prices on the various routes of the ferry system? Do the funds from these user fees cover full incremental cost, marginal cost or some other cost concept? If not, what is the size of the subsidy that the users of the ferry system are receiving? These questions are analyzed in this section of the paper.

If one would ask the user of the ferry system they would undoubtedly claim that user fees have been going up and are too high relative to what they would like to pay. Figure 8.1 shows that they are partially right. The top line in Figure 8.1 plots the common fare structure for vehicles on five of the major runs on a fiscal year basis since 1970.

Figure 8.1 Average Fares on Main Routes

For the Wash.Ferry System



It is clear that prices for vehicles have been going up dramatically since the mid-1970s. But we all know there has been a lot of inflation since the mid-1970s. The important question is what has been happening to the real price of ferry services. The second line on the left side of Figure 8.1 shows what has happened to the deflated price for vehicles. It has remained relatively constant, and if there is a trend, it is in the downward direction. The third line on the left reflects what happened to the Seattle-Everett CPI over the same period. The bottom two line in Figure 8.1 show what has happened to nominal and real passenger fares. The undeflated (nominal) fares show a slight increase but the real price for passengers has moved slightly downward.

Comparisons of Fare Revenues with Operating Costs

Aggregating the fares collected from the various routes provides the annual revenues for the ferry system. These revenues are compared to the operating costs of the system in Table 8.1. As the next to last column indicates revenues covered 91% of the costs in FY 1973, or the subsidy was 9% of operating expenses (last column), the subsidy was largest in FY 1980 and 1981 at 41% where only 59% of costs were covered by fares. For FY 1983 the revenues covered 63% of cost so the ratio of subsidy to expense was 37%. (See Figure 8.3 for visual presentation of how this ratio changes over time. Figure 8.3 presents the ratio information for six major routes.) If data on capital costs were included, giving a better estimate of full incremental cost (long-run marginal cost) the size and percent of the subsidy would be even larger. (Estimates of capital cost for the Washington ferry system range from 8 to 22 percent of operating costs.)

The next task is to analyze the distribution of subsidy between vehicles and passengers. First the proportion of revenue generated by vehicles and passengers was calculated. The actual revenue by each class of users was available from 1978 to 1983 from published reports. Before 1978 estimates were made of the revenue generated by each class of user using the current fare times the number of vehicles or passengers. These proportions were then used to allocate the total subsidy calculated in Table 8.1 for each user class. The pre-1975 calculations were as follows:

$$\left(\frac{P_i \times Q_i}{TER}\right) (OE-FR)$$

P_i is fare for vehicles or passengers

Q_i is the number of vehicles or passengers

(OE - FR) is operating expense minus fare revenue found in Table 8.1

TER is total estimated revenue

When the above calculation is divided by Q_i, then an estimate of the subsidy per vehicle or passenger is obtained.

$$\frac{\left(\frac{P_i \times Q_i}{TER}\right)(OE - FR)}{Q_i}$$

Table 8.2 shows these calculations for vehicles and Table 8.3 shows these calculations for passengers. Figure 8.4 summarizes the vehicle and passenger subsidy graphically.

Table 8.1

Expenditures, Revenues and Subsidy for the Washington State Ferry System

FY 1973-83

Operating Total System	Operating Expenses	Fare Revenue	Subsidy (OE - FR)	Ratio Revenue/ Expense	Ratio Subsidy/ Expense
FY83	$67,244,127	$42,378,043	($24,866,084)	.63	.37
FY-82	62,172,394	39,009,579	(23,162,815)	.63	.37
FY-81	59,919,140	35,190,479	(24,728,661)	.59	.41
FY-80	48,333,216	28,753,496	(19,579,720)	.59	.41
FY-79	38,702,696	27,861,347	(10,859,349)	.72	.28
FY-78	36,825,546	25,884,035	(10,991,511)	.70	.30
FY-77	31,458,675	23,208,624	(8,250,051)	.74	.26
FY-76	26,975,124	20,698,189	(6,276,935)	.77	.23
FY-75	23,320,015	17,458,511	(5,861,504)	.75	.25
FY-74	19,286,818	16,171,012	(3,115,806)	.84	.16
FY-73	16,139,757	14,622,936	(1,516,821)	.91	.09

Table 8.2
Estimate of Vehicle Subsidy for the WSFS

FY 1975-83

	Fare Revenue	Subsidy for Vehicles	Vehicle Subsidy to total Subsidy	Total No. of Vehicles	Size of Subsidy per Vehicle
FY-83	$30,368,642	($18,047,130)	.73	6,457,052	$2.79
FY-82	27,982,843	(16,781,281)	.72	6,269,350	2.68
FY-81	29,461,376	(20,271,325)	.82	6,451,874	3.14
FY-80	24,100,086	(16,073,241)	.82	6,696,314	2.40
FY-79	21,647,352	(8,392,673)	.77	7,074,909	1.19
FY-78	19,035,392	(8,215,512)	.75	6,991,032	1.18
FY-77	15,781,864	(5,610,035)	.68	6,314,278	.89
FY-76	13,867,787	(4,205,546)	.67	5,804,684	.72
FY-75	12,046,373	(4,044,437)	.69	5,362,295	.75

Table 8.3

Estimate of Passenger Subsidy for WSFS

FY 1975-83

	Fare Revenue	Passenger Subsidy	Passenger Subsidy to Total Subsidy	Total Passengers	Size of Subsidy per Passenger
FY-83	$11,307,822	($7,520,533)	.21	10,108,617	.74
FY-82	10,174,045	(7,234,225)	.28	10,129,082	.71
FY-81	9,869,938	(7,603,715)	.18	10,185,225	.75
FY-80	8,223,268	(6,635,360)	.18	10,018,077	.66
FY-79	7,207,401	(3,347,203)	.23	10,059,350	.33
FY-78	6,546,607	(3,028,035)	.25	9,908,325	.31
FY-77	7,426,759	(2,640,017)	.32	9,254,178	.29
FY-76	6,830,402	(2,071,389)	.33	8,534,641	.24
FY-75	5,412,138	(1,817,067)	.31	7,865,327	.23

Figure 8.2 Ratio of Fare Revenue to Operating Costs for Wash. Ferry System

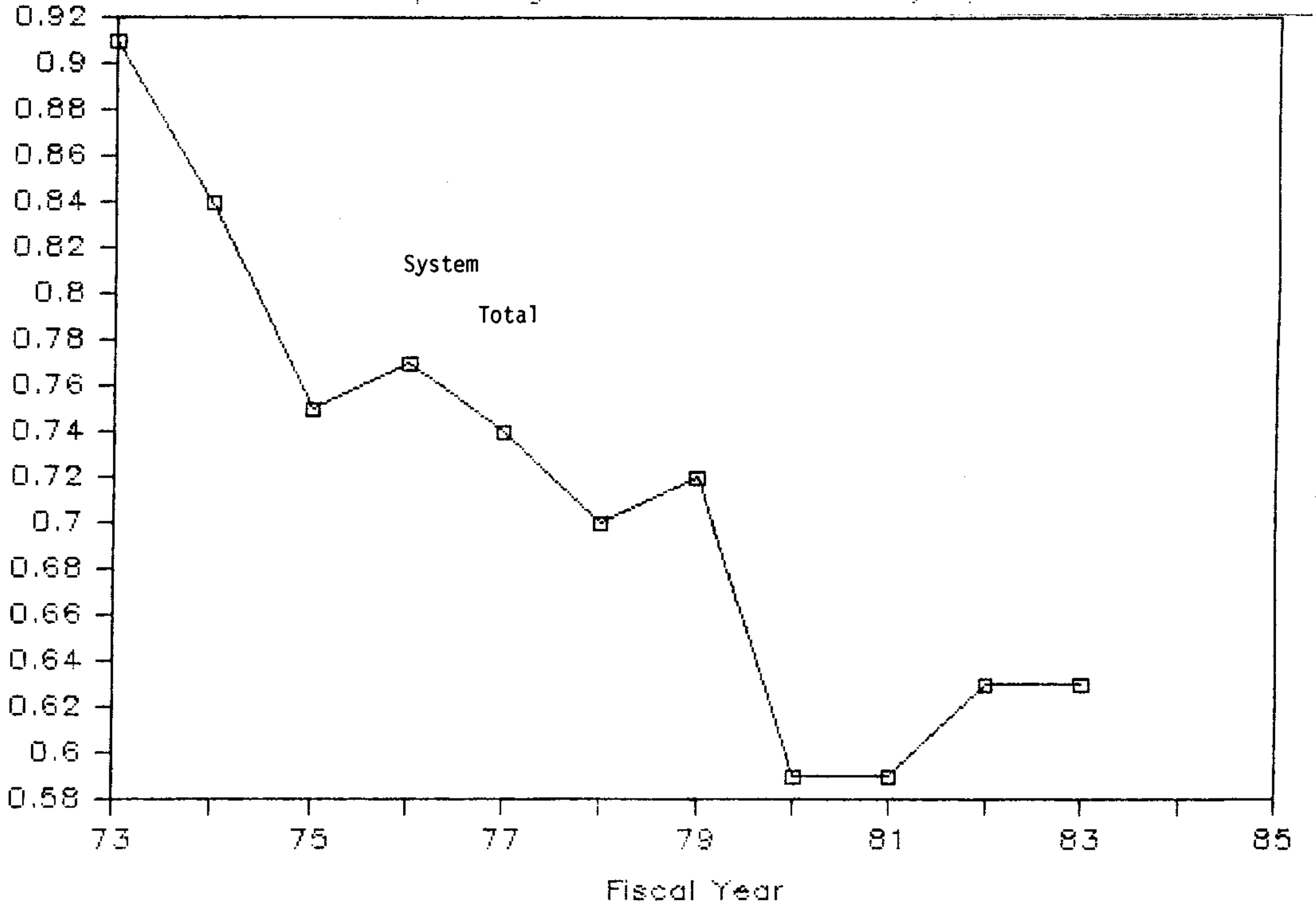


Figure 8.3 Ratio of Fare Revenue to

Operating Costs for Wash. Ferry System

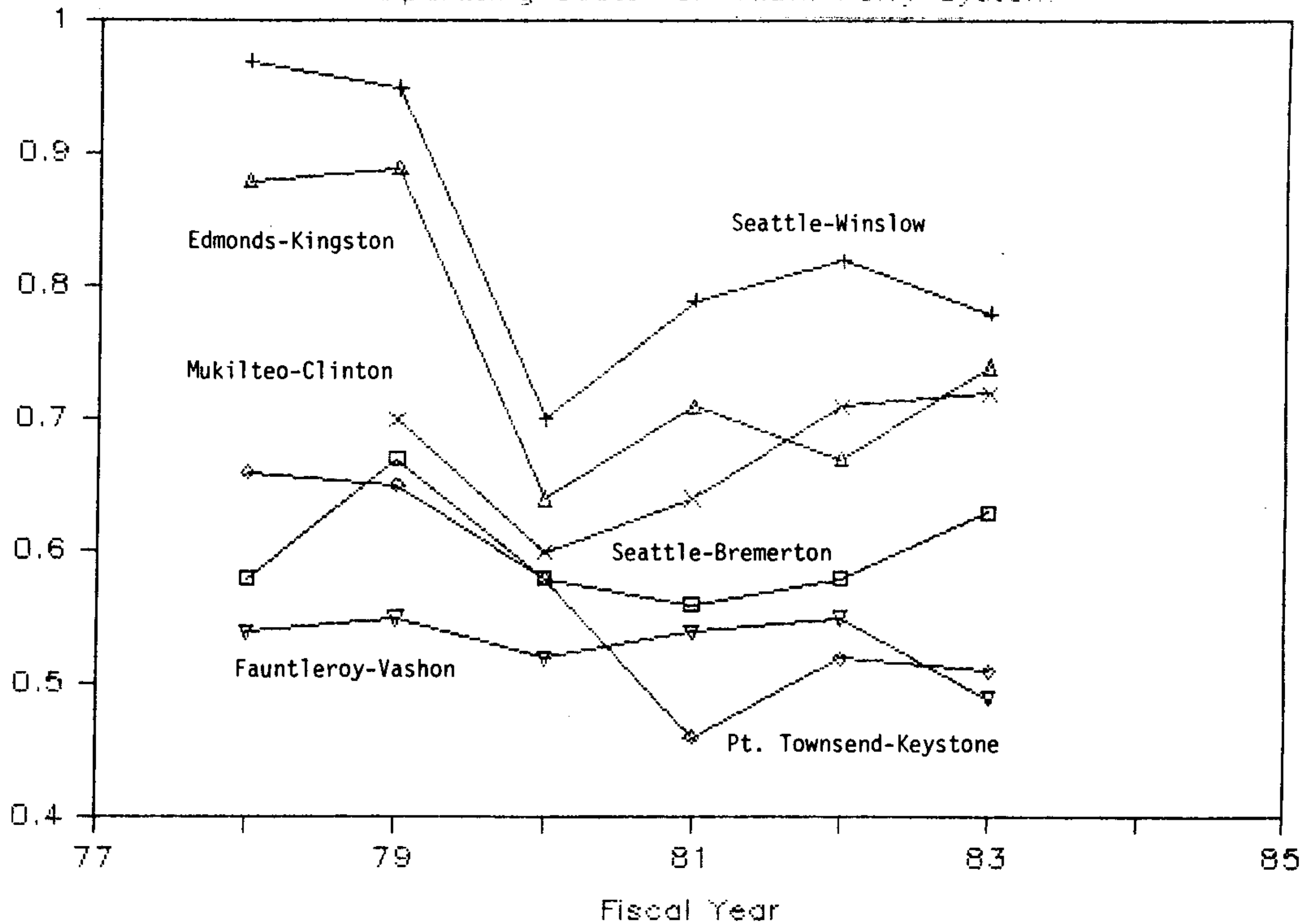
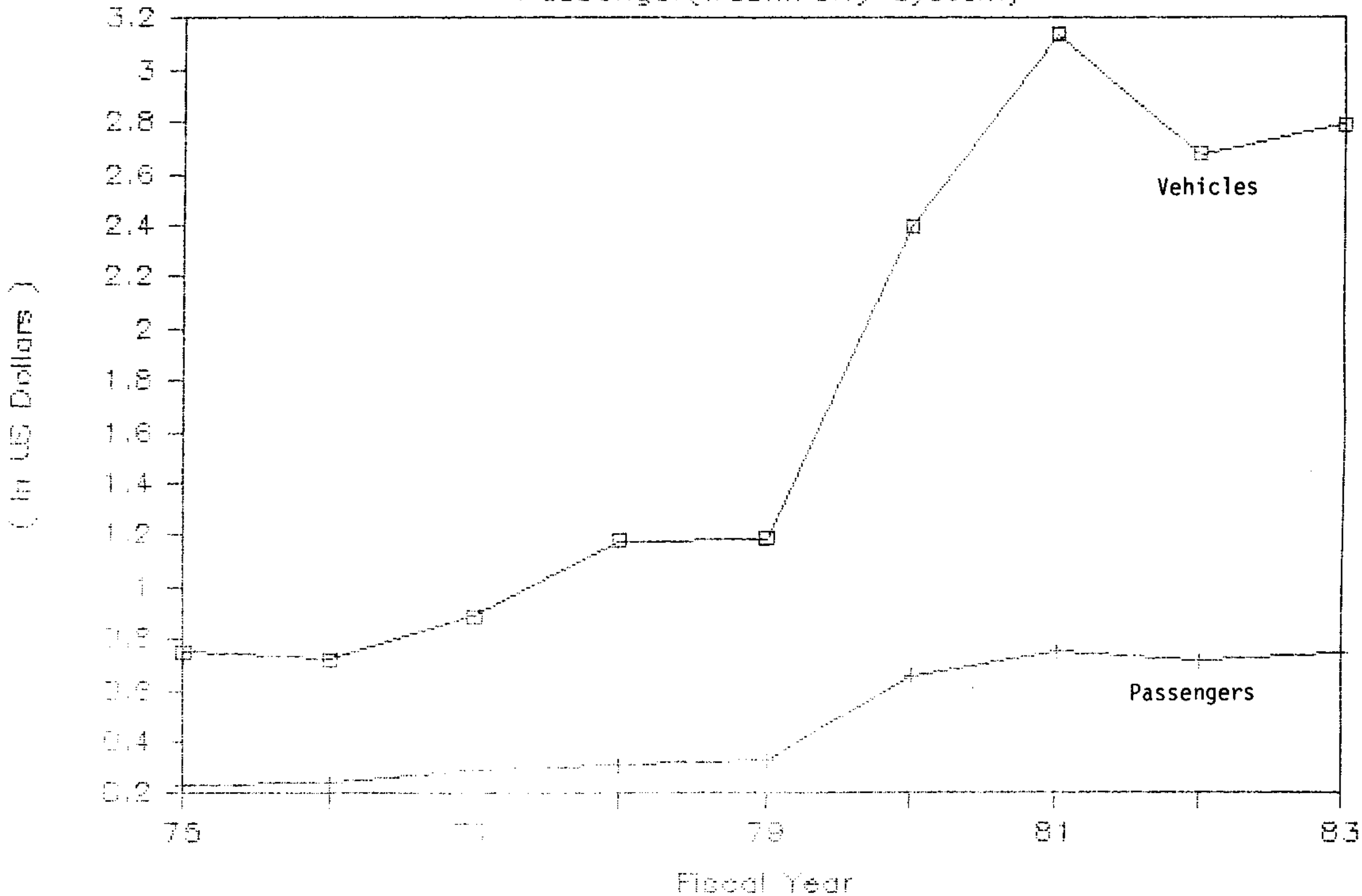


Figure 8.4 Subsidies per Vehicle and Passenger(Wash.Ferry System)



For fiscal year 1983 our estimates show that the subsidy per vehicle was \$2.79. This subsidy increase from 72¢ in FY 1976. Of the total subsidy that occurred in FY 1983, 73% went to vehicles. The remaining 23% went to passengers. The subsidy per passenger in FY 1983 was 74¢, increasing from 23¢ in FY 1975.

Table 8.4 presents data for the major individual routes similar to that for the total system as found in Tables 8.1, 8.2 and 8.3 For example, in FY 1983 fares covered 78%. Of costs on the Seattle-Winslow route and only 49% on the Pt. Townsend-Keystone route. (The share for fare revenue to cost is shown graphically in Figure 8.3 for the system and Figure 8.4 for each major route.)

Again, referring to the Table 8.4, the Seattle-Winslow route generates 21% of the system costs while providing 26% of the systems revenue. The estimated subsidy per vehicle was \$1.34 and 29¢ per passenger. As expected, the vehicle and passenger subsidies are less for this route than many of the other routes as this route is subsidizing the other routes (cost percentage is 21%; revenue percentage is 26%). This subsidization of the other routes appears to have existed since the detailed route data became available.

Estimates of Price Elasticity of Demand

Price elasticities of demand are calculated by the formula $\frac{\Delta Q/Q}{\Delta P/P}$. Since we know how fares have changed over time and how quantities of vehicle and passenger traffic have changed, elasticity estimates can be made for the individual routes. The movement of nominal and real fares was shown previously in Figure 8.1 for the five major routes with common fares. The change in the number of vehicles and passengers since 1975 is shown in Figure 8.5.

Table 8.4

Expenditures, Revenues and Subsidy per User Class
for Individual Routes of the WSFS for FY 1978-83

Primary System Routes	FY-83 Operating Expense	Fare Revenue	Subsidy (OE - FR)	Ratio Revenue/ Expense	Cost % of total System	Revenue % of total System	Total Vehicles Crossing	Subsidy per Vehicle	Total Passengers Crossing	Subsidy per Passenger
Seattle/Bremerton	10,330,180	6,463,963	(3,866,217)	.63	.15	.15	679,340	3.53	1,833,313	.76
Seattle/Winslow	13,946,822	10,887,762	(3.059,070)	.78	.21	.26	1,524,861	1.34	3,100,793	.29
Fauntleroy-Vashon-South	10,304,290	5,266,640	(5,037,650)	.51	.15	.12	1,254,811	3.20	1,297,868	.74
Edmonds Kingston	7,520,668	5,587,400	(1,933,268)	.74	.11	.13	856,735	1.74	1,034,762	.41
Mukilteo-Clinton	7,283,554	5,236,519	(2,047,035)	.72	.11	.12	1,252,172	1.31	1,453,332	.27
Pt. Townsend Keyston	3,228,381	1,590,679	(1,637,702)	.49	.05	.04	208,608	5.90	299,416	1.30
	FY-82									
Seattle/Bremerton	11,527,810	6,656,089	(4,871,721)	.58	.18	.17	749,714	4.09	1,990,885	.83
Seattle/Winslow	12,490,059	10,268,311	(2,221,748)	.82	.20	.26	1,525,174	1.00	3,157,075	.20
Fauntleroy-Vashon South	9,979,250	5,148,170	(4,831,080)	.52	.16	.13	1,265,062	2.97	1,367,180	.67
Edmond Kingston	6,550,434	4,386,558	(2,165,876)	.67	.11	.11	696,230	2.46	893,385	.48
Mukilteo-Clinton	6,531,900	4,658,830	(1,873,060)	.71	.11	.12	1,149,850	1.27	1,373,230	.29
Pt. Townsend Keyston	2,757,855	1,523,133	(1,234,722)	.55	.04	.04	210,578	4.50	289,060	.94
	FY-81									
Seattle/Bremerton	11,542,184	6,479,893	(5,062,291)	.56	.19	.18	870,447	3.8	2,158,622	.80
Seattle/Winslow	11,675,566	9,206,003	(2,469,563)	.79	.19	.26	1,556,401	1.1	3,139,834	.22
Fauntleroy-Vashon-South	10,138,490	4,615,704	(5,522,786)	.46	.17	.13	1,259,424	3.4	1,439,799	.81
Edmonds Kingston	5,737,374	4,050,637	(1,686,737)	.71	.10	.12	733,935	1.84	889,856	.36
Mukilteo-Clinton	6,838,830	4,389,075	(2,449,755)	.64	.11	.12	1,245,779	1.6	1,445,000	.34
Pt. Townsend Keyston	2,475,947	1,325,827	(1,150,120)	.54	.04	.04	203,149	4.4	271,385	.89

Table 8.4 (Cont.)

Primary System Routes	Operating Expense	Fare Revenue	Subsidy (OE - FR)	Ratio Revenue/ Expense	Cost % of total System	Revenue % of total System	Total Vehicles Crossings	Subsidy per Vehicle	Total Passengers Crossing	Subsidy per Passenger
	FY-80									
Seattle/Bremerton	9,950,730	5,803,679	(4,147,051)	.58	.21	.20	1,019,063	2.7	2,353,968	.56
Seattle/Winslow	9,970,254	6,955,725	(3,014,529)	.70	.21	.24	1,453,792	1.4	2,874,064	.30
Fauntleroy-Vashon-South	7,144,857	4,129,316	(3,015,541)	.58	.15	.14	1,388,209	1.7	1,468,563	.39
Edmonds Kingston	4,279,926	2,731,351	(1,548,575)	.64	.09	.09	586,662	2.03	711,556	.46
Mukilteo-Clinton	6,181,283	3,699,462	(2,481,771)	.60	.13	.13	1,322,287	1.5	1,376,177	.32
Pt. Townsend Keyston	2,090,561	1,090,663	(999,898)	.52	.04	.04	199,875	3.9	242,088	.83
	FY-79									
Seattle/Bremerton	7,588,270	5,108,701	(2,479,569)	.67	.196	.18	1,032,450	1.61	2,284,344	.34
Seattle/Winslow	7,515,981	7,179,882	(336,099)	.95	.194	.26	1,660,680	.14	3,011,502	.03
Fauntleroy-Vashon-South	5,930,800	3,871,200	(2,059,600)	.65	.15	.14	1,441,500	1.14	1,432,800	.26
Edmonds Kingston	4,111,837	3,646,565	(467,272)	.89	.11	.13	913,705	.40	1,033,113	.09
Mukilteo-Clinton	4,708,786	3,288,108	(1,420,678)	.70	.12	.12	1,349,253	.85	1,287,581	.20
Pt. Townsend Keyston	1,393,876	761,298	(632,578)	.55	.04	.03	178,972	2.7	223,514	.62
	FY-78									
Seattle/Bremerton	7,489,949	4,365,149	(3,124,800)	.58	.20	.17	918,051	2.2	2,129,985	.48
Seattle/Winslow	7,271,291	7,042,707	(228,584)	.97	.20	.27	1,729,555	.09	3,011,616	.02
Fauntleroy-Vashon-South	5,175,443	3,404,104	(1,771,339)	.66	.14	.13	1,364,263	1.05	1,314,289	.26
Edmonds Kingston	4,560,236	4,022,081	(538,155)	.88	.12	.16	1,046,527	.40	1,188,992	.10
Mukilteo-Clinton										
Pt. Townsend Keystone	1,072,208	573,925	(498,283)	.54	.03	.02	143,630	2.6	192,499	.65

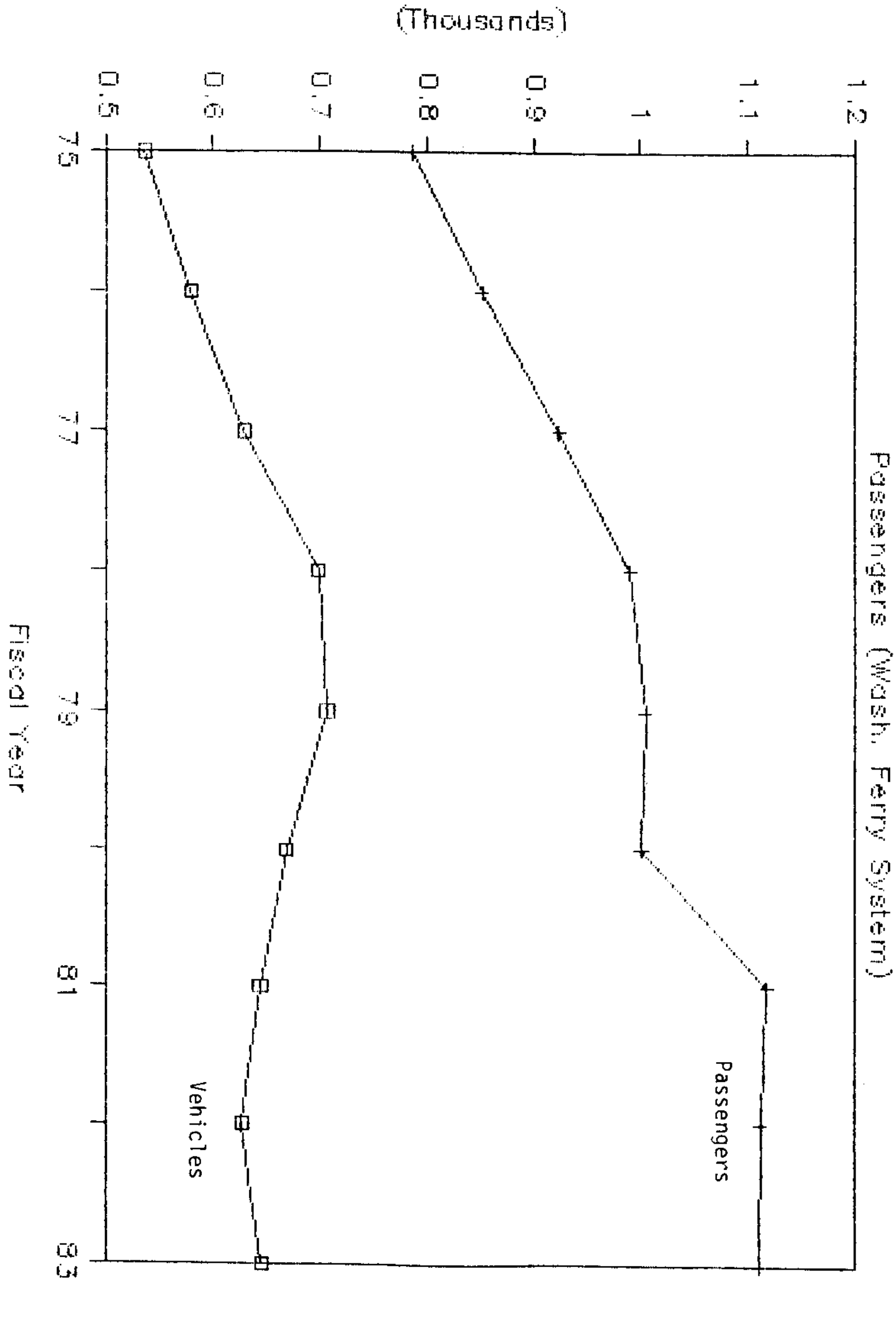


Figure 8.5 Number of Vehicles and
Passengers (Wash. Ferry System)

Since the number of users have generally increased through time when nominal prices were going up, it is not surprising to find a positive price elasticity. Microeconomic theory tells us that when prices go up the quantity demanded will fall, other things being equal. But micro theory is referring to the relative price of the quality being demand. So the proper $\Delta P/P$ to use for the elasticity calculations is the real price of ferry services--that is, the nominal price deflated by the Seattle-Everett CPI.

Table 8.5

Price Elasticity for the Five Major Routes with a Common Price for the WSFS for FY 1966-1983

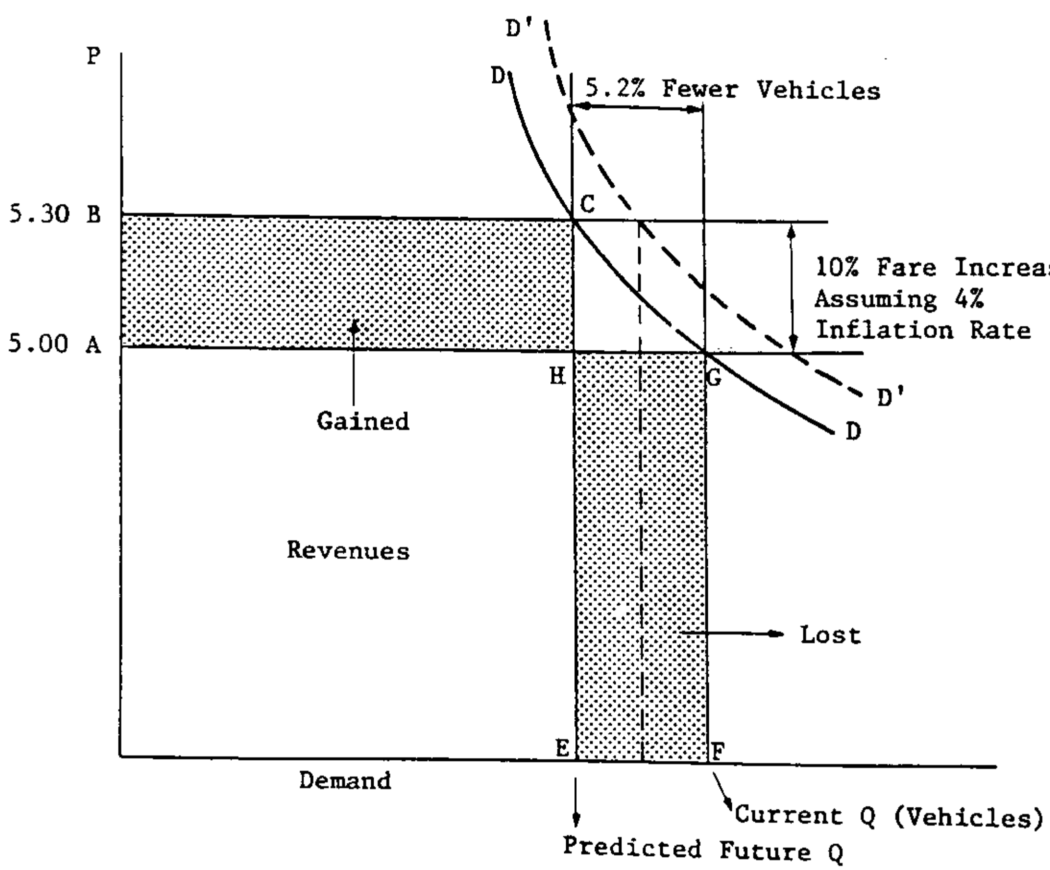
	Nominal Price	Real Price Vehicle
Vehicle	+.41	-.86
Passenger	+.18	-1.05

These number are clearly biased in the upward direction since other things have not remained constant; that is, the demand curve has been shifting outward through time because the population of the Puget Sound area is increasing, as are personal incomes. If the bias were removed, one would anticipate that both demand curves would be inelastic. The implication of the inelastic demand curve is that a fare increase will increase total revenue even though the quantity of ferry services demanded will fall.

Figure 8.6 explains these changes diagramatically. Assumed a fare increase of 10% from 5.00 to 5.50 per vehicle. If we assume a 4% rate of inflation than the real price increase will be 6%. Thus, the real price will go from \$5.00 to \$5.30. Since a 1% increase in real price causes a 0.86% loss in number of vehicles using the ferry, traffic will fall 5.16% (6% WP v .86% WQ). The gain in total real revenue from the nominal increase in price of 50¢ and a real increase of 30¢ will equal area ABCH while the loss of vehicular traffic will cause real revenue to fall by area HEFG. As long as the elasticity is less than one this later area will be smaller. Because of a growing population and personal incomes, the demand curve is not likely to be stable. It is likely to shift out to D^1. Consequently, the gain in revenue will be larger than ABCH and the ridership loss will be smaller than HEFG.

FIGURE 8.6

Impact of a 10% Fare Increase on Vehicle Traffic



Smith in his study of converting various highways in Wisconsin into toll roads came up with the following percentage declines in traffic for a $1 toll charge (using his toll concept A):[40]

Passengers - work	26.4
Passenger - recreation	17.6
Passenger - other	27.4

Smith's study for Indiana toll roads using previous fare collection data estimated that following percentage increase in fare would increase total revenues by the following percentages showing that all the price increases would be in an area of the demand curve which is inelastic:[41]

Fare increases of

	10%	30%	50%
Passengers	7.9%	22.8	33.1
Commercial	7.8%	22.1	33.0

In a report by Levinson, Regan and Leissieu for the six toll bridges and tunnels operated by the Port Authority of New York and New Jersey, the following elasticities were reported:

	Elasticity
Reducing tolls in off peak hours by 50¢ or $1.00	-0.24
Increasing tolls in peak hours by $1.00	-0.30

[40] W. Smith and Associates (1983) p. 9.

[41] W. Smith and Associates (1984).

Work related travel	-0.18
Non-work related travel	-0.22

These elasticities are within the range of -0.07 to -0.29 commonly reported for increases in toll rates on bridges and tunnels. For all market segments, the toll elasticity of -0.18 conforms favorably with the toll elasticity of -0.20 cited by Kulash as representative of toll increases on urban bridges.[42]

In the study by Bullock and Leonard (1982) on fare elasticities of Washington ferries, they estimated real price elasticities to be

vehicles	-0.26	(±0.13)
passengers	-0.19	(±0.16)[43]

using a model which adjusted for employment, population, population, personal income and retail sales growth as well as changes in gasoline prices. They found other variables, particularly employment growth, were much more important in determining Q than a change of price.[44]

Their review of the literature on the price elasticity of the mass transit industry over the past three decades indicated a price inelasticity where a 1% increase in price would lead to a 0.3% loss in riders. Our review of the price elasticity literature agrees:

- Parody and Brand (1979): -0.3 to -0.4 for mass transit and the range fell to -0.2 to -0.3 for peak-period fares.
- Fromme (1974): for air travel

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[42] Levinson, Regan and Lessieu (1980) p. 25.

[43] Bullock and Leonard (1982) p. 10.

[44] *Ibid*, p. 12.

	Short Haul	Long Haul
Business	-.76	-.63
Pleasure	-1.23	-.94

for Itchen toll bridge in England - 0.26

-Atkings (1982) for 11 U.S. toll facilities -0.22

-Rogers (1983) for bus travel - see Table 8.6

Table 8.6

SUMMARY OF ELASTICITY VALUES FOR BUS TRANSPORTATION

Urban		Rural		Peak	Off Peak	U.K.		U.S.A.		Other	
-0.21	-0.60	-0.45	-0.63	-0.09	-0.32	-0.20	-0.40	-0.09	-0.32	-0.32	±.10
-0.09	-0.32	-0.14		-0.20	-0.40	-0.21	-0.60	-0.15	-0.20		
-0.15	-0.20				-0.287		-0.40	-0.45			
-0.40	-0.45				-0.39	± .04	-0.42	± .08			
-0.20	-0.40				-0.27	+ .02	-0.23	±1.8			
-0.16					-0.30	± .06	-0.41	± .11			
					-0.30	± .02	-0.41	± .05			
					-0.35	± .03	-0.22	± .03			
					-0.33	± .03	-0.28	± .04			
					-0.26	± .02	-0.36	± .10			
					-0.45	-0.63					
					-0.14						
					-0.16						
Mean	-0.29	-0.41		-0.15	-0.36	-0.33		-0.30		-0.32	
Overall Mean Value					-0.317						

Source: D. A. Rogers (1983) "Price Elasticity: A Case Study," PTRC Education and Research Services.

IX. Should the Current Ferry System Pricing Policy Be Changed?

Theoretical Pricing Scheme

The theoretical model developed in this paper suggests that the ideal pricing policy would have two parts:

1) The user of this service should pay a fare equal to marginal social cost of each run. The fare should be higher during peak- traffic periods. This pricing scheme would provide for the efficient use of ferries, docks and other components of capital stock.

2) A fixed or access charge on all users of the ferry system to cover all the fixed costs of the system.

The total of the two fees would cover full incremental cost or long-run marginal cost and would insure a correct investment strategy.

If there are external benefits--benefits which do not accrue to the users--then non-users should subsidize the ferry system by the difference between marginal social benefits and marginal private benefits.

A recent study by the WSDOT (1981) estimated the total benefits of the ferry system to be $2.7 billion annually. The question is whether these benefits accrue primarily to the user or to non-users. If the benefits accrue primarily to the user then user fees should cover the full incremental cost of the system. If some of the benefits accrue to non-users then the system should be subsidized by that proportion. The listed benefits are shown below with our estimate on whether the benefits are internal to the users or external.

1. Delivery of Goods (2 million tons of cargo)	- Primarily Internal
2. Mass Transit for Commuters (23% of all trips)	- Primarily Internal
3. Recreational use (32% of all trips)	- Primarily Internal

4. Time Saving (1,400 driving years)	- Primarily Internal
5. Save Energy	- Primarily Internal
6. Lower Vehicle costs of operation (570 million miles of highway travel avoided - saving $190 million)	- Primarily Internal
7. Accident Reduction (2,500 accidents avoided saving 20 lives and $10 million in property damage)	- Primarily Internal
8. Reduces need for Highway Construction as far as fund of construction is concerned. ($100 million in Debt Service for Construction and $75 million in maintenance costs)	- Primarily External
9. Higher Land Values	- Primarily Internal
10. Pollution Reduction	- Primarily External
11. Expands Choices in Recreation Expands Choices in Housing	- Direct Benefits - Internal - Indirect Benefits - External
12. Increased Economic Development and Tax Base primarily in San Juan Island, Kitsap, Clallam and Jefferson Counties (increase in retail sales $1.4 billion; wages and salaries, $950 million; property taxes, $56 million; state and local taxes, $13 million)	- Internal and External

Since the economic development could well have occurred elsewhere in the Puget Sound area not dependent on the ferry system most of the general socio-economic benefits will fall primarily on the user.

The conclusion of this section is that the user receives most of the benefits of the ferry system so should be expected to pay most of the incremental costs. If Washington's experience is similar to Wisconsin's at least 30% of these costs would be paid by out of state motorists, so the one third of the burden of financing the ferry system would be exported.[45]

Comparisons to other Subsidies in Transportation Since the ferry system is a component part of WSDOT its fare revenue should equitable efficient and adequate. If prices are equal to marginal private benefits, if there are no externalities, then prices should also be equal to the full incremental cost of the ferry system. Then the pricing system would be equitable in the sense of the benefit theory of taxation and horizontal equity--but not vertical equity unless it can be shown that people using the ferry system on the average have higher incomes and wealth than other people in the State.

The fare structure would clearly be adequate if fares covered full incremental cost. The revenue raising system for the ferry system would appear to be efficient in the sense the fare system would seem simple, certain, convenient. But the fare system would clearly not be neutral when compared to other transportation modes.

While the federal highway system follows a full incremental cost pricing scheme, Table 6.1 clearly shows that for highway, streets and road non-user payment varies between 7.3 to 38.7% is paid by non-users. For the State of Washington Table 6.3 shows a 28.3% non-user payment for all road in the State, and Table 6.4 shows that 32% of total revenues

[45]Smith and Westefeld (1983) p. 68.

was covered by non-user for passenger cars and 41% for 3 axle tractor and semi-trailer.[46]

Our review of the literature indicates significant non-user support of most transportation. For example:

1. In Pennsylvania

> For a highway facility to be considered for toll financing by the Commonwealth, the Committee recommended that the project must demonstrate a revenue-to-cost ratio of at least 75%. The requirements on non-earmarked state and federal funds should be limited to 10% of the capital cost. Where appropriate, surplus toll revenues from other toll roads, local government funds, or private contributions can be used to complete the financing of the project.[47]

2. Carll stated the following in his somewhat dated study on urban transport pricing in the San Francisco area:

The Golden Gate Bridge - "Fare revenues pay for only about half operating expenses and no capital costs" before fares were increased by 50%.[48]

> To summarize our San Francisco story in a few words: operating revenues for the five existing major transit operators in the region (including the BART and Golden Gate systems) are forecast to meet only 43 percent of the operating budgets at current fare levels in the next five years. Over a 10-year period, the percentage would drop to 36 percent. New transit development proposed in the MTC Regional Transportation Plan is assumed to require two-thirds of operating expenses to be paid from non-fare revenues. Given the full extent of transit development indicated in the MTC Plan, operating subsidies in real dollars would surpass the highest level of funding over provided for highways, roads, and streets in the region, and to that expense would be added cost of capital investment... .

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[46] In the Feasibility Study of Supplemental Toll Financing.

[47] Rao and Gettings (1983) p. 17.

[48] Carll (1975) pp. 23-24.

In seeking justification for the growing transit subsidies, we may note: (1) a better organization of metropolitan areas possible with subsidies transit, as high densities are effectively served and land consumption reduced; (2) transit subsidy offsets the "underpricing" of private vehicle use; (3) transit subsidy serves social causes such as aid to the disadvantaged that should not be priced; (4) encouragement of transit usage may hold down the total cost of urban transportation systems and thus promote resource conservation.[49] The policy objectives important for transport pricing now are minimizing energy consumption, maximizing use of the existing transport system, and especially making full use of public transit capacity, and minimizing adverse environmental effects. Relief of congestion and financing further development are also pricing objectives to be considered but would rank well down on the list as goals to be achieved by pricing.[50]

3. Eastman's study of cost allocation of airport and airways--

experience and theory suggests that federal expenditures on the airport and airway system should be allocated as follows: 26.4 percent to the public (non-users), 12.3 percent to general aviation, 50.3 percent to air carriers, and 10.1 percent to military and government aviation.[51]

A recent tabulation was made for 1975 by the National Transportation Policy Study Commission, showing separately the revenues and private expenditures on transportation and government subsidy to transportation. As shown in Table 4, the government subsidy varies widely as the share of total transportation bill: in the extreme, from 86.6 percent in the case of school buses to 0 percent for intercity passenger transportation community operates without some subsidy from government. The costs of intercity freight movements by air were borne 16.9 percent by government subsidy, the cost of intercity passenger movements by air 6.4 percent by government subsidy, and the cost of intercity passenger movements by rail 47.5 percent by government subsidy.

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[49]Carll (1975) p. 24-25.

[50]Ibid p. 28.

[51]Eastman (1982) p. 30.

Selected government subsidies from Eastman's Table 4

Category	Percent
Intercity	
Water-Freight	24.0
Aviation-Freight	16.9
Water-Passenger	38.5
Aviation-Passenger	6.4
Local-Transit	48.1[52]

Capitalization of Past Subsidies

If any transportation, but in particular urban transportation, is subsidized or if the system of highways, streets and roads are improved then the subsidy or improved transportation benefits will be capitalized in land and housing value. This capitalization process is no different than what happens with improved and/or subsidized education, police and fire protection or any of the benefits of local or state government. Property values will tend to increase as the benefits of government are capitalized.

Brander in his "Toward a Theory of Rational Road Pricing" states the following:

> The question of the impact of improved transportation upon land values is straightforward once the basic interrelationships are understood. Highway investments increase the accessibility to certain areas. This improved access generates increased land rents, particularly in the peripheral areas of an economy. When this increase in rents is capitalized, it becomes an unearned increment to those fortunate enough to possess property rights in the affected areas. This process tends to occur most frequently in areas adjacent to large urban agglomerations, and comes about because of the typical reaction of transportation planners to the process of urban growth and sprawl. As an urban area

[52] Ibid p. 31.

> grows, congestion develops and worsens. Instead of imposing congestion tolls to restrict demand, the adjustment is made on the supply side. Highway investments are made to increase capacity. In turn, this response fuels the forces driving urban and suburban expansion, and so the cycle is repeated. The process is, in other words, a cumulative one. The essential point is that without this reaction on the part of the highway planner, the process would be considerably weakened. It is the reaction, therefore, which generates part of the increase in land rents and the concomitant increase in capital values. It is apparent that some fraction of this unearned increment should be captured by government to assist in the financing of the highway project which made it possible. The location rents so captured would then be deducted from the total capital cost of the project as the first step in the analysis. A collection mechanism would have to be developed, but this would present no real difficulty once the principle was accepted.[53]

To give some idea how property values on the Island countries might be effected the following example has been developed. Assume:

1) the operation cost subsidy is $3.00 per vehicle and the fixed cost subsidy is $2.00 per vehicle;
2) the user, a commuter makes 250 trips per year;
3) the average mortgage rate is 12%

then the increase in property value would be approximately $10,000.[54] However, if we assume the commuter uses public transportation and the subsidy is only $1.00 per passenger then the increase in property value

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[53]Brander (1982) pp. 327-28.

[54]$\frac{(\$2.00 + 3.00)\ (250)}{.12} = \$10,417$

is approximately \$2,000.[55] If the number of trips per year is only 50 then the user with his or her vehicle will have an increase in property value of approximately \$2,000[56] and user who is only a passenger will have an increase in property values of some \$400.[57] These increases are similar to the increase in property values for a new floating bridge in the area or a new interchange off the freeway, assuming a similar subsidy.

Impact of closing the subsidy. What would happen if the current subsidy was removed, if the ferry system went to a full incremental of long-run marginal cost pricing scheme. First, property values in the Puget Sound area would fall by the capitalized value of the subsidy--\$1,000 to \$10,000 in our example. Second, because demand appears to be inelastic particularly on the routes where the ferry service is the traffic would fall some but total revenues for the ferry system would increase. On the routes where there is a competing highway system, demand for ferry services would be more elastic. There, traffic would fall even more and total revenues might also fall.

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[55] $\frac{(\$1.00)\ (250)}{.12} = \$2083$

[56] $\frac{(\$5)\ (50)}{.12} = \$2083$

[57] $\frac{(\$1)\ (50)}{.12} = \$417$

Distributional Impacts of Raising the Fare

Assume that a political decision has been made to charge the users of the ferry system the full incremental cost or the long-run marginal cost of the system or at least to raise the fare schedule for the user. Who will bear the burden of these increased prices?

A survey on the Seattle-Winslow route provided the following information about users:[58]

Percent Male - Female	63% - 37%
Average Number of Trip Per Week	4.7
Principal Access Mode	Auto - 87%
Average Household Income	$26,865
Less than to 10,000	7.5%
10,000-20,000	22.0%
20,000-30,000	20.9%
30,000-50,000	29.9%
50,000- or more	10.0%
Average age:	38.5
Under 25	10.0
25-34	31.0
35-49	38.0
50-64	18.0
65-74	3.0

A more general survey was done by the Washington State Ferries in January 1979 of commuters on six routes. The results were somewhat similar.[59]

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[58] Roess, Grealy and Berkowitz (1981) p. 3.10-3.12.

[59] Washington State Ferries (1979) pp. 19-20

Percent Male - Female	63% - 30%
Average Number of Trips Per Week	10
Walk On	59.3%
Low Occupancy Vehicle	23.9%
High Occupancy Vehicle	3.6%
Median Income	$24,178
Less than $10,000	8.5%
10,000-19,000	25.4%
20,000-29,999	29.5%
30,000-or more	29.2%
Occupation:	
Professional/Manager	48.0%
Clerical/Sales	17.5%
Craftsman/Operative	13.0%
Student	6.6%
Education:	
High School Grad or Less	15.9%
Tech/Voc or Same College	35.3%
College Grad	23.4%
Post Grad	23.2%
Median Age - 35.9	
Under 24	11.9
25-34	32.8
35-49	33.5
50 +	19.7

A more detailed breakdown can be estimated from the Census of Transportation survey done in 1977 which looked at the income levels for the users of other modes of transportation at the national level. If it can be assumed that the Washington ferry users have the income characteristics of the average of auto and air travelers (See Table 9.1) then the following distribution would exist:

Family Income - 1987	Percent of Income of Ferry Users in 1977
Under $5,000	5.6
5,000 - 7,499	5.1
7,500 - 9,999	5.7
10,000 - 14,999	18.2
15,000 - 19,999	16.7
20,000 - 24,999	16.1
25,000 - 49,000	16.1
50,000 +	5.3

What all these data sets suggest is that raising ferry fares could well be less regressive than raising the gasoline tax or the general sales tax. (Obviously these data are only suggestive and a more detailed analysis of income characteristics of the ferry users relative to auto users and the general state taxpayer would be an important part of a Phase II proposal).

Table 9-1

Income Distribution of Passengers by
Mode of Travel
(Percent)

Family Income	Bus	Auto	Train	Air
Under $5,000	19.3	6.4	9.9	4.8
$5,000 - 7,499	12.2	6.2	6.5	4.0
$7,500 - 9,999	8.4	6.2	5.4	5.0
$10,000 - 14,999	20.4	21.6	15.3	14.7
$15,000 - 19,999	15.3	19.7	13.5	13.8
$20,000 - 24,999	10.9	15.9	13.5	16.2
$25,000 - 49,999	12.0	21.1	30.5	33.9
$50,000 +	1.5	3.0	5.4	7.7
Median	$12,464	$17,438	$19,773	$22,398

Source: U.S. Department of Commerce, Bureau of the Census, 1977 Census of Transportation, National Travel Survey, Travel During 1977, Report TC77-N-2, Tables 3G, 3E, 3H, 3I.

IX. Summary and Conclusions

If the Washington State Ferry system was owned and operated in the private sector and the firm maximized profits, microeconomic theory provides us with a model of the firm's pricing policy. The firm would attempt to determine where marginal cost and marginal revenue are equal and would produce that quantity of ferry service indicated by this equality. Knowing their optimal output and the demand curve for ferry services the firm would determine the price to be charged (See Figure 3.1).

The firm would likely be a monopolist because of the high capital costs of the fleet and terminal facilities which would limit the entry of new firms into the market. Consequently, the firm would probably discriminate between the various classes of users, setting a higher price on the routes with no alternative highways for commuters using the system during peak hours, for tourists, and other classes of users with inelastic demands. The price for each user group would be set to vary inversely with the elasticity of demand.

But even if

1) there was some competition between routes or modes of transportation or between vehicle only ferries and passenger only ferries,
2) firms could rent space in terminal buildings so fixed costs were relatively low,
3) only normal returns were being made by the firms because of competition or because of public utility regulation,

value of service pricing which varies inversely with the elasticity of demand could exist because of shifting demands between peak and off-peak periods, random demand shifts, unstoreable supply, difficulties in allocating common or joint costs.

To price ferry services this way would require detailed cost and demand data to be collected on each route so that the firm could price in ways to maximize profits. Or it would experiment raising and lowering prices to see whether the profits on each route would rise or fall. The firm would be charging what the market would bear. But those consumers using the system would be equating the price they were paying to the benefits they were receiving so that P = MC = MB. However, the quantity of ferry services provided by the firm could be less than socially optimal because of the externalities that the ferry system provide the State.

Consequently, the users of the ferry system would likely go to their elected representatives and argue in favor of some sort of public utility regulation of the private firm or that the ferry system be owned and operated by a governmental unit so that price and output could be made more socially optimal.

For optimal pricing and output decisions to be made in the public sector additional data would need to be collected. Not only would detailed cost curves and demand curves be needed on each route that the private firm was required to collect to make pricing decisions but, in addition, social costs and benefits would need to be estimated. In addition, the decision process becomes more complex because the state regulators or state operators can not be concerned with just efficiency in providing ferry services but they must be concerned with questions of intermodal competition, and how changing subsidizes will affect property values. Pricing and quantity decisions in the public sector become decisions about global efficiency of the transportation system; about adequacy--are there revenues to cover costs; and about equity--is the system of collecting revenues to finance the ferry system fair.

Equity is basically a political question--do the voters think the pricing and quantity decisions are fair. Scholars in public finance have developed different ways of thinking about what are equitable or fair ways to raise revenue. The equitable method of raising revenue receiving more attention currently is that revenue collections should follow the flow of benefits received from the government services being financed. However, this approach assumes that some level of government (normally the Federal government) has already solved the problems of inadequate income distributions.

The pricing rule which comes out of the benefit theory of revenue raising is that price equal the marginal benefits that the various users of the ferry service receive (P = MB). Thus, the commuter at the peak period could pay one fare, the off-peak user could pay another lower fare, the vacationer another, etc. This form of equity requires the collection of detailed data on demand curves which reflect the benefits being received by the various users. It also requires the collection of data on external benefits to potential users, to property owners, to the communities where economic development is taking place, etc.--so that all who benefit directly and indirectly can share in the paying for the costs of the ferry service.

For the system to be efficient as well as equitable P = MB = MC, that is price needs to be equal to both benefits and cost at the margin. So again detailed data are required on the various costs curves as well as the demand curves.

Unfortunately, the simplicity of this pricing rule breaks down the closer we get to the complexities of the real world. For example, does price equal short-run or long-run costs and benefits. Since the State must decide on whether to buy new ferries, since potential users are making decisions about where to live, since local governments are developing strategies for economic development, it seems that moving towards the equality of long-term marginal cost and benefits is more appropriate.

If long-term average costs are declining, marginal costs will be below average costs. Then, a P = MB = MC rule will lead to an inadequate revenue base; losses will be made. Then decisions on how the ferry services' budget deficit should be financed are necessary. Should the deficit be covered out of the general fund or should the users be required to cover all the system cost using a value of service or some average cost pricing scheme? The decision process again involves wrestling with the concepts and the trade-offs between equity, efficiency and adequacy. Will taxpayer subsidization of the ferry system lead to a more ideal solution than the user paying the average costs of the system when neither solution is optimal?

Given the inadequate data base on the costs and benefits of ferry services it is difficult to arrive at anything but tentative conclusions from this study. But here are two suggestions on improving the pricing of ferry services:

1) The system of fares should differentiate between the different users and the benefits they receive. At a minimum, users during peak periods, when congestion occurs, should pay higher fares than in the off peak periods. Since the congestion appears to be just with vehicles,

further differentiation between passenger and vehicle fares seems appropriate. Maybe separating commuter passengers from vehicles with high speed, passenger-only ferries is an appropriate way to meet the different classes of demand. The general principle being recommended is that fares should be inversely related to the elasticity of demand.

2) Once more clarity is obtained on the value of ferry service, externalities and on the subsidies of other modes of transportation, moving towards value of service or some average cost pricing rule seems appropriate. This recommendation is based on the assumption that there is little difference between marginal and average cost in the long run. It is also based on the political shift to a more conservative policy where the feeling is that those who benefit from government should pay for the costs they create; and a lessening concern that government (particularly state and local government) should be involved in redistribution of income. A third reason for a value of service or a P = AC rule is that the gasoline tax, other motor-vehicle charges, the retail sales tax, or other Washington general revenue sources are assumed to be more regressively distributed than an increase in fares. Thus, even those who are concerned with vertical equity should prefer higher fares to higher taxes, other things being equal (obviously the users of the ferry system would prefer subsidization through other taxes than increase fares.)

If there is a substantial difference between SRMC and LRAC then an ideal pricing policy appears to be one with two parts. The first part would be to have the price or fare equal to the SRMC. In addition, there would be a fixed charge to cover the deficit. This fixed charge could be paid annually by passengers or in connection with the vehicle license fee for users with vehicles.

Would value of service pricing, average cost pricing or marginal cost pricing with a fixed charge lead to higher fares. Evidence presented in this study indicates that the real price for ferry services have been tending downward. Since data showing the ratio of subsidies to operating cost have trended upward (or the ratio of fare revenues to operating costs have trended downward) and both ratio are effected by inflation, it would indicate that while real fares have gone down, real costs are likely to have gone up. Consequently, unless externalities have grown in recent years, fares are likely to rise following a more ideal pricing rule.

Perhaps the most important conclusion to come out of this study is the need to gather more information on the shape of the cost curves since the shape and relationship between the various cost curves determine what the ideal pricing policy should be. For example, are short-run marginal costs below long-run average costs, requiring a subsidy or some value of service pricing scheme? Are these relationships the same for all routes or are some routes subsidizing others? In addition, calculating the short-run percent variable (ratio of MC/ATC as described in Section V) will give information about capacity needs. Seeing what is happening to long-run average total cost or measuring the long-run percent variable will tell whether there are increasing or decreasing returns to scale. This information is also crucial for planning capacity needs.

Not only is it important to measure the cost curves in determining the ideal price, but assuming a value of service pricing scheme, you must also measure demand curves so that elasticities of demand can be calculated. As mentioned in the text, price should vary inversely with the elasticity of demand.

A Phase II proposal will be prepared to estimate cost and demand functions so a more ideal pricing policy can be specified and implemented for the Washington State Ferry System.

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