THE ECONOMICS OF ROAD TRANSPORT

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Tillo E. Kuhn

INTRODUCTORY STATEMENT

Summary

Due to the great increase in motor vehicle traffic, the provision of highways, roads, streets and bridges has become a most important function of government at the present time. Complications arise because the vehicles using the public roads are privately owned and operated.

In this study a mining company is first assumed, which endeavours to minimize total transport costs (costs of both vehicles and private road) and maximize output with different combinations of factors of production. Next, important economic principles and procedures are established with the help of a toll road model. The planning of toll road investment, the determination of investment priorities, charges, revenues and costs are analysed in theory and practice.

Finally, highway provision is treated as a government function. Economic principles of road planning and operation, as well as possible pricing policies, are discussed. The conclusions are tested in the light of practical experience.

Contribution to Knowledge

Possibly the main value of this study lies in its exposition of all economic aspects of the provision of highway services. Economic theory and criteria are applied to highway investment planning, as well as to output, cost and revenue factors. Most other studies appear to put emphasis on pricing problems, with little attention being given to questions of investment.

More specifically, the consistent application of the dissimilar charging method to both toll roads and to public highways, may be regarded as a new approach. The three-dimensional technique of cost, revenue and output determination, and the resulting concept of extreme values, have not been used before in this form as far as is known. It is further believed that parts of the highway system analysis and the rigorous application of economic theory to problems of highway pricing policy constitute contributions to knowledge in this sphere.

Related Work

The author first became interested in the economics of road transport when doing research for an essay entitled The Meaning and Measurement of Profitability in Regard to Expenditure on Roads, which won the Lord Rosebery First Prize, 1953, of the University of London. Subsequently, on behalf of the London School of Economics, he carried out a special economic investigation of the nationalized road transport industry in Great Britain, just before large portions of it were returned to private ownership.

In Canada the author was fortunate enough to gain further knowledge relating to the thesis subject during his employment by the Railway Association of Canada and the Canadian Good Roads Association. He attended the sessions of the Highway Research Board in Washington, D.C., in 1955 and 1956 and corresponded over a period of years with a number of organizations and individuals doing work in this field. In 1955 he wrote a historical essay Roads in Canada for the Encyclopedia of Canada. Early in 1956 he prepared a brief Urban Traffic and Transportation which formed part of a larger submission of the Canadian Federation of Mayors and Municipalities to the Royal Commission on Canada's Economic Prospects. During the summer of 1956 he acted as consultant to the Ontario Department of Highways during its preparation of a long-range plan for the King's Highway System.

August 21, 1957

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Tillo E. Kuhn

INTRODUCTION AND CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

Page

CHAPTER V

Page

CHAPTER VI

CHAPTER VII

"It was the Vehicle that made the Road.
It was the Wheel that made the Vehicle.
But the Wheel having made the Vehicle,
and the Vehicle having made the Road,
the Road reacted back upon that which
made it."

Hilaire Belloc, The Highway and its Vehicles, London, 1926.

INTRODUCTION

It is the technical function of the road to provide a track over which traffic can move. Without traffic there need be no road. Thus, provision of the road is only a means to the end of producing transportation service -- the movement of goods and persons from place to place. Yet traffic will flow, and goods and persons can be moved, only after the road has been provided.

It should be the economic function of the road, in competition with other forms of transport, to enable traffic to move from one point to another at minimum total cost of transportation. The total cost of transportation per unit of traffic, allowing for both road and vehicle costs, will depend on the volume of traffic. Yet the volume of traffic is a quantity unknown prior to the provision of the road.

The economist, trying to determine the exact relationship between road and traffic, will come to the conclusion that both are part and parcel of one economic function: the production of transportation service. The highway and the vehicles that travel on it are inextricably bound together by technical realities and economic laws to render one jointly produced service: transportation. Unfortunately, the implications of the essential economic unity of road and vehicle, of plant and equipment, are sometimes not readily understood when practical problems are dealt with.

By contrast to road transport, railway companies treat both tracks and vehicles as one single undertaking, with managerial control common to both. All financial decisions, whether pertaining to rolling stock or to tracks, are taken within the same organization. This organization, moreover, acts strictly according to business principles. The railway company, within the legal and regulatory framework imposed by the state, endeavours to maximize profits; it sells to the public, in varying admixtures of price and quality, the final service produced: transportation. The public buys the ton-miles or passenger-miles it requires, but is not in the least concerned with such questions as the financial status of rolling stock relative to tracks, cost-allocation between the two, and similar internal railway problems.

The Dichotomous Nature of Road Transport

The situation is entirely different in the field of highway transport. The responsibility for the provision of the "track" -- the road, street or highway -- rests normally with the state, whereas the vehicles which use the track are generally operated and owned by private individuals and commercial undertakings. The theoretical and practical difficulties arising out of this divided ownership and management of what technically and economically really could be a joint undertaking, are numerous.

Private and public interests do not necessarily coincide. Without going into a detailed discussion of the problem at this time, we can say that the state normally renders all those services which are predominantly subject to social welfare criteria, such as defence, maintenance of law and order, care for the destitute. In a wider sense, the state will carry out most activities which result in greater social than private benefits, i.e. functions characterized by the predominance of external economies or diseconomies. The state may also assume functions in cases where one single planned decision produces better results than the sum of individual decisions. Provision of highways, treated as yet another of these general governmental activities, appears <u>prima facie</u> to be subject to the same criteria.*

Private motor transport, and vehicle ownership and operation, on the other hand, are subject to the most stringent laws of the free enterprise economy. Competition and business principles normally prevail within this sphere to the exclusion of altruistic and general welfare motives.

Inevitably conflicts arise between these two economic philosophies in the realm of roads and road transport. Professor Shorey Peterson summed up the situation in these words:

> "The main economic issues concerning highways seem to have their root in a vacillating allegiance to the procedures of typically governmental activities, on the one hand, and, on the other, to the principles and standards which operate in the private economy." (1)**

The economist is understandably bewildered at first, when he is confronted with the claims and counterclaims, the statements, proposals, denials and rebuttals of the various interested groups within the private and the public sector. Most of the arguments used are derived from historical evidence and constitutional precedents, are motivated by regional, sectional and political claims and are essen-

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* A more detailed treatment of these problems will be found in Chapter V <u>et seq</u>.

** (1) This and subsequent source references are listed in the Appendix.

tially subjective in character; they therefore obscure -- rather than shed light on -- the basic economic issues of the highway problem.

Accepting the premise that transportation is an economic activity, subject to the laws which should govern the allocation of relatively scarce resources among alternative uses, it follows that an initial effort must be made in any study of road transportation to understand the economic principles underlying the highway problem. Only when the means of objective economic enquiry have been exhausted should recourse be taken to subjective argument. In this way the highway administrators and planners, the civil servants, the engineers and the elected representatives of the people who by their votes in parliament or council, or by administrative judgment, decide the appropriation of funds for road purposes, should all be guided by sound economic precepts in their activities. Certainly, there will still remain a range of practical problems, which in the everyday conduct of affairs cannot be solved except by subjective decision, but this area of doubt will progressively be narrowed down as additional knowledge is gained through research and impartial, scientific enquiry.

Under the circumstances the most convenient theoretical approach to the complex problems of roads appears to be a study in the abstract of a simple "road model". The advantages of this procedure can best be stated in Schumpeter's words:

> "In every scientific venture the thing that comes first is Vision. That is to say, before embarking upon analytic work of any kind we must first single out the set of phenomena we wish to investigate, and acquire 'intuitively' a preliminary notion of how they

> hang together or, in other words, of what appear from our standpoint to be their fundamental properties .... The total or 'system' of our concepts and of the relations that we establish between them is what we call a theory or a model." (2)

In our model, which is described on the following pages, both road and vehicle ownership and operation are vested in one agency. Thus some of the complications discussed before can be ruled out for the time being. Once the basic economic laws and relationships have been determined by means of this "road archetype", they can be applied, in successive stages, to the more complicated cases of a toll road and complete road systems operated by public authorities.

I. A SIMPLE ROAD MODEL

We assume that for the specific purposes of one firm, and for this one firm alone, transportation facilities are required between points A and B. The firm can perhaps be visualized as a mining company operating at B, in an otherwise unsettled region. The mined ore has to be taken to A for further processing or for sale. In the reverse direction the necessary supplies for the mining operations have to be hauled from A to B. It is further assumed that the magnitude of the transport task which will have to be performed is known in advance to the management; in other words: the tonnage which will have to be hauled over the new route can be predicted for -- say -- the next 25 years. It is estimated that workable ore deposits at B will be exhausted within that time. The mine and with it the transport route will then be abandoned, because they constitute "specific assets" and cannot be transferred to other uses.

Transportation at Lowest Total True Cost

The management of the mining company is at the outset confronted with the problem whether to choose rail or road transport, or possibly another medium, for instance haulage by air or by water. Detailed plans and cost schedules for various projects will be drawn up. Presupposing rational behaviour on the part of the company the one particular medium of transportation will be chosen which promises to perform the given transport task over the given period of time at the lowest total true cost.

As frequent use of the concept of "total true cost" will be made throughout this analysis, an explanation of the term is called for. The individual items which together constitute "total true costs" are shown in Table 1. The terms used are explained below.

Definition of Terms Used

Fixed and Variable Costs

Fixed costs: all those costs which do not vary with output; output in our case meaning ton-miles, or tonnage hauled, or some other unit measuring transportation services rendered.

Variable costs: all those costs which vary with output.

In order to satisfy the economic purist seeking theoretical perfection it must be pointed out that the classification into "fixed cost" and "variable cost" items used above is arbitrary. When an extremely <u>short</u> accounting or planning period is applied, for instance one day, practically all costs become "fixed costs", in the sense that they do not vary with output and cannot be avoided even if output is cut down to zero. Labour costs, normally treated as "variable costs", definitely become "fixed costs" under this hypothetical one-day accounting system, provided the workers are hired on a daily or weekly contract basis.

Conversely, taking an extremely <u>long-term</u> view, all costs become "variable costs". When taking the life-span of the most durable assets as the accounting period, even capital expenditures on those items become variable costs. Proof: <u>ex ante</u>, at no output no costs at all will be incurred, as all expenses are still avoidable. Consequently, for our mining company every single item on the project cost sheet belongs <u>ex ante</u> to the variable cost category.

The obvious shortcomings of the fixed and variable cost concepts do not, however, impair their practical value in some other contexts. The application of fixed and variable cost criteria to the pricing of transport services will be discussed critically later.

Depreciation

Only depreciation on assets lasting at least the projected 25 years, such as permanent structures, tunnels, cuttings, embankments, will normally have to be charged. Depreciation will be "paid" into an amortization fund by simple bookkeeping transaction. Allowances for asset replacements becoming necessary during the operational period would be included in the 25-year fixed cost budget.

The main objective of depreciation is to gradually "unfreeze" the capital locked up in plant and equipment so that it can be used for another venture when the earnings potential of the initial project has been exhausted. In this sense depreciation calls not only for the full recovery of capital funds, but in addition for reserves to cover increases in the general price level and rises in the costs of new equipment due to technological improvements.* This concept may not conform to the depreciation rules of the tax collector in the real world, but it seems to be valid from the point of view of the economist.

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*A good example of depreciation policy which takes into account technological progress is provided by recent action of Trans-Canada Air Lines. TCA purchased a number of Super-Constellation airliners over the years. The more recent acquisitions are being depreciated at a much faster rate, to make it possible for the whole fleet to be written off by the time propeller planes become obsolete for competitive reasons (introduction of turbine power-plants).

After all, proper economic planning would require that management, through realistic depreciation allowances, should endeavour to maintain capital "fully intact" -- in the sense that the reserves are sufficient to finance a new project at today's prices, using today's methods, and not those of twenty or thirty years ago.

Interest Charges

This cost figure should represent interest on all capital invested. The true amount can be arrived at only by an elaborate, year-by-year calculation, taking into account the rate of interest held to prevail at the time when investment takes place (and throughout the project period if new capital expenditures are required during the 25-year period, or if planned capital outlays can be distributed over time).

It is important to note that the load of interest charges can be "staggered" and thereby reduced. Taking the example of the trucks again: 100 vehicles with a life of five years are needed at a time; therefore a total of 500 trucks will be purchased, but in batches of one hundred vehicles every five years. Consequently interest charges on an investment of only 100 trucks at a time will have to be charged.

The lowering of interest charges resulting from the "staggered load of capital investment" may give road transport a considerable cost advantage over the railways with their more durable assets; the cost difference will be the greater the higher the prevailing rate of interest. It is easy to see that with this inverse correlation between durability and interest payments, the rate of interest is essentially a tax on durability.

Another factor which has an influence on the level of interest payments is the amortization policy pursued. Take the example of a completely specific asset -- a tunnel or the like -- which has no value at all in alternative uses once the mining and transport operations are suspended. Supposing this structure is estimated to cost $100,000. On a straight-line amortization basis over 25 years 4 per cent, or $4,000, will be written off the capital value of this asset every year; the $4,000 will be paid into a sinking fund or amortization account and interest would be paid on the diminishing balance.

Two courses of action can be taken. One possibility is to repay capital borrowed with the accruing amortization funds. In this case the second year's principal on which to pay interest would be reduced to $96,000, the third year's to $92,000, and so on, until at the end of 25 years both capital debt and interest charges are reduced to zero.

Alternatively, the sinking fund balances could be invested, for instance in government bonds, and could themselves earn interest. Therefore amortization charges amounting to a little less than 4 per cent will be required. Which course of action will be taken will depend on the comparative level of interest rates. If, for instance, capital was borrowed at 6 per cent and government bonds yield only 4 per cent, repayment of principal will be more advantageous.

Quality of Service Considerations

There are other important factors which will influence the investment decision of the firm. The quality, the speed, the convenience and the flexibility of the proposed transport services will be compared. The faster the service the lower is the value of goods in transit at any time; this in turn keeps down the interest charges on inventories -- leading to definite money savings for the firm. Other things being equal road transport is usually considered to give service of higher quality than the railways, because it can render direct door-to-door transport with consequent smaller damage or loss of goods in transit. Differences in quality of service -- in practice a most important factor in a competitive transport market -- are easily stated in descriptive terms, but it may be difficult to translate some of them into dollars and cents. The respective premiums of insurance against loss and damage of goods in transit, quoted for road and rail transport, might be used for guidance.

Social and Nuisance Costs

Lastly, there is the theoretically elusive group of "social costs". In the case of our model -- with the mining company assumed to operate in an unsettled region and owning all the land -- we are in the fortunate position of being able to state that in this instance social and nuisance costs are at the same time real costs to the firm. If, for instance, a locomotive emanates sparks and thus causes a forest fire, the resulting loss would normally be borne by the community as a "social cost" and not be charged to the transport agency. Similarly with damage, dust and disturbance caused by road vehicles. In our special case, however, the losses of timber or general amenities are losses to the mining company and its employees and to nobody else. Social costs will therefore certainly be taken into account although it will be difficult to put them down in money terms.

Resale and Scrap Value

Finally, from the computed total of all these cost items the estimated resale and scrap value of plant and equipment at the end of the 25-year period will be deducted. As regards the railway plant, rails, ties and other component parts can probably be dismantled easily and used elsewhere or sold as scrap. A highway cannot be dismantled; once constructed it cannot be transferred to another geographical location.

However, it can be visualized that the highway will be of some value even after mining operations have ceased at point B. For instance, the very existence of the road may lead to an increase in the economic value of neighbouring forests or resource areas and hence to their exploitation. A lumber camp, or a base camp for mining explorations, may be established at B after the mine has been abandoned. In those cases the highway would command a resale price.

A priori it is impossible to say whether the highway or the railway will have the greater resale and scrap value. Whatever plant realizes a higher price at the end of the 25-year period, and hence offers a greater reduction in over-all costs, will have a competitive advantage in that respect.

Criterion of Cost Minimization

The final figures represent "total true costs" for the various proposed road or rail transport projects. It is in the interest of the firm and of the economy of the country as a whole, that the project offering the required transportation services at the lowest total true costs, taking into account money costs and quality considerations, should be chosen. If the right plan conforming with this criterion of cost minimization is accepted and investment takes place accordingly, then -- and only then -- scarce resources are put to uses where they yield the highest returns, both to the firm employing them and to the community at large.

Road or Rail? -- Diagrammatical Representation

The factors determining the investment decision can be represented diagrammatically. In Figure 2 let the vertical axis measure total true costs and let the horizontal axis measure transportation produced and demanded per unit of time (in our case ton-miles for the 25-year period). We stipulated that the amount of transportation needed was known in advance and fixed; hence the demand curve becomes a vertical line (DD'), indicating that OR quantity of transportation is required -- neither more nor less.

Sh-Sh' is the supply curve for highway transportation, Sr-Sr' the supply curve for railway transportation. OT represents the fixed costs of road equipment and plant at zero output; similarly, OU is equivalent to the initial outlay on railway tracks and rolling stock which has to be undertaken before operations can be started. It must be noted that at zero output the fixed costs for rail transport are higher than those of road transport (OT $<$ OU). The main reason for this is the initial high cost of the construction of the rail bed; in the field of road transportation in the extreme case no investment in plant is needed if special vehicles which can travel anywhere are used. Alternatively, a very cheap unimproved earth road can be built for low traffic densities. Therefore at small quantities of output total true costs are lower for road than for rail transport.

Moving to the right on the horizontal axis, the cost margin between road and rail narrows, and the initial advantage of highway transport diminishes, as output expands. The technological capacity of the railway plant to handle bulk cheaply comes into play; the substantial rail overhead costs are spread over a larger output and therefore total rail costs rise relatively slowly. The highway plant, on the other hand, soon becomes congested; variable costs go up steeply because of traffic delays, increased maintenance costs, etc.; soon the stage is reached when new capacity has to be added to the road plant if production is to be expanded still further; a new lane must be constructed, the road surface has to be improved -- expensive schemes which increase total costs of the plant greatly. At relatively large output quantities rail transport will provide the cheaper service, and supply curve Sr-Sr' will lie <u>below</u> supply curve Sh-Sh' at outputs greater than OV, as shown in Figure 2. We assume in our case that at the required relatively small output OR road transport has a definite cost advantage over rail transportation (MR $>$ LR) and will therefore be chosen.

<u>Indivisibility of Factors of Production</u>

There now still remains the need to scrutinize more closely the nature and the interrelationships of the various cost components which together make up the supply curves. The smoothly drawn supply curves in Figure 2 seem to indicate that production of transportation can be increased very easily and in infinitely small doses. This is a rather unrealistic assumption. In fact transportation is one of the industries in which the difficulties of the "indivisibility of factors of production" are quite pronounced. As regards the railway plant at least one continuous single track between A and B is required, however small the output. With progressive increases in the production of transport services a siding for the passing of trains halfway between A and B may have to be provided. With yet further increases in traffic soon the point will be reached when a complete second track may become necessary; no smaller "investment dose" will do under the circumstances.

The same applies to the highway plant. No matter how little traffic is anticipated the land right-of-way has to be acquired -- a substantial initial investment. After the possibilities of passing places on a one-lane highway have been exhausted, more substantial capacity increases become physically imperative. For technical reasons it is not practicable to add just one inch to the width of the road throughout its entire length or to give it a better surface at a few places only; an additional lane will have to be constructed or the road will have to be re-surfaced from beginning to end. In any case substantial expenses will be incurred.

This "lumpiness of investment", one of the more baffling features of transport economics, is demonstrated in Figure 3. The straight lines FC_{p_1}, FC_{p_2}, FC_{p_3} .... represent the various investment doses for road or rail plant appropriate to different levels of output. Fixed costs of plant go up in definite steps (from M to N, from there to P and so on) as plant capacity is increased. Distance OM is equivalent to the initial right-of-way costs and perhaps some rudimentary grading, plus cost of track in case of rail transport.

Curve FCe - FCe' represents fixed costs of equipment. These costs are "fixed" from the point of view of vehicle operation only.

In relation to the operation of the entire highway plant (both road and vehicle operation) they can be regarded as variable costs. The ordinary accounting terminology normally employed in road transport is used here. Curve FCe - FCe' is drawn as a smooth line because indivisibility of investment in vehicles is not an important factor, at least not in the case of road transport. (The addition of one truck to one hundred already in use leads to only a 1 per cent increase in fixed costs of equipment).

The family of curves VC_1, VC_2, VC_3 .... represents variable costs of both plant and vehicles associated with the corresponding fixed cost of plant levels FC_{p_1}, FC_{p_2}, FC_{p_3} .... . Neglecting maintenance expenses which are -- in the absence of traffic -- necessitated by climatic conditions, at zero output no variable costs are incurred. VC_2 and succeeding variable cost curves may or may not lie on a higher level than VC_1 does; in other words, the "envelope" curve AVC, which may be taken to represent average variable costs, does not necessarily have the upward slope which is implicit in the way Diagram 3 is drawn here. In many cases higher levels of expenditures on plant may result in a lowering of the variable cost schedules. This problem will be dealt with subsequently.

To explain the interrelationship of these various factors we move to the right along the horizontal axis towards increasing levels of output. As we approach production OT, successively larger doses of equipment (curve FCe - FCe') will be applied to the plant, the size of which remains constant (FC_{p_1} being a horizontal, straight line) at OM. With a higher ratio of vehicles to track congestion will result; fuel and maintenance costs will go up with travelling speed reductions; there will be a greater number of accidents with a consequent rise in compensation claims and repair bills. In short, variable costs VC_1 will rise steeply after a point. This in turn will inflate total costs TC_1 (TC_1 is the sum of VC_1, FCe and FC_{p_1}).

Once we exceed the yet higher output level OT it will become imperative to enlarge the plant capacity by the additional lump investment MN, to bring fixed costs of plant to the level FC_{p_2}. This move will very likely lead to an immediate reduction in variable costs (from UT down to VT on VC_2), because the vehicles can now travel faster and more smoothly, can carry heavier loads on the improved track and are subject to fewer accidents and repairs. It can be seen from Figure 3, within the output range O-T plant investment level OM (FC_{p_1}), together with variable costs VC_1, is the most economical one. With increasing output, in the range OT - OW, plant investment ON (FC_{p_2}) with variable cost schedule VC_2 leads to lower total cost points lying on curve TC_2. For subsequent still higher output levels, total cost curves TC_3 and TC_4 will be found to be appropriate. For purposes of investment analysis the various total cost curves (TC_1, TC_2, TC_3, TC_4, .. TC_n) corresponding to series of alternative plant sizes, may be represented by the "envelope" average total cost curve ATC.

Optimum for Given Plant - Equipment Combination

For a particular investment scheme (fixed costs of both road plant and vehicle plant given) short-term average cost curves can be shown diagrammatically. In Figure 4 output is measured along the horizontal axis, whereas the vertical axis indicates average costs (i.e. cost divided by quantity of output). AFC is the average fixed cost curve for both plant and equipment. AVC represents average variable costs of equipment and plant. The two cost curves add up to average total costs, shown by curve ATC.

At zero output average fixed costs are infinitely high (fixed costs divided by nought). AFC falls rapidly at first as overhead costs are spread over an increasing number of units of traffic, but gradually the AFC curve begins to flatten out. Average variable costs increase only moderately in the lower output range, but then congestion sets in, with resulting higher gasoline consumption, vehicle maintenance costs, road repairs, etc.; consequently the AVC curve rises steeply. The U-shaped ATC curve reaches its lowest point F' at output D. This is the <u>optimum point of production</u> for a given plant-equipment combination, with OD ton-miles (or other units of output) being produced at the minimum average total cost OF.

Yet output D may not be the one desired by the firm; quantities OK (or perhaps only OG) may be required at <u>higher</u> average total costs OH (or OL, respectively). Bearing in mind that normally transportation services, unlike other products, cannot be stored over time, a <u>larger</u> (or smaller) plant appears to be needed; this implies investment on a different scale and the drawing up of an entirely different set of average cost curves.

<u>Optimum with Different Combinations of Factors of Production</u>

Useful as Figures 3 and 4 may be to show simple supply functions, they cannot demonstrate the possibility of the same output being produced with different combinations of factors of production. The optimum utilisation of two factors is a problem with which we are frequently confronted in economic theory. One way of attempting a solution is to make use of an isoquant diagram.

In Diagram 5 total expenditure on the highway plant is measured along the horizontal axis, whereas the vertical one measures total expenditure on vehicles. Quantities of output are indicated by curved lines which can be called "isoquants." Each isoquant corresponds to a particular quantity of output, the output increasing with the distance of the isoquants from the origin. Thus in Diagram 5:

'z' ton-miles > 'y' ton-miles > 'x' ton-miles.

The isoquant diagram is based on the following assumptions:

(a) the two factors of production can continuously be substituted for each other;

(b) when expenditure on one factor is decreased output can be maintained at the same level by expending proportionately a little more on the other factor.

The greater the ease with which one factor can replace the other in order to keep output constant, the "straighter" (i.e. the less curved) the isoquants will be. Conversely, right-angled isoquants (see Diagram 6) indicate that the proportions in which the two factors can be combined are rigidly fixed, the ratio being:

OC : OD is equal to OE : OF is equal to OG : OH.

<u>Any</u> deviation from this production ratio is less efficient.

In our example 'x' <u>ton-miles</u> can be produced by: (Diagram 5)

(1) OK plant expenditure combined with OS equipment expenditure,
or (2) OL " " " " OR " " ,
or (3) nil " " " " OT " " .

Possibility (3) is once more the extreme case of special, very expensive (OT!) vehicles operating without road; isoquant 'x' therefore touches the vertical axis at T. However, it is assumed that the bigger transport tasks 'y' and 'z' simply cannot be performed without some expenditure on plant. It must be noted that isoquant 'x' runs parallel to the horizontal axis from L' to M' and further to the right; the explanation is that if vehicle expenditure is held constant at OR and plant expenditure is increased beyond OL to OM, no larger output of transportation results; in other words, the flow of vehicular traffic, held constant at OR expenditure, is adequately accommodated on OL highway; the additional plant expenditure LM is wasteful because it does not increase production of transportation.

The same applies when plant expenditure is held constant and vehicle expenditure is increased progressively. Let us assume that in Figure 5 increasing doses of equipment expenditure are combined with the same plant expenditure, held constant at OE. Moving vertically upwards from E, at point F 'x' ton-miles are produced with the addition of OF' equipment expenditure; at G (OG' equipment expenditure) the output increases to 'y'; and at H to 'z' ton-miles. From that optimum point upwards increased vehicle expenditure -- without fitting the plant for the greater flow of traffic -- will lead to congestion and hence to no further increases in transportation output beyond quantity 'z'.

Factor Prices Introduced

What is the most efficient combination of productive resources? The answer to this all-important question can only be given when the prices of the factors are introduced. Supposing 'y' ton-miles of output are wanted; they could be produced in the following alternative ways:

	Equipment Expenditure		Plant Expenditure		Total Expenditure
(a)	\$ 6 million	plus	\$ 1 million	equals	\$ 7 million
(b)	\$ 4 million	plus	\$ 2 million	equals	\$ 6 million
(c)	\$ 2 million	plus	\$ 6 million	equals	\$ 8 million

Alternative (b), with lowest total cost of \$ 6 million represents the optimum combination of the two factors.

The answer to the problem of the optimum utilization of productive resources can also be found geometrically (Figure 7): determine the slope of the price line (in our case, with both axes drawn on the same scale, the 45° lines P1, P2 and P3); move the price line until it is tangential to the desired production isoquant. At the point R, where P3 is tangential to the desired isoquant 'y', the most efficient combination of factors of production can be achieved.

Proof (Figure 8): Take slope of price line as given; draw price line PP' at random through isoquant field. Supposing output quantity 'y' is required. Move along PP' to point K, where price line cuts isoquant 'y'. Combining expenditures OL and OM the desired output 'y' could be produced. However, by shifting along isoquant 'y' to point N (where slope of PP' is tangent to isoquant 'y'), the same output quantity 'y' can be produced with <u>smaller expenditures on both plant and equipment</u>.

Proof: $OP < OL$; and $OQ < OM$.

A similar, if somewhat more complicated proof can be given when moving from the inefficient production point R to N. In the new situation $OQ < OS$, representing an unambiguous <u>saving</u> of the magnitude QS on plant expenditure. Equipment expenditure, on the other hand, has been <u>increased</u>, with $OP > OT$. However, the additional cost of equipment TP amounts to only QU in terms of plant expenditure at current prices (indicated by slope of price line PP'); therefore the substantial <u>net gain</u>

US (in terms of plant expenditure) can still be realized when shifting production from R to N.

To repeat our conclusions: the point of tangency of price line and desired isoquant represents the best possible combination of factors, at minimum total cost. If price line and isoquant are tangential, their slopes must be equal at that point. Hence, the ratio of marginal productivity of expenditure on equipment (MPEe) to the marginal productivity of expenditure on plant (MPEp), is equal to the ratio of the price level of equipment expenditure (Pe) to the price level of plant expenditure (Pr). These relationships can be written down more simply as:

MPEe : MPEp is equal to Pe : Pp.

Using the various methods described the firm will finally decide to adopt the one particular project which promises, with the right combination of factors of production, to yield the right quality of service at the <u>lowest total true cost over time</u>.

<u>Simplifying Assumptions Stated</u>

It must be emphasized that in our model case the task of rational selection was greatly facilitated by a number of simplifying assumptions. These were:

(1) Complete absence of governmental control or interference.

(2) Common ownership and management of both plant and equipment.

(3) Amount of transport needed known in advance.

(4) Dynamic changes in traffic flow, and all peak and off-peak problems neglected.

(5) No transport services offered competitively by other carriers or outside transport agencies.

(6) Social costs held to be real costs to the firm.

(7) Only two factor inputs.

It could rightly be said that our road model operated in an economic vacuum, in some sort of pure "test-tube" environment, removed from all the real complications of every-day life. In the next part of the analysis, when considering the case of the toll road, some of the simplifying assumptions will be dropped. This will enable us to arrive at more realistic economic solutions.

II. A TOLL ROAD MODEL

The previous chapter served as an introduction to the more complex analyses which must be applied to road problems in the real world. We have seen that under the circumstances described and given factor prices, very definite input-output solutions can be found. Arriving at what might be termed "physical transformation functions" of varying combinations of plant and equipment, of truck or road and vehicles, we were able to show how to achieve the desired output of transportation services at minimum total cost. Using analogous techniques we could also have demonstrated, under the restrictive assumptions made, how to maximize output with a certain given supply of input factors or level of total costs.

With the groundwork thus laid for an understanding of more complex situations, we pass on to the case of a privately owned and operated toll road. In order to investigate systematically concepts and relations and yet keep the discussion within a manageable framework, we shall continue to use the convenient device of model building.

New Assumptions

Let us assume that an entrepreneur is contemplating a venture into the field of toll roads. We stipulate that he will be guided in his decisions solely by the principle of profit maximization. He is not concerned with the safety or convenience of the motorists, unless these factors contribute to his net revenue; he is impervious to the needs and the general welfare of the public at large unless its interests coincide with his own.

We assume further that the state in no way influences, restrains or encourages our toll road operator. He is perfectly free to choose any desired location for his route, set his own standards of design, construction and maintenance, and embark on a perfectly flexible rate charging policy. We stipulate that he can raise the funds necessary to finance the venture in any way open to him, as long as he does not avail himself of the state's faith, credit or support.

We further assume that the toll road entrepreneur operates in a truly competitive environment which itself has developed over the years under the conditions of perfect government neutrality just stated. By this we mean that there are in existence already various water, railway and air transport networks which were, or are, neither hindered nor promoted by state taxation, subsidization, regulation or granting of special privileges.

There are also a number of privately owned toll roads and bridges, but the government operates the majority of highways and streets. The highway department, which is presumed to be omniscient in this respect, charges just and appropriate shares of total costs of the public road system to benefiting property owners by means of a land tax, and to motor vehicle operators as a whole -- as well as to various vehicle categories within that group -- through motor fuel taxes and license fees. To maintain perfectly competitive neutrality the government refunds to all toll road operators the amount of gasoline tax generated on their facilities; in order to preserve the competitive balance the government further does not raise or lower the gasoline tax levied on the general highway network.

Toll Road Compared with Mining Road Model

With these new assumptions in mind, the essential differences between the simple road model described in the previous chapter and the toll road model can be assessed. In the former case ownership and operation of both road and vehicles were vested in one agency. Now our toll road entrepreneur has control over the highway only, whereas vehicle operations become a separate function exercised independently and without compulsion by a multitude of motorists. This introduces the necessity of assessing demand for highway services, a problem which will be of importance again and again throughout this study.

Demand itself is determined by the presence of competitive transport services, which are now being introduced. The analysis has to take into account the existence and performance not only of other transport media, such as water, rail and air services, but also of a government-provided road system and of other privately owned toll roads. Social costs, finally, can no longer be regarded as real costs which are necessarily being borne by the toll road company.

Initial Investment Decision of Entrepreneur

Before the entrepreneur will definitely decide to embark upon a toll road venture, he will first scan the entire field of investment opportunities for other possibilities open to him. He will seek information on potential earnings in mining developments, electric power production, forest exploitation, secondary manufacturing, and hundreds of other economic pursuits. He will compare the approximate estimated net revenues which could be derived from these ventures, taking into account the varying degrees of risk associated with each of them and therefore the level of interest rates which would have to be offered to attract capital.

Since the entrepreneur is entirely guided by the precept of profit maximization he will finally select, from equally risky alternatives, the one with the highest potential net yield. Similarly, he will prefer the least risky one of a number of ventures which promise to yield identical returns. In this way he will eventually arrive at a rational decision. We assume that he favours a toll road venture.

Does our toll road promoter in his preliminary decision-making act in the best interests of the economy as a whole? Without perhaps consciously realizing it he -- in combination with hundreds and thousands of other investors -- is striving to maximize, at that particular instant of time, the marginal efficiency of capital, not only of the portion he controls but of capital generally. How is this brought about? The marginal efficiency of capital can be defined as "the expectation of profit to be derived from starting a new project or increasing the output of an old one. It has no necessary connection with the profit already being earned, on a plant already built, operating at a scale of output already selected, but is rather the expectation of net gain from adding something more." (3)

As time moves on, economic resources become available for capital investment every hour, every day, every week. Simultaneously a great variety of uses for capital investment opens up: new wants develop and can profitably be satisfied, increases in population have to be catered for, productive processes become obsolete or inadequate and give rise to demands for modernization and extension of capacity. Choices which investment opportunities should be given priority over others -- since not all schemes can be undertaken at the same time -- are continuously made by a multitude of promoters and entrepreneurs, such as our potential toll road operator. By individually exercising their best judgment they collectively equalize the expected marginal efficiency of all capital at any period of time. Thus, at any given moment, no potential investor could improve his schedule of expected net returns by switching to some other venture. For society as a whole the expected marginal efficiency of capital is equal in all uses and therefore maximized. The most efficient planned deployment of the community's resources available for investment has been achieved -- but only at the particular instant of time, for although all the investment decisions embody best knowledge, they do not necessarily represent best foresight.

It must therefore be emphasized that this process guarantees only the best <u>ex ante planning</u> of investment at any time. Once resources have been committed to specific uses different conditions pertain. Past investment decisions are not sacrosanct; they may <u>ex post</u> turn out to have been completely wrong however conscientiously investors acted at the time. Yesterday's plans, illusions, production processes, machinery, must be scrapped if they do not contribute to tomorrow's revenue.

Thus a very distinct line must be drawn in our thinking between the planning of investment -- the problem with which we are concerned at the moment -- and the continuing operation of a productive process. Quite separate analytical processes will have to be applied to the two situations throughout this study.

<u>Toll Road Investment Analysis</u>

We assumed that our entrepreneur decided to launch a toll road project rather than any other venture, after having appraised investment opportunities in general. A whole host of questions has now to be settled by him. Where to locate the road? What qualities of service to provide? How much money to spend on land acquisition, construction, maintenance and operation? What charges to impose on users? All these and other factors form part of what is generally called a "feasibility study" in the technical literature. The first logical step in pursuing such a feasibility study will consist in assessing the potential demand for toll road services in various areas.

Assessment of Potential Demand for Toll Road Services

Suppose a toll highway between the two large centres C and D is contemplated by the entrepreneur. Towns C and D are already connected, via the smaller community E, by both a railway line and by a public highway of rather inferior quality compared with highways elsewhere. There are also the subsidiary centres G, F, H and I, linked with each other and with towns C, D and E as shown on the map (see Figure 9).

For an estimate of the potential traffic which might be induced to travel on the proposed toll road, ideally a study is made of origin and destination, route selection, composition and volume of all traffic in the region (i.e. over all forms of transportation). Probably some statistics exist on total passenger and freight traffic moving by rail between C, E and D which could be used. To simplify the analysis water and air transport are assumed to be non-existent.

Next, origin-and-destination studies of highway traffic will be carried out. The necessary information on direction of travel, selection of route of trips from various points of origin to various destination points, can be obtained by such methods as roadside interviews, license plate records, return postal cards and home interviews. The traffic data will be compiled so as to show the number of passenger cars and commercial vehicles of various weights and sizes.

If a complete origin-and-destination survey should prove to be too expensive and elaborate, traffic volume and classification counts will be carried out instead. Crews will be designated to strategic points on the highways to count the volume and composition of traffic. The results of these surveys of present traffic, obtained by origin-and-destination studies or by traffic counts, can conveniently be shown in chart form (Figures 10a and 10b).

However, the ultimate aim of the survey is not the determination of traffic during the current survey year (N_0), but of <u>future</u> revenue traffic, i.e. of traffic which will use the toll highway during its projected lifetime. Different methods of approach have to be considered. Initially, past trends are analysed and -- after making various assumptions -- extended into the future over the project period. Thus after appropriate statistical calculations traffic during, for instance, survey year plus five years (N_5) might be predicted to be 1.5 times the N_0 traffic. Similarly, N_{10} might be predicted at 2.0 times, N_{15} traffic at 2.6 times, N_{20} traffic at 3.1 times and N_{30} traffic at 3.8 times the level of N_0 traffic volumes. This represents a rate of increase of roughly 4 per cent, compounded annually over the period. The growth factors are then uniformly applied to ascertained present traffic data to arrive at the desired predictions for years N_0 to

N_{30} for each and every route.*

Traffic Predictions - Refinements

A straightforward prediction of future traffic based merely on past trends must in most cases be regarded as too unreliable a method for the purpose. Thus, for instance, the additional element of "induced traffic" is of importance. Induced traffic can be defined as "traffic which does not even exist prior to the construction of the road, but can be expected to develop as a consequence." In our model certain producers of food and manufactured goods located at F, G and C might indicate, for instance, that by using the proposed toll road they would be able to gain access to the markets D, H and I from which they are barred because of existing high transport costs between C and D. Conversely, producers at D, H and I might expect to extend their marketing spheres to C and beyond if transport facilities were improved. It might further be regarded as likely that a number of new industries would locate themselves in the region, bringing yet further custom to the toll road.

With the aid of economic geography, correlation analyses and location theory a number of techniques can be developed to assess expected normal and induced traffic growth. By field studies conducted elsewhere it might be shown, for instance, that the "potential traffic desire" between two centres, such as C and D, varies almost

*Basically, this procedure was followed and similar results were obtained by the Ontario Department of Highways for the planning of the King's Highway System.(4) (5) The development program for the King's Highways is, however, flexible enough to permit easy adjustments should superior traffic prediction techniques be developed.

directly with the size of population and inversely with the distance between the two points. A strong correlation might also be found to exist between the level of industrial and commercial activity -- measured by some convenient yardstick -- and the amount of commercial traffic generated.

In short, a mere mechanical interpretation projection of existing traffic patterns is not sufficient and should therefore be supplemented by more complex analyses. As Tjalling C. Koopmans put it: "The fact that highway traffic results from the interdependent choices of many decision makers, each with an objective of his own, gives to traffic theory a strong social science flavor."(6)

In our model, after the potential demand for toll road services between C and D has been assessed in these various ways, the entrepreneur conducts similar feasibility studies for a number of other proposed routes in different locations and in different parts of the country. For later comparison the results might be tabulated or shown in chart form (see Figure 11).

<u>Assessment of Potential Net Earnings</u>

The next step consists of determining the potential net earnings for each proposed toll road project. It will be recalled that under the assumptions made it was the entrepreneur's prime objective to maximize net earnings and therefore the scheme promising the highest rate of net profit would be chosen by him.

Net earnings (N_e) are the difference between gross earnings (G_e) and total costs (C). Therefore:

$$(1) \quad N_e = G_e - C$$

Gross earnings are the sum of the products of the rates and the quantities sold; in our case the sum of toll rates charged to different types of traffic (p_n) multiplied by the quantities of highway services consumed by the various user groups (q_n):

$$(2) \qquad G_e = \sum p_n q_n$$

And therefore:

$$(3) \qquad N_e = \sum p_n q_n - C$$

Obviously the toll road entrepreneur will not embark upon any schemes which would result in a negative N_e, or a loss. He will therefore rule out projects for which $C \gtreqless \sum p_n q_n$. In other words, unless at least the condition $\sum p_n q_n \gtreqless C$ is satisfied projects will not even be considered by him. However, this condition defines only the bottom limit and there still remains for the entrepreneur the task of choosing from a number of alternatives the one which maximizes net earnings.

Toll Rates Charged and Quantities Consumed

We have seen before in (3) that net earnings are the sum of the product of rates and quantities sold less total costs. Leaving costs aside for the time being, how can actual values for toll charges and for quantities of highway services consumed be determined by the entrepreneur?

Obviously, the two factors are inter-related. At some relatively high level of toll rates no highway services will be consumed. Conversely, when no price at all is charged quantities sold will be extremely large.* In our case, with the presence

* The three main reasons why not infinitely large quantities of transport services will be sold when they are provided free of charge are: (i) in many cases demand for transport services is derived demand, that is, it is not consumed for its own sake; it is limited by the primary demand, for instance for goods the necessary haulage of which in turn gives rise to demand for freight transport; (ii) transport services, once being provided, cannot be stored -- they must either be consumed or they perish instantaneously; (iii) traffic in excess of highway capacity (i.e. congestion) will diminish the attractiveness of road travel; hence demand for highway services, even at zero charges, is limited for quality-of-service reasons.

of competing highways and a railway stipulated, the upper level of toll rates which will attract at least some customers is clearly determined by the maximum benefits all those motorists, who are particularly dissatisfied with their present travelling arrangements, can derive from switching from alternative routes (or from railway patronage) to the new toll highway.

If toll rates exceed benefits offered by the new highway under these most advantageous circumstances, then even the most eager of potential highway patrons will flinch from the transfer of his custom and consequently no highway services at all will be sold.

Conversely, as toll rates are lowered progressively, more and more motorists will find it profitable to switch to toll highway usage since benefits to be derived from the move exceed charges. Finally, at some extremely low -- and at the outside, zero -- level of charges, all potential traffic to be had would be diverted to the toll highway. We have seen (see footnote on page 33) that there is an absolute limit to the potential traffic which can be attracted in the short run, but that does not concern us here.

Turning back to the example illustrated in Figure 9, all passenger and freight movements which formerly had been accommodated on the Primary Highway and the railway connecting C-E-D, would be transferred to the toll route if rates were extremely low. In addition, some of the traffic normally flowing over Secondary Highways F-I and G-E-H would also be attracted. Even if the toll highway merely offered service qualities identical to those provided by the competing media, then our entrepreneur could presumably still corner all the transport business to be had by fixing the rates just a little below the charges (motor fuel taxes on public highways, freight and passenger charges on the railway) imposed elsewhere.*

Benefits Offered to Toll Road Users

From the foregoing discussion it is becoming clear that benefits offered to toll road users will, in the last resort, decide what charges can be levied. Since the "benefit" concept is at the very core of our analysis it warrants closer scrutiny.

Some definitional difficulties arise. These were stated in the following way in a recent official report of the United States Government on problems of highway economics:

> "The subject of highway benefits is susceptible of great breadth and wide variety of interpretation. The favorable effects of highway improvement, like those of any great developmental work, are widely diffused throughout the economy. ... it is well to begin with a strict interpretation; and to define benefits in terms of quantities or attributes that we can hope to measure with some accuracy." (7)

For the purposes of the toll road model it will be best to restrict the present discussion, as a starting point, to benefits realized directly by motor vehicles using the highway. Just as was assumed before (page 26) that social costs are of no con-

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*Under assumptions of complete competitive neutrality (see page 25), stipulating inter alia that no fuel taxes are to be levied for travel on toll roads, probably many a private route could most effectively compete with public highways. The main reason is that in the real world long-distance highways carrying great volumes of traffic usually "subsidize" low traffic density sectors (county, township roads and the like). This does not imply advocacy of the toll road method of highway finance per se, which is severely handicapped by expensive, but necessary, toll collection arrangements.

cern to the toll road operator, we stipulate for the time being that he is indifferent to the social benefits which may, or may not, be conferred by his activities. We shall see in Chapter IV what possibilities exist for the toll road operator to derive additional revenues from those more indirect benefits conferred by the new highway upon property, business enterprises, and the community at large.

But even if we restrict our analysis to benefits which are realized directly by motor vehicle users, it may easily happen that we get sidetracked into a discussion of the perennial problem of meaning and measurement of "utility", or "benefits". We might then have to answer, for example, the following questions: How many units of "satisfaction" will a motorist derive from using the new toll road, rather than an alternative route? Can the utility which one motorist derives from toll road use be compared, unit by unit, to the utility realized by another motorist? Can individual utilities, or benefits, derived from toll road use be combined into composite benefit schedules for all motorists? Pursuing these and similar enquiries we may be forced to resort to a utility theory of values based on psychological considerations, which will get us nowhere.

Since we are dealing here really with technical and applied economic problems, we must endeavour to base our benefit concept on externally or objectively observable facts, and not on elusive psychical premises. The greater the ease with which "benefits" can be measured -- in whatever way they have been defined by us -- the better for our immediate, practical purposes. This approach is in line with the procedure suggested in the "First Progress Report", (quoted on page 35).

Definition of Road User Benefits

For the purposes of our toll road model we can do no better than to follow Marshall and define road user benefits as "the maximum amount of money individual motorists are prepared to give up in order to avail themselves of toll highway services rather than go without them". Using this definition we circumvent the difficulty of having to measure "utility" or "benefits" directly; instead we measure consumers' satisfaction indirectly through observable effects.

For benefits to be measurable, in a practical sense, a unit of measurement and a zero point must be chosen. As far as the latter requirement is concerned, it should be taken into consideration that our toll road entrepreneur is confronted with traffic which has existed for some time. Presumably users of transport services, over the years gone by, have explored many variations and combinations of routes and have now settled into the most rational traffic pattern, i.e. the one which draws optimum benefits from the existing network of roads and railways. From the entrepreneur's point of view the necessary benefit analysis resolves itself therefore simply into a straightforward comparison of the hypothetical, superior toll road situation with the existing traffic pattern. There is no need to bring in third, fourth, fifth, etc. situations, since the present one is already the most rational one from the users' point of view and therefore the one with which the toll road entrepreneur has to compete.

This is not to say that we depend on the existence of some traffic in order to define the zero point of measurement. If there is no highway at all, or no means of transportation whatsoever, the absence of traffic becomes the starting point for benefit measurements.

We stated before that the sums of money individual motorists are prepared to pay for highway services are the best indication for the benefits they derive from such travel. Money is therefore our chosen yardstick for benefit measurement. From the point of view of our analysis it is most convenient that we stipulated a "charging what the traffic will bear" regime. If the toll road operator acts according to this condition, the maximum charges he can exact from each motorist are also equal to the maximum benefits conferred by the rendering of highway services. It follows that benefits conferred upon individual users are identical to marginal revenues at each quantity of output point, as increments in revenue coincide with the additional rendering of highway services to one more user. Cumulatively, the sum of individual benefits conferred will also be equal to total revenues from users.

This is demonstrated in Figure 12, where the curve DE represents both marginal revenues and marginal benefits at different levels of output. The curve will slope downwards to the right like an ordinary demand curve, as shown in the diagram, not only because differing intensities of demand will be satisfied progressively, but also because with an increase in the <u>quantities</u> of highway services rendered, a deterioration of <u>quality</u> (i.e. congestion) will set in.

What possibilities are there for the toll road entrepreneur to obtain accurate information on benefits conferred? Since he can practise a perfectly flexible charging policy according to our assumptions, it might be possible for him to assess benefits, and hence the optimum level of tolls, through experimentation once the toll road is in operation. By lowering and raising his charges in individual cases, always trying to maximize revenues, he may eventually arrive at the correct demand schedule.

However, price experimentation is not a practical possibility in our case, since it presupposes that the toll highway has been built and is actually being used. The problem under discussion is that of planning investment in a toll road and hence the trial and error approach to revenue assessment cannot be used. It will also be seen later that price experimentation is not a feasible approach as far as public road systems are concerned. An alternative method of benefit assessment is therefore needed.

This alternative approach -- and it is a widely used one -- consists of breaking down "highway benefits" into a number of subcategories which lend themselves to measurement. The subjective contents of "benefits" are isolated and minimized by sorting out in turn all possible advantages a motorist could derive from using a better highway and translating these advantages into money terms. It should be noted that basically benefit measurement is an empirical procedure to assess in money terms the cost-saving features of a hypothetical or existing superior highway situation, compared with an inferior highway situation; the inferior situation becomes the zero point of measurement.

Highway user benefits, on reflection, appear to be composed of many diverse factors which range from elusive psychological considerations, such as aesthetic appreciation of a roadside beauty-spot, to measurable savings in vehicle operating costs. There is a great deal of literature on road user benefits and a selected list of references is contained in the Appendix. Briefly, the most important benefit factors are:

(i) Savings in distance. Shorter travelling distances reduce all vehicle costs which vary with mileage, such as: fuel consumption, tires, vehicle depreciation, repairs, inspection.

(ii) Savings in time. These have a twofold effect: in the first place drivers and passengers save time which is of value to them. Secondly, more intensive use can be made of vehicles; therefore costs which do not vary with mileage, such as insurance, cost of terminal installations, general overheads, can be spread over a greater number of ton-miles (vehicle-miles, passenger-miles, etc.) performed, with consequent savings in unit costs.

(iii) Savings through improvements in road quality. Elimination of steep gradients, excessive curves, intersections, blind spots, leads to reductions in fuel consumption, wear of clutch, gear shift mechanism and brakes. Smoothness of surface reduces fuel consumption, wear and tear of tires, springs, chassis.

(iv) Reductions in accident costs, through improvements listed under (iii) and reductions in accident risks through travelling time and distance savings.

(v) Reductions in driver fatigue, boredom and irritation through landscaping, provision of road-side facilities, elimination of obnoxious billboard advertising and monotonous road layout.

These diverse benefits are valuated differently by different people. A pleasure driver may be mainly interested in beautiful vistas made accessible to him, whereas a commercial vehicle operator may only take into account dollar-and-cent savings in time and running expenses. The toll road entrepreneur is therefore really confronted with a multitude of potential users, each of whom appraises services offered differently by means of his own preference universe. But in the real world user behaviour is not as complex as might be expected on theoretical grounds. The total vehicle population to be found on the road can probably in most cases be broken down into a small number of fairly homogeneous types with very similar technical performance and characteristics.

Potential operating cost benefits to be derived from the use of a superior highway, such as savings in fuel consumption, reductions in vehicle wear and tear, can easily be determined empirically and stated in money terms. Time savings might be more difficult to assess in monetary terms. Whereas in the case of commercial vehicle chauffeurs and taxi drivers the hourly wages paid could be used as a yardstick, it might be argued that the time of the man driving to work or returning home from the office, or the time of the occasional and pleasure driver, are of no economic value. On the other hand anything people are prepared to pay money for has economic value and it has been shown again and again on existing toll roads that many individuals value their time very highly. Reductions in accident costs and the psychological and aesthetic factors, finally, might be assessed by experiment or estimate.

In any case, we can be convinced that the toll road entrepreneur will find ways and means to judge fairly accurately the benefits which will be bestowed upon motorists by a new highway built to given standards. Still leaving aside the question of how much it would cost to build such a highway, he can then plot, as shown on Figure 12, marginal benefits offered to each motorist or group of motorists, and the total quantities of highway services provided cumulatively at each point. Benefits can at the same time be taken to represent the maximum charges which can be extracted from each user, as long as the basic condition:

"benefits offered (b_n) must be at least equal to rates charged (p_n) to each type of traffic", or: $b_n \geqq p_n$, is satisfied.

We stipulated that the toll road entrepreneur had complete freedom of rate charging. Still leaving in abeyance cost problems, gross revenues will be maximized if total quantities OE (or q_n) of highway services of given standards are supplied and charges identical to the ordinate values of the benefit (marginal revenue) curve DE are imposed (see Figure 12). Total gross earnings ($\sum p_n q_n$) tend to become equal to the area under the arc DE as the number of users approaches infinity. Since $q_d = f(p)$, given users' preferences, (q_d being the quantity demanded), gross revenue -- which is the integral of the demand function -- can be represented in this way:

$$(4) \qquad \int_0^{q_n} f(p)\, dp$$

<u>Charging What the Traffic Will Bear?</u>

Gross revenues are charges multiplied by quantities; in our case the sum of an infinite number of rectangles, each of a height corresponding to rate charged and with an infinitesimally small base representing quantity consumed (see Figure 12). It is sometimes argued that such a rate policy, with infinitely small variations of prices charged, would be impossible, or at least impracticable. This may be true and in the real world it may be more convenient to let rates go down in definite "steps", such as from OF (= NG) to OA (= BC) and OH (= IM). Total revenue collected would then be the area within points OFGKBLIMO. As a matter of fact, many electric power companies use rate systems that go down in such steps after certain quantities of consumption are exceeded. But this does not in the least detract from the validity of our revenue maximization formula (4). The same electric power companies would not hesitate to apply it, were it not for the fact that the extra revenues thus obtained would be more than offset by the additional administrative and organizational expenses of a perfectly variable tariff system.

Going further, the proposition is frequently put forward in discussions on transport matters that there is something sinister, inherently immoral and unethical in charging differential rates to different transport users. The practice is usually referred to in discussions as "charging what the traffic will bear", or "rate discrimination". Equity, it is claimed, demands that a flat, uniform tariff at, for instance, the level OA be charged to all users. Total revenue accruing would then be the area OABC. It is usually conceded by these critics of differential charging that the supplier of services should have the option of charging at any level (for instance OF or OH), in order to maximize the rectangular revenue area, as long as the charges apply uniformly across the board.

Very little remains of the anti-rate-discrimination argument once its moral and emotional disguises have been removed. Of course all economic life is ruled by the supreme rule of "charging what the traffic will bear". It is applied with great vigour and whenever possible by all sellers of goods and services. Only because generations of economists have been brought up on assumptions of pure and perfect competition have we come to regard the uniform market price, set at marginal cost level, as the rule rather than the exception. We are learning slowly that the so-called imperfections, the monopolies, duopolies, oligopolies, are all-pervasive; that advertising, control of entry, licensing, government regulation, brandnames, special service features, trade associations, cartels, market strategy, the opening of a retail store in a particularly favoured location, are all attempts to create little economic "niches" which are sheltered from the chill winds blowing across the desolate market place of pure and perfect competition.

Consumer's Surplus

We need have no qualms, then, about letting our toll road entrepreneur indulge in "discriminatory rate practices" -- at least for the time being. Our lassitude, incidentally, also serves us well by eliminating the theoretical complications of the so-called "consumer's surplus". The term was first used by Marshall(8), but the essential idea is Dupuit's(9). Consumer's surplus, or consumer's rent as it is also called, is the difference between total "utility" accruing to consumers from consumption of a given quantity of a commodity (represented by the integral of the demand function) and the price actually paid times the quantity bought. In our example (see Figure 12) at given uniform price OA and quantity purchased OC = AB, the consumer's surplus would be represented by the area ABD under the arc DB.

A number of objections have been raised against the concept as such; a further discussion of it has to be postponed until later. Suffice it to say that in our model, with the entrepreneur charging perfectly flexibly to the limits set by each user's demand function, gross revenue is maximized and no consumer's surplus remains.

Cost Analysis

After having carried out studies of demand, and hence gross revenues, for a number of proposed toll roads, the entrepreneur will then enquire into the cost side of these projects. We have seen how he estimated marginal gross revenues at varying levels of output, which could be exacted from potential highway users. He will now initiate studies to determine the marginal costs associated with these different quantities of highway services.

The cost studies will proceed in ways similar to those described in Chapter I and illustrated in Figures 2 and 3. The main difference is that the toll road entrepreneur, in contrast to the mining company, is concerned with fixed, variable and total costs of the highway only and can neglect vehicle costs, except insofar as they enter into his demand analysis.

In Figure 13 the curve AKBHN represents the marginal costs of providing highway services at different levels of output. Without further enquiry there is little we can say about the shape of the marginal cost curve. No significance should be attached to the way in which it is drawn in Figure 13; it is assumed here that marginal costs of providing the first few units of highway service are relatively high and that they then fall as economies of scale are reaped or initial fixed costs are spread over a greater number of production units; for purposes of illustration we assume that at very large output quantities marginal costs rise again, due to diseconomies of scale, the bidding up of factor prices and so on. Neglecting indivisibilities of factors of production, a problem which was adequately discussed on pages 14, 15, 16 and 17, and illustrated in Figure 3, a fairly smooth marginal cost curve will be obtained. This implies that infinitely small additions to output requiring infinitely small incremental cost doses are possible. This is an unrealistic assumption, but our main line of argument does not depend on it.

Total output produced and consumed is determined by the intersection of the marginal cost and marginal revenue curves (at point B in Figure 13) and will be OC (or q_n). Marginal costs associated with the production of different quantities of output (c_n) are identical to the ordinate values of the marginal cost curve. Total costs ($\sum c_n q_n$) will tend to become equal to the area OCB under the curve AB as the number of highway service quantities supplied (q_s) approaches infinity.

It is assumed here that costs are a function of quantity produced, or $c = f(q)$. Total costs are the integral of the marginal cost function and if $c_{marg} = f(q)$, then they can be represented in this way:

$$(5) \quad \int_0^{q_n} f(q)\,dq$$

As demonstrated in Figure 13, costs and revenues are both functions of output. Hence:

$$(6) \quad N_e = \sum p_n q_n - \sum c_n q_n$$

Or in infinitesimal amounts of q:

$$(7) \quad N_e = \int_0^q p\,dq - \int_0^q c\,dq$$

where p is a function of q, [i.e. $p(q)$], and c is a function of q, [i.e. $c(q)$], so that $N_e = \int p(q)\,dq - \int c(q)dq$.

In Figure 13, area OABC $\equiv \int_0^C c(q)dq$ and area ODBC $\equiv \int_0^C p(q)dq$. It is the difference between areas ODBC and OABC, or the difference between the integral of the marginal revenue function and the integral of the marginal cost function, which the entrepreneur will seek to maximize with all means at his disposal. In other words, it will be his prime objective to obtain the greatest possible net revenues (the difference between total revenues and total costs).

<u>Planned Level of Output</u>

Let us look more closely at the marginal revenue and marginal cost curves in Figure 13. We stipulated that the toll road entrepreneur was able to assess very accurately individual benefits conferred upon users through various quantities of highway services supplied. We also assumed that he was managerially and organizationally capable of translating the ascertained benefit schedule into a minutely adjustable charging system. We further stipulated that infinitely small variations in output, with resulting infinitely small variations in cost, were possible.

If these conditions prevail, the entrepreneur will choose to supply OC quantities of highway services, since he cannot increase his net earnings by supplying any other quantities of output. At output level OC the extra cost of supplying the additional last, very small increase in quantity of highway services, is equal to the additional benefit enjoyed by the user of that last unit of service. Since under a regime of "charging what the traffic will bear" price equals benefits, it follows that at output OC the marginal cost of supplying the last unit is equal to marginal benefit derived from that unit, and hence to price.

If this is so, then the optimum position from the entrepreneur's point of view has been reached. If he were to increase his output to (say) OF, the costs incurred by him in order to supply the quantity increment CF would be equivalent to the area CBHF. At the same time additional benefits conferred upon users, and hence charges collected would only be equivalent to CBGF. The loss to the toll road entrepreneur of supplying additional quantities CF would therefore be equal to the area of the curvilinear triangle BHG.

Similarly, if he were to decrease his output by (say) quantity CI he would stand to lose. At output OI the marginal cost of supplying the last unit would be only IK, but benefits conferred would be as much as IL. At output OI his total net earnings would only be equivalent to the area ADLK. Compared with the optimum output OC, determined by the intersection of the marginal cost and marginal revenue curves, the entrepreneur would therefore lose net earnings equivalent to the area of the curvilinear triangle LKB.

While output OC is, as we have seen, the optimum one from the entrepreneur's point of view, is it also a logical one as far as the users are concerned? If OC units of highway services are being offered and consumed no user could possibly be worse off than prior to the operation of the toll road, since benefits will be equal to toll charges. Users are not compelled to drive on the toll road and their choice of routes is a purely voluntary one. They cannot be 'overcharged' since the slightest overall increase of the rate schedule over and above the maximum level of the benefit schedule would presumably induce them all to return to the old routes or to the other means of transportation.

Is output OC the optimum one from the community's point of view? Will adoption by the toll road entrepreneur of the particular production and investment plans associated with output OC lead to the best allocation of scarce resources within the economy as a whole?

It might be argued from a social or community point of view that the toll road operator, by pursuing ruthless "charge what the traffic will bear" rate practices, will be reaping excessive monopolistic profits to the detriment of the public. It might be said that the entrepreneur would actually be "underproducing" and hence "underemploying" productive resources, since at outputs larger than OC his total gross revenues would still exceed total costs, and consequently net revenues would still be accruing to him. For example, he might be compelled by government decree to operate, in the public interest, at output level OM in order to satisfy <u>all</u> demands for highway services. True, in that case quantities OC to OM would be provided at a loss equivalent to area BMN (the difference between cost area CBNM and benefit-marginal revenues area CBM). But the loss sustained by providing these additional highway services would be more than offset by the excessive profits (equivalent to area ADB) made on the preceding units of output. In other words, it might be argued that the toll road operator would still be in business as long as the potential loss from providing services to the community at less than cost (area BMN in Figure 13, for instance), was smaller than the net earnings extracted at lower output levels (area ADB).

This line of reasoning, within the framework of the present analysis and under the assumptions stated earlier, must be rejected absolutely. It is most misleading since it introduces different criteria, such as income distribution desiderata, monopoly pricing and control problems which were deliberately not brought into the discussion at this stage. The line of reasoning is primarily directed at the implications and consequences of a regime of "charging what the traffic will bear". It seeks to attack the fact that a potential consumers' surplus (area ADB in Figure 13) is priced away and is turned into a producers' surplus. The argument in the preceding paragraph is thus concerned with the alleged "excessive" size of net earnings or the "unreasonably high" rate of profit accruing to the entrepreneur. It is essential however, that we concentrate at this stage on the most immediate and important question: will the toll road entrepreneur plan the investment of productive resources in the most efficient manner? An analogy drawn from the realm of railway transportation will clarify the issue.

Investment Planning - Analogy with Railway Transport

Let us translate the toll road situation described on the preceding pages into a comparable problem of railway transport. Supposing the management of a railway company has to decide how best to invest productive resources for modernization or expansion of operations. After special studies have been carried out the merits of various proposals for capital investment in plant or equipment might be compared. Thus the advantages of, say, the purchase of modern diesel locomotives might be contrasted with those of investment in an improved rail route linking two points. Using methods similar to those described in Chapter I and illustrated in Figures

5 - 8, the railway company will determine the most effective combination of track and vehicle expenditures in order to minimize total transportation costs.

Supposing it has been found that investment in a new rail route connecting two points, involving construction of a tunnel, elimination of excessive grades and curves, shortening of distance and the like, will be most profitable for the company and will be proceeded with. The decision will undoubtedly be based on the consideration that this project promises to yield the greatest benefits (in terms of overall cost savings and service improvements) relative to costs. The railway company, in its endeavour to maximize net benefits (gross benefits less costs) will therefore act exactly like the toll road entrepreneur in the situation illustrated by Figure 13. It will also apply similar criteria to determine the most desirable level of output.

It is important to note that the decision whether to invest in rolling stock or in track modernization, or in both, is one which concerns the railway only. It is also an internal management matter, of no interest to anyone else, to decide what quantities of output shall be produced. Going further, no outsider would have the right to question the way in which the costs of the particular rail route improvements are internally allocated to the various types of traffic making use of the facility, nor would normally anybody consider probing into the way in which realized cost savings are divided between, for instance, passenger and freight traffic.

Even the question whether or not cost savings realized by the railway company are passed on to users in form of lower rates would normally not arise at all in connection with the planning of operational improvements. The public would merely expect the railway company to invest money in the most "profitable" manner, i.e. in such a way that the greatest possible cost reductions are achieved. Whether these cost reductions will then accrue entirely to the railway company in form of higher profits, or whether the users will benefit through lower rates, would be regarded as a different problem altogether. Normally reliance would be put on competition to maintain the level of rates at a low level and not on other factors.

It is clear that the railway company's actions have to be judged in the light of two different sets of circumstances. In the first place an investment decision has to be made. Undoubtedly it is in the public interest that scarce resources are put to the most profitable use. The railway management is presumably the agency best qualified to decide how to effect the greatest improvements in efficiency and cost savings with these scarce resources. Presupposing rational action, the railway investment decision will therefore also lead to benefit maximization for the community at large.

Secondly, social welfare criteria might be applied to the problem of distributing the benefits resulting from the investment among different individuals or groups within the community. One might ask: should the railway company be allowed to make great profits? And: should these large profits not be passed on to the community in the form of lower fares?

It should be observed that in the first instance we are concerned with the most efficient allocation of resources for productive purposes. Our interest centers, as it were, on the size of the pie which production will yield. In the second case our aim is a socially desirable distribution of the various slices of the pie.

To achieve the second objective the railway company might, for instance, be compelled by law to charge only rates which will yield "reasonable" profits. In other words, a certain proportionate relationship between rates and costs might be enforced by special regulation and legislation. In our example, with some reductions in costs made possible by rail track improvements, the railway company would then presumably be compelled to lower its rates accordingly.

This course of action to which the railway company might be compelled by law would, however, probably inhibit the management in its endeavours to increase efficiency. If all cost savings have to be passed on automatically in form of lower rates or other concessions, there would be no real incentive for the company to introduce improvements in the first place. The second objective of fair shares for everybody might therefore conflict with the first objective, the most efficient allocation of resources.

For this reason reliance might be placed on competitive forces to keep the level of profits down. Competition may force the railway to modernize its plant, for instance. The improvement in the rail route may then conceivably not lead to greater profits for the railway at all, but may just barely allow the company to stay in business in the face of, say, truck and airline competition. A high rate of profit, supposed to be socially undesirable, appears therefore in many cases to be caused by the absence of competition, rather than by other factors. New investment by outsiders in transport facilities in the particular region, and hence competition, will, however, be encouraged by high profit expectations. Thus in the sequence of events, investment will not lead to high profits, but rather high profit expectations will induce investment and this in turn will, in the long run, cause realized profits to fall.

We can therefore tentatively conclude that in the case described the criteria for the most efficient allocation of resources for investment purposes will, in the long run, also satisfy the requirements of distributive justice.

The same reasoning can be applied to our toll road model. It certainly is most desirable from the community's point of view that the toll road entrepreneur should invest in the project, and select the particular output level, which promises to yield the greatest benefits relative to costs. He will have every incentive to adopt such a course of action because it will also give him the highest net earnings relative to costs.

<u>Assumption of Equal Charges</u>

As an additional test for this proposition let us assume for argument's sake that the toll road operator -- under some anti-monopoly and rate equalization laws -- is forced to charge uniform tolls to all users. What is the position if he charges a flat tariff at the level OE (see Figure 13)? If he charges uniform tolls of the magnitude OE he will still produce, as before, OC quantities of highway services since he could not improve his net earnings by shifting to any other level of output. Total revenues would be equivalent to the area of the rectangle OEBC, total costs equivalent to the area OAKBCI and therefore net earnings equivalent to AEBK. We could say that part of the "producer's surplus" which would ordinarily have accrued to the toll road entrepreneur in its entirety (area ADBK) under a regime of "charging what the traffic will bear", is now passed on to users in form of a "consumers' surplus" (area EDB). Hence, a socially more desirable distribution of benefits to be reaped from the toll road project can be achieved by enforcing a uniform charging system, without violating the criteria for the most advantageous allocation of resources and for the choice of the most efficient level of output.

It should be noted, however, that there is no guarantee whatsoever that the toll road operator will select this particular level of uniform toll charges. Depending on the shape of the marginal cost and revenue curves -- and we can say nothing about their configuration without further enquiry -- it would be a great coincidence indeed if the toll level OE, socially desirable for investment and production reasons, would be identical to the level of charges desired by the toll road entrepreneur.

For example, let us assume that the marginal cost and revenue curves are shaped as shown in Figure 13 a. Since the toll road operator seeks to maximize the size of net earnings, he will probably choose to produce output OI and not OC (see Figure 13a); his net earnings in that case are AFKM, presuming that they could not be increased by producing at any other output level. Hence socially desirable output and investment objectives (quantity OC) under these circumstances do not coincide with the objectives of the toll road entrepreneur (quantity OI).

Let us recapitulate. We assumed that the toll road entrepreneur was compelled by law to charge uniform rates. We endowed the toll road operator, however, with powers to set the one-price tariff at a level of his own choice; this is a realistic condition considering the very great difficulties confronting legislatures or government departments when they attempt to take rate making upon themselves. Consequently, the toll road operator will set his rate level in such a way that his net earnings are maximized. We have seen in Figure 13a that the quantity of output produced under these circumstances may well be smaller than the one produced under a regime of "charging what the traffic will bear" (see Figure 13).

Based on these considerations a general rule can be established. Regardless of the configuration of the marginal cost curve a uniform tariff system, compared with a regime of "charging what the traffic will bear", will have the following results:

(a) it will <u>never</u> lead to <u>greater</u> output quantities;

(b) it <u>may</u> lead to the <u>same</u> output quantities;

(c) it <u>may</u> lead to <u>smaller</u> output quantities.

It appears, therefore, that the enforcement of uniform charges <u>may</u> result in lower production and underemployment of resources, whereas "dissimilar pricing"* <u>will always</u> lead to maximum production and employment of resources.

This is not to argue, however, that even greater output quantities could not be achieved. The toll road entrepreneur could be forced by law, for example, to increase his production

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*The term "dissimilar pricing" is used by A. M. Milne (10) in preference to "discriminatory pricing", as a substitute phrase for "charging what the traffic will bear". His terminology will be followed in this study.

until he made neither a profit nor a loss.* In that case he would be obliged to charge OD and produce OG, with net earnings on the initial units of output (area AHD) exactly cancelled out by net losses on the subsequent quantities (area HBL); users consuming service quantities OI, in this instance, would then "subsidize" consumers of quantities NG (see Figure 13a). Even greater output quantities could of course be achieved if the toll road entrepreneur is state subsidized, or recompensed for certain unremunerative services.

If we assume that the general welfare criterion "marginal costs equal marginal revenues" applies to all economic activities, however, then it is likely that dissimilar pricing will produce the socially more desirable output solution. One of the best writers on the subject of transport economics, A.M.Milne, recognized this possibility by stating in his book <u>The Economics of Inland Transport</u>, that:

> "... the principle [of dissimilar pricing] may promote a greater utilization of indivisible and fixed resources and may thereby permit indivisible and fixed costs to be spread over a larger volume of traffic. In this way the practice of discriminatory pricing may confer economic benefit, a benefit represented by the fact that transport rates and fares are rendered lower than they would be in the absence of discriminatory pricing.

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* If we interpret total costs as including "reasonable return on capital" or "reasonable profit", or some such concept, our example would illustrate a public utility rate regulation situation.

When interpreted within a cost framework, the principle of charging what the traffic will bear indicates how an indivisible cost - whether an indivisible variable cost or a fixed cost - can be spread over different traffics with the minimum of discouragement to actual and potential transport users." (11)

"A reluctance to indulge in dissimilar pricing, on the ground that such a pricing practice does not accord with what is to be expected when a transport service is provided as a "public service", may render unremunerative services which would be remunerative if a greater measure of dissimilar pricing were adopted." (12)

Toll Road Model - Conclusion and Summary

Returning once more to our analogy with railway transport, we can say that some analytical complications arise in the toll road case merely because of the separate ownership of vehicles on the one hand, and of the highway facilities on the other. This problem, of course, does not exist in the field of railway transport. Yet it appears that the theoretical differences between rail and road transport are not very important.

Let us take the question of selection of output levels, for instance. The railway will simply make an internal decision to run so many trains per day on a certain route and will construct the track accordingly. The toll road entrepreneur will have to go outside his own organization, into the transport market, to assess the demand for highway services. But we will find on closer inspection that the railway in the last analysis also has to go into the market to assess the demand for freight and passenger transport in the first place, in order to plan for the right number of trains per day and the right type of route. The demand analysis methods, the economic and physical working rules to be used, would basically be the same for railway management and toll road entrepreneur. The only slight difference is the fact that the railway produces and sells the final product "transportation", measured in ton-miles, passenger-miles or other units, whereas the toll road operator sells the intermediate product "highway services made available". It is a difference of degree and not of substance.

Before we go on to analyse in Chapter III further theoretical and practical implications of the toll road model, it will be helpful to summarize the discussion pursued so far.

(1) A potential toll road entrepreneur, assumed to be operating within a perfectly competitive environment, will as a first step compare all investment opportunities open to him.

(2) Guided by the precept of profit maximization he will choose the one project which promises to yield the highest potential net earnings at the lowest degree of risk. His choice will be in the best interest of the community as a whole.

(3) Within the framework of a feasibility study he will study the present and potential future demand for toll road services in various areas.

(4) Potential net earnings (gross earnings less total costs) for each project will be estimated. The entrepreneur will logically adopt a "charge what

the traffic will bear" rate policy. Hence, gross earnings will be equal to maximum benefits conferred on toll road users.

(5) A supply analysis will be carried out which consists of estimating marginal costs associated with various levels of output.

(6) It is the toll road operator's ultimate aim to maximize net earnings. Therefore he will choose the one project which promises to yield the greatest net earnings relative to investment outlay.

(7) The level of output of highway services will be determined by the intersection of the marginal cost and marginal revenue curves. At any other level of production the toll road operator's net earnings will be smaller.

(8) The same criteria for investment planning and choice of output level apply equally to railways and to toll roads. The final decisions in each case are in the best interest of the community as a whole.

(9) Distributive justice and welfare arguments are directed at the level of profits, and hence the absence of competition, rather than at the results of planning of investment.

(10) High profit expectations will induce investment and this will, in the long run, cause profits to fall.

(11) It can be tentatively concluded that the criteria of efficient resource allocation for investment purposes will also satisfy the requirements of distributive justice.

III. PRICE, COST AND OUTPUT DETERMINATION

In Chapter II it was assumed that the toll road entrepreneur will be able to assess fairly accurately costs associated with various levels of output. It was also stipulated that he will be in a position to measure, by market research or technical studies or in some other way, the toll charges individual users are willing to pay for highway services rendered to them. It was found that the most desirable level of output will be determined by the intersection of the marginal revenue and marginal cost curves.

In this chapter an attempt will be made to examine more thoroughly the forces and factors which shape the marginal cost and marginal revenue curves. Problems associated with the determination of price, cost and output solutions will be discussed.

Fallacy of Assuming Homogeneous Highway Service Units

So far in our analysis it was taken for granted that there are homogeneous units of highway service which are being demanded and supplied. Thus in diagrammatical problem presentation (for instance in Figures 12 and 13) "quantities of highway services", measured in ton-miles, passenger-miles or vehicle-miles, were plotted along the X-axis. This procedure, which was adopted to simplify the analysis, ignores the important fact that homogeneity of output or consumption units is the exception rather than the rule in the realm of transportation.

Unfortunately, in many instances planners, economists, government officials and transport operators without hesitation compute, add, price, allocate resources to, regulate and tax ton-miles (or vehicle-miles, or passenger-miles), demanded and supplied under the most diverse of circumstances, as if they were all identical units and strictly comparable to each other.

The confusion arises perhaps because physical units of measurement are involved. A ton-mile, for instance, is the movement of one ton a distance of one mile. Everybody knows what a ton is and everybody knows what a mile is; both units of measurement -- taken separately -- are internationally recognized. It does not follow, however, that the ton-mile, or the other transport units, can serve as standards of measurement. Let us look at distance. Distance seems to be a very simple concept. Yet great care has to be taken to ensure scientific comparability of distances and the basic unit of the metric system, the metre, is elaborately defined as "the distance, at 0° Celsius, between the centres of two lines engraved on a bar of platinum-iridium kept in Paris". It seems reasonable to suggest that the use of the ton-mile as an accurate unit of measurement should be deferred until an internationally accepted "standard ton-mile" makes its appearance somewhere in a heavily guarded, temperature-controlled glass shrine.

The following quotation will underline the point that there is a great variety of "ton-miles" to be found in this world:

> "According to the [U.S.] Bureau of Public Roads, the average ton-mile cost of carrying goods on a human head is 88 cents; by oxcart 68 cents; by pack animals 20 cents; in trucks on passable roads 15 cents; in trucks on improved highways 10 cents. Coastal tribes in East Africa transport grain to nearby villages at approximately $1.40 per ton-mile.... Oxcart transportation in Guatemala and

Panama is still $1.00 per ton-mile compared to 22 and 12 cents per ton-mile respectively by truck. The average ton-mile cost in the United States for Class One Motor Carriers is estimated at 5.5 cents. Where good roads prevail, pay loads are larger and hauls longer, as in the Rocky Mountain Section of the United States, the average ton-mile cost for the same classification is a low 4.0 cents." (13)

Returning to our model, it will be recognized that one highway service unit supplied will differ greatly from another, seen from the toll road operator's point of view. To accommodate a vehicle in the middle of the night, during an off-peak period, will cost practically nothing. Yet the same vehicle added to a traffic volume which already fully utilizes the maximum capacity of the roadway will call for most substantial expenditures, for instance on lane widening or construction of an extra lane. Similarly, the provision of structures, base, surface, shoulders and right-of-way for extremely small and light vehicles will require relatively small expenditures compared with the cost of roadway components necessary for heavy and large vehicles. To give a specific example: it will be impossible to say without further study whether it will cost more or less to accommodate ten vehicles of one ton each, than one vehicle weighing ten tons, on a one-mile stretch of highway. Yet in both cases 10 ton-miles of highway services are being rendered.

The same applies to the demand for toll road services, looked at from the users' point of view. Demand for highway travel will probably be very intense during peak traffic hours when potential users are prepared to pay substantial sums to get to the office in time, or to return home quickly. There will be very little demand for highway services, on the other hand, on a winter's morning between 2 and 4 a.m. Furthermore, demand for a ton-mile of passenger car travel will differ fundamentally from demand for a ton-mile of highway service required by a big tractor-trailer combination. Again, we cannot compare the demand for a mile of highway travel of ten passenger vehicles of one ton each, with the demand for a one-mile trip by a ten-ton truck. Yet in both cases 10 ton-miles of highway services are being demanded.

It is easy to see that "highway service" is a multi-dimensional concept, varying with time and place, frequency of use, quality of service, size, weight and speed of vehicle, and other factors. It is less easy to devise methods to explain and assess the inter-relationships between these variables. Most admirable studies have been published which show highway costs as a function of vehicle occupancy over time or space. Other studies now under way seek to establish the relationship between vehicle weight (or axle weight, or pressure per square inch of tire in contact with the pavement, etc.) and the costs of constructing and maintaining different types of highway. (14)

Yet to this day nobody has found a scientific answer to the following, relatively simple problem: Suppose it has been found by engineering research and experiment that heavy commercial vehicles require road surfaces and base courses twice as thick and costly as those necessary to accommodate passenger cars. If only one road lane is required to carry all the passenger cars and trucks, it has been decided to hold the heavy vehicles responsible for, say, half the total cost of surface and base course. Suppose now that there are a great many more passenger cars and only a few trucks and a second road lane has to be built. It is not practicable to segregate traffic, i.e. to designate heavy vehicles to one of the two lanes only, with passenger cars being allowed on one or both. Consequently both lanes have to be constructed to superior standards. How are the costs of the second lane, and especially costs of extra surface and base course thickness, to be allocated among passenger cars and trucks?

There are probably as many answers to this question as there are writers on the subject. Add to the problem described above other factors, such as construction costs caused exclusively by climatic conditions -- regardless of traffic use -- and the difficulties inherent in our discussion will become even more apparent.

Use of Three-Dimensional Diagrams

To introduce greater realism into this discussion of highway price, cost and output determination, use will be made of three-dimensional diagrams in the following analysis. It should be emphasized strongly at the outset that this technique can only be regarded as an expository device. It cannot provide any solutions, but rather is meant to demonstrate the difficulties of arriving at solutions.

In most of the current literature on highway pricing and the allocation of cost responsibilities to different vehicle groups usually three variables are considered, but only the relationship between two of these is normally discussed at a time. In most cases the relationship between vehicle weight and highway costs (prices) is singled out for detailed analysis and then the influence of traffic volume on road costs (prices) receives separate treatment. The fact is therefore frequently overlooked -- and also not drawn to the attention of the reader -- that both traffic volume and vehicle weight react simultaneously upon highway costs, form an integral and inseparable part of the road cost universe and therefore cannot properly be analysed separately.

The three-dimensional diagrams which follow may demonstrate the more complex relationships which arise when there are three variables. Initially here too the effect of traffic volume and vehicle weight on highway costs and prices will be studied. It should be borne in mind that these are not the only important factors and that there are many others -- such as vehicle speed, driver behaviour, climatic and safety considerations -- which should be taken into account as well.

It should also be noted that the two variables, traffic volume and vehicle weight, which have been singled out for analysis are not necessarily independent of each other. Thus in real life there may be a strong positive correlation between the volume of traffic and the proportion of heavier vehicles travelling on any one highway. Thus on a heavily travelled primary highway a greater percentage of large, long-distance tractor-trailer combinations may be found than on a secondary highway. However, any conclusions which can be drawn from such observations do not materially affect the subsequent theoretical analysis.

Highway Cost Analysis - Influence of Vehicle Weight

In Diagram 14 highway costs are plotted against the vertical axis, whereas the other two axes denote vehicle weight and traffic volume.

Vehicle weight could simply be gross vehicle weight. Gross vehicle weight determines partly the cost of highway bridges, since these have to be designed to the maximum loads they are called upon to carry. As far as the cost of highways, rather than structures, is concerned most engineers believe that axle load is the better unit of measurement. As Thomas H. MacDonald, Commissioner, U.S. Bureau of Public Roads, put it:

"The axle load of vehicles is the principal determinant of the supporting capacity that must be provided in the surfaces and foundations of roads. All roads, of whatever design, are limited in their axle-load supporting capacity."(15)

Other experts claim that "pressure per square inch of tire in contact with the road surface" is a unit of weight cost measurement superior still to axle loads. Going further, in effect another dimension might be added to the simple weight concept of highway costs. If there is a correlation between the deterioration of component parts of the highway and the number of load applications inflicted upon the pavement and base course, -- and many highway engineers believe this to be the case -- then "weight" *per se* would not be a very satisfactory measure. It would be better then to introduce "number of axle loads of 'x' weight applied to the highway per period of time" or some such concept.

However, for the purposes of this analysis it is sufficient to bear in mind that vehicle weight -- whether measured by axle load, gross vehicle weight, number of load applications per period of time, or in any other way -- will influence the design, construction and hence the cost of certain components of the highway. As will be seen subsequently, climatic and other factors also contribute to the cost of these items.

Highway Cost Analysis --- Influence of Traffic Volume

Traffic volume, as a concept, requires a time dimension. It has been defined in the following way:

> "Traffic Volume - The number of motor vehicles moving in a specified direction or directions on a given lane or roadway that pass a given point during a specified period of time, viz., hourly, daily, yearly, etc." (16)

Complementary to traffic volume is highway capacity, defined as "... the ability of a roadway to accommodate traffic." (17)

What is the cost relationship between the two concepts?

The maximum number of vehicles to be accommodated at any given instant of time will largely determine the geometric design of the highway, i.e. all the horizontal and vertical dimensions of the facility, such as number of traffic lanes, their width, sight distances, alignment, profile, gradients, maximum curvature, shoulder widths and so on.

But even when maximum traffic volume is known, geometric design standards do not automatically follow. Important assumptions have to be made as to the size of vehicles, their speed, the time intervals between vehicles departing from the starting point and the smoothness or irregularity of traffic flow on the open highway. The provider of highway services, in our case the toll road operator, also has to observe certain minimum standards of safety, congestion, distance between vehicles, passing opportunities-- in short, quality of service factors -- which the highway users, or the law, will insist upon.

In passing, the relationship between vehicle speed and the traffic volume which can be accommodated on a given type of highway --

and hence highway costs -- should be mentioned. M. Beckman, C. B. McGuire and C. B. Winsten in their conceptually advanced <u>Studies in the Economics of Transportation</u> [18] discuss the maximum flow of vehicles which can safely travel on a road at various uniform speeds. The writers point out that since "flow" is the quotient of "speed" divided by "spacing", hypothetical or empirical spacing functions must be postulated. Depending on one's idea of what constitutes "safety", certain values for the distances required to decelerate vehicles from various speeds can be assumed to arrive at the "minimum safe spacing of vehicles" and hence maximum flow. Evidence from the Highway Capacity Manual [19] is cited which shows:

> "In most of these studies the uniform speed corresponding to the point of maximum flow has been found to be surprisingly low, in the 11 - 25 mph range; the maximum flow itself is usually around 1800 vehicles per lane per hour." [20]

The reason for this is:

> "... that at high levels of speed, the added spacing that is necessary for a further speed increase more than offsets the direct effects of speed itself in bringing about an increase in flow." [21]

The concept of "speed", if introduced into our highway cost analysis, would therefore constitute a fourth dimension of the cost universe. If, as the studies quoted above seem to indicate, accommodation of the maximum of 1800 vehicles per lane per hour calls for a travelling speed of (say) 20 mph, then under peak traffic conditions a passenger car cruising at 50 mph, or at 5 mph, would occasion greater highway costs than the same car going 20 mph at the same time of the day.

It would also seem, from the users' point of view, that permissible travelling speed is an important highway service factor. Motor vehicle operators would certainly be prepared to pay additional tolls for high-speed travel. If the speed concept is introduced into our cost analysis, it would therefore also have to be taken into consideration in the subsequent highway revenue studies.

However, it is impossible within the framework of economic analysis to go into all the effects of traffic volume, speed and other related factors on geometric design requirements, a subject which properly belongs within the purview of the traffic engineer and the highway design engineer. It may suffice to quote an authoritative opinion on the subject:

> "Research in traffic operations over the past several years has established the effects of traffic volume on geometric design requirements for both rural and urban facilities to a high degree of reliability, especially for the items which have the greatest effect on construction costs." (22)

In this connection attention is also drawn to probably the best reference source, the Highway Capacity Manual issued by the Bureau of Public Roads.(23)

Three-Dimensional Highway Cost Analysis

Bearing in mind that traffic volume and vehicle weight are only representative labels for a number of other factors which cannot be studied at this time, we can now consider Figure 14. Highway service units, which were treated before (Figures 12 and 13) as simple, homogeneous quantities and therefore as points on a plane, now become points in space in this three-dimensional diagram.

To take a specific example: in Figure 13 distance OC on the horizontal axis denoted (say) 10,000 vehicle-miles of highway services rendered; CB (= OE) therefore indicated the marginal cost of providing highway services for the ten-thousandth vehicle-mile. By comparison in Figure 14 highway service quantities are no longer treated as simple, homogeneous units, but are broken down into two component parts: accommodation of traffic volume -- a flow and time concept -- and accommodation of vehicle weight -- an intensity of use concept. Thus distance A'A may indicate highway services rendered to the one-thousandth vehicle moving at a certain hour of the day in a specified direction over a certain one-mile stretch of the highway. In that case OA' would measure highway services for 999 vehicles and OA for 1,000 vehicles.

Similarly, distance OB' might measure highway services rendered to 14-ton vehicles and -- if one-ton weight increments are used -- OB to vehicles with gross weights of 15 tons. Linking the two variables, C'C will then denote highway services rendered to a 15-ton vehicle travelling in a given direction and at a certain time on a certain stretch of highway which is already being used by 999 motor vehicles.

The marginal costs of accommodating these increments in highway use are measured by vertical distances from the points denoting the service units. In our example (Figure 14) distance CD* would be a measure of the marginal costs of providing highway services for one more vehicle added to a traffic volume of 999 vehicles already travelling, this one vehicle weighing 15 tons, rather than 14 tons or less like all the other vehicles.

* To simplify the diagrammatical representation distance, rather than rectangles, will be taken to represent marginal costs.

We can now proceed to other examples of highway services being rendered. Distance OF might measure the accommodation of motor vehicles with a gross weight of 5 tons and OE the rendering of road services to 200 vehicles, at a certain hour under certain conditions. Consequently distance GH would represent the marginal cost of adding one vehicle with a gross weight of 5 tons, rather than of 4 tons or less like all the other vehicles, to an existing traffic volume of 199 vehicles. Similarly, distance LM might measure the marginal cost of accommodating one 2-ton van, rather than a lighter passenger car, in addition to 99 vehicles already using the particular stretch of road.

So far we have obtained three marginal cost points in space: points M, H, and D. Using analogous procedures additional points will be obtained. For example, distance PN would measure the marginal costs caused by a very light passenger car when accommodated under peak-traffic conditions. In the same way distance RQ would denote the marginal cost of providing highway services for an extremely heavy vehicle during off-peak hours.

By carrying out hundreds and thousands of observations, by relating in a multitude of cases vehicle weight and traffic volume simultaneously to highway costs, it will be possible to build up gradually a picture of highway costs associated with increments in vehicle weight and traffic volume. If sufficient numbers of cost measurements are recorded as points in space, eventually the contours of an irregularly shaped marginal cost surface will emerge. An example of such a marginal cost surface is shown in Figure 15.

Let us assume that in this diagram point B denotes the maximum combination of traffic volume and vehicle weight that will ever be imposed by any motor vehicle at any time. The vehicle calling for the most extreme combination of vehicle weight (or size) and traffic volume services, will have a weight equivalent to distance OC on the X-axis and it will travel during the peak-traffic hour, thus resulting in a total traffic volume measured by OA on the Y-axis. The <u>marginal cost</u> of serving this "extreme" vehicle will be equal to the vertical distance BE. The <u>total cost</u> of providing highway services for all motor vehicles up to and including the one denoted by point B will be equivalent to the space below the marginal cost surface and bounded by points ONADBECF.

It should be emphasized that in the example illustrated by Figure 15 the size of the total cost "pie slice" just described indicates <u>maximum total costs</u> of the most extreme service quantities the highway will ever be called upon to serve. Enclosed within the highway service boundary lines OABC are, therefore, by definition, all the less exacting use combinations. This does not mean that a number of actual highway use combinations need actually be located along these boundary lines. In other words, the projections of the irregular lines DE and EF do not have to be straight lines.

The configuration of the total cost "pie slice" can perhaps best be explained by a number of examples. Let us assume that distance OV on the X-axis denotes highway weight services rendered to a passenger car. Let us now postulate that this passenger car travels during the peak traffic hour, thus contributing -- as the last addition -- to a total traffic volume equivalent to distance OA. The highway services required by this motor vehicle are then designated by point T and they could be rendered at a marginal cost equivalent to distance TU. The two highway users denoted by points T and B would, therefore, require the same traffic volume services, although they differ greatly as regards the amount of weight they inflict on the highway. There need be no other vehicles, of whatever weight, besides the two just mentioned which require the same extreme traffic volume services. All other highway-use combination points would then be located to the left of line AB and further inside the rectangle OABC. Hence irregular line DE, the locus of all the marginal costs associated with extreme traffic volume services, may be curved inwards in the direction of origin O.

To take another example: point Q may designate highway services required by a heavy vehicle (weight OS) travelling at off-peak conditions (traffic volume OP). The marginal costs of accommodating this user would be equivalent to distance QR. Point R is, of course, as we have seen before, one of many marginal cost points which together determine the contours of the marginal cost surface.

It will be quite impossible to say without further study whether highway-use situation T will occasion higher marginal costs than highway-use situation R, or the other way around. In the former case the costs of accommodating the weight of one passenger car will be very low indeed, but possibly an extra lane may be required to allow the car to travel at the height of the traffic peak. In the latter case, traffic volume costs will be negligible if the truck uses the highway, for example, between three and four o'clock in the morning; but conceivably an extra inch of pavement may be required to carry the additional weight of the vehicle.

Cost responsibilities for each vehicle, if they had to be worked out, would depend on the exact spatial configuration of the marginal cost surface. Marginal costs would, of course, also be influenced by the number of vehicles sharing in additions to pavement thickness, number of lanes etc., if these increments are added in "steps" rather than in infinitely small doses -- a state of affairs likely to be encountered in practice.

For instance, an additional traffic lane may allow an extra traffic volume of (say) 1,000 vehicles per hour to be accommodated on the highway. The marginal costs of adding one traffic lane would then be shared by these thousand vehicles making use of it. Similarly, one additional inch of rigid or flexible pavement may make possible, for instance, additional 250,000 load applications of 20 tons gross vehicle weight each per annum. The marginal costs of the extra inch of pavement should then be distributed among the vehicles inflicting the additional load applications on the highway.

Can we say anything about the shape of the marginal cost lines DE and EF and all the other contour lines in the vertical plane? They will have the same characteristics as the ordinary two-dimensional marginal cost curves illustrated, for example, in Figure 13. The two axes are now AD, measuring marginal costs, and AB, measuring quantities of highway services rendered in terms of vehicle weight or numbers of load applications; traffic volume service is held constant. The same applies when we hold lesser quantities of traffic volume service constant (for example quantities OG or OP) and vary the amount of weight services supplied. Again, marginal cost curves for these specific situations will be obtained.

Exactly the same procedure applies when we hold highway weight services (or number of load applications) constant, for example at level OC. As traffic volume is increased a number of marginal cost points in space will be obtained which, when connected, will form a marginal cost curve between F and E. There is nothing whatsoever we can say about the shape of these and all other marginal cost curves which together constitute the contours of the marginal NDEF. There is not even any evidence either way whether there is a high "ridge" running from N to E, or whether there is a depression running diagonally through the surface of the total cost block. In other words, there is no a priori evidence that distance BE is greater or smaller than distances AD and CF.

The problem of determining highway costs occasioned by individual vehicles or vehicle categories will be discussed once more at a later stage. It is sufficient now to accept the proposition that "highway costs" are a multi-dimensional concept, and that extremely complex cost problems are encountered, even when traffic volume and vehicle weight only are considered as pertinent factors.

Climatic and Other Overhead Costs

The characteristics and significance of climatic and other highway overhead costs can also be demonstrated with the aid of three-dimensional diagrams. In Figure 15 distance ON might represent the legal, planning and other highway costs which have to be incurred prior to the construction of the road.

In addition to these preliminary costs there are construction costs which are incurred regardless of traffic volume and vehicle weight to be accommodated. The nature of these costs can best be explained by locating along both the X-axis and the Y-axis extremely small units of highway service some distance away from the point of origin. In Figure 15 distance OG denotes (say) a traffic volume of one pedestrian per year; similarly, OI may indicate a load application of one pedestrian per annum. The <u>marginal</u> costs of providing highway services for one pedestrian using the highway once per year are then represented by distance HL. The <u>total</u> costs of accommodating up to and including one pedestrian per annum can be measured by the size of the space bounded by points ONGKHLIM.

The climatic and overhead costs, apart from legal and other preliminary costs, will include all those expenditure items which are necessary to create a legally recognized highway. For instance, existing legislation may call for a minimum right-of-way of, for instance, 66 feet, before the highway is recognized as a public or private thoroughfare. In addition, substantial drainage, grading and frost protection expenditures may be incurred -- regardless of traffic volume and weight -- solely for the protection of the road from the ravages of erosion, precipitation and temperature extremes.

<u>Practical Importance of Cost Analysis</u>

It will be worthwhile to stop here for a moment to consider whether the intricate mental gymnastics of a three-dimensional cost analysis will be of assistance in solving problems of theoretical or practical importance.

As will be seen on the following pages, the configuration and size of the marginal cost "pie slice" is definitely of theoretical interest in terms of the original toll road model. The general shape of the marginal cost surface will determine, in conjunction with the marginal revenue surface yet to be discussed, the magnitude of net revenues. Cost information will be essential too for the planning of the appropriate level of output.

The three-dimensional analysis will also prove most useful when practical issues of highway user taxation have to be decided. Most of the current discussion in this field revolves around the so-called "incremental method of motor-vehicle tax allocation".* This method is given prominence in the "First Progress Report of the Highway Cost Allocation Study" submitted to the United States Congress by the Secretary of Commerce under the terms of an act which stipulated that such a study be carried out over the period 1956 to 1959. The first report of this study project -- which probably constitutes the most intensive effort ever made by any country to delve into the problem of highway cost allocation -- states:

> "One of the principal methods of attack on the motor-vehicle tax allocation problem will be that of differential-cost analysis. The incremental solution is perhaps the best known of the methods employing this general concept. This solution recognizes that two principal factors govern the variation of highway costs -- traffic volume and size of vehicle. By recourse to design practices and highway research findings the effort is made to develop, for each traffic-volume group of roads, a series of increments of cost. The first increment is shared by all vehicle groups, including the lightest. Successive additional increments are shared by successively smaller groups of vehicles in ascending order of size. This procedure is applied to each

*For a selected list of references on the incremental method see Appendix.

major element of highway cost -- right-of-way, grading, surface and base, structures and maintenance." (24)

A proper discussion of the incremental method and other techniques of highway cost allocation will have to be postponed until later. The above quotation underlines, however, how extremely relevant and topical the preceding discussion on highway cost determination is. The same goes for the concept of climatic and other highway overhead costs which was analysed in the preceding section. The "first increment ... shared by all vehicle groups", mentioned in the Progress Report, is equivalent to the first marginal cost dose required to open up the highway to traffic, however light (defined by points ONGKHLIM in Figure 15). This initial cost increment is also sometimes defined as the "costs of a basic road", i.e. of a highway designed to carry passenger cars or other light traffic only. In the real world, as a rule, these climatic, legal, and other overhead costs are quantitatively quite important.

Generally speaking, the incremental method is an attempt -- inspired originally by highway engineers -- to make use of marginal cost pricing, under a different name, for purposes of motor vehicle taxation. We shall see in a later discussion whether this method meets the requirements of true marginal cost pricing and various other economic criteria. The three-dimensional technique of highway cost analysis will then once more be very useful.

<u>Three-Dimensional Highway Revenue Analysis</u>

Following analogous procedures the three-dimensional technique can now be applied very easily to marginal revenues. In Figure 16 the vertical axis measures the marginal revenues collected from highway users. Since we stipulated that the toll road entrepreneur adheres to the precept of "charging what the traffic will bear", marginal revenues are at the same time maximum charges which can be extracted from motorists for service units and hence presumably also maximum user benefits conferred by consecutive increases in quantities of highway services provided.

In practice the toll road entrepreneur will simply charge the highest possible fees users are prepared to pay in each case. He will be most anxious, however, to note the individual quantities of highway service units in terms of vehicle weight and traffic volume for which the tolls are being paid. The service quantities might be ascertained by observation at the toll gate when the fees are being paid by the users. Thus the toll collector would note down, for example, that a passenger car owner paid $2.00 for use of the highway at nine o'clock in the morning, or a truck operator $5.00 at eight o'clock in the evening. It would be more convenient, however, to ascertain the maximum fees motorists are prepared to pay for highway use by means of market research. Interviewers would simply ask potential users not only how much they would be willing to pay, but also what vehicles they were driving and at what hours and how often they were proposing to use the toll road.

In effect the toll road entrepreneur will try to obtain, by means of observation or by market research, as much information as possible on maximum toll charges which can be extracted from users, related to vehicle weight and traffic volume service in each case. For our theoretical model it will be convenient to imagine that the toll road operator charges a double tariff: one fee for usage of the toll road at a certain time and another charge based on vehicle weight, or a similar "intensity of highway use" concept.

Both charges will be "flat" fees and he will vary them in such a way that they jointly produce a maximum toll.

For purposes of theoretical exposition let us now look at such a hypothetical two-fold tariff system. The "traffic volume" charges might take the form of fees which vary over time in accordance with users' demands. During peak traffic hours demand for highway services will be very intense and hence these tolls initially very high. It is easy to see why the marginal revenue plane slopes downwards to the Y-axis; as more and more vehicles are admitted, not only will the intensity of demand decline, but the quality of service will deteriorate, congestion will set in, the likelihood of accidents will increase, travelling speeds will decline and hence the tolls prospective users are prepared to pay will fall. Finally, at traffic volume OA all traffic which is willing to pay zero or higher charges has been attracted. If it is desired to draw even more vehicles onto the highway, then negative tolls will have to be introduced; in other words, additional users would have to be paid subsidies to induce them to use the toll road.

Similarly with the "vehicle weight or size" charges. These can perhaps best be visualized as tolls on the number of load applications per period of time, or space occupancy over time. In effect they might be regarded as tolls levied on the intensity of highway use, per hour, per month or per year. Again, as the demand for intensity of highway use is progressively satisfied, the prices which motorists are willing to pay for such services will decline. We can imagine a commercial vehicle operator who would be willing to pay very high tolls for the first x-hundred load applications exercised by his trucks on the highway. These would correspond to very urgent, very profitable freight the trucker wants to move. His -- and his customers' -- demands for subsequent units of highway service will not be as urgent and hence he will offer to pay only greatly reduced tolls. As we move to the right on the X-axis the marginal revenue plane will therefore slope downward in that dimension.

Alternatively, we can regard the second type of tariff as a straightforward levy on vehicle size and weight every time the highway is used. For technical operational reasons there presumably exists a range of "optimum" vehicle sizes and weights. At points below such a hypothetical optimum range motorists and commercial vehicle operators will be prepared to pay relatively high additional charges in order to take advantage of increments in vehicle weights and dimensions. Once the optimum range has been exceeded, users will have very little incentive to use bigger vehicles and will therefore not offer to pay high marginal weight and size tolls. As a consequence the marginal revenue plane will eventually slope down to the X-axis, as shown in Figure 16. Distance OB might define the absolute limit for the largest and heaviest vehicle known tc exist. In practice OB would be equivalent to the largest and heaviest commercial vehicle permitted by law.

Let us now look at an example of a combined weight and traffic volume user charge. Distance EG, for instance, may measure the maximum toll a commercial vehicle operator is willing to pay for highway use under specified conditions. Assuming that the vehicle concerned has a gross weight of 10,000 lbs., and is to be added to 499 vehicles already travelling on the highway, then maximum toll charge EG has to be positioned in such a way that OD (= EF) measures a traffic volume of 500 vehicles and OF (= ED) measures a highway weight use of 10,000 lbs. In the same way hundreds and thousands of other maximum revenue observations will be determined and plotted; consequently, the spatial configuration of the marginal revenue surface will eventually emerge.

It is important at this stage to rid ourselves of the notion that charges necessarily go up with increases in gross vehicle weight or vehicle dimensions. We are discussing the repercussions of a rate system based on "what users are willing to pay". A priori we cannot say whether user behaviour is such that higher weight charges can be levied on a 19,000 lbs. or a 21,000 lbs. vehicle, than on a 20,000 lbs. truck. The way in which Figure 16 is drawn should therefore not be taken to indicate that charges which can be extracted decline all the way with weight increases; the curves plotted against the X-axis and the Y-axis may rise initially and then fall, or they may have some other shapes.

The irregularly shaped marginal revenue surface in Figure 16 defines the maximum limits of charges users are prepared to pay under the various possible combinations of weight and traffic volume services rendered. Consequently, the size of the space below the marginal revenue surface and contained within points OACBI is a measure of the magnitude of total revenues collected when all traffic willing to pay zero or higher charges is admitted to the highway.

Practical Importance of Revenue Analysis

It might be argued that the two-tariff system, or the notion that tolls can be associated with definite weight and traffic volume quantities, unnecessarily complicates the analysis. It could rightly be said that users are simply interested in total outlay and not in a breakdown of the prices they have to pay under the headings "volume of traffic toll" and "vehicle weight toll".

True, the total toll charge will, in the final analysis, determine whether the motorist is going to use the highway or not. It should be emphasized, however, that the same user with the same vehicle will be prepared to pay different charges at different times of the day, of the week or the year; hence, he does in effect adhere to a two-structure tariff system.

Finally, from the toll road planner's point of view and for theoretical reasons it is essential to recognize the two aspects of the user charges. If the cost analysis reduces all highway costs to the two factors "traffic volume" and "vehicle weight", then it must find its counterpart in a corresponding charging system based on these factors as well. Only in this way can the optimum output and investment solution be found.

From a practical point of view the three-dimensional revenue analysis will prove exceedingly useful when the so-called "benefit approach" to motor vehicle taxation is discussed later in this study. The benefit approach, like the incremental cost method, has achieved a certain degree of prominence in the United States in recent years.

There is no evidence that existing toll roads in the United States or elsewhere charge on the basis of <u>both</u> vehicle weight and addition to traffic volume. Most toll charges go up in stages with gross vehicle weights (or axle loads). As a rule tolls are also graduated according to mileage travelled; in many cases the mileage charges are regressive, i.e. tolls per vehicle-mile decline with increasing length of trip. For purposes of our toll road model travel distances -- and hence mileage rates -- can be neglected if we discuss a highway which connects two points only, with no intermediate points of egress or entry. If such intermediate points do exist and if therefore different users desire to travel different distances, then separate models for these various cases have to be constructed.

There has been at least one proposal for variable toll charging. The Bureau of Economic Résearch, Pittsburgh, Pa., recommended variable charging as "... an effective and variable traffic regulation device inherent in a toll road." The Bureau stated:

> "The toll can be made variable with the time of day, the day of the week, the month of the year, the length of the trip, as to one or more classes of use ... Opportunities for traffic regulation by use of variable tolls are numerous. So far as is known the variable toll device has not thus far been exploited in connection with toll highways." (25)

The Bureau of Economic Research suggested that such "price rationing" of highway services could be used to assure rapid movement of high priority traffic, deemed to be of great economic value to the community.

Output Determination

We now come to the last stage in our three-dimensional analysis: the determination of the most profitable level of output by the toll road operator. The marginal cost surface shown in Figure 15 and the marginal revenue surface of Figure 16 are now combined in Figure 17. When looking at this diagram some allowance should be made for the difficulties encountered in drawing the complex spatial interrelationships between the marginal cost and marginal revenue surfaces.

Following the reasoning developed in Chapter II and demonstrated in Figure 13, the best level of output from the toll road entrepreneur's point of view will be determined by the intersection in space of the marginal revenue and marginal cost surfaces. In our case the two surfaces cut through each other at extreme output combination point D (projected to point C). Hence the optimum output will be OA units of traffic volume service, combined with OB units of vehicle weight service. These are the most extreme output values. Any further increases in traffic volume service or vehicle weight service could be provided only at a marginal loss by the entrepreneur.

Let us suppose now that the marginal cost curve ED for the given extreme traffic volume OA, arrived at by varying quantities of weight services, is fictitious, in the sense that there is no other vehicle making use of extreme traffic volume service OA; in that case line ED would not really exist as drawn, but would be curved towards the origin. Will this affect our analysis? The answer is that our analysis still applies, provided marginal costs and marginal revenues are properly defined and measured. Even if there is no other vehicle -- beside the one denoted by point C -- to share the costs of the extra highway facilities needed to bring service quantities up to levels OA and OB, these extreme outputs will be produced as long as the one vehicle pays the corresponding marginal costs. If there are no other users requiring extreme service quantities OA and OB, marginal costs of the last combination of highway service units (CD) will, of course, be very great indeed.

To recapitulate: at output combination OB and OA the marginal costs of rendering the last unit of highway service (CD) are identical to the maximum toll charge (CD) which can be exacted from the vehicle operator in question. In other words, the motor vehicle which is most costly to accommodate on the highway -- combining heavy weight and large size with desire for peak-hour travel -- and which at the same time is just about able to cover the marginal costs it occasions, will determine the optimum level of output of highway services.

This is a most important conclusion. Suppose we were confronted not with problems of profitability and net revenue maximization, but only with the question of optimum output determination; we would then only have to concentrate on equalization of marginal costs and marginal revenues at extreme output levels. The configuration in space of the rest of the cost and revenue planes would not concern us as long as the minimum condition "marginal revenues must <u>at least</u> equal marginal costs" is satisfied for all vehicles. Under the circumstances our time and energy would not be spent on the determination of intermediate marginal cost and revenue positions, but would be concentrated on finding the extreme values. We would try to find answers to such questions as: what extreme traffic volumes can be accommodated without incurring a loss on the peak facilities (extra traffic lanes, wider right-of-way etc.) which would have to be provided? And: what are the charges which can be borne by the heaviest and largest vehicles and are they at least equal to the extra highway costs attributable to these vehicles? Merely for the purposes of output determination the rest of the revenue and cost schedules -- difficult to arrive at under the best of circumstances -- would be of no particular interest to us.

The Importance of "Extreme Values"

The practical significance of the proposition that only the "extreme values" of traffic volume and vehicle weight or size (and speed or any other factors which might be introduced) are required to arrive at optimum output solutions, should be recognized. In the real world, highway engineers do try to find these extreme values empirically or intuitively in order to apply them to the planning of public highways and the regulation of motor vehicles.

As far as vehicle sizes and weights are concerned, highway authorities deliberately rule out the most extreme values by restrictive regulations. Instead of limiting the weight or space intensity of highway use to economic values by means of the price mechanism (i.e. by letting output be determined by the intersection of the marginal cost and revenue surfaces, as shown in Figure 17), the authorities generally "ration" highway services by vehicle weight and size regulations. Thus instead of allowing the biggest and heaviest motor vehicle in existence (equivalent to distance OB in Figure 16) to use the highway, vehicle weights and sizes are deliberately cut back by regulation to what highway engineers and administrators believe to be the "economic limits" (for instance distance OD in Figure 17).

It is then a matter of debate precisely what those economic limits ought to be. There does not seem to be one answer. Existing commercial vehicle weight and size regulations in the Canadian Provinces and in the United States show extremely great variations from the most restrictive to the most liberal provisions. For example, the permissible maximum gross weight for commercial vehicles or vehicle combinations is 106,000 lbs. in Ontario, but only 20,000 lbs. in Newfoundland.[26] Generally speaking, there has been a very marked trend over the years towards both higher legal load and size limits, and the use of greater numbers of heavy and large vehicles on the highways.

For some years research into the question of extreme weight and size values has been going on in the United States. The Highway Research Board stated in 1954 in a study and problem outline:

> "There appears to be general agreement, engineering-wise, that highways can be built to carry weights much heavier than those currently permitted but at a greater cost for the highway facilities. Likewise, truck and trailer manufacturers generally agree that freight vehicles of much greater gross-weight capacity can be built. The carriers, the users of both the highways and the vehicles, are divided in their opinions regarding needed changes in size and weight regulations, because some commodities need heavier payload weight allowances, whereas other commodities need larger payload cargo space.
>
> The trucking industry claims that costs of transporting freight can be reduced with vehicles of larger size or greater gross weight than are permitted .... and the industry generally is pressing for further increases in vehicular sizes and weights. Whereas, primarily because of the desire to protect their extensive system of existing pavements and bridges and because of the greater costs involved in further increasing the weight capacities of highways, <u>state officials oppose increases in size and weight limits</u>.
>
> From either viewpoint, <u>the technological aspects are not the</u>

prime limiting factors, rather the economic factors are predominant. It is in the joint economic relation between motor truck operations costs, and highway facilities costs, that there is a dearth of factual data."[27] (underlining supplied)

Hoy Stevens, of the Bureau of Public Roads, in a paper entitled Economic Research In The Truck-Highway Weight Problem[28] also stressed the economic nature of the problem.

Research into the question of extreme vehicle size and weight values must go on in the interest of highway transport as a whole. Excessively heavy construction of highway, demanded by only a few vehicles, must be avoided; at the same time size and weight limitations must not be frozen at too low a level, considering total true transport cost reductions which may be made possible by the use of larger and heavier equipment. In the United States both the AASHO Road Test Project[14] and the Highway Cost Allocation Study[29] are now looking into the question. In Canada the writer, under a project sponsored by the Joint Highway Research Programme of the Ontario Highway Department and the University of Toronto, attempted to assess the demand and future market for heavy commercial vehicles, taking into account the views of trucking operators and truck manufacturers; a report on the findings of this study will be published later in 1957.

Just as in real life vehicle size and weight services are "rationed" by restrictive regulations, so traffic volume, at its extremes, is "rationed" by congestion. In practice highways are not planned and designed for peak traffic capacity (represented, for example, by distance OA in Figure 16), but are deliberately built for a smaller volume of traffic (such as OA in Figure 17) which is regarded as the "economical" one. Based on empirical yardsticks highway engineers normally design roads and streets for the expected 30th highest hourly traffic volume in a year. In this way there will be twenty-nine hours of peak traffic conditions when highway facilities are insufficient and users simply have to endure congestion. The deterioration of quality of highway services to this limited extent is regarded as reasonable and necessary.

In summary we can say that if we are not concerned with individual cost responsibilities and individual toll charges which can be extracted from users under a dissimilar pricing regime, then definite optimum output solutions can be found by merely determining the extreme values of vehicle weight, vehicle size, traffic volume, traffic speed and other factors. It was seen that some practical procedures exist to limit output to economic ranges of values and that continuing research is directed at improving these procedures.

However, in the case of our model, the toll road operator is definitely interested in the size of his prospective net earnings and hence he has to have complete revenue and cost data over the whole output range. Net earnings are, of course, the difference between total revenues and total costs. The magnitude of net earnings is diagrammatically delineated by the contours of the marginal revenue and marginal cost planes. In Figure 17 net earnings are defined by points GEDFH. It is the size of this net earnings "pie slice" that the toll road operator wishes to maximize.

Conclusion

In conclusion it should once more be emphasized that the three-diagrammatical analysis employed in this chapter must not be regarded as a key to the many highway price, cost and output problems which confront us in the real world. It is most valuable as an expository device. As such it is certainly superior to any analytical technique which employs merely two variables at a time. Most of the current controversy on highway economics stems from the fact that one writer discusses the vehicle weight aspect of road costs, the second the influence of traffic volume and the third space occupancy, or some other cost element.

In this chapter only two of a great number of factors which together form "highway costs" were discussed. Even these two relatively simple highway cost components were shown to be more complex than might have been thought initially. For instance, a time dimension had to be introduced and traffic volume became "number of vehicles per unit of time" and vehicle weight "number of load applications per unit of time". Similarly, vehicle speed was seen to influence the maximum flow of traffic a given highway can accommodate.

The field of highway economics seems to have a great attraction for many people -- legislators, engineers, economists and others -- who believe that conclusive and irrefutable solutions to the numerous existing problems can be found with a minimum of effort and thought. On a theoretical level of discussion it has been shown, however, that even in the most uncomplicated of all cases, the toll road, great difficulties have to be overcome before determinate highway cost, price and output results can be obtained. On a practical plane one would expect that existing toll roads -- which after all are simple organizations compared with our complex, far-flung and diverse public road systems -- might be leading the way with advanced highway price and cost techniques. There is no evidence that such methods are employed by toll road authorities at the present time.

The present chapter will have served its purpose if it has emphasised the fact that there are no simple solutions in highway economics. A careful and critical approach will therefore be an asset when problems of public road systems are discussed later in this study.

IV - TOLL ROAD MODEL - FINAL CONSIDERATIONS

In the last chapter toll road costs and revenues, as well as the problem of determining optimum output, were subjected to detailed analysis by means of three-dimensional diagram techniques. In the present chapter we shall once more return to the main theme: the planning of toll road investment. First the question of additional revenues which the toll road operator may be able to derive from activities only indirectly related to the highway proper will be discussed.

Additional Revenue-Producing Activities

According to the initial assumptions on the basis of which the toll road model was set up, the entrepreneur is being neither restrained nor encouraged by the state in the pursuit of his activities. This implies that he is perfectly free to engage in other revenue-producing activities which may be related to and contingent upon the operation of the toll road. By assumption the entrepreneur in our model decided to embark upon the promotion and operation of a toll road as his main activity. We shall therefore limit our discussion of additional revenue-producing pursuits to those which are subsidiary in character to the main activity. In other words, we shall deal only with gainful activities which are made possible by the existence of the toll road.

Changes in Land Values

There is a very definite relationship between improvements in highway transport facilities and the value of adjacent land. In some cases highway development may have a depressing effect on property values in the vicinity; a farm might for instance be cut in two by the road, forcing the farmer to take circuitous routes to reach his fields; or the character of a quiet residential district may be adversely affected by a heavily travelled urban expressway running through it. However, within the framework of our toll road model, these negative effects presumably will be reflected in the higher land prices and toll road operator will have to pay to property owners thus affected for the necessary right-of-way.

In practice much more important than the negative effects will be the increases in land values resulting from highway improvements. The <u>First Progress Report of the Highway Cost Allocation Study</u>[30] discusses in a most thorough fashion the effects of road development on both rural and urban land appraisements and notes significant increases in property values in all cases which were studied in the United States. It is shown that the construction of the Gulf Freeway in Texas, for example, resulted in land value increases of 121 and 78 percent in two control areas close to the freeway, whereas land prices in two remoter areas advanced by only 26 and 5 percent (see Table 18). D. M. Winch in his study "The Economics of Highway Planning"[31] shows similar land value changes in the New York area attributable to parkway construction (see Table 19). Unfortunately, no Canadian studies can be quoted.

While there is strong historical and empirical evidence for a positive correlation between highway improvements and land values, the actual nature and character of the interrelationship is difficult to appraise. The First Progress Report states:

> "In the case of property-value changes resulting from highway improvements we can, perhaps, in theory ascribe virtually all of the rise in property values to the

capitalization of time savings and other vehicular benefits; but the two problems of (1) isolating property value changes due to highway improvement from rises in value due to other causes, and (2) accounting for the increases thus identified in terms of transferred or capitalized vehicular benefits, present formidable obstacles to a quick solution. The effects, both favorable and adverse, of new highways on properties of various types are extremely complex, but a body of information along this line is accumulating."(32)

If we accept the view that land value increases are "simply the indirect effects of benefits realized in the first instance by the motor vehicle"(33) and hence are "transferred benefits", to use the terminology of the First Progress Report, then we have to effect a reconciliation of this idea with one of the key assumptions of our toll road model. If, as stipulated, the toll road entrepreneur charges exactly "what the traffic will bear" then there are by definition no benefits left to be transferred to other spheres once users have got through paying their tolls. The same applies to the other categories of "transferred benefits" which will be discussed subsequently; these would theoretically also fall prey to the perfectly flexible and dissimilar charging system of the omniscient -- and greedy -- toll road operator.

However, this is taking a very extreme and unrealistic view of things. We can well imagine that in practice a significant proportion of land value increases, although initiated in the first place by highway development, will really be caused by a secondary wave of population growth, change in land use, general industrial and commercial development and other economic factors not directly dependent on the highway and which may thus elude the net of the toll collector. It is also a moot point to decide whether the toll road operator can really afford to charge away all possible direct and indirect user benefits, since he may have to rely on a certain amount of economic growth to generate sufficient traffic for his toll road.

We can also recognize a category of benefits which, although conferred by highway development in the first place, have nothing to do with vehicular travel and therefore cannot be turned into toll revenues. The First Progress Report[7] cites the following examples of such "nonvehicular benefits": pedestrians' use of sidewalks, drainage of adjacent land by storm sewers, public utility installation on the right-of-way, services provided to abutting property by street lighting, action of the road as a firebreak and so on. Not all of these nonvehicular benefits will arise in the case of our toll road, since they are more typical of city streets.

In any case, it can be expected that the toll road operator will indulge in land speculation as an additional source of revenue; this is very likely because trends in land values depend so much on the exact location of the highway, the points of exit and entry, control and layout features, charges and so on -- all matters of prior knowledge to the toll road entrepreneur.

Expected earnings from real estate activities conducted in conjunction with toll road building will therefore certainly be taken into account by the entrepreneur in his initial planning and investment deliberations. The same applies to other developmental activities he may pursue. Under modern conditions, time of travel is more important as a location factor than distance in residential, industrial or commercial development. New industries locate themselves along major highways and rely to an increasing extent on road transport which offers faster and better services -- although frequently at higher rates -- than the railways. The toll road operator may therefore very well gainfully engage in industrial promotion and site development for productive purposes. In this way he will "sell" a whole range of services -- transportation, industrial land, possibly buildings and other services -- in the same way as a suburban developer sells houses, land, access streets, sewerage, water and power supply, play grounds, parks, zoning laws and a planned neighbourhood to his clients.

In all this the toll road operator has to resolve conflicts between his main function as a provider of highway services and the various additional activities he may engage in. If he really charges in such a way that no transfer of benefits to other spheres takes place, he will inhibit any economic growth in the region and hence neither his traffic nor his land value expectations will be realized. If, on the other hand, he adopts a more liberal toll charging policy but drives up land values too high in his subsidiary role as a real estate speculator, he will certainly not attract industry and hence motor traffic.

Clearly, he will have to strike an economic balance between his main and his subsidiary activities. His aim will be to maximize over time net revenues, from whatever sources they are derived and in whatever proportions. In extreme cases he may give away land free to settlers or industry in order to encourage traffic. In other instances he may charge no tolls at all, or very low tolls, in order to promote industrial activity and increases in land values.

The toll road operator's decisions in this respect will largely be determined by the length of the project period he sets for himself. Supposing he anticipates unfavourable environmental and technological changes in the not too distant future and he therefore aims at net revenue maximization over a relatively short period of time. In that case he will possibly ignore the long-range revenue potential of, say, industrial and residential development; he will instead concentrate on the short-term revenue producing activities.

If, on the other hand, he adopts a long-range policy, his initial tolls may be set at a very moderate level because this will encourage general economic and traffic growth. Over time he will, of course, adapt his pricing approach to the changing situations as they develop. In this way the short-term toll charging tactics will be subordinated to the long-term net revenue maximization strategy which calls for the encouragement of economic growth and development.

<u>Other Additional Sources of Revenue</u>

There are other profitable sources of revenues, more directly connected with the toll road, which he will tap. As an important by-product of limited access to the highway -- an essential feature of any toll road -- there will be great scope for a variety of service establishments catering to motorists, such as hotels, restaurants, shops, gasoline and service stations. The rights to operate service establishments might be let on a contract basis to concessionaires who would bid for the franchises.

In the real world, such concessions can become very lucrative sources of revenue for transport operators. Wilfred Owen and Charles L. Dearing in their book <u>Toll Roads and The Problem of Highway Modernization</u> quote an example from the field of air transportation:

"... of the $1.9 million in revenues realized at La Guardia Airport by the Port of New York Authority during 1949, $1.1 million was so-called nonflight revenue. They included income from newsstands and eating counters, restaurants, parking areas, taxi concessions, and gasoline stations serving automobiles."(34)

The same authors demonstrate that revenues from concessions constitute important sources of income for a number of parkways and toll roads in the United States. The Merritt Parkway, for example, obtains rent from gasoline stations and royalties on gallonage sold. In 1949 the revenue from these sources amounted to $271,200, or more than the $225,049 expended for maintenance on the 37 miles of parkway. On the Pennsylvania Turnpike, concession revenues in the fiscal year 1949 were $362,000 or about 27 percent of the $1,334,000 expended for all operating purposes.(35)

Undoubtedly the toll road entrepreneur in our model will also avail himself of these lucrative sources of incomes. Again a conflict arises between main and subsidiary activities. A small number of selected and well-placed service establishments will be an asset to the toll road itself, provided a proper economic balance is struck. For example, very high gasoline prices may cancel out all the fuel-saving advantages which motorists hope to derive from toll road use. Also, if the number of service establishments increases unduly, attractiveness and safety of travel offered normally by the road will be diminished and hence traffic will decline.

While a small number of roadside establishments may serve a proper purpose, the case of advertising signs on the highway is unequivocal: motorists derive no advantages whatsoever from the presence of roadside billboards. This is a fact the toll road operator will bear in mind. Finally, additional revenues may be obtained by permitting power, telephone and natural gas companies to place their transmission facilities on the toll road right-of-way.

To conclude this discussion on additional revenues which can be derived from activities related to toll road operation, some broad, general principles should be stated. The opening of a toll road* will create opportunities for a number of profitable activities which are, however, subsidiary in character since they will cease to exist when the main activity is terminated. These auxiliary revenue producers thrive, in the last analysis, on so-called "transferred benefits" made possible in the first place by vehicular use. Theoretically these other lucrative pursuits could be fully exploited and be made to pay under the ordinary toll charges system. Thus even general state and community services provided by vehicular means,** such as fire and police protection, military transport,

* In many cases land values in adjacent areas rise even before the highway has been built; this proves that land price trends, as influenced by highway development, can be predicted fairly accurately and should therefore be anticipated by appropriate commercial action.

** The First Progress Report lists the following categories of transferred vehicular benefits and points out that at the same time some of them may also be regarded as nonvehicular benefits: "(1) the social and economic benefits of Federal, State and local government services provided by vehicular means, e.g. fire and police protection, postal service, and school buses; (2) the importance of the availability and use of roads by military vehicles; (3) widely diffused developmental benefits, both social and economic, brought about by highway improvements; and (4) the creation of business opportunities, such as the development of industrial and commercial establishments that has occurred along Massachusetts State Route 128, the New York Thruway, and other expressway facilities.
It will be generally acknowledged that all of the above-listed benefits are indeed transferred benefits derived in one way or another from vehicular use. They do present some peculiar problems, however. For example, the benefit derived from highways in connection with fire protection is one of reducing the time and effort needed for fire apparatus to arrive at the scene of a fire. Obviously, the value of time to the fire department, measured in terms of the value of the property it can save, is something very different from the value of time to the ordinary automobile or commercial-vehicle operator."(36)

postal services, school buses, could theoretically be charges on the basis of "what the traffic will bear." It has to be recognized, however, that there is no distinct boundary line between direct, indirect and transferred vehicular benefits, which could presumably all be converted into revenue by means of toll charges, on the one hand, and nonvehicular highway benefits which would have to be tapped by some other means, on the other hand.

The toll road operator may find it more convenient and more profitable, therfore, to tap these subsidiary revenue sources indirectly, by engaging in real estate dealings, industrial development, and by operating service establishments which cater to motorists. He will always be guided by the basic precept of net revenue maximization; he will therefore in his investment calculations very carefully balance the potential revenue contributions of one activity against the possible resultant revenue losses sustained by another activity.

It is important to note, firstly, that he will not neglect any sources of income made possible by the opening of the toll road; and secondly, that he will, in the long run, transform all of the direct, indirect or transferred benefits created by toll road use into revenue accruing to him. Although in practice some widely diffused social and economic developmental benefits brought about by highway improvement will escape the attention of the toll road operator, in theory at least and over a very long period of time, all benefits will be turned into revenue under the widest interpretation of a "charging what the traffic will bear" regime.

Profitability and Priority of Toll Road Projects

Following the arguments developed on the preceding pages, the toll road operator will therefore interpret "gross revenues" -- one of the working parameters for his investment deliberations -- in the widest sense and will include under this heading not only estimates of potential toll road receipts, but also gross earnings from subsidiary activities. Total costs will only mean real costs to him, since he will try to pass on as large a proportion as possible of nuisance and other general costs to the community. However, as the scope of his activities expands and as they embrace all revenue-generating direct, indirect and transferred benefits, so the magnitude of costs which can be passed on to the community at large will contract. If the toll road operator owns all the adjacent land, the nuisance costs caused by highway dust, noise and fumes will be borne by him in form of lower land values. The costs of annoying motorists by means of advertising signs or rows of hot-dog stands on the roadside, through accident costs caused by lack of access control and through other social costs, will be borne in full by him through reduced toll user receipts.

It will be useful for the subsequent toll road investment analysis, as well as for the discussion of public road systems in the following chapters, to interpret the terms "total revenues" and "total costs" as including all direct and indirect revenue and cost factors. This will make it possible to take the desirable overall view of highway finance.

After having carried out cost, revenue and feasibility studies for a number of toll road projects, the entrepreneur will now be in a position to arrive at a final investment decision. In principle he will be justified to carry out all projects which promise net revenues (or net benefits) above costs, if costs include interest charges.*

We might therefore visualize our entrepreneur as promoting in some order of priority <u>all</u> profitable projects until he reaches the last one which yields no net revenues at all. Although this may be possible in theory, there will be limiting factors in practice. If we realistically assume that there are degrees of risk associated with the promotion of toll roads, the entrepreneur will embark only upon projects which yield some extra net revenues; these might be regarded as payments for risk-bearing services rendered by the promoter. Some low-profit or high-risk projects will therefore be disregarded by him. His physical and mental capacity to promote, co-ordinate and to make decisions will also put a check on the number of projects he can engage in at any moment of time.

More important is the fact that the toll road entrepreneur does not act in isolation, but is subjected to influences stemming from the actions of other promoters of profitable projects and from the general economic environment. The toll road entrepreneur himself, by virtue of his role as a promoter of capital investment projects, may drive up the rate of interest at which funds can be borrowed and hence decrease the number of profitable toll road undertakings. The promotional activities of other entrepreneurs will have the same effect. Accepting Professor David McCord Wright's working proposition "that under certain reasonable assumptions the rate of interest would be set by the intersection of the schedule of the marginal efficiency of capital with the rate of saving"(37),

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*In line with the definition and breakdown of total highway costs given in Chapter I and Table 1, interest charges are included in total toll road costs.

the rate of interest will go up when the marginal efficiency of capital* shifts upwards, provided the level of savings remains constant.

Following Professor McCord Wright's apt comparison,(39) it can be imagined that there is a constant flow of investment funds into channels of investment opportunities within the entire economic system at any given moment of time. Apart from general economic and social factors which create investment opportunities, such as population growth, technical invention and change, changes in tastes and consumers' demands, entrepreneurs and promoters like our toll road operator will largely be instrumental in opening up new channels of investment opportunities and directing the flow of investment funds into these channels. If the flow of investment funds (i.e. the flow of savings) remains the same, but investment opportunities and hence the rate of promotional activity increase, then funds will automatically be "rationed" by higher interest rates and/or inflation. In either case, and this is of prime importance for our model, total costs of all projects will be increased -- through higher capital charges or through general factor price increases -- and hence a number of the previously least profitable planned projects will be eliminated altogether.

The whole process, which is difficult to describe in words since it is dynamic and not static, may be regarded as an almost automatic adjustment device regulating the minimum level of net revenues required for the allocation of investment funds. Although the rule still applies that the toll road entrepreneur would be justified to carry out all projects which promise net revenues above

*Defined as "the expectation of profit to be derived from starting a new project or increasing the output of an old one".(38)

costs, in view of the inherent instability to which this minimum measuring mark itself is subjected, it will be necessary to employ an additional measuring technique to judge the relative profitability of each project and hence the priorities for the allocation of resources for investment purposes.

Relating Net Revenues to Capital Investment

There are two methods to arrive at rational investment priorities.* Firstly, the net revenues which each project offers are related to the capital investment in each case. This is the businessman's normal calculation of the rate of profit; the result is usually shown as an annual figure. Out of a number of proposed projects the toll road showing the highest annual profit rate will be given first investment priority. The arithmetical formula for the calculation of priority figures on this basis is:

$$P = \frac{G_e - C}{I} \times 100$$

where P is (annual) rate of net profit in percent, G_e is gross (annual) revenue, C is total (annual) cost and I is capital investment in the facility.

Relating Net Revenues to Total Costs

Following the second method net revenues are related to total costs; the result is shown as a percentage ratio. The formula is:

$$R = \frac{G_e - C}{C} \times 100$$

* For a very good discussion of the use of priority calculations in highway planning and a thorough description of arithmetical methods see R. J. P. van Glinstra Bleeker's Some Economic Aspects of Road Development, a paper given at the International Road Federation World Meeting in Rome, 1955.(40)

where R denotes the benefit/cost ratio, G_e gross revenue and C total cost. Either annual figures, or figures relating to the lifetime of the project can be used in the formula; in the latter case discount rates must be employed. Again, the project promising the highest revenue/cost ratio will be given first priority.

As R. J. P. van Glinstra Bleeker points out[41] net revenues (or net benefits) can be related either to capital investment or to total costs for purposes of priority determination. It is important, of course, that the same method is used for all projects thus to be assessed.* For purposes of toll road investment planning the second formula, using anticipated revenues and costs for the entire project period, may be more convenient since the necessary data have been compiled for planning purposes anyway and are therefore readily available. For comparing the profitability of the toll road with investment possibilities in other fields on a yearly basis the first formula must be employed.

Restatement of Steps Taken by Toll Road Entrepreneur

To bring the discussion in its entirety into proper focus it will be convenient to recapitulate the various steps taken by the toll road operator to finally arrive at a rational investment planning decision. The toll road promoter in our model will proceed in the following manner:

(1) Initial survey of investment opportunities existing in the economy generally will be carried out; taking into account risk, the field offering greatest profit expectations will be chosen; it is assumed, for the

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*The profitability calculations can also be used to determine priorities for subsidiary revenue producing activities, such as those described at the beginning of the chapter.

purposes of the model, that toll road promotion is being selected.

(2) Costs and potential revenues offered by a number of toll road projects will be studied.

(3) By benefit analyses and other market research methods maximum gross revenues will be estimated, which can be extracted from users under a perfectly dissimilar pricing system at various levels of output.

(4) Estimates of marginal costs associated with various levels of output will be carried out.

(5) From (3) and (4) optimum output, set by the intersection of the marginal cost and marginal revenue curves, will be determined.

(6) From (3), (4) and (5) net revenues for each project will be calculated.

(7) Potential net revenues of subsidiary activities will be calculated and added to the result of (6).

(8) As a general rule, all projects yielding some net revenue will be considered by the toll road promoter. Due to changes and uncertainties inherent in the economic process, possible projects will be arranged in order of priority. Priority ratings will be established by means of "net revenue/cost" or "net revenue/capital investment" ratios.

(9) The toll road entrepreneur will select the project with the highest priority rating for immediate implementation.

Secondary Managerial and Technical Decisions

The sequence of actions and decisions outlined above will establish the essential, basic framework for toll road investment. In particular, the process will provide broad, general solutions for the location of the toll road, the desirable maximum output values and the extent of additional revenue-producing activities. There still remains the task of solving a whole host of secondary problems within the basic framework of the main investment decisions.

An example of such secondary planning problems is the precise determination of the extreme output values according to the technical categories "intensity of traffic service", "volume of traffic service", "speed of traffic service" and so on. Suitable techniques were discussed in Chapter III.

Another group of problems calling for technical or managerial decisions arises from the fact that certain given quantities and qualities of highway services can be produced with different admixtures of fixed and variable costs, since these are inversely related to each other. The same output results over time may be achieved, for example, by high fixed costs (in other words, very durable highway construction) coupled with low maintenance expenditures; or alternatively by low initial construction expenditures combined with high costs of upkeep. Provided that no deteriorations of service qualities or diminutions of service quantities are incurred, the combination offering the lowest total costs over the project planning period will be chosen. Appropriate methods for arriving at solutions were described in Chapter I.

Fluctuations in Traffic Demand over Time

Yet another category of problems is introduced when fluctuations in demand for highway services over time are taken into account. Great variations in highway travel will normally be experienced over a period of 24 hours. Daily traffic volumes will, for example, show sharp hourly peaks between 8 and 9 a.m., possibly between 12 noon and 1 p.m. and finally during the traditional 5 to 6 p.m. "rush-hour". There will also be weekly, monthly and seasonal variations. Superimposed on top of each other these traffic variations may produce exceptionally high compound peak traffic volumes.* In addition to these repeated fluctuations there will be a long-term secular growth (or a secular decline) of traffic. If we take an extreme view, each year, each month, each week or day, and in the last analysis each hour or even minute, will therefore have its own, unique demand schedule for highway services. Consequently, there will be different sets of desirable "extreme values", depending on the demand conditions and cost requirements of the various traffic peaks. The question then obviously arises which one of the many demand schedules should be selected for investment and production plans.

D. M. Winch in his The Economics of Highway Planning demonstrates ably how the different demands for highway services which

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* A good example of a combined daily, weekly and seasonal peak is quoted in the Ontario Department of Highways' study A Plan For Ontario Highways:

> "... on Sunday, July 10th, 1955, between 8 p.m. and midnight, only 720 motor vehicles travelled northwards on Highway 400 from Toronto towards Barrie, but 12 times as many vehicles, a total of 8,700, travelled in the opposite direction. This is in marked contrast to the general experience on most other routes where the peak volume of traffic going one way is usually not more than twice as high as that in the opposite direction." (42)

arise when "time" is introduced can be reconciled and how the most economical (i.e. the most profitable one for the toll road operator, in our case) final output solution can be found.[43] The guiding basic principle is that of cost minimization and utility (in our case, revenue) maximization. A number of different plans will be drawn up, each showing the optimum volume of traffic as determined by the point of intersection of the specific demand (marginal revenue) and marginal cost curves. Thus there may be a plan for morning traffic, one for noon traffic, one for afternoon rush-hour traffic and one for midnight traffic; similarly, weekly, monthly and seasonal variations may be introduced by preparing additional plans to cover the various situations. Finally, it is pointed out by D. M. Winch, these plans "must be reconciled, and the optimum compromise will be that plan which involves the least total unnecessary costs at times when it is not the optimum."[44] And: "Thus by this method of totalling unnecessary costs of sub-optimum solutions at each time we can calculate the best compromise solution, and the problem of the peak can be solved mathematically."[45]

Secular growth of traffic is treated in a similar way, with the difference that unnecessary costs of each plan in future years "must be discounted at the current rate of interest to arrive at its current capitalized value."[46] D. M. Winch points out that over longer periods of time compound solutions become possible, such as a plan which calls for land acquisition for a four-lane divided highway and construction of only a two-lane road now, with the second two-lane road to be constructed later when needed. He finally states:

"However many plans, compound and single, are considered over whatever period of time, with whatever complex peak and growth patterns of demand, this method will always give one method as the best. In complex cases the calculations will be complicated, or rather there will be a very large number of simple calculations, but there will always be a determinate optimum solution for any given set of data."(47)

It should be noted that D. M. Winch's "costs" in this analysis are both vehicle and highway costs combined, since he considers a public highway system and therefore aims at over-all highway transport cost minimization (and "utility" maximization). He therefore computes "unnecessary costs" of the sub-optimum solutions not only in terms of total highway transport costs (both road and vehicle costs) which could have been avoided if the better plan had been adopted, but also in terms of the loss of "utility" or "benefits" caused by not carrying some portions of traffic at all under the inferior plan.

The situation is somewhat different in the case of our toll road model. Under our assumption of perfectly dissimilar pricing, Winch's losses or gains in "utilities" or "benefits" are simple revenue losses or gains under the terms of our model. Winch's avoidable or unnecessary overall highway transport costs* will in our model partly be represented by unnecessary overall highway costs, partly by revenue losses (due to increased vehicle costs, hence to reduced "benefits" offered by the toll road

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* By definition there can be no cost <u>reductions</u> when we adopt an inferior instead of a superior plan, but only cost <u>increases</u>.

operator to road users, hence to revenue reductions).

Reconciliation of Different Traffic Demands

The process of reconciling different schedules of demand for highway services, can now be restated in terms of the toll road model. The following represents a modification of D. M. Winch's analysis, using different assumptions and employing a different diagrammatical approach: his earlier original contribution to work in this field is gratefully acknowledged by the present writer.

Figures 20 and 20a demonstrate diagrammatically two different highway traffic situations: one may be taken to depict peak traffic demand during a weekday 5 to 6 p.m. rush-hour (Figure 20), whereas the other might illustrate the much lower traffic requirements during the midnight-hour (Figure 20a). Both diagrams are drawn to the same scale, with the same units of measurement on both ordinates and abscissae. We must imagine that ordinarily additional diagrams should be drawn to represent other variations of traffic demand which are encountered over the toll road planning period; but here these two situations will suffice to explain the technique used.

We will take the following analytical steps in sequence:

(1) produce an optimum plan for each traffic situation,

(2) apply sub-optimum plans to each situation,

(3) adopt the one plan which results in the smallest unnecessary costs when it is not the optimum plan.

Let us first consider Figure 20 which depicts the rush-hour traffic situation. Curve MEBF represents marginal revenues at different levels of output of highway services and curve LNB the corresponding marginal costs. Given these data, output OA will be chosen -- determined by the intersection of marginal cost and revenue curves -- yielding gross revenues equivalent to the area OMBA, total costs equal to OLBA and consequently net revenues of the magnitude LBM. We may call this solution "Optimum Plan One".

Turning now to Figure 20a, the midnight-hour traffic case, we are confronted by the same marginal cost curve LNB and by the marginal revenue curve KNG. Optimum output will be OC, again determined by the point of intersection between marginal cost and revenue curves. With gross revenues OKNC and total costs OLNC, net revenues will be KLN. We may call this solution "Optimum Plan Two".

Since only one plan can actually be put into effect, we now have to choose between the two (or three, four etc.) alternatives. We therefore substitute inferior plans for optimum ones in each case and measure which combination entails the smallest disadvantages.

In Figure 20 "Plan Two" is now introduced which calls for OC output. At this level of production of highway services the maximum gross revenues which can be extracted will be only OMEC, since the highway plant cannot accommodate all potential revenue-traffic; total costs will be OLNC and net revenues only LMEN. Compared with "Optimum Plan One", which is the appropriate one for this level of output, gross revenues CEBA have been lost and costs CNBA have been saved. The net revenue loss incurred under the sub-optimum plan compared with the optimum one, is therefore equivalent to NEB, (the shaded area in Figure 20). This is a loss of net earnings sustained, in effect, because the highway plant was too small to accommodate all peak traffic.

We now introduce the inferior "Plan One" to the midnight-hour traffic situation (Figure 20a). The very large highway plant necessary for the great quantity OA of highway services causes the rather high total costs OLBA. Gross revenues will at the best -- allowing anybody to travel who pays tolls, however small -- be equivalent to OKNG. Net revenues (or net losses) in absolute terms will be equal to the difference between areas OLBA and OKNG. The relative net loss, incurred by adopting the sub-optimum plan instead of the optimum one, will be equivalent to GNBA (the shaded area in Figure 20a). This loss is caused by the unnecessarily large size of the highway plant.

The final step consists of a comparison of the relative losses (revenue decreases or cost increases) incurred if either sub-optimum plan is adopted. The sub-optimum plan resulting in the smaller disadvantages will be chosen as the best over-all solution. In our case, judging merely by casual visual inspection, Plan Two seems to be the superior one, since it entails losses of revenue, when introduced to the rush-hour situation, which are smaller than the additional costs which have to be borne when Plan One is applied to the midnight-hour traffic situation (area ENB $<$ area GNBA).

If the merits of more than two plans are to be compared, analogous procedures are used to select the "least-cost" sub-optimum plan.

Different Combinations of Traffic Flows

D. M. Winch points out that the same analytical technique can also be applied to problems of different combinations of traffic flows.[48] An illustration for such a problem, a very frequently encountered one in real life, is provided by our original toll road location map (Figures 9 and 11). The question is: would it be more advantageous for the toll road operator to let the highway between cities C and D pass through the intermediate minor centre E (situation one) or should E be by-passed and be served by means of the feeder road L-E (situation two). (See Figure 11)

Using most ingenious diagrammatical techniques, D. M. Winch arrives at output solutions for each of the component traffic flows under the two situations (C-E, E-D and C-D direct; flow on the feeder road L-E under situation two is the sum of traffic flows C-E and D-E) and consequently optimum plans. The possible disadvantages of routing through-traffic C-D via the minor centre E, are then compared with the disadvantages of accommodating local traffic C-E and D-E via the less convenient feeder route L-E. Just as in the case of the peak traffic solutions described earlier, the plan which offers the smallest sub-optimum disadvantages will be chosen.

By extending these analyses it would be possible to work out simultaneously solutions for different choices of traffic routing, as well as for various traffic peak and growth situations. However, enough has been said* to indicate the general nature of the methods which can be used. There is certainly great scope for the practical application of these techniques in the field of highway transport and determinate solutions to very pressing problems could thus be obtained. As D. M. Winch concludes:

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* The mathematically inclined reader should refer to Studies in the Economics of Transportation[49], Part I, for further detailed discussions of similar problems.

"Given all the data there is no problem so complex that it is not capable of theoretical solution, and working on the above principles there is no reason why the detailed calculations could not be delegated to an electronic computer."(50)

Planning of Highway Systems

Similar procedures might be adopted to solve problems of planning entire road systems, rather than one particular stretch of highway only. Let us assume, for example, that a main toll road will be built to connect major centres A and B (see Figure 21). The question is posed whether additional feeder route A to minor centre D, and feeder route B to minor centre C would be profitable propositions. It is assumed that communities D and C have no highway connections at all. *

This problem, which is very similar to problems of railway branch line extensions or abandonments, can be solved by comparing the overall gross revenue contributions and cost additions occasioned by each separate traffic flow. If feeder route DA is built, the cost of this extension has to be compared with the potential contributions to revenues of the following traffic flows:

(1) traffic between D and A;

(2) traffic originating at D, but proceeding through A to B; this would be the feeder route's contribution to main route traffic between A and B;

(3) if the second feeder road B to C is built, traffic

*The model can, of course, be rendered more complex by adding other points to be served -- ad infinitum, if desired -- by assuming the existence of inferior roads from which traffic would be abstracted and so on.

originating at D, but proceeding through A to B and from there to C; this would be the feeder route's contribution to both main route traffic between A and B, and to second feeder road traffic between B and C.

Similarly, if feeder route B to C is built, extra costs of this facility have to be compared with revenue contributions of the following traffic flows:

(1) between B and C;

(2) originating at C, but travelling also between A and B;

(3) if feeder A to D is built, traffic originating at C, but destined for D and hence travelling both between A and B and A and D.

A simple yardstick for determining the economic justification of feeder routes would be the criteria of net revenue contributions for the system as a whole. However, as can be seen from the remarks above, there are mutually interdependent factors which complicate the analysis; thus the revenues needed to justify the construction and operation of one feeder route will be determined also by what other routes have been added to the highway system as a whole.

M. Beckmann, C. B. McGuire and Ch. B. Winsten comment in the following way on the difficulties inherent in the planning of entire highway systems:

> "... to get the most out of an integrated program of road construction one would have to compare a huge number of possible combinations of road capacities that might be added. The principles of economics have not been developed far enough to permit shortcutting such a vast analytical problem."(51)

While in no way underestimating the seriousness of possible theoretical and practical obstacles, it is suggested that appropriate solutions to the very important problem of system planning can be obtained more easily than the authors quoted above seem to believe.

Continued Operation of the Toll Road

We now digress from our main theme -- toll road investment planning -- and turn to its effects on the continued operation of the toll road. What are the economic problems once the highway has been built and resources have been committed to a particular scheme?

No distinct analytical line can be drawn between the planning of a long-term project and the planning of day-to-day operations. In both cases scarce resources have to be allocated in the most efficient way, and therefore basically the same economic principles should apply. However, there are some special considerations and these can best be discussed once more within the framework of our toll road model.

To take the easiest case first, let us assume that in the light of experience all prognostications made by the toll road operator during the investment planning phase of his activities turn out to be absolutely correct. The number of vehicles using the toll road, the tolls they are prepared to pay, the costs associated with different outputs -- these and all other working variables have been predicted by the toll road entrepreneur with Laplacean accuracy. This ideal situation, in which all ex post operational experiences are identical to the conditions anticipated, obviously does not call for any further discussion beyond the one devoted earlier to the ex ante planning of investment, since criteria and variables are identical in each case.

We can also dispose very quickly of the second possibility, the case of correct predictions coupled with faulty ex ante planning decisions. Here the situation simply calls for a new investment appraisal in the light of the circumstances at the particular time, coupled with an improvement in the planning methods.

The third case, in which the proper ex ante investment decisions were made but the predictions turn out to be wrong for a variety of reasons, is really the only interesting one analytically. Let us first consider the possibility that demand for highway services turns out to be greater than anticipated, i.e. that the marginal revenue curve has shifted from the position assumed to be correct when the toll road was planned and built (BGC in Figure 22) to the actual position DHIE. Quantities of output remain the same at level OF, as the highway has been built already to certain specifications. Supplying the same output as planned, (OF), the operator now realizes a windfall profit of unanticipated net revenues KGB (see Figure 22). However, even greater net revenues could be collected by him by increasing the capacity of his highway to supply OK units of highway services. If this plant expansion is effected another net revenue increment, equivalent to GIH (shaded area in Figure 22) could be realized by him.

The question then arises whether it will be worthwhile for the toll road entrepreneur to expand his plant, by building another lane or whatever is required, in order to collect GIH net revenues. This becomes in principle simply another investment decision, to be treated in the same way as the other major toll road investment decisions discussed before. Basically the new project, which involves highway capacity expansion from OF output to OK output, is economically justified since it promises to yield some net revenues. But in practice it will be subjected to some priority tests by the entrepreneur (for example by relating net revenues GIH to project costs FGIK) and it will eventually take its proper place among a number of other profitable projects contemplated by the entrepreneur. The case of a downward shift of the cost curve can be treated in the same way.

We see, therefore, that the cases of underestimating demand, or overestimating costs, and hence underdesigning plant, can be treated by means of the same investment analyses which we used before. We now consider a rather different situation: that of an over-designed toll road. Turning to Figure 23, let us assume that the actual demand for highway services (curve PSQ) is much less intense than was anticipated at the time when the toll road was constructed (curve LMN). The highway was designed and constructed to produce OR quantities of highway services, whereas under the actual demand situation OU would be the optimum output. Therefore a loss equivalent to QSMR is incurred because of highway over-capacity.

It stands to reason that the toll road operator in this situation will endeavour to cut down on unnecessary costs as much as possible. He will reduce his output to optimum production OU, if any of the marginal costs incurred in the output range OU to OR are avoidable.

However, what will happen if all resources signified by marginal costs within area OTMR are irrevocably committed? When will the toll road operator go out of business? Under the circumstances depicted in Figure 23 the entrepreneur will carry on with his operations as long as the loss incurred on account of highway over-capacity (shaded area QSMR) is smaller than the ordinary net revenues TPS (stippled area in Figure 23). In other words, as long as there are still some overall net revenues to be had, the toll road operator will continue to remain in business. If, however, overall losses are incurred then the toll road will cease operations.

The exact circumstances and the timing of such a discontinuance of operations have on several occasions aroused theoretical interest, particularly among transport economists. The issue arises because of the "lumpiness" of inputs which can often be observed in the transport industry. In Figure 24, which will illustrate a typical case, the vertical axis now measures average annual total costs and revenues, whereas the horizontal axis measures time in years. We assume that annual total costs (CC') are constant over time and are therefore represented by a straight horizontal line. Revenues (RR') are supposed to decline over time, due to changes in demand, increased competition or for other reasons.

For purposes of illustration we assume that total costs are made up of the following components:

(1) direct operating costs (such as wages) which are incurred continuously;

(2) fairly long-run operating costs (such as major pavement repairs and replacements) which are incurred in "doses" at intervals of about 15 or 20 years;

(3) long-run operating costs (such as reconstruction of bridges and other structures, rebuilding of whole

stretches of highway etc.) which become necessary only in 50-year intervals.

Under these circumstances some expenditures become postponable for long periods of time. Although the ordinary operating costs, such as for wages, fuel, light, and toll collection expenses, have to be met out of revenues practically every day, the expense for the replacement of a bridge, once it is built, does not have to be incurred again for several decades.

Because of the "lumpiness" of expenditures on durable items, the toll road in this example can therefore continue to stay in business for protracted periods of time, although total costs are not covered by total revenues. In Figure 24 total revenues fall below total costs in year 70. According to our previous analysis toll road operations would then cease. In our example, however, high replacement costs for structures etc. were incurred in the year 50 and no new expenditures on that account are anticipated until the year 100. Consequently, these costs do not have to be met now and operations can continue. Even when after a further decline of revenues, pavement replacement costs are not met anymore in year 85, the toll road still does not have to close down since the pavement expenses are postponable until the year 95. The toll road will only go out of business when finally ordinary operating expenses (wages etc.) cannot be met from revenues after year 90. In this example, therefore, the toll road might manage to survive for an additional 25 years after it first incurred apparent losses.

Cases of this kind have occurred in the real world. Operating at a loss may take the form of allowing insufficient depreciation for durable equipment, or of indulgence in so-called "deferred maintenance", or "running down of equipment". What is known as "cut-throat competition", -- basically charging below total costs for limited periods of time for reasons of market strategy -- is yet another example.

It should be noted, however, that the circumstances under which operating at a loss will occur, are fairly specialized. Firstly, there must be lumpiness of input factors, and secondly, short-run (marginal) costs must be very different from long-run (total) costs. The moment we introduce larger, more complex plants these conditions will not prevail any more. When we visualize a whole highway system, constructed over many years, consisting of many durable assets in various stages of replacement need, both the lumpiness of renewal of plant and the divergence between long-run and short-run costs disappear. Every year some bridges and other structures will be replaced; if they are reconstructed fairly evenly over time and if their average lifespan is 50 years, the postponable proportion of total costs will on the average only be 2 percent. The same applies to pavements and other component parts of the highway.

The larger the highway plant, the smoother the expenditure requirements will be; if they are not met out of revenues, at least part of the system will have to be closed down.

Possible Weaknesses of Toll Road Model

Finally, as an extra check on the accuracy of our theoretical analysis, the toll road model will be subjected to extra examination partly in the light of actual toll road experience.

Charging What the Traffic Will Bear?

The assumption that the toll road entrepreneur will and can indulge in perfectly dissimilar charging might be regarded as one of the main weaknesses of our model. This is a very important objection since the later analyses of public road systems depend largely on the same assumption; the point should therefore be discussed at some length.

We have to distinguish sharply between what is theoretically desirable from the toll road entrepreneur's point of view and what is feasible in practice. To take the former consideration first: there can be no doubt that perfectly dissimilar pricing is a most desirable theoretical objective from the entrepreneur's point of view. It is the one and only method which will enable him to maximize net revenues. As we have seen earlier in this chapter, the entrepreneur's long-range strategy objective of net revenue maximization from all sources of income may require short-term tactical deviations from the "perfectly dissimilar pricing" rule. However, for all revenue-producing activities taken together and over a very long period of time the rule still applies.

It is quite a different matter to equip the toll road operator with different standards of motivation altogether and say that he would not wish to "indulge in discriminatory rate practices" and that he would instead "charge fair prices to all customers", whatever that may mean in practical terms. It would also mean begging the issue if we assumed government rate legislation, provisions for toll charge equalization and so on. If we rule out state interference and stipulate, as we must, that the toll road operator is motivated by the desire to maximize net revenues, then perfectly dissimilar pricing inevitably becomes the theoretical ideal.

Even if we introduce perfect competition the desire of the toll road operator to "charge what the traffic will bear" will still be there. Whenever the smallest imperfection of market conditions occurs, whenever there is a slight relaxation of competitive conditions, the entrepreneur will logically take advantage of it and deviate from the uniform market price. As we will see in our discussion on the practical aspects of dissimilar charging, he can do so in a variety of ways -- by variations in service qualities, by introducing quantity discounts and even by charging equal prices in circumstances when conditions differ.

Practical Objections to Dissimilar Pricing

From the toll road operator's point of view a very important objection against a highly complex rate structure will be the additional administrative costs and difficulties it may involve. In order to reconcile the theoretical ideal of perfectly dissimilar pricing and the practical objective of net revenue maximization, the extra costs of ascertaining, charging, collecting and enforcing a complex toll system will be weighed against the extra gross revenues thus obtained. It is likely that the administrative difficulties and costs of dissimilar charging will be greater, and hence the advantages smaller, the larger the size of the toll road organization considered.

Analytically, we might overcome this phenomenon -- which should really be considered under the separate heading of "diseconomies of large size" -- by calculating gross revenues net of collection costs. Diagrammatically we would then obtain a whole series of marginal gross revenue curves, one each for each pricing system adopted, consisting of a series of "steps" and in the extreme case consisting of a straight line. The most rational solution from the toll road entrepreneur's point of view would be dictated by the point of intersection of the marginal cost curve and the one marginal revenue curve which encloses the largest gross revenue area, and hence the one with the greatest number of "steps". This solution is depicted in Figure 25, where adoption of charging scheme MR_1 leads to net revenue maximization (stippled area) at output OC and total costs OABC.

Other objections to dissimilar pricing stem from the users of highway services. Motorists, when planning a trip, may prefer one single toll quotation, rather than a series of prices applying to different situations. However, dissimilar charging may be regarded by users as a virtue, rather than a vice, if it manifests itself to them in the form of "quantity discounts", "loyalty discounts", "off-peak inducement tolls" and other pricing methods which ostensibly result in toll reductions, and not in toll increases. The toll road operator in that case basically operates during off-peak hours with a single uniform tariff, set to maximize net revenues. In addition, for subsequent quantities of highway services, he offers various price reductions in order to utilize excess capacity. It should be noted that during peak-traffic hours he will not apply this technique.

Generally speaking, "charging what the traffic will bear" can very easily assume an air of great respectability if it is interpreted and defined in the right way. As A. M. Milne put it:

> "The phrase "charging what the traffic will bear" can assume two meanings. First it may mean that prices are to be fixed in such a way that in respect of each traffic

carried the maximum revenue is obtained regardless of the particular costs involved. In accordance with this interpretation of the principle no traffic should be charged a lower rate or fare when it will bear a higher rate or fare. The second meaning of the phrase -- the meaning which is relevant to our discussion ...-- can be more conveniently couched in negative terms and expressed in the form that <u>no traffic should be charged a price which it will not bear when, at a lower price, the traffic would be prepared to move</u>. When interpreted in this second way the principle may promote a greater utilization of indivisible and fixed resources and may thereby permit indivisible and fixed costs to be spread over a larger volume of traffic. <u>In this way the practice of discriminatory pricing may confer economic benefit, a benefit represented by the fact that transport rates and fares are rendered lower than they would be in the absence of discriminatory pricing</u>."(52) (underlining supplied)

It is therefore likely that dissimilar charging practices can be made palatable to users by stressing the rate reduction aspect; in this way probably most of the objections of consumers of transport services -- and of regulatory authorities -- can be overcome. Another "discriminatory" charging method to which neither users nor authorities could very well object, would be the varying of service <u>qualities</u>, including differing treatment in the granting of credit facilities.

What charging policies have been pursued by the toll roads in the United States? In their work Toll Roads and the Problem of Highway Modernization,(53) published in 1951, Wilfred Owen and Charles L. Dearing, state that in the United States "in all cases the [toll road] authorities are empowered to set the level of tolls to be charged for use of the facility."(54) Although not directly analysing the rate policies pursued by toll road authorities, the two authors apparently held the view that the two criteria of "cost of service" and "benefits rendered" were the basis of toll road charging at that time:

> "For the outstanding merit of the toll system is its ability to assess costs accurately and directly in accordance with costs incurred and benefits received."(55)

In a paper given at the December 1956 Meeting of the American Economic Association, entitled Toll Road Rates and Highway Pricing,(56) Charles L. Dearing subsequently comments, however, rather critically on the pricing methods of toll roads in the United States during the post-war period. Dearing considers "charging on the basis of costs" as the ideal, or desirable, charging policy:

> "If any road can be operated on strict commercial principles, surely toll roads can. The problem of determining costs attributable to various classes of vehicles, then, should be considerably more simple than that posed by an analysis of a state highway system.
>
> The toll authorities should be in a position to set prices which reflect the cost of the road to various users, charging various classes of traffic their full share of separable costs and allocating the remainder by some rational formula,

perhaps at the outset following patterns set in railroad rate setting. The goal of the [toll road] authorities should be to eliminate any monopoly profits and any subsidies."(57) (underlining supplied)

Dearing observes that in actual fact costs of rendering individual service units are virtually ignored and that toll road authorities have adopted instead straight "charging what the traffic will bear" rate practices:

"... what about the cost of providing the services of the toll road to the various classes of vehicles in the determination of rates? The answer, in brief, is that they are not considered. Under no circumstances in toll roads investigated is there any attempt to set tolls with the idea of offsetting the cost of providing road services to the various classes of vehicles. Only in the over-all cost sense are the effects of rates considered. That is, rates must be set so as to cover bond servicing requirements, operations costs, and contributions to sinking and other funds.

<u>If any principle obtains with regard to setting initial rates, it is that they are set with a view of charging what the traffic will bear</u>."(58) (underlining supplied)

Still applying the two criteria of "cost of service" and "benefits rendered" as the most desirable standards of charging, for public highway systems as well as for toll roads, Dearing comments:

"We have observed earlier that most states have encountered difficulty in resolving the theoretical and administrative problems of reconciling or combining the incremental [cost] and the benefit theory of user charging. In view of the fact that modern toll road administrators should have been able to avoid most of these problems, it appears strange that they have for all practical purposes adopted a straight "what the traffic will bear" basis of pricing."(59)

Leaving in abeyance for the time being the question whether the incremental cost and the benefit approaches to user charging -- two methods which were evolved in the United States and seem to enjoy a certain measure of acceptance there -- are in fact theoretically desirable, it is very encouraging to note that our toll road model stands up so well to the test of practical experience.

We did stipulate for purposes of our model a strictly "commercial" approach and we did vest powers to vary rates at will in the toll road operator; it appears from Dearing's analysis that, broadly speaking, these conditions also apply to toll roads in the United States. We did expect that the toll road entrepreneur would indulge in dissimilar charging policies and would try to maximize net revenues (i.e. to reap "monopoly profits"); we further expected that the toll road operator would probably not attempt to assess individual cost responsibilities, but would consider costs only in the overall planning sense. Again, these results are fully confirmed by actual toll road experience in the United States.

Some other, minor aspects of our toll road model are also corroborated by observed practice. Quoting from a study of toll charges in the United States(60) Dearing shows that rates decline with increasing volume of highway use generally and with increasing volume of "weight-use" in particular:

"There are ... significant differences between passenger car and commercial user tolls. The rates for heavier vehicles increase but not in direct proportion to weight. In a 1953 study of vehicle toll charges it was found that per ton-mile the heaviest vehicle paid about half the toll charge of a passenger car on the basis of average weight and about 30 per cent on the basis of the maximum weight of the truck. This study considered only the published toll rates.

Two other elements lead to the conclusion that these figures, low as they are, are still higher than the true rates truckers have to pay. First, states having toll roads also have third-structure taxes, which in some cases are levied on a mileage basis. Those states have cancelled the tax liability of truckers for mileage covered on their toll roads.* Second, several authorities have incorporated a discount for commercial vehicle users, based on the dollar volume of tolls paid by a single trucking firm. This, of course, also reduces the effective toll rates.

The use of one or both of these devices can effect a considerable reduction in published rates. For example, over the bulk of mileage on one toll road the published rate for the heaviest class of vehicle is four times the passenger

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* This conforms to our assumption of non-interference of the state and its objective of preserving competitive neutrality; in our model we brought this principle to its logical conclusion by stipulating that toll road users would in effect not pay any gasoline taxes either.

car toll. After deducting the refund for the third-structure tax and after taking full advantage of the volume discount, the heaviest vehicle may pay a net toll equivalent to only about 150 per cent of the passenger car fare."(61)

There emerges from Dearing's description of actual toll road charging practice in the United States a pattern which conforms surprisingly closely to the one depicted in our model, considering that the U.S. toll road authorities are subject to some degree of regulation and legislative supervision, much in the same way as public utilities and, for example, Crown Corporations in Canada are.

The final point still to be considered in connection with dissimilar charging is whether existing toll roads recognize the limits to profitable output expansion set by the equality of marginal costs and marginal revenues at "extreme values". It is one thing to suggest that quantity discounts and a rate system which is regressive in terms of vehicle weight increases, are simply commercially justified manifestations of dissimilar pricing policies; it would be quite another thing to find that certain traffic which does not even cover its costs is currently moving on toll roads. This would be quite inadmissible under the terms of our model, which stated that for each unit of highway services marginal costs must <u>at least</u> be covered by marginal revenues and that this condition sets the limits of profitable output.

Dearing does not explicitly state that, for example, quantity and weight discounts granted to truckers have had the result of extremely large and heavy commercial vehicles being accommodated at a loss on toll roads in the United States. Apart from observing that only very superficial cost information has been developed so far, he seems to imply that there is some "subsidization" of certain types of traffic, coupled with "monopolistic" rate charging to other types of traffic. However, without further evidence that some traffic is actually being carried at a loss -- the only really meaningful definition of the term "subsidization" -- we can assume that monopolistic and subsidized toll charges are simply higher and lower rate levels, respectively, within a perfectly rational system of dissimilar pricing.

Demand Analyses

The demand analysis described within the framework of our toll road model also appears to conform fairly well to current practice in this field. It was explained earlier that assessment of demand resolved itself largely into an assessment of potential user benefits. Drawing once more on Dearing's study of actual procedures as the best possible reference source, we see that theory and practice correspond in all important details:

> "Before the toll road is opened for use, traffic engineers make intensive studies of travel patterns to estimate what part of existing traffic will be diverted to the toll road and to furnish the basis for determining the toll rates. Motorists are stopped and interviewed; data are punched, tabulated, added, adjusted seasonally, correlated, compared, expanded, and projected.
>
> The engineers place special emphasis upon cost savings to truckers, which are broken down into a number of categories and analyzed for purposes of prediction. (Principal considerations are: reduction in fuel, maintenance, tire, depreciation, and insurance costs; savings

in time per trip; and increase in truck utilization and improvement in service.) Competitive conditions of parallel facilities are evaluated in these investigations. Time savings over competing routes are particularly important as the toll road, in order to be financially successful, must attract some of the traffic from those routes. With these factors evaluated, a toll rate is established for passenger cars. Then toll rates for commercial vehicles are set using the passenger car rate as the base. Thus factors of demand are analyzed at length to determine initial rates."(62) (underlining supplied)

Conclusion

Some time was devoted in this chapter to the testing of our toll road model in terms of conditions encountered in the real world. By adopting this procedure we have built up a basis for the subsequent discussion of the economic problems of public road systems.

Governments, in their economic activities, are supposed to be guided by principles which apply to private enterprise. Let government simulate private enterprise behaviour, so the argument goes, let it be subject to roughly the same economic checks and disciplines and it will achieve the same measure of efficiency.

There is probably agreement that toll roads -- although they are not completely "free" enterprises -- are economically more akin to private enterprise firms than any other form of road organization known at the present time. We have now seen that these toll roads themselves, although operating within the almost ideal framework, do not conform at all to the behaviour pattern apparently expected of them in the first place. As Dearing put it:

> "In summary, toll rates are established without regard to assigning costs in proportion to the degree to which various classes of vehicles may have contributed to those costs. Also, until changing circumstances have made such impact as to cause a marked effect upon total revenues, there has been little attempt to modify rate structures with the idea of adjusting them to current economic conditions.
>
> In many respects this conclusion is somewhat distressing with respect to the failure, to date, of toll road authorities to price their services in accordance with what most of us would consider a rational basis."(63)

We now have two very good reasons for extreme caution when we subsequently analyse the economics of public highway systems:

(1) the failure of toll roads in the real world to conform with the behaviour apparently expected of them;

(2) the non-conformity of our own toll road model with the economic standards imputed to both public highways and toll road organizations.

We will have occasion in the next chapters to discuss these two points at greater length.

Finally, lest the impression be given that the extensive use made in this study of a theoretical toll road model implies its acceptance as a practical method of highway finance, a few words should be said about the role toll roads can be expected to play in solving current highway problems. A proper discussion of the merits and disadvantages of toll roads seen as a practical proposition is outside the scope of this study* and some very superficial remarks must therefore suffice.

Both toll roads and public highways functionally, technically and operationally fulfill the same purpose: the provision of highway services for motor vehicle traffic. The private and public highway agencies are therefore directly in competition with each other, providing identical services and differing only in their methods of finance. Since the provision of highways has traditionally been handled as a function of government, the success of toll roads must be regarded as an indictment against the efficiency of the public road system. In other words, we might say that toll roads will thrive on excessive economic waste and personal frustration endured by motorists on competing public roads.

The supersession of a poor public highway by a good toll road by itself cannot be regarded as undesirable, since it is a move from an economically less efficient situation to a more efficient one. However, equal results could also have been achieved by improvement of the public highway to the same superior standards.

Attention must therefore concentrate on the only points of difference: the financing and user charge arrangements employed by the two highway agencies. It is in this respect that the toll road system shows its real weaknesses; all other things being equal,

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* Apart from the references already given, the subject of toll roads, with particular reference to Canadian conditions, is very well discussed in the Canadian Tax Foundation's <u>Taxes and Traffic</u>(64), in G. D. Campbell's <u>An Analysis of Highway Finance and Road User Imposts in Canada</u>,(65) and in an article by Roger E. Carswell.(66)
The pros and cons of toll roads were also exhaustively reviewed by A. J. Wedeking (for toll roads) and K. B. Rykken (against), with J. Harvey Perry as the discussion chairman, at the 1956 Annual Convention of the Canadian Good Roads Association in Banff, Alberta.(67)

the extra costs of toll collection facilities are usually in excess of the generally experienced costs of collecting gasoline taxes and license fees for the support of the public highway system.* The necessary costs of toll gates, complete access control, collection facilities, are relatively high and have to be incurred regardless of traffic volume.

The toll road method can be used successfully only in cases where there are to be found: (i) few entry and exit points (i.e. rural areas only); (ii) large volumes of traffic;** (iii) deficient

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* Taxes and Traffic states: "For fiscal years ended in 1953 the costs of collecting tolls on the New Jersey Turnpike were 1.7 per cent of all revenue, for the Pennsylvania Turnpike 4.9 per cent, for the Maine Turnpike 8.7 per cent, and for the Wilbur Cross Parkway 15 per cent."(68) By contrast, the Report of the Select Committee on Toll Roads and Highway Financing, Ontario Legislature, shows: " ... the cost of collecting gasoline tax in Ontario including vendors commission is just slightly over 1 percent."(69)

** The minimum number of vehicles needed to support a toll road can be calculated by means of the following empirical formula given in Edwards, Kelcey and Beck, A Compilation of Information and Data Pertaining to Toll Road Facilities in the United States:(70)

$$V = \frac{C}{T} = \frac{0.000257 \times I}{T}$$

Example: I = \$1 million per mile

T = 2 cents per vehicle per mile

$$V = \frac{0.000257 \quad \$1\ \text{million}}{\$0.02} =$$

= 12,800 vehicles per mile per day is the minimum number of vehicles required to support the toll road.

I = Investment per mile

V = Number of vehicles per average mile per average day

T = Average toll per vehicle per mile

C = Average daily cost per mile for interest, amortization, maintenance and all operating costs, empirically calculated to be: 0.000257 x I parallel public highways.

It is generally held now in Canada that there are very few, specialized cases in which these conditions apply. More trust is put in the improvement of the planning and financing of the public highway networks. This topic will be discussed in the following chapters.

V - PUBLIC HIGHWAYS - THE BACKGROUND

In the preceding chapters we dealt first with the relatively simple case of a mining company which operates motor transport vehicles on its privately owned road purely for its own purposes. Subsequently, we introduced a number of complicating factors by constructing a toll road model. We saw that the toll highway is owned and operated by an entrepreneur who provides highway services for a multitude of motorists. The entrepreneur has to go into the "transportation market place", as it were, to sell these services to users. He is therefore forced to relate in some way the quantities and qualities of highway services he is willing and able to supply to the service quantities and qualities demanded by the users. The link between one and the other, we saw, consists of an elaborate relationship between benefits offered to motorists, revenues obtained and costs incurred. The guiding principle for the entrepreneur is net revenue maximization. The revenue-cost relationship not only provides the most desirable output solution, it also constitutes an automatic check whether the project should be undertaken at all and what investment priorities should be allotted to it by the entrepreneur.

Characteristics of the Public Highway System

When we now deal with the final case, that of a public highway system, we not only introduce a number of important additional factors which will complicate our analysis a great deal, but we also remove some of the precepts and automatic checks which circumscribed the economic decisions and actions of the entrepreneur in our toll road model. However, many principles common to both road organizations remain; it will therefore be useful to draw as much as possible, in the analysis which follows, on the knowledge of the economic problems of highway planning which was gained earlier from the study of the toll road model.

First, certain broad general characteristics of the public highway system and the ways in which it differs from the toll road will be discussed.

Existence of Monopoly Powers

While the toll road in our model did have to contend with some degree of competition from public roads and from other forms of transportation, the public highway system in the real world wields wide monopoly powers. Admittedly, there is some competition on certain segments of the road network where users can turn to air, water and rail transport, and in very rare instances to toll roads. On other sectors, for example in the sphere of urban arteries and residential streets, local access and farm roads, development and mining highways, there are no substitutes available. For all practical purposes we can therefore accept the proposition that the public authorities, in their function as providers of highways, exercise a very wide degree of monopoly power; indeed this monopoly power is probably greater than that of a private monopoly which tends to be limited by the threat of potential competition or public control.

Linked to the existence of monopolistic powers in the sphere of highway provision is the fact that no real market exists in which these services are sold and bought. One reason for the absence of a market is the lack of compulsion for the monopoly supplier to sell his services, since revenue is forthcoming from general fiscal funds in any case. Another reason is that almost insuperable technical and administrative obstacles arise when the attempt is made to negotiate sales of individual highway service units with the respective purchasers. The absence of a market for highway services means, as we have seen before, that we are also confronted with the absence of all the checks, balances, controls and procedures which are normally associated with the working of the market mechanism. To find practicable substitutes for these market forces will be one of the key themes of the subsequent analysis.

<u>The System Aspect of Public Highways</u>

The "system" aspect is one of the most important characteristics of public highways; yet it is a concept which is very difficult to define. By a system we mean a heterogeneous set of things and parts, which, when connected, form a complex whole. The individual components of the system are joined together because thus arranged they function more efficiently and render better service.

This principle can be widely observed in the field of the so-called "public enterprises".* If many electric power stations are linked together by means of a grid system they are jointly able to provide better services at lower unit costs, than when they are operating separately; in the connected network the power consumption

*"Public enterprise" will be used as the generic term to describe all undertakings which are directed by the government, or by bodies set up by the government to direct their affairs in the public interest.

The term "public utility" will be used to describe undertakings which, although privately owned, are subject to extensive state intervention and control. The "public utility" approach to highway provision stipulates that the highway function is performed by a government department, or by a body set up by the government, in such a way that the behaviour of genuine public utilities is simulated. This concept will be discussed later in this chapter.

load can be distributed more widely over many generating plants, peaks of demand for electricity in one region are offset by troughs in other districts, coal-burning plants are able to make up for hydro-electric power deficiencies created, for instance, by a drought. In addition to these economies of scale of production, very substantial economies of marketing and distribution will also accrue to an electric power system. If every user had to be connected individually to the power plant by means of separate cables and transformers, electricity distribution costs alone might prove prohibitively high. Since in reality, however, whole districts can be served very cheaply by means of one main connection from the power plant, mass consumption at low unit costs for all users becomes possible. Similar considerations apply to other public enterprises, such as water, gas, urban transport, sewerage, telephone and railway systems.

A public highway system embraces a most heterogeneous collection of road and street facilities. At one extreme we find the residential street and the village lane, at the other extreme the multi-lane, divided highway, built to the most exacting technical specifications. The highway user characteristics also differ greatly: a great variety of vehicles, from the heaviest, tractor-trailer combination down to the bicycle, are served by the public highway system.

The fact that the highway plant is made up of so many different parts, contributes greatly to the value and effectiveness of the system as a whole. Property owners and residents in a particular locality could conceivably undertake the construction and operation of a service street as a private venture. However, this single road would be almost useless to them unless it were connected to other roads. Let us look at extensions to the service street from the point of view of these basic users: as their private laneways are joined to the street, as other streets are added, as important points of traffic attraction develop and these in turn are connected, by main thoroughfares and long-distance highways, to focal points in other districts and cities, the various combinations of traffic origin, destination and routing which the system as a whole will make possible is increased to staggering proportions. Ultimately, the public road system will serve all users which can be reached by land and will provide access to an almost unlimited number of points. In more developed countries practically every house, farm and place of work has road access and almost every citizen draws to some degree on road transport services every day.

From the users' point of view, the services rendered by a well-developed public highway system are, therefore, infinitely superior to those provided, for example, by a number of separate roads which connect only a few points each. The integrated public road network also allows users to choose freely from a great variety of routings and at any given moment of time traffic flows will consequently follow the most rational pattern, i.e. the one which minimizes total road transport costs for all traffic. Very important are, further, the economies derived by all traffic from the joint use of the highway facilities; heavy commercial vehicles, farm trucks, delivery vans and passenger cars will simultaneously travel on the highway, thus contributing jointly to the costs of construction and maintenance of the road at lower unit cost shares for each of them. Again, this is made possible by the highway system, which attracts and serves such diverse forms of traffic.

The economies of scale which can be reaped from treating public highways as an integrated whole, rather than as a multitude of separate stretches of road, are also very important on the supply side. In many cases these economies have probably not yet been fully exploited by public highway authorities. By standardizing technical processes, specifications, materials and equipment, by centralizing certain functions which serve all segments of the system, such as planning, research, purchasing, by generally using mass production methods, very great savings in unit costs of rendering highway services can be realized.

To recapitulate: a highway system can be regarded as a combination of many different parts which, when working jointly, produce greater quantities and better qualities of highway services at lower total costs, than when operating separately. The ultimate economic limits of size of the system will be reached when the last (marginal) network extension will yield benefits which are equal to the costs attributable to the system extension. Suitable techniques to arrive at solutions for the optimum output, or the optimum size of the highway plant, were discussed in Chapters III and IV of this study.

Cost savings and benefits stemming from the operation of highways as an integrated system will accrue to both users and providers of the services. Great economies of scale can be reaped on the production side. From the users' point of view a highway system improves the service quality due to the greater number of points served; it also leads to cost savings made possible by greater choices of routing and by joint use of the facilities. In the last analysis a highway system will effect great overall reductions in road transport costs, with consequent beneficial effects on the entire economy.

Highways Operated "In The Public Interest"

Very closely linked to the system concept of public highways is the fact that roads are operated by government bodies "in the public interest". The entrepreneur in our toll road model had only his own interests at heart and once these interests had been defined, all his actions followed logically. But it is very difficult to derive precise working rules from so vague a concept as "the promotion of the public interest".

Broadly speaking, promotion of the public interest means that available resources must be used in such a way that they yield the greatest aggregate benefits for the community at large. This definition opens up more questions than it answers. We have to ask: What exactly are "aggregate benefits"? How are they to be measured? What do we mean by "available resources"? What time period should be adopted?

It is the purpose of this study to find at least partial answers to these and similar questions. Some preliminary observations can be made now. The private enterprise firm, the toll road in our case, and the publicly operated highway system are at opposite ends of the scale. The toll road operator will view the world around him from within the very narrow confines set by his activity. Aggregate benefits will be of interest to him only if they can be turned into revenues accruing to his firm. Social costs will be ignored by him and passed on to the community at large whenever possible. His planning horizon may extend merely over a very limited period of time, since he may have decided from the outset to stay in the toll road business for a short while only, in order to reap initial, exceptionally high profits. The magnitude of net revenues he manages to accumulate in the course of his activities is the ultimate measure of his success.

The public authority uses criteria which are quite different. The maximization of social benefits and the minimization of social costs are of first and foremost importance. The planning horizon is set as wide as possible, partly because the promotion of the public interest is entrusted to a self-perpetuating, permanent body and partly also -- if we assume perfect knowledge of the future -- public interest should know no time limits, but only priorities. In practice, although the possibility of obsolescence will set a time limit on the commitment of resources by the public authority, its planning perspective will be much wider than that of the toll road entrepreneur. Cash profits, finally, cannot be used as a measure of success by the public authority, which must instead attempt to maximize net social benefits.

In order to effect the transition from the toll road model to the case of the public highway system, we have to remind ourselves constantly that we are moving from a narrow, restricted situation to a general problem which calls for a very broad approach.

The Institutional Setting

The three* main characteristics with which public enterprises generally seem to be endowed -- the existence of wide monopoly powers, coupled with the lack of a market, the "system" aspect, and finally the recognized need for the promotion of the public interest -- have resulted in a variety of institutional approaches which differ

* Some students of the problem recognize the existence of large overhead costs as an additional distinguishing feature; the issue will be dealt with subsequently.

according to the objectives which are being pursued. Sometimes competition is prescribed, presumably in the public interest, in order to curb the existing monopoly powers. Thus in Canada, for example, the two main railways -- the Canadian National Railways and the Canadian Pacific Railway -- compete with each other over a wide range of services and routes. Yet in the interest of the railway system as a whole many of the rates quoted by the two companies are the same and some routes, as well as certain terminals, are operated jointly. In addition, also in the public interest, the former railway company is run as a nationalized undertaking.

In the field of Canadian air transport, the state-owned Trans-Canada Air Lines were given monopoly powers on main routes; these were justified for reasons of continuity of service, co-ordinated growth and system efficiency. On minor routes and feeder lines, on the other hand, competition between private air carriers has sometimes been permitted. In Britain, to promote efficiency and co-ordination of the transport system as a whole, the railways, long-distance road transport firms, the majority of canals and some other transport undertakings, were transferred from private to public ownership under the provisions of the Transport Act of 1947. All these facilities were placed under the supreme control of the British Transport Commission and as a result competition between the various undertakings was significantly lessened. With a change in government, part of the long-distance road transport industry was returned to private ownership under the Transport Act of 1953, with the object of increasing competition in the freight sector of inland transport. Numerous other examples could be cited which show that sometimes contradictory institutional approaches result when different objectives are emphasized.

It is impossible, within the framework of this study, to go into a detailed analysis of the various institutional arrangements which are found in practice and a few words on them must suffice. The most common types are: the government department, the state-owned enterprise or the Crown Corporation and the public utility.

Government departments normally exercise functions which could not be performed by private enterprise, since the services rendered benefit the community at large, rather than specific user groups. Examples of traditional government activities are: public health and welfare, maintenance of internal law and order, national defence, education and diplomatic relations. The expenses incurred by government departments when exercising these functions are met from general tax funds. The activities of these departments are directed, in the last resort, by the collective will of the people, expressed through the legislature.

The second institutional type may take the form of a government-operated enterprise, of a Crown Corporation or a nationalized undertaking. In all cases the department or enterprise, although state-operated, sells its goods or services on a quasi-commercial basis to users. Examples are the postal services, publicly owned electric power, sewerage and water systems, nationalized railway companies, producers of strategic materials and so on. The important economic feature of this institutional type is the wide managerial powers over investment policies, pricing of services, etc. which are usually vested in the heads of these organizations by the legislature. There is less reliance on financial support from general fiscal funds and less control over the day-to-day affairs of the undertakings by parliament.

Finally, there is the public utility. This is basically a privately owned monopoly which is subjected to government control and supervision and emerges chastened from the process under the name of "public utility". The reputation of the name -- which, incidentally, is ideally suited for the purpose since it seems to suggest that all other economic activities are of a more frivolous character -- is upheld by frequent references to the low profits the company is making, the fact that the dividends are just barely enough to sustain the widows and orphans who invariably own all the shares and so on. The public utility either enjoys a natural monopoly, or it is given monopoly powers by virtue of an exclusive state franchise.

The public utility is in most cases prevented from pursuing uninhibited monopolistic practices by a number of positive and environmental restraints. There is in the first place always the threat of nationalization; hence the extensive public relations programmes. Secondly, the public authorities concerned may regulate rates and limit profits to a "reasonable level", or to a level consistent with a "fair return on capital". It is a debatable question whether state control in this form is desirable and effective. Schumpeter remarks critically on the theoretical basis of public utility regulation:

> "... [there is nothing of] any benefit to the analytic apparatus of economics to report from the American discussion on rate regulation that dealt with the problem of the 'reason-

able return on the fair value of the property' which the Supreme Court held public utilities should be permitted to earn. The various 'theories' of valuation for indemnity, taxation, and rate-regulation purposes that the legal mind produced offer curious examples of logical muddle. Many economists did useful work in trying to clear it up and seem, for example, after efforts extending over more than half a century, to have convinced lawyers that the attempt to define a 'reasonable' rate of return with reference to the value of a property that is itself derived from expected returns, involves circular reasoning." (71)

There are no distinct boundary lines between the spheres of any of these institutional types. Many municipalities, for example, choose to own and operate their water works, urban transport systems and power plants themselves. Other local governments entrust these functions to privately owned public utility companies. There are various intermediate institutional types which, for example, combine the features of a public utility with those of a government department.

The Highway Function - Experience in Canada

It has now to be decided into which of these institutional categories the function of providing public highways fits best. Traditionally, highways have always been treated as a proper function of public authorities, except during the relatively short-lived toll road era in the last century. Responsibility for roads in Canada was from the beginning assumed by the government and this practice, with minor exceptions, has been continued to the present day. Of the three levels of government, provincial authorities have assumed the greatest share of highway responsibilities in Canada. During the period 1919-1952 the provincial governments spent almost $3.3 billion on highways, streets, bridges and ferries, or 86 percent of the Canadian total of approximately $3.8 billion. Municipal governments spent about $290 million for the same purpose, or 8 percent of the total, and the Federal Government $215 million, or 6 percent of the total.(72) It can thus be seen that the bulk of public highway expenditures has been carried out by provincial governments, or more particularly by provincial highway and public works departments. These departments also have jurisdiction over most of the approximately 575,000 miles of road in Canada, with the municipalities (mainly urban streets) and the Federal Government (roads in National Parks and other federal lands) being responsible for only a small proportion of total Canadian road mileage.

Experience with the operation of highways other than by public authorities has been very limited in Canada. There are a number of toll bridges and toll ferries in Canada, but their insignificance is demonstrated by the fact that revenues from these facilities amounted on the average to little more than $2 million per annum between 1939 and 1952.(73) In 1953 the Province of British Columbia, and more recently the Province of Quebec, established toll road authorities which organizationally might be described as public utilities; while the first toll highway in Quebec is still in the planning stage, some larger toll bridge projects have been successfully launched in British Columbia. In comparison with total government expenditures on roads in Canada, which may exceed $800 million during the fiscal year 1957/58, the scope of highway operations carried out by these other organizations appears, however, to be negligible.

If historical experience affords any guidance, the provision of highways in Canada is appropriately a function of government. Accepting this general premise, the question of the relative shares of highway responsibilities to be assumed by the different levels of government must then remain a matter of debate. In recent years some convincing arguments have been put forward, to the effect that the urban municipalities should be relieved of some of the more burdensome obligations for main traffic arteries at present under their jurisdiction and that the responsibilities of the provincial authorities and the Federal Government should be enlarged instead. However, for purposes of the present study, the distribution of jurisdictional responsibilities is a secondary problem. More important is the fact that in Canada public authorities are traditionally regarded as the appropriate agencies to be responsible for highways.

Experience in the United States

Historical experience has been slightly different in the United States. Although there too the provision of highways and streets has been recognized as a general governmental function from the earliest times, in more recent years the institutional approach has differed somewhat from the one adopted in Canada. Whereas in this country there is no, or only a very tenuous link* between expenditures on highways by provincial authorities on the one hand, and provincial revenues obtained from road users on the other hand, the practice of dedicating all or part of the proceeds of motor-fuel taxes and motor-vehicle fees to highway purposes is widespread in the United States. This practice is followed by all except four States and is required by constitutional amendment in 26 of them.(75)

The Public Utility Approach to Highway Provision

The dedication of highway-use proceeds to highway purposes can be regarded as a partial move towards the acceptance of the "public utility" approach to highway provision. This approach has found considerable support in the United States and its adoption in Canada has been suggested on a number of occasions. It should therefore be subjected to scrutiny.

The dominant feature of the "public utility" concept of highway provision is its quasi-commercial approach to finance and the pricing of the services. While most advocates of the concept would still let public authorities retain operational control and jurisdiction over the highway plant, the discretionary powers of the government in financial and fiscal affairs in this field would be rigorously circumscribed. In particular, all taxes derived from the ownership and operation of motor vehicles, such as motor vehicle

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*The Ontario Department of Highways' report A Plan for Ontario Highways states:
"Highways are financed in Ontario by appropriations of the Legislature from the Consolidated Revenue Fund, into which go receipts from nearly all tax sources and special fees. The Legislature tends to appropriate funds somewhat in proportion to the funds received from special highway taxes, such as on gasoline and motor vehicles. Over the years, however, there have been notable exceptions when appropriations were much less than the special revenues, and conversely, when annual highway budgets exceeded special highway tax revenues." (74)

license fees, motor fuel taxes and special imposts on commercial motor carriers,* would be regarded as "user taxes", or as special fees for the use of the highway plant. In this way, user charges would be levied in addition to, and quite separately from, general taxes.

The highway authority, under the public utility approach, is then under obligation to relate its highway expenditure programme in some fashion to user tax revenues, in other words to balance its accounts. Although all protagonists of the public utility concept agree on this fundamental working principle, there is considerable disagreement among them on subsidiary technical and bookkeeping problems. For example, there is debate as regards the magnitude of government contributions from general tax funds which might be credited to the highway account, whether to stipulate rigid "pay as you go" policies with annual revenues covering both current and capital expenditures, or to permit more flexible long-term investment methods, and how to calculate the various road users' shares. The merits and defects of these subsidiary details have probably been debated at greater length over a longer period of time, than the advantages or disadvantages of the public utility concept itself.

In general terms, then, the public utility concept treats highway provision as a function which is quite different and distinct from other government functions; the concept also segregates road user taxing and highway spending from all other fiscal activities pursued by the government.

* Some groups go as far as to suggest that sales taxes, excise taxes, excise and customs duties levied on motor vehicles and motor vehicle accessories, should also be regarded as user taxes in the narrow sense of the word and hence be credited to public highway accounts.

In effect, the quasi-commercial approach introduces additional rigidities and curbs to the government's powers to collect and allocate general revenues as it sees fit. Many criticisms which have been levied against the public utility concept stress these consequences. The First Progress Report notes that "numerous students of government, tax experts, and budget officers have for many years decried the practice of devoting specific tax revenues to highways or any other individual function"(76) and then quotes Glenn D. Morrow, at the time Research Associate, Bureau of Business Research, University of Kentucky, as stating in part as follows:

> "The dedication of revenues for the support of particular activities severely restricts fiscal management by placing the administration of these activities outside of general budgetary control procedures. As a consequence, overall fiscal control cannot be exercised as effectively; the periodic allocation of available resources to meet expenditure requirements becomes more difficult; the execution of work programs cannot be synchronized as well; and full advantages of many other budgetary control functions, including such housekeeping functions as accounting, purchasing, treasury management, etc., cannot be fully realized."(77)

Notwithstanding these and similar criticisms, there has recently been a further strengthening of support for the public utility approach to highway provision in the United States. Evidence for this is provided by the success of the toll roads in recent years -- for toll roads are the ultimate in user charges -- and in certain user-tax provisions contained in the Highway Revenue Act of 1956.(78)

The First Progress Report[79] cites three reasons for the wide-spread popularity of road-user taxes and of the policy of dedicating their proceeds to the support of highways: first, their lucrative character; second, the popular appeal of a taxation system which purports to exact from each user a fair charge for the service he receives; and finally, the recognition that there is need for competitive equality among alternative transportation media.

The "equity" aspect and the "competitive" aspect of highway and road user taxation will be dealt with later in this study. The first reason given, the lucrativeness of highway user taxes, must be assessed in the light of conditions in the United States. It will be realized that these are rather different from those prevailing in Canada.

It is held by many students of the problem that motor vehicle transport in the United States has already passed its peak period of expansion and that the expected further growth of motor vehicle ownership and travel -- although quantitatively still impressive -- will take place at a gradually declining percentage rate. In 1953, for instance, there were 2.8 people per motor vehicle in the United States.[80] One writer on the subject contends that "... the reasonable saturation point appears to be 1.75 persons per vehicle ..." and predicts that saturation would be reached in the United States by 1965.[81] This contention is supported by evidence from two highly motorized states, Florida[82] and California[83] where the trend towards greater vehicle density proceeded at a much decelerated rate after a ratio of about three persons per vehicle had been reached.

The general proposition can be accepted that motor transport in the United States is well integrated into the social and economic fabric and is now heading for an era of consolidation and some moderate expansion. Broadly speaking, no unsurmountable difficulties of finding sufficient revenues for the modernization and development of the most important highways and urban arteries from road user sources are to be anticipated in the United States. It is against this background that we must consider the growing support for a public utility approach to the provision of highways.

For years associations of highway users, automobile clubs and spokesmen for the trucking industry in the United States have clamoured for the dedication of highway revenues to highway purposes; for them it was a matter of funnelling lucrative taxation proceeds, collected from a well-established industry, into the right channels; foremost in their minds was not the lack of highway funds, but rather the risk of having surpluses diverted to other governmental activities.

In addition there was growing impatience in many parts of the United States with the slow pace at which modernization of obviously inefficient highway segments proceeded. Road users were quite willing to submit to additional taxation if only they could be certain that the funds thus collected would lead to immediate tangible highway improvements. Thus a climate of opinion most favourable to a "user tax" or "toll charge" approach developed. Richard M. Zettel in his <u>Objectives and Concepts of Highway-User Taxation</u> -- one of the best analyses of the problem in terms of conditions in the United States -- put it this way:

> "Phenomenal growth of traffic, new and costly conceptions of highway design, failure to adjust user taxation to investment requirements and possible misuse of user tax

funds from the motorists' standpoint may, in concert, have given rise to the modern version of an old method [i.e. toll charges] of getting capital for highways and the means of repaying it."(84)

Largely due to the efforts of highway user groups, the practice of highway user revenue dedication, as we have seen, became well established in the United States. Once motorists knew that they wanted the public utility approach, which is so admirably suited for a "going concern", general acceptance of the principle was probably not difficult to obtain -- after all, almost all taxpayers and voters in the United States are also motor vehicle owners.

Environmental Conditions in Canada

It is important to observe that in Canada, by contrast, the rendering of highway services cannot be regarded as a profitable, self-sustaining and well-established activity. This country, far from possessing either a fully developed highway network, such as the U.S. Interstate Highway System, or a mature motor transport industry, is in the middle of a difficult growth period. The sheer physical problems of opening up the country and of linking the widely-separated regions require enormous efforts. After years of concentrated construction work it has become apparent that the Trans-Canada Highway, undertaken as a national project to link for the first time all provinces by means of a modern paved road, will not be completed before the end of 1960. Apart from the urgent need to modernize at great expense some of the presently grossly inefficient road and street facilities in Canada's larger urban centres, efforts may have to be made in the near future to bring the inadequate highways of the Maritime Provinces and other regions up to tolerable standards.

In addition to these high "transport overhead costs", or "national linking-together expenses" as they have been called -- one of the pecuniary penalties resulting from Canada's large geographical size -- there are the strains imposed by economic and population growth. For many years now the rapid expansion of motor vehicle ownership and usage has completely outstripped the capacity of the authorities to provide the road and street facilities necessary for efficient traffic circulation. Campbell shows for example:

> "In 1953 there were nearly 575,000 miles of highways and rural roads in Canada. Of this total only 33.2 per cent, or 190,997 miles, were surfaced, while only 5.3 per cent, or somewhat less than 31,000 miles, were paved. By way of contrast, nearly 60 per cent of the total rural mileage in the United States was surfaced, and nearly 22 per cent was paved in 1953."(85)

Despite the great increases in the number of motor vehicles which were experienced during the post-war period,* the Canadian vehicle-ownership ratio had decreased to only four persons per motor vehicle by 1956, a proportion which had been reached in the United States already in the late 1930's. Hence the mere catching-up with the trends experienced earlier in the United States will require further large extensions and improvements of the highway system, quite apart from the efforts necessary to eliminate deficiencies which accumulated in the past.

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*Total motor vehicle registrations in Canada more than doubled in only 8 years, from 1,845,000 in 1947 to 3,954,000 in 1955.(86)

Even if and when the time-lag of about twenty years between the American and the Canadian trend in motor vehicle ownership and usage is eliminated -- and there is evidence* that this will eventually happen by virtue of faster Canadian growth rates -- it is still very doubtful indeed whether highway transport in Canada, for many years to come, can be as self-sustaining on a user-tax basis as road transport in the United States is. The greater size of this country in relation to population, and hence the huge distances between centres which have to be spanned by highways, must be considered. On a per capita basis Canadian citizens support a larger highway mileage (about 41 miles per 1,000 people), than any other country in the world except Australia (59 miles). Figures for other countries are: New Zealand 38 miles, United States 21 miles, Union of South Africa 13 miles, U.S.S.R. 9 miles and United Kingdom 3 miles per 1,000 people.[(87)] Another consequence of the unfavourable relationship in Canada between population and size of the country, or highway mileage to be supported, is the low ratio of motor vehicles per highway mile and hence of road user taxation available to support the network. According to statistics quoted by Karl M. Richards,[(88)] in 1953 there were 17 vehicles per mile of highway in the United States, but only 5.8 in Canada.

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*An Ontario Department of Highway study, <u>Future Passenger Car and Commercial Vehicle Travel</u>, states:
"A comparison between Ontario traffic growth rates and those reported by various U.S. road administrations shows that Ontario's traffic is expanding and is expected to continue to expand at a considerably faster rate than found anywhere in the U.S. It would appear that this is a result of Ontario's vehicle miles of travel per capita catching up very rapidly."[(87)] The statistical results of this comparison are shown in Table 26.

In any comparison of the highway problem between Canada and the United States the fact must finally be taken into account that the severity of the climate, snow, ice, frost, unfavourable soil, topography and drainage conditions which are encountered in this country, make for very heavy additional expenses.

Campbell points to the fact that "in the 19-year period from 1935 to 1953, the total revenues from road user imposts accounted for 71.9 per cent of all road and street expenditures in Canada ...".[85] While such a juxtaposition of data is not too meaningful unless the attempt is made to contrast <u>economically desirable</u> highway revenues and expenditures with each other and with actual experience, the comparison nevertheless shows that highway user taxes cannot be regarded as a lucrative source of extra revenues for the government. In view of the factors considered this is not surprising, nor is there any evidence at this stage of the discussion that it should be otherwise.

<u>Rejection of the Public Utility Concept</u>

There seem to be a number of good reasons to reject the application of the public utility approach to highway finance in Canada. On a theoretical level, all the objections which have been raised against the public utility concept as such apply with equal force to its extension to the highway sphere. The public utility might be regarded as a hybrid between the public enterprise and the private monopoly; conceivably it might combine the less desirable features of both. Under the public utility approach to highway provision, government authorities would then be required to simulate the actions of an economic institution which itself does not conform to any theoretical ideal.

On a practical level it appears that the concept was evolved in the United States to suit certain conditions which, however, do not exist in Canada. In this context it is impossible to ignore the very powerful influences on highway policies exercised by geographical, climatic, socio-political and particularly economic and traffic growth factors; all these environmental features differ greatly in the two countries. It would be just as logical to urge adoption of British road finance methods in the United States, as it is to suggest that Canadian authorities should necessarily copy the procedures of their colleagues south of the border. Similarly, it is impossible to disregard the great regional differences existing within Canada. Highly industrialized and densely populated Ontario, for example, with one motor vehicle for every three persons, may be in a good position to finance ambitious highway programmes from user taxation. Newfoundland, on the other hand, with one motor vehicle for every ten inhabitants, will probably require quite different financial and organizational approaches to its particular highway problems.

Economic considerations do not lend support to the proposition that highway expenditures in Canada as a whole or in any region should be rigidly tied to highway revenues as the public utility approach demands. Expenditures on roads should be determined on the basis of ascertained needs of the system, coupled with comparisons of the economic benefits to be reaped by spending public funds in one particular way rather than in another. During a period of expansion and rapid growth of motor traffic, not enough funds would be forthcoming to finance the development of the highway and street system. Hence heavy economic losses would be incurred by the community as a whole through underinvestment in roads. During a period of stagnation or moderate growth of motor vehicle traffic, on the other hand, excessive spending on roads might be encouraged by the public utility method to the detriment of other government investment projects. There are many competing uses for public money and, unless compelling arguments to the contrary can be put forward, the highway function should be subjected to the same economic criteria and public finance controls as all other government functions.

Highway transport in Canada is now going through an expansionary phase which calls for great public investment in road and street facilities. This partly explains the current interest in highway finance and the special status with which the subject has been endowed by some. But the problem has to be seen in historical perspective: in the past money spent on railway development yielded the greatest benefits; today highways and the St. Lawrence Seaway offer great scope for public investment; tomorrow even more profitable opportunities may open up in the spheres of atomic energy, urban renewal, and air transport.

Similar considerations should prevail on the revenue side. Highway user imposts cannot be treated in isolation, but must be judged in the light of the efficacy of the taxation system as a whole. Our criteria must be how much money should be collected from taxpayers as a whole, and secondly, how to distribute the burden in the most efficient manner among individual taxpayers. It does not appear that the public utility approach can be used for guidance when these questions have to be decided.

On balance the public utility approach, with all the rigidities it introduces into government planning, with its emphasis on pseudo-commercial notions, must be rejected. Perhaps the spread of the public utility concept, just like the success of toll roads, can in some cases be traced back to certain shortcomings in the performance of public highway authorities and of government generally. To use Zettel's phrase: "user taxation was conceived of expediency, born of necessity, and nurtured of politics."(90)

There is no reason why a government, acting according to sound economic principles, should not be able to perform the highway function efficiently. This possibility will be discussed in the next chapter.

VI - PUBLIC HIGHWAYS - ECONOMIC PROBLEMS

In the last chapter some important background factors were discussed which have to be taken into account in any realistic appraisal of public highway problems. With particular reference to Canadian conditions, we arrived at the conclusion that the so-called "public utility" approach to highway finance must be rejected. For practical and theoretical reasons the provision of highways will therefore be treated as a public enterprise or government function throughout the remainder of this study. In this chapter the attempt will be made to analyse the economic problems posed by public highways.

The Main Economic Objectives

It is essential to distinguish first quite clearly the various economic objectives we intend to pursue. Too many different issues, too many divergent ideals we might try to attain spring to mind when we look at the highway problem as a whole; as one doyen of highway research in the United States put it: "To visualize the whole picture at once has already given me mental indigestion."(91)

Following the procedure established in the toll road analysis we shall first discuss highway investment problems, such as the allocation of funds to the highway function, the selection of the optimum plant size and the best level of output. Subsequently the pricing of highway services will be analysed. Finally, as a subsidiary problem to pricing, possible methods of collecting charges from users will be considered.

At the outset the logical interdependence of these broad problem areas and their relative significance must be defined.

Some difficulties arise when a systematic treatment of the natural sequence of events and decisions is attempted. In one sense the investment decision of the highway authority -- which will anticipate traffic flows, choice of routes by users, motorists' willingness to pay certain charges and other demand factors -- must come first and is more important than the subsequent pricing policy. In another sense, however, the optimum location, size and output of the highway plant to be constructed is determined by the pricing policy, since it in turn influences the demand for highway services.

The dilemma thus posed by the fact that the sequence of decisions appears to be the reverse of the sequence of events, has baffled many students of road transport economics. One school of thought, the advocates of the public utility approach, stipulate the following order of economic action: first, introduce a pricing policy which serves, *inter alia*, objectives of fairness and equity of taxation, maintenance of competitive neutrality between different transportation agencies and the balancing of highway revenue and expenditure accounts at any moment of time; secondly, make revenues produced under the given pricing regime, or anticipated under a proposed pricing regime, the basis of your subsequent highway investment and expenditure decisions.

A number of bookkeeping refinements have been suggested by adherents of the public utility approach to highway provision; for example, it is proposed that not *all* highway expenditures need to be balanced by highway revenues, since there should be a credit item from general fiscal funds equivalent to the community services rendered by highways. It is further suggested by some, but not all, advocates of the public utility concept, that highway expenditures of a capital investment nature may be written off in the accounts over a period of years.

These proposed modifications need not occupy our attention now. It is more important to recognize that a concept which would let the pricing policy, and hence revenues, determine the investment policy, distorts the logical pattern of relationships between inter-related factors. Basically, planning of new investment is independent of pricing, but at the same time pricing also has to be taken into account as a dependent, but necessary, part of the entire highway plan. Hence it will be far more satisfactory to treat the investment analysis, the determination of priorities, the allocation of funds and the evolution of pricing policies as interconnected parts of the same problem.

Although the more sophisticated versions of the public utility approach can achieve quite satisfactory results, there is always the danger that too much emphasis is placed on the magnitude of revenues collected from road users in the past as the principal determinant of future highway expenditures. It is only too easy to slip into a narrow bookkeeping approach, with highway revenues and expenditures all neatly balanced year after year, while great social losses are incurred because more dynamic -- and less easily measurable -- highway development possibilities are completely neglected. It is therefore desirable that we should get away from the contemplation of past fiscal records and evolve a more dynamic approach to highway development and financing.

In the following analyses we shall treat highway investment planning -- in other words resource allocation designed to achieve output maximization over time -- as being of greater importance and deserving first priority. Pricing policies, seen both as revenue-raising and as consumption-rationing devices, will be regarded as playing a subordinate role to highway investment decisions. Theoretically ideal pricing policies and user-charge techniques which are feasible in practice will finally have to be reconciled.

New Definitions of Working Variables

We noted before that we move from the narrow specialized case to the broad, all-embracing economic concepts when we effect the change from the toll road model to the public highway system. This calls for re-definitions of our working variables.

The toll road operator based his decisions and actions only on those costs which resulted in money outlay to him and only on those benefits conferred by the provision of highway services which resulted in revenues to him. He endeavoured to pass on to the community at large as many as possible of the social costs caused by toll road operation, but we saw that most of these became real costs to him as he widened the scope of his activities to include, for example, industrial development, land speculation and so on. Similarly, by broadening the range of projects he took on, almost all social* benefits were turned into money revenues accruing to him.

By simply carrying this process of extension of activities further and further, we will eventually reach the position occupied by the public highway system. All activities external to the privately-owned toll road, which were favourably or unfavourably

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* To simplify the terminology all non-vehicular benefits (i.e. those called "direct", "indirect" and "transferred" non-vehicular benefits in the First Progress Report (92)), will be called "social benefits" from now on.

influenced by its operation, are then internal to the economy as a whole and hence of direct concern to the public highway department and other authorities. In other words, all economies and diseconomies which were external to the toll road, now become internal economies and diseconomies of the public highway provision function, when looked at from the point of view of the national economy. Hence <u>all benefits</u> attributable to, and <u>all costs</u> caused by, public highway provision must be taken into account in road investment planning.

In the following sections some examples are given of how highway benefits and costs might be interpreted in this broad way.

<u>Highway Benefits</u>

Benefits conferred by highway provision were measured, in our toll road example, by the maximum amount of money users in the aggregate were prepared to pay for the services rendered. The highway authority, acting in the public interest, is concerned with social aggregates and will therefore, in the widest sense, measure highway benefits in terms of additions to gross national product. Assuming full employment, highway benefits will be measured not only in terms of savings in cost, time, inconvenience etc., which road users can directly realize, but also in terms of transportation cost, production cost and distribution cost savings accruing to the entire economy. When there is unemployment then the favourable employment-creating effects of investment in highways must also be taken into account.*

This is to say, in effect, that highway planning -- like all other economic planning -- must take all relevant circumstances into account. It must not be forgotten that the transport industry is a service industry and that the provision of highways must therefore also serve some wider economic, social and political purposes beyond the mechanical conveyance of vehicles from one point to another. Highway development may exercise most beneficial effects on land use, growth of secondary industries, and development of natural resources, and these economic consequences should be considered. Construction of highways between agricultural areas and large population centres, for example, might stimulate the production of perishable food-stuffs which can then be successfully marketed over greater distances. Coordination between the highway department and the department responsible for agriculture, when assessing highway development benefits in such a case, is essential. The same applies to the mining industry, forestry, fisheries, the tourist trade and in the widest sense to all economic activities which are served by highway transport.

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* As G. J. Ponsonby points out, inefficiencies result if the unemployment criterion is given preference over transport and traffic considerations. Referring to the failure to cope with the great increase in the volume and speed of modern traffic in the big cities of Great Britain, he states: "This grave omission, whilst to some extent reflecting an error of policy, was partly due to the conception of roads as a means of reducing unemployment. It was 'policy' to build roads in depressed areas, and wherever there was a surplus of labour. This involved a permanent reluctance to undertake reconstruction in built-up areas, where so much of the total sums involved are absorbed by land purchase and compensation."(93)
Some "overdevelopment" of remote rural roads in the United Kingdom took place during the 1930's, to provide work locally.

Highway Costs

Highway costs too must be assessed in such a way by the public authorities that social cost factors, which would escape attention under an ordinary bookkeeping approach, are taken into account. Highway noise, fumes, dust are factors to be considered, also possible detrimental effects of road layout on land values.

It is sometimes argued that the rapid depreciation in the value of fixed assets of one transport agency caused by the emergence of a competing medium can be regarded as a real loss to the community. It is contended, for example, that social costs are being incurred when a railway line is forced to close down because all its business has been taken over by trucks and buses using a parallel highway; in this case the abandonment of railway cuttings, graded tracks, tunnels etc. and other items with little or no resale value is regarded as a loss, to the community, of "valuable assets".

It should be emphasized that in such instances the historic costs of fixed assets are quite irrelevant and cannot be debited to the "social cost account" of the highway agency. If durable assets of railways -- and for that matter of pipelines, highways, airports, canals and harbours -- are rendered obsolete due to competition more quickly than through normal physical wear and tear, then this is a case of faulty planning at the time these assets were acquired, which only now has come to light. We are concerned with the allocation of scarce resources for current and future productive purposes and we must judge the economic value of durable assets acquired in the past by their contributions to current and future output. Hence historic costs are irrelevant and the loss in book values of durable structures or equipment owned by one transport agency cannot possibly be debited as a current social cost to the competitive medium.

Problems of Benefit and Cost Measurement

We interpreted benefits conferred and costs caused by highway development in the broadest possible way. With some justification the criticism could be put forward that our definitions are unrealistic, because there are no measuring techniques available to match these wide interpretations. Admittedly, there will be practical difficulties in assessing all benefits and all costs to a great degree of accuracy in all circumstances, but this does not mean that we should not set our aims high. We must start off with our cost and benefit assessments from the safe but narrow base of measurable items, such as savings and losses in time, vehicle operating costs, accident costs; this will eliminate at least some areas of doubt which might adversely affect our highway investment decision making. It should then be our prime aim to narrow down further the scope of guesswork by improving our measuring techniques.

It appears that the Highway Cost Allocation Study, which is currently being conducted in the United States, may proceed in this way from the well-known and well-established facts into new spheres where ignorance still prevails. This is gratifying, because so many times investigations in this field seem to start off from a very wide basis, with sweeping terms of reference to enquire into the general economic nature of roads and road transport; but then, in order to produce tangible results quickly, the scope of research is narrowed more and more -- partly by taxonomy -- until the final conclusions are all but useless since they apply to such a limited aspect only of the original subject.

There is a strong tendency running through much of the literature on highways and highway economics to cling to things which are measurable. Dearing called it a "futile quest for arithmetic certainty".[94] No doubt the strong engineering flavour of the subject of highways has something to do with it. This should be overcome, as was suggested, by proceeding from the narrow area of measurable costs, benefits and other ascertainable economic facets, to broad and general concepts. There are great opportunities for co-operation between engineers and economists in this field. Already a substantial body of information has been built up on the favourable effects which highway improvements have on direct vehicle operating costs.

To quote but one example of many possible ones: controlled tests conducted in the United States have established the very marked effects which rises and falls in the highway profile have upon fuel consumption and travelling time of motor vehicles, particularly of heavy tractor-trailer combinations. It will be useful to illustrate the types of results which can be expected in this field by drawing on information contained in the First Progress Report. Let us take the case of an extremely heavy vehicle (140,000 lbs. gross vehicle weight), with the representative weight-power ratio of 400 lbs. per horsepower (manufacturer's net horse-power rating). The First Progress Report[95] shows that the following favourable effects on the performance of such a vehicle were observed when the rate of rise and fall of the highway profile*

*The rate of rise and fall is the arithmetical sum of the amounts of rise and fall in feet for any section of highway divided by the length of the section in hundreds of feet.

was reduced from 6 to 3 feet per 100 feet:

(i) Gasoline consumption decreased from 1.40 gallons per mile to 0.70 gallons per mile.

(ii) Composite travel time reduced from 5.00 minutes per mile to 2.4 minutes per mile.

(iii) Gross ton-miles moved increased from 50 to 100 gross ton-miles per gallon of gasoline consumed.

(iv) Gross ton-miles moved increased from 820 to 1,780 gross ton-miles per hour of travelling time.

Numerous other illustrations for highway improvement effects exercised on lighter vehicle types, with different weight-power characteristics, could be quoted, but this one specific example will suffice to indicate the type of information which can be provided by engineering research and operating tests. As soon as we take the next step and try to assess in money terms the savings made possible by, for example, a reduction in the rate of rise and fall of the highway profile, we move into the realm of economics. The economic character and importance of the load which can thus be carried more efficiently has to be assessed; time savings have to be translated into money savings by taking into account the faster turnover of vehicles, reductions in overhead costs (license fees, insurance charges etc.) per ton-mile or per vehicle-mile, proportionate reductions in labour costs and so on; allowances also have to be made for the use of lighter tractors made possible by lower power requirements, for differences in services performed (line haul versus pickup and delivery), differences in ratios of payload to tare weights and for many other factors.

It can readily be seen that there is great scope for further research, particularly in view of the fact that so far relatively little information has been compiled which goes beyond the basic vehicle operating test and engineering data such as those mentioned before. The field for fruitful enquiries widens even more when we take into account broader social benefits, such as reductions in accident costs, industrial development, improvements in land use, creation of better marketing possibilities and decentralization of population.

It is impossible within the scope of this study to deal exhaustively with all the methods which could conceivably be employed to assess the beneficial or detrimental effects of road development. Changes in property values should certainly be studied, since they lend themsevles easily to estimation. The creation of business opportunities brought about by highway improvements, on the other hand, cannot be measured very simply and special techniques may have to be evolved. It is suggested that the effect of road and street improvements in large urban centers offers a particularly profitable field for investigation in the widest sense. In urban areas the social costs caused by the lack of efficient road transport facilities appear to be quantitatively especially important, as for example the readily observable decay of the central core of many a large city testifies.*

Quite clearly other scientific disciplines, such as economic geography and history, should also be brought to bear on the subject.

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*The present author attempted to draw attention to the wider aspects of the city traffic problem in the section of the Canadian Federation of Mayors and Municipalities' brief to the Gordon Commission which dealt with urban transportation.(96)

Location theory may make valuable contributions to highway planning. Advanced statistical and mathematical techniques are already being used in the field of traffic engineering. Town-planners, architects, social scientists have a great stake in urban problems. No doors to future scientific enquiries in this field should remain unopened.

<u>Allocation of Public Funds for Highway Purposes</u>

We now come to an important part of our analysis, the allocation of funds for purposes of public highways. The state is continuously confronted with the very difficult problem of deciding how to allocate funds to different government services, of which the provision of highways is one. We are here not concerned with the question of the proper delimitation of spheres of government activity and of those which should rightfully be reserved for private enterprise. We assume that the state is carrying out all the functions which it can fulfil better than private enterprise and vice versa. We further take it for granted that both the level of <u>total</u> taxation and of <u>total</u> government expenditure are optimum, in the sense that a higher or lower level of either would result in a less advantageous situation, or in less preferred circumstances, for the country as a whole.

Re-stated, the problem of the state under these assumptions is therefore the optimum allocation of disposable funds or resources, the total level of which is optimum, to different government functions. In the abstract, the most beneficial allocation of resources and the maximum contributions to the social product will be achieved when the (marginal) net returns from (marginal) government outlay on Function A are equal to the (marginal) net returns from an equally large outlay on Function B, and when both are equal to net returns accruing from government outlay in all other spheres.

Problems of Measurement of Returns from Different Government Activities

This formula for the optimum allocation of resources by a government breaks down in practice, because of the difficulties inherent in measuring and comparing returns from the rendering of different government services. Whereas we found before that the measurement problems might be overcome within one particular sphere, namely that of highways, it seems almost impossible to develop a yardstick of resource allocation efficiency which could be applied to a number of diverse and unrelated government functions. How could one, for instance, ever hope to compare the net benefits accruing to the country from improvements in the maintenance of law and order made possible by the construction of a new courthouse, with those attributable to a new bridge? Obviously any attempt to compare one with the other is doomed to failure. Even the old remedy of economists in such cases -- translation into money terms -- is of no avail, since the administration of justice, and many other government activities as well, simply do not lend themselves to such monetary or numerical assessment.

As a concession to reality we therefore have to admit that a large proportion of government outlay will not be subject to the economic cost / net return calculus and will be determined by political judgment. Of course, there will still be ample scope for economic decisions as well and some authorities -- for instance those responsible for transport and for public works -- may rely predominantly on economic criteria.

Inter-Agency Competition or Central Planning?

It may well be that in this economic-political sphere of government budgeting one department will be vying with another for the allocation of funds. Going further, two divisions within one department may be competing with each other, for example the one responsible for airport development with the waterways authority. How are the conflicts of interests to be resolved?

Different solutions have been prescribed for the optimum allocation of funds between government departments. Pseudo-competition between the various agencies concerned with transportation in the United States has, for example, been suggested:

> "Competition in transport today also has a significant bearing on the organization of administration of public policy ... Transportation is not a single industry ... and a uniform program is not the answer to today's issues... The problems are so distinct ... that separate commissions could function more efficiently and more expeditiously. Each could deal with the problems of its own mode without the pressures of the conflicting claims of the other. Each would be compelled to recognize the competitive requirements of its own charge. Finally, the competitive pressures of independent and separate responsibility would serve as a stimulus to initiative, imagination, and adaptation that is sorely needed in transportation today. Competition is an excellent antidote to bureaucracy and vested interest."(97)

By contrast to this concept, which might be called the "competitive approach to public policy", the central planning method is espoused by other writers. Little, for example, favours the latter solution for public enterprises:

> "[The question can be raised] whether it is not possible to

introduce into public enterprise some element of competition. ... Thus it has been suggested that, for some industries, it would be better to have several boards which would compete against each other, rather than one central board. There would, however, be disadvantages in not having a central board for an industry. In any industry there are probably certain economies of 'co-ordination', such as central research and the dissemination of information. Perhaps more important in some people's view is the fact that the industry would become more difficult to control if there was no single central organization responsible to the Minister. ... the same presumed advantages, which would result from having an industry split up into a number of competing boards, could be rather better obtained with a central board, if that board adopted a suitable policy."(98)

We are in this study primarily concerned with the economics of highway planning *per se* and we must therefore return from the dizzy heights of general economic policy to our more earth-bound subject. However, it should be realized that the allocation of public funds at a higher level of political and economic decision-making, in the last resort, delimits the scope and magnitude of highway investment planning.

Little Conflict Between Political and Economic Objectives in Highway Sphere

These limitations imposed on the highway function by general economic policy and also the blending of political and economic processes in the decision-making, has been decried by some as "political interference with an economic activity". However, it is suggested here that the alleged conflicts between political and economic objectives, as well as the apparent dissension between the "competitive" and the "central planning" approaches to fund allocation, might largely be resolved by better planning and housekeeping arrangements <u>within</u> the highway or public works departments.

Certainly under conditions on the North American continent, highways, roads and streets do not serve special groups -- they serve everybody. Hence, the criteria of road planning should generally also coincide with political desiderata, such as "the maximum satisfaction from government expenditure for the maximum number of people." It follows that efficient road planning methods should serve political ends very well too. It further follows that the final results and recommendations of these technically and economically sound planning procedures should find a good reception at the highest economic policy level. If decisions there are made purely on political grounds, the public service aspects of highway development plans might be stressed to get the expenditure programme approved. It would, for instance, be hard to decide for the political representatives in power whether a constituency which voted for the opposition should be "punished" by withholding road improvement funds from the area -- thus risking the permanent alienation of those voters -- or whether the electorate should be "won over" by especially good treatment. In the end, ordinary traffic and economic criteria may influence the final decision more than anything else. If, on the other hand, a central planning board has the last word in the allocation of funds for the various government purposes, then the technical quality and competence of the plans prepared by the highway department should favourably influence the policy decision.

It is for these politico-economic reasons that the so-called "highway needs studies" -- which serve simultaneously as internal masterplans for highway departments and as documents to guide legislators in the allocation of funds for road purposes -- have been so eminently successful in the United States and elsewhere.* Most of these studies follow a fairly standardized pattern, although refinements are introduced as experience is gained over the years. Usually a classification of the highway system according to function performed by each segment or component is attempted first. Thus several classes, such as freeways, major trunklines, minor trunklines, feeder highways, secondary roads, urban expressways, residential streets, etc., each serving a distinct function and purpose, are established. Next, desirable technical standards are worked out for each road class. Subsequently, a complete physical inventory is taken of the existing highway plant and the actual technical state of each component part is contrasted with the desirable standards. Improvement and development priorities are then worked out with the worst deficiencies being allotted the highest priority rating. Finally, costs of the complete programme, as recommended by the highway department, are estimated.

Specific recommendations on the financing of the programme and the pricing of highway services are usually not within the terms

* Highway needs studies have been carried out in many of the States, in most cases by the highway departments concerned with the help of independent consulting organizations, such as the Automotive Safety Foundation of Washington, D.C. The first Canadian needs study, also prepared with the help of the A.S.F., was completed at the end of 1956 in Ontario; the report was made public by the Ontario Highway Department under the title A Plan for Ontario Highways.(5) The present author was privileged to be associated with this study for a limited period during 1956.

of reference of the highway needs studies, but sometimes companion documents dealing with these matters are prepared separately. It has been suggested that the Ontario study(5) should also be followed by a financial plan of action, since otherwise the proposed optimum highway development programme may not be put into effect.

General Features of Allocation of Funds

What general features of interest can be deduced from the description of the processes relating to the allocation of public funds? Firstly, we observe a blending of economic and political criteria at the top decision-making level. As far as highway development is concerned there need be no conflicts, since the economic and political desiderata largely coincide. It should be added, though, that some regional conflicts can arise; divergences of interest might further become apparent when a long-term development policy, to the neglect of established areas, is being implemented. For example, a government might deliberately subsidize under-developed or growth areas by means of highway programmes. There might also be conflicts between rural and urban areas, when the former have a greater weight in the election process than warranted by the number of inhabitants.

Secondly, it can be seen that the adoption of efficient planning, management and housekeeping arrangements within the highway department itself, will in most cases also result in the desired allocation of necessary funds. Highway needs studies and other planning instruments will be very useful, both in the case of political decision-making and when a central government planning board exists.

Road Revenue-Expenditure Equation as Guide to Public Policy?

Reverting once more to the "public utility" approach to highway provision, it may be remarked that an enforced linkage between highway expenditures and highway revenues would introduce unnecessary rigidities and distortions into a process which in practice works probably very well. The public utility concept -- in order to minimize political interference -- would establish equality, or some fixed proportionate ratio, between highway expenditures and highway user revenues. We have seen that expenditure determination is partially or completely subject to political decisions; in fairness to the advocates of the public utility approach we can assume that this difficulty might be overcome by suitable institutional arrangements.

However, the real difficulties arise when we consider the revenue side of this allegedly ideal equation. If we use revenues collected from road users in form of license fees, motor fuel taxes and special fees as the criterion for the "social profitability" of highway expenditures, then the underlying assumption is that the existing user imposts are at the ideal level. This assumption is inadmissible. By drawing on the example of a specific road project Winch puts the theoretical case very well:

> "It is important to note that the levels of expenditure and revenue incurred by a project are in no way a criterion of whether that project is worth while. Various forms of 'solvency quotient' have been devised by writers in the U.S.A., and the idea is prevalent in the minds of many actually responsible for planning. It relates the anticipated earnings from a project in the form of increased

highway user tax revenues with the expenditure on the project. There are two objections to use of this as a criterion. Firstly user taxes do not always measure benefit. Thus straightening a curved road might reduce fuel consumption and fuel tax receipts, showing negative revenue from the project while the benefit might be considerable. Secondly it assumes existing rates to be at the ideal level. If a project is solvent by this criterion it means that users are prepared to pay the expenses of the project ... If it is not solvent, however, it may mean that tax rates are so low that users will not be charged the full expenses involved, though they might be prepared to pay them; alternatively it might mean that tax rates are so high as to discourage traffic which would be prepared to pay the costs of the project ... It therefore puts the cart before the horse in saying that a project must be solvent at existing rates of taxes in order to be worth while, rather than that a project which is worth while can be made solvent at the right taxes."(99)

The same reasoning applies also, of course, to the relationship between revenues and expenditures of all projects contemplated by a highway department and hence to the "solvency" or the "social profitability" of the highway function as such.

Revenue-Expenditure Relationships - Practical Experience

In practical terms, it is also interesting to note that there does not seem to exist anywhere a consistent pattern of user tax rates and of highway revenue / expenditure relationships. In Canada gasoline tax rates range from 1 cent per gallon (Northwest Territories), 6 cents (Yukon) and 9 cents (Manitoba) to 17 cents per gallon in Newfoundland and Nova Scotia.(100) Vehicle registration fees also show great variations. During the post-war period (1946-52) user revenues in Canada as a whole accounted for 80 percent of provincial expenditures on roads and streets, but for only 42 percent in Newfoundland as compared with 102 percent in Ontario and 116 percent in Saskatchewan.(101)* Making certain assumptions as to annual mileage travelled, fuel consumption etc., Campbell shows that great variations in user imposts per vehicle-mile or per ton-mile paid by the same vehicle types exist in different parts of Canada.(104)

Campbell's comparison of median road user imposts per vehicle-mile paid by selected vehicles in Canada and the United States further brings out the fact that the Canadian charges are from 101 per cent to 133 per cent higher than in the United States.(105) Analogous comparisons of road user taxes imposed in the various parts of the United States show very great variations indeed. Stipulating annual travel of 9,500 miles at 16.5 miles per gallon, the First Progress Report shows, for example, that total annual road user taxes paid by a light-weight passenger car in 1956 ranged from a minimum of $28 to a maximum of $68 within the United States. Assuming 70,000 miles of annual travel at 4.3 miles per gallon, total road user taxes paid by a 5-axle diesel combination varied from $1,284 to $4,304 in the United States.(106)

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*These percentages are lowered considerably when municipal road expenditures are included, without making allowance for municipal revenues from local taxes, which -- although not specifically earmarked for roads and streets -- are presumably partially levied for this purpose.
Objections can also be raised, on grounds of accounting and economic principles, against a crude comparison of road revenues and expenditures on a yearly or period basis, without taking into account the capital value of existing highway assets.(102) (103)

Broadly speaking, road user imposts are lowest in the United States, higher in Canada and highest in Europe. Motor fuel tax rates range from a few cents per gallon in the United States -- regarded there sometimes as "confiscatory" -- to the equivalent of almost one dollar per gallon in some European countries. The relationships between motor vehicle revenues and highway expenditures are much less favourable for the road users' viewpoint in Europe than they are on the North American continent. Total direct expenditures on highways and streets in the United States (excluding capital outlay for toll facilities) amounted to $50,299 million from 1947-56. During the same period highway and street receipts from user imposts, toll charges and certain property taxes (but excluding federal funds* and bond issue proceeds) were $40,395 million. Hence in the United States user revenues accounted for about 80 percent of road expenditures in the post-war period.(107)

In Great Britain, on the other hand, highway tax receipts vastly exceeded expenditures. In the eight years from 1948 to 1955 altogether £1,677 million were raised from fuel taxes and vehicle and license duties. Expenditures from the so-called "Road Fund" in this period were only £219 million. Not counting road expenditures and revenues of local authorities, highway user revenues in Great Britain accounted therefore for nearly 800 percent of highway expenditures. The road expenditures which would have been justified in Great Britain under the public utility approach, might possibly

*Federal funds amounted to $5,694 million during the period 1947-56; they were, however, derived from general funds and are therefore not taken into account here on the revenue side. Beginning July 1, 1956 the highway user has become the almost sole provider of Federal funds for highways. Consequently in future compilations of highway revenues and expenditures, the motor-vehicle contribution will show substantially higher percentages.

have been unrealistically large, considering other economic and fiscal factors.

It can be concluded that there is neither theoretical nor empirical evidence that the equation of highway user revenues and disbursements could provide much guidance when decisions on the allocation of funds for different government purposes have to be made. The level of road user taxes -- a factor which would assume a causal role under the public utility approach -- is arbitrarily fixed and may predominantly be determined by political considerations. There is also evidence that the demand of motorists for motor fuel (and for the licensing of vehicles) is inelastic in terms of changes in user tax rates. One reason for this is the fact that road user taxes amount to only a very small proportion of the total cost of owning and operating an automobile. The average Canadian motorist, for example, pays about 25 cents a day, or $90 a year, in user taxes, whereas the true economic cost of vehicle operation and ownership amounts on the average to well over $1,000 annually.[108]

Guiding Principles for Allocation of Funds

It is suggested that the determination of the magnitude and priorities of road investment projects must come first. This is an internal task of the highway department. The proposed highway development programme, complete with cost and benefit estimates, must then be reconciled with the claims for funds of other government departments. Within the overall limits imposed by total planned government expenditures, all projects which promise to yield net social benefits over and above social costs should be considered. Since the total proposed expenditures on socially worthwhile projects may exceed total budgeted government expenditures, a proper sequence of priorities must be worked out. The procedures followed would resemble those employed by the toll road operator (see Chapter IV) when calculating project priorities, except that all variables, such as costs and benefits, are interpreted in the widest social sense.

Within the general framework of economic and fiscal policy, highway user taxes can also be made to play their appropriate part, both as devices for the raising of revenues and as devices for the rationing of highway use to economic quantities. Highway pricing problems will be discussed in greater detail in the next chapter.

Generally, it should be the aim of economic policy to give all public enterprises and departments an equal chance to prove themselves. There should be "equality of promotion" of, for example, all forms of transportation and of all public works. The government should endeavour to preserve economic neutrality between different activities by refraining from granting special subsidies, preferential credit facilities and state guarantees to one public enterprise, when such promotional treatment is not also given to all other enterprises which have equally good claims for such encouragement. In short, there should be equal opportunity for growth of all public economic functions, taking into account, of course, differences in the stage of development reached by different agencies and differentials in the contributions to external economies they may make.

Jurisdictional difficulties may arise in the highway sphere when this concept of "equality of promotion" is put into practice. In Canada, due to special historical and constitutional circumstances, the Federal Government plays a very minor role in promoting and financing road development. As we have seen before, the main burden of highway costs is borne by provincial governments. However, all other forms of transportation -- water, pipeline, air and rail transport -- are under federal jurisdiction. It has been argued that due to the smaller fiscal resources of the provinces relative to those commanded by the federal government, highways are suffering a promotional disadvantage vis-a-vis the other forms of transportation.

In the same way it is also argued that urban arteries and streets, which are the responsibility of municipal governments, suffer from neglect compared with provincial highways. Since there is no overall government agency to look after <u>all</u> forms of transportation and <u>all</u> roads and streets, it is held, there therefore exist promotional inequalities between different transport media, between different regions and between urban and rural facilities. To give a hypothetical example: actual federal expenditures on a harbour in the Maritimes might yield much lower net social benefits than corresponding investment in (say) an urban expressway in Montreal would have yielded, if only the jurisdictional circumstances had permitted the Federal Government to take on the latter project.

This opens up the very wide field of inter-governmental fiscal and economic relationships, which is worth a lifetime's study by itself. It can merely be suggested here that the responsibilities of the three levels of government for highways and streets might profitably be re-defined in the light of modern conditions in Canada. The tendency in the United States has been for the Federal Government to grant increasing amounts of money -- specifically earmarked for approved highway projects -- to the individual states. Apart from the Trans-Canada Highway agreement between the Federal Government and the provinces, there has been very little federal aid for road purposes in this country. It is frequently suggested that the Canadian system of unconditional federal grants to the provinces is much superior to the approach in the United States where the earmarking of financial aid is preferred, since the former method leaves greater freedom of economic decision -- based on more intimate knowledge of local or regional conditions -- to the provinces.

In conclusion of this discussion on the political and economic processes which determine the allocation of funds for highway purposes, it should be emphasized that no one system will suit every country or every region. There are important differences in tradition, economic circumstances and constitutional arrangements to be considered. At the present time the tendency in the United States seems to be to segregate the highway function from other government business and to subject it to centralized planning techniques.

Canada may or may not follow this trend, but in any case it is important to bear in mind that wide areas of budgeting will always be subject to political considerations and to decision-making at the ministerial level. As The Economist put it: "Try as he will the civil servant cannot quite act like a rate of interest."(109) In the last analysis the political authority must be the final judge of the relative merits of the "essays in probability" and the "essays in compromise", as economic planning reports and political reports were once called by a senior civil servant and economic adviser to the British Government.(110)

Investment Planning by Highway Department

To carry our analysis a step further, we now assume that "optimum" funds -- by whatever political or economic planning processes -- have been allocated for highway purposes. It is then the highway department's responsibility to spend these given funds in such a way that the maximum aggregate social benefits are obtained for the community as a whole.

The highway department is confronted with a wide choice of many possible projects, all scattered over a wide geographical area. The list of proposed projects may include, if we ignore jurisdictional difficulties, such diverse facilities as urban expressways, mining roads, bridges, causeways, traffic interchanges, primary highways and local roads. The highway department is therefore in somewhat the same position as our toll road operator when he had to decide which projects to select and in what sequence.

The project selection processes employed by the toll road promoter as described in Chapters II, III and IV, will largely also apply to highway investment planning. There is no need to restate them here, since the basic techniques employed are the same. Notable differences between the two cases are:

(i) Theoretically at least, there is no limit to the number of projects the toll road entrepreneur will promote, as long as each one of them yields net revenues. Limitations on the number of projects launched by him are imposed by the actions of other promoters and by general economic considerations, such as price trends, the prevailing rate of interest, risk elements, etc. The investment activities of the highway department, on the other hand, are circumscribed by the funds budgeted for highway purposes and it is the budget process which reflects the general economic forces such as the level of employment, inflationary or deflationary trends, the rate of interest, the availability of resources for government purposes and so on. The highway department's scope of autonomous decisions is therefore more restricted than that of the toll road operator, since the responsibility for the determination of the overall extent of highway work rests with the economic policy makers.

(ii) The highway department will interpret the working variables "costs" and "benefits" in the widest possible way. Appropriate definitions and interpretations were discussed at the beginning of the chapter.

(iii) Planning by the highway department will be an all-embracing process, which will treat all highways and streets as part of an integrated system, whereas the toll road operator tends to deal with separate projects.

(iv) The "time" horizon of the highway department will be more extensive, not only because it will aim at long-term maximization of net social benefits, but also because it will be in a better position to take a long-term view than the toll road operator. The main reasons are, firstly, that the provision of highways is a continuing public function and responsibility; secondly, that governments are self-perpetuating, permanent organizations; and thirdly, that governments may produce better long-range forecasts since they themselves control some of the important variables.

Bearing these differences in mind it will be very easy to adapt the investment planning procedures of the toll road model to suit the requirements of the public highway authority. Initially the social profitability of each of a number of individual projects must be determined. With the help of appropriate benefit and cost analyses -- which are identical in both cases provided all subsidiary and related activities of the toll road operation are taken into account -- the net benefits will be calculated, as illustrated in Figure 13. In this diagram curve DM represents now the gross social benefits and curve AKBH the social costs associated with various levels of output of highway services. Net social benefits (ADLBK) will be maximized when OC quantities of highway services are being rendered by the public highway. At this point the marginal social costs of providing the last unit of highway services are exactly equal to the marginal social benefits derived from this last service unit.

Very little reflection will convince us why this must be the most socially desirable output position for one particular highway project. If at output OC marginal social costs are just equal to marginal social benefits, this implies that at that point the things which are being given up by the community in order to produce the last highway service unit are exactly balanced by what that unit is worth to the community. This obviously is the most preferred position from the community's point of view, since at any other output either social costs are in excess of social benefits for some output units (and thus the social loss could be avoided by restricting output) or social benefits are in excess of social costs for some output units (and social gain could be increased by expanding output).

As indicated by Figure 13 the highway department will work out the net social benefits (i.e. the difference between gross social benefits and social costs) for a number of possible highway projects, each planned and assessed for optimum output conditions. As presumably not all projects yielding net social benefits can be carried out at once with the limited funds at the disposal of the highway department, rational priorities will be determined with the aid of procedures such as those described in Chapter IV. The net social returns on social capital can be estimated and used for the purpose; the method which involves the minimization of unnecessary costs when a number of optimum plans are applied to (unavoidable) sub-optimum situations, will make possible further refinements.

It is also possible to accord priorities to highway work in order of the magnitude of deficiencies in each case. Using methods which resemble those of the pathologist in medicine, the highway engineers and highway planners will study all the aspects of the very worst cases under the jurisdiction of the department; the avoidable costs of accidents, the loss of time, the economic waste caused by delay, bad pavements, steep grades etc., will be assessed and will be contrasted with the costs of effecting the needed improvements. The project with the highest ratio of avoidable social costs to project costs will be given first priority. This method is, of course, just a variation of the ordinary cost - benefit analysis, since "avoidable social costs" are the same thing as social benefits. The so-called "sufficiency ratings", which enjoy great popularity among highway engineers, belong to this category.

The System Concept Reintroduced*

We can now reintroduce the system concept which was discussed at length in an earlier chapter and apply it to our public highway investment and priority analysis. Let us assume that the net benefits accruing from every single road project which is being considered can be broken down into two distinct and separate parts: (1) net benefits arising from the project itself, when looked at in isolation; (2) net benefits arising from the contribution of the project to the efficiency of the other projects and of the highway system as a whole.

Net benefits (1) cause no special difficulties and can be assessed with the help of the ordinary analytical tools described in the preceding chapters. Net benefits (2), on the other hand, are of particular theoretical interest since their magnitude is determined by the planning of the system as a whole.

Let us assume that three projects, denoted by the letters 'a', 'b' and 'c', are being considered, but that only two of them can actually be carried out. Applying the system concept, the construction of each one of these three projects will always make a positive net contribution to the efficiency of the network as a whole. At the same time the construction of one project will affect the efficiency contribution of any other project in one of the following three ways:

Complementary Relationship: construction of one project raises the net system efficiency contribution of the other project.

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*The writer is particularly indebted to Konrad S. Gizbert, Economist, Department of Transport, Government of Canada, for valuable suggestions relating to this section.

Neutrality: construction of one project has no effect on the net system efficiency contribution of the other project.

Competition: construction of one project diminishes the net system efficiency contribution of the other project.

These inter-relationships are not necessarily symmetrical, since one project may be complementary to the other one, but the second may be competitive to the first. Other combinations are possible as well.

Let us illustrate the various possibilities by means of an example. In Figure 27 project 'a' is a main route linking the large centres A, B, C and D with each other and with the rest of the highway system. Proposed project 'b' is a secondary route which connects the smaller communities E and F with each other and with centres B and C. In this situation the segment BC of route 'a' will draw traffic away from 'b' and hence this part of 'a' will be competitive to 'b'. The other sectors of highway 'a' are, of course, complementary to 'b'. Route 'b', on the other hand, will merely act as a feeder to 'a' -- provided it is the more circuitous connection between B and C -- and hence it will be complementary to the main route.

Let us now introduce as a third project the route 'c', which connects centres A and G and thus is an extension of route 'a'. These two projects are obviously complementary to each other, since 'c' acts as a feeder for 'a' and 'a' acts as a feeder for 'c'. What is the relationship between 'b' and 'c'? If the link 'a' between A and B does not exist, the construction of one project will have no effect on the other one, since they are not even connected; hence neutrality between 'b' and 'c' exists.

Let us recapitulate; if we compare the projects in pairs then the following relationships can be observed:

Route 'a' is partly competitive, partly complementary to 'b'.

Route 'b' is complementary to 'a'.

Routes 'c' and 'a' are complementary to each other.

Routes 'c' and 'b' are neutral to each other.

We said before that only two of the three projects can be carried out with the available resources and hence priorities have to be decided upon. Let us assume that all three highway projects entail equal costs, but that net benefits of the first category -- those accruing from each project when looked at in isolation -- differ; let us suppose that 'a' is expected to yield 5 net benefit units, 'b' 6 units and 'c' 4 units. Therefore, if contributions to system efficiency are not taken into account, project 'b' would logically be given first priority and 'a' second priority; when considered purely on their own individual merits, 'a' and 'b' would thus yield a total of 11 net benefit units.

Let us now introduce the inter-related net contributions to system efficiency of each pair of combinations. These are summarized in the following tabulation:

Project Combinations			Individual Cross Effects (net benefit units)			Total Cross Effects (net benefit units)
			a	b	c	
I.	a + b	(competition)	6	1		7
II.	b + c	(neutrality)		6	6	12
III.	a + c	(complementary relationship)	9		7	16

It will be useful to explain the reasons for these cross effects. If Project Combination I is adopted, then 'a' is partly in competition with 'b'; thus some traffic from points F, B, E and C, which might have used route 'b' to get to all the other points and to the rest of the highway system, will now travel via route 'a' which offers a better connection. Hence the construction of 'a' will have a depressing effect on the net system efficiency contribution of 'b' and it will amount to only 1 unit, as shown in the tabulation. Route 'a', partly helped by feeder route 'b', will contribute 6 units to system efficiency.

Let us now look at Project Combination II, visualizing construction of the routes 'b' and 'c' which are neutral to each other. Route 'b', which is not hindered any more by route 'a', now makes a substantial system contribution of 6 units. The contribution of route 'c' is assumed to be also 6 units.

Under Project Combination III, finally, the complementary relationship of the two routes 'a' and 'c' can be observed. We can visualize that a great deal of traffic from G and beyond can now travel to points A, B, C, D and to remoter system destinations by means of the two inter-connected and complementary highways 'a' and 'c'. Consequently, the net system contributions of both these routes will amount to 9 and 7 units as shown in the tabulation.

We now have to add the internal net benefits accruing from each project individually to the system contributions in each case, in order to arrive at a final solution. Bearing in mind that we stipulated the internal benefits to be 'a' = 5 units, 'b' = 6 units and 'c' = 4 units, we arrive at the following results:

Combination	Internal Benefits (units)	Cross & System Effects (units)	Grand Total (units)
I. a + b	5 + 6	7	18
II. b + c	6 + 4	12	22
III. a + c	5 + 4	16	25

Taking into account both individual, internal project benefits and the system effects, Combination III will be chosen in our example since it will yield higher total benefits than any other project combination. If a choice had been made on the basis of individual project benefit assessment only, then Combination I would have been selected by the planners.

Many other examples could, of course, be devised when different circumstances are assumed and various project combinations are attempted. The one illustration given here should suffice to emphasize the point that the investment and priority planning of public highways must be conducted on a system basis if maximum efficiency is to be achieved. In practical terms this calls for a thorough assessment of the cross effects which one project exercises on all other projects and on the system as a whole. Failure to do this may result in bad planning and great inefficiencies.

The actual example of a belt highway, which was constructed around the outskirts of a large metropolitan area, may serve as an illustration. Referring to our Figure 27, this belt highway can be visualized to link other centres with the metropolis, in the same way as route 'a' in our drawing connects centres G, A and D, with (say) a large city situated around E and F, with outskirts reaching to B and C. When the belt highway 'a' between point B and C was planned, the fact was not considered that it might be competitive to the existing inferior urban route 'b' (and other parallel routes) which provided internal connections between one side of the metropolis and the other. Hence the belt highway was constructed as a four-lane divided, limited access highway of sufficiently high standards to accommodate all traffic anticipated on the sector BC.

As soon as highway segment BC was completed, however, motorists desiring to travel between the general urban areas around E and F now preferred to use the superior route EBCF and back, rather than the existing congested urban artery 'b' linking E and F directly. Hence, the sector BC of route 'a' became hopelessly overcrowded, with the ordinary long-distance traffic between B and C and points beyond impeded by all the local traffic diverted from the urban area around E and F. If the competitive nature of routes 'a' and 'b' in this area had been recognized in the planning stage, provision for a six-lane or eight-lane highway between B and C might more appropriately have been made; alternatively, simultaneous improvement of the urban route 'b', or construction of a new route between E and F might have been considered.

The example of the metropolitan belt highway will emphasize the great need for all-embracing planning techniques in the sphere of highway provision, if the services are to be rendered efficiently and at the lowest total cost to the community as a whole. System planning becomes a very complicated process once more than three projects are considered simultaneously. However, as was remarked before, there is reason to believe that electronic computers could most advantageously be used for the purpose.

Discriminating Monopoly

Having discussed at some length specific problems arising from the system planning of public highways, we shall now return to various points of general theoretical interest. It will be recalled that in this chapter we proposed that the public highway authority, in the course of investment planning, should in effect be simulating the actions of a "discriminating monopolist". The use of this concept and, indeed, the very term may arouse some criticism.

In defence of our analysis it should be pointed out that so far we have been concerned with the ex ante planning of resource allocation for highway purposes only. Problems relating to the selling and pricing of highway services will be dealt with subsequently; as far as our theoretical thought processes are concerned, no discriminatory action has as yet taken place.

It is true, we decided that individual benefits accruing from highway use should be assessed on the basis of the maximum charges which could theoretically be extracted from users under a discriminatory pricing regime. After we had seen that the highway function should appropriately be entrusted to a public authority, we extended and widened the concept until it embraced all benefits conferred by roads, however diffused throughout the economy. These social benefits were assessed once more in terms of the maximum charges which could theoretically be extracted from all beneficiaries -- from highway users, owners of adjacent land, industrial developers and all other subsidiary recipients of highway benefits -- under a highly discriminatory pricing system. It would seem, therefore, that our monopolistic highway authority is not even content to restrict its discriminatory practices to road provision, but extends it to other related spheres as well.

This second line of criticism can also be met by the argument that actual highway charges need not be determined and collected in this fashion; we are not yet committed to any particular pricing policy and we shall see later what other approaches, apart from the discriminatory and monopolistic one, exist.

In order to avoid verbal confusion it may be useful to describe the actions of the public highway department during the course of its investment planning not in terms of "discriminatory monopoly practices", but rather to visualize them as involving the "assessment of social benefits on a differential basis". In the same way --using different terminology -- we might say that the highway authority does not seek to maximize "consumers' surplus", but rather endeavours to maximize "net social benefits" or "social surplus". Once more it should be borne in mind that the most desirable division of social benefits, or of social surplus, into portions accruing to the producer (in our case the state) and to consumers, is a pricing problem and will be discussed later.

Maximization of Social Surplus - Theoretical Considerations

Some theoretical points which have been raised by writers in this field should now be clarified. In particular the so-called "Dupuit Taxation Theorem", which has had a long history and varied reception, is relevant to our discussion. The engineer Jules Dupuit, in a treatise published in 1844, [(9) & (111)] established the essential features of the consumers' (or producers') surplus concept, which was later used by Marshall and has attracted the attention of economists to this day.

Dupuit pointed out that the total "utilité", or benefit, resulting from the existence of a canal, road, bridge or other public facility, cannot be measured merely by total user charges, since many users would, if necessary, pay more than they are actually paying. Dupuit therefore measured the true total benefits accruing from the existence of a public facility by the aggregate of the maximum prices that would be paid for individual small units of the service.

To illustrate the proposition diagrammatically (see Figure 28), let us assume that SB is the supply curve. As Hotelling points out[112] -- and we follow his lucid restatement of the Dupuit Theorem very closely here -- this supply curve can be regarded as coinciding with the marginal cost curve, provided that competition among producers prevails, in the sense that each regards price as fixed beyond his control and that each adjusts production to obtain net profit maximization. The demand curve is DB, with the buyers of the services presumed to compete freely with each other.* Price (under competition) and quantity are the co-ordinates of the intersection B; in other words, the competitive price level will be OA and quantities produced and consumed equivalent to OC.

Under the circumstances depicted by Figure 28, total benefits resulting from the existence of the road, canal or bridge are equal to the total area under the arc DB, i.e. equivalent to ODBC. The consumers' surplus is the total benefit area (ODBC) less the amount paid by consumers (the product of price and quantity, i.e. rectangle OCBA). Hence the consumers' surplus is represented by the curvilinear triangle ABD.

*It should be noted that there must be no opportunities for resale of commodity or service units from one buyer to another.

The producers' surplus is then equivalent to the excess of money received by producers (area of rectangle OCBA) over the aggregate of the marginal costs (curvilinear figure OCBS). Hence the producers' surplus is equal to the lower curvilinear triangle SBA. The total net benefit, representing the value to society of the services rendered, is the sum of the consumers' and producers' surpluses and is therefore equivalent to the large curvilinear triangle SBD. Putting it another way, total net benefits are the difference between the integral of the demand function and the integral, between the same limits, of the marginal cost function. Dupuit shows that any deviation from the output and price position depicted in Figure 28 entails net social losses.

It can be seen at once that the theoretical apparatus used by us in Chapter II and demonstrated in Figure 13 conforms very closely to the Dupuit approach, the main difference being that we assumed a monopoly situation whereas Dupuit stipulated competition. Without attempting now a detailed comparison and re-assessment of our model in terms of the Dupuit theorem, let us see what other economists had to say on his proposition.

Schumpeter points out (113) that Marshall elaborated on the theorem without mentioning Dupuit's name and actually coined the terms "consumers' surplus" or "consumers' rent". Marshall states the concept in these general terms:

> "... the price which a person pays for a thing can never exceed, and seldom comes up to that which he would be willing to pay rather than go without it: so that the satisfaction which he gets from its purchase generally exceeds that which he gives up in paying away its price; and he thus derives from the purchase a surplus of satisfaction. The excess of the price

which he would be willing to pay rather than go without the thing, over that which he actually does pay, is the measure of this surplus satisfaction. It may be called consumer's surplus." (114)

Marshall then goes on to demonstrate the concept by using the example of the purchase of tea for domestic consumption. Schumpeter remarks that "Marshall knew why he used tea ~~as~~ an example by which to display it" (113), but we will come to this point when we consider the various objections raised to the theorem.

After Marshall the concept received a varied reception. Pigou accepts the consumers' surplus concept in principle, but emphasizes the great difficulties which would arise from its application in practice as a tool to measure increases or decreases in what he called 'the national dividend':

> "Unfortunately, however, this type of measure is altogether impracticable ... It involves the money figure that would be obtained by adding together the consumers' surpluses, as measured in money, derived from each several sort of commodity contained in the dividend. As Marshall* has shown, however, the task of adding together consumers' surpluses in this way, partly on account of the presence of complementary and rival commodities, presents difficulties which, even if they are capable of being overcome in theory by means of elaborate mathematical formulae, are certainly insuperable in practice." (115)

* Pigou here refers to Principles of Economics, pp. 131-132, footnote, where Marshall points to the obstacles which are encountered when the attempt is made to measure "aggregate utility" by adding several or all consumers' surpluses derived from the consumption of a number of commodities.

Among the many other writers who dealt with the subject, J. R. Hicks stands out, who comes to the following conclusion:

> "But enough has been said to show that consumers' surplus is not a mere economic plaything, a curiosum. It is the foundation of an important branch of economics, a branch cultivated with superb success by Marshall, Edgeworth and Pigou, shockingly neglected in the last twenty years, but urgently needing reconstruction on a broader basis. Beyond all doubt it is still capable of much further development; if economists are to play their part in shaping the canons of economic policy fit for a new age, they will have to build on the foundations of consumers' surplus."(116)

I. M. D. Little, while lauding Hicks' contribution, states on the other hand:

> "Our conclusion is that consumers' surplus is a totally useless theoretical toy."(117)
>
> "One of its chief demerits is that it is the result of a partial analysis only. It is assumed that, as a result of the change, there will be no significant change of price elsewhere."(118)

Hotelling, in the article referred to before(112), strongly supports the Dupuit theorem; he is of the opinion that "... for moderately small variations, with a stable price level and stable conditions associated with commodities not in the group ...",(112) Dupuit's measure of social net benefits is a most satisfactory one. He concludes, with particular reference to a road or bridge:

> "It is certainly a better criterion of social value than the aggregate $\sum p_i q_i$ of tolls that can be collected [under com-

petitive conditions] on various classes of traffic, as Dupuit pointed out for the case of a single commodity or service. The actual calculation of [net social benefits] would be a matter of estimation of vehicular and pedestrian traffic originating and terminating in particular zones, with a comparison of distances by alternative routes in each case, and an evaluation of the savings in each case. Determination whether to build the bridge by calculation merely of the revenue $\sum p_i q_i$ obtainable from tolls is always too conservative a criterion. Such public works will frequently be of great social value even though there is no possible system of charging for their services that will meet the cost." (119)

Arising from Hotelling's first article (112), a lengthy controversy between him (121) (123) and Ragnar Frisch (120) (122) developed, which is, however, not of direct interest to us since it deals predominantly with the application of the Dupuit Theorem to questions of taxation. Discussion on the consumers' surplus concept has continued to the present day, but considering the limited scope of this study probably enough has been said to indicate the general trend of thinking.

What general conclusions, applicable to our particular problem, can we draw from all this? Let us first briefly state the main objections to the concept. Undoubtedly, it can be used as a tool of partial analysis only. Dupuit clearly formulated his theorem in terms of a single commodity or service; Marshall also recognized this particular limitation and so did Pigou, Little, Hotelling and the others. But the limitation, however important it may be in the sphere of general welfare and utility measurement, does not really constitute an obstacle for us, since we are attempting a partial analysis of one particular service only -- highway provision.

A second related objection is based on the fact that the consumers' surplus concept cannot be applied to things such as food in general, since this presupposes that the marginal utility of income does not change when an individual (or society as a whole) spends more and more money on additional service units which are offered at ever decreasing prices. Marshall circumvented this difficulty by using the example of tea, which obviously does not form a large proportion of total expenditures. We could again point out that we are dealing with one consumption good only and that the inaccuracies introduced by income effects can therefore safely be ignored. However, it is more relevant to emphasize that we are concerned now with investment planning and that pricing problems in general, and the income effects of pricing in particular, are completely outside the scope of our present discussion.

Hotelling[112] mentions the following additional objections:

(i) Pleasure is essentially non-measurable, therefore it cannot be represented by consumers' surplus or by any other numerical magnitude.

(ii) Consumers' surpluses arising from different commodities are not independent and cannot be added to each other.

(iii) The surpluses of different persons cannot be added. Hotelling meets these three objections -- of which the third one is especially relevant to our problem -- by "ranking" satisfactions in the way graphically represented by indifference curves. On a practical plane and referring to the example of a road or bridge he proposes, as we have seen before,[119] a fully-fledged benefit analysis, involving the assessment of savings to users in time, distance travelled, operating costs, etc. This, of course, completely agrees with our own approach.

In conclusion of this brief review of the theoretical literature dealing with the consumers' surplus theorem, it should be pointed out that most writers assume perfect competition. By contrast -- due to the special nature of our problem -- a monopoly situation was stipulated in our case. We are further not concerned with problems of utility measurement and income distribution -- the field the other writers are predominantly interested in -- but rather with investment planning and social profitability calculations.

Enough has probably been said on the theoretical aspects of our highway investment approach to indicate that the analytical objections which may be raised are not major ones. Undoubtedly discussion in this field will continue and further refinements will be introduced. In the meantime the assessment of social benefits on a differential basis appears to be the best method which is presently available for highway investment planning.

How much further progress in this field can be made, will obviously depend on the quality of practical estimation methods which may, or may not, be evolved. For this very reason Little, for example, prefers profitability to consumers' surplus as a criterion for the social desirability of a proposed public enterprise investment or a proposed price change:

"In contrast to any so-called consumers'-surplus criterion, profitability really is a criterion. If the aim is profits, and an enterprise is started with that in view, then we can, at least, tell whether its objective was achieved. Profitability is easy to test, and it is possible to gain experience in profit estimation. There remains the fact that the objective is not 'ideal', and also the fact that considerable monopoly power may have to be wielded in order to obtain the profit. This is not, in itself, an objection, because one can also estimate, and gain experience in estimating, the profit or loss that would accrue as a result of making the change and adopting a certain pricing policy."(124) (underlining supplied)

Reverting to our own problem we find that we too are basically concerned with the maximization of "social profitability" by means of the most efficient allocation of resources for highway purposes, in the same way as Little advocates profit maximization as an objective for public enterprises. He too visualizes the estimation of social profits on the basis of what they would have been in a monopoly position, just as we did in the course of our investment analysis. Hence our prime objective of "social surplus maximization" is identical to Little's objective of "social profitability maximization".

Basically, whatever terminology is used and whatever theoretical approaches are adopted, the same practical difficulties of measuring contributions to social output or welfare eventually have to be faced. Until reliable tools and measuring devices have been developed we will have to improvise and adjust ourselves to changing circumstances as well as we can. This will put greater responsibilities on the planner, the expert, the engineer, the civil servant and the consultant. As Little put it:

"The conclusion is clear. The best criterion for investment decisions must, within very wide limits, be determined at dynamic and administrative levels - and not at the level of static welfare theory.[125]

VII - PUBLIC ROADS - PRICING POLICY

In the last chapter the planning of investment in public roads was discussed. We will now finally deal with highway pricing problems, a subject which is fraught with controversy. A careful and systematic approach is indicated; we shall therefore first examine our basic premises and objectives.

Basic Premises and Objectives

In the preceding chapter we evolved economic analyses and techniques which will enable a highway department, which has given resources at its disposal, to achieve optimum highway investment, priority and output solutions. Before we begin now to evolve optimum pricing policies, let us first see how far the investment, priority and output desiderata we have set ourselves circumscribe our freedom of action in this new sphere.

In connection with the overall allocation of funds for highway purposes, we decided to treat the provision of public roads and streets as one of a number of government functions. In particular, we did not establish any fiscal or bookkeeping link between road expenditures on the one hand and road user revenues collected by the government on the other hand. Subject to some other criteria still to be discussed, we therefore have almost complete freedom to adopt any pricing policy which appears expedient as far as the revenue-producing side of highway taxes is concerned. This initial lack of fiscal encumbrances will greatly facilitate clarity and directness of our highway pricing analyses.

We saw first in the toll road model and subsequently in the chapter on public highway investment planning, that optimum output for any one highway, or segment of the road plant, will be achieved when marginal costs of the last service unit rendered are equal to the marginal revenues and hence to the price charged for the last unit. For brevity's sake we shall in future refer to the "marginal cost-pricing rule" which, when applied to extreme output values, determines the optimum quantities of services to be rendered. Our marginal cost-pricing rule does not restrict us much as far as the pricing of intermediate service units (those between zero output and optimum output) are concerned. Here the maximum limit of charges is determined by "what the traffic will bear". If our price for highway services exceeds this ceiling, then traffic will be lost and our carefully planned highway plant will be operating below the optimum level of output. At the optimum output point the "charges the traffic will bear" are, of course, identical to marginal costs.

As far as the consumption-rationing side of highway pricing is concerned, our charging policy therefore has to adhere to two rules. The first rule calls for the rationing of highway use to optimum output by means of marginal cost-pricing of the last (or extreme) service unit. The second rule demands that no highway service unit should be priced at more than "the traffic will bear". Subject to these two prime rules, which apply simultaneously and under all circumstances, we have freedom to set our highway prices as we wish, since thus we will not interfere with the objectives of investment planning and optimum output operation.

Extraneous Pricing Objectives

In addition to these simple rules and objectives, which really form an integral part of optimum resource allocation for highway purposes, there are a host of other pricing objectives. Some of them lead us far afield into political, legal, fiscal and -- in connection with the concept of "equity" -- pseudo-ethical spheres. They are strictly extraneous objectives as far as our analysis is concerned and we shall therefore subordinate them to the two prime rules which we stated before. This does not mean that they may not be useful and desirable objectives in their own right. However, they should not be confused with the primary economic objectives.

In the following paragraphs some outstanding examples of extraneous objectives which can be encountered in the highway sphere will be discussed. This will set the stage for a subsequent demonstration of the many different pricing policies a public highway authority may conceivably adopt.

Maximization of Government Revenue

Maximization of government revenues is probably the simplest and most straightforward pricing objective a public authority or a public enterprise can pursue. It amounts to "charging what the public will bear" in the widest sense, with limitations set by political and economic considerations. Imposts on road users and other highway beneficiaries are simply treated as lucrative sources of revenue for the government. Unless there are weighty political considerations which dictate a more moderate course of action, the upper limits of charges are identical to those found in a perfectly discriminatory monopoly situation.

Competitive Neutrality

Sometimes the attempt is made to adjust the taxation system in such a way that "competitive neutrality" between rival economic activities prevails. In the field of transportation it is held, for example, that each agency "must pay its way" and that one form of transportation must not "subsidize" the other. We shall later examine questions of competition in transport in more detail; may it suffice now to say that under the most frequently encountered working definition of "competitive neutrality" each individual user is charged exactly according to costs of providing the service -- not more and not less -- and for the transport activity as a whole, revenues must exactly equal costs.

Encouragement of Maximum Use of a Public Service

In cases where the social benefits conferred by one particular government activity are widely dispersed throughout the whole community, where no one user or group of users is particularly favoured, or where the provision of the service leads to very large external economies, the service is sometimes rendered free in order to encourage maximum use. Examples are the free provision by the state of parks, playgrounds, education, libraries, art galleries and in some cases -- alas not in North America -- of broadcasting services. The costs of these services are borne from general tax revenue, ideally from income tax sources.

Equity of Pricing

Equity of pricing is an objective which is very frequently pursued in the highway sphere; it is unfortunately also the one objective which is most difficult to define, since it involves principles of justice, ethical judgments, and social policy decision. Just to illustrate the complex nature of the equity concept, it might be noted in passing that one writer found it worthwhile to devote an entire book to the study of fairness and equity in the field of public utility operation.[126]

In one sense a perfectly dissimilar charging regime might be regarded as achieving complete and universal equity, since every user pays exactly the price of "what the service is worth to him". Even social justice is served since the poor man will pay little and the rich man will pay a great deal.

This is, however, not the way in which "equity of taxation" is most commonly interpreted in discussions on highway pricing matters. Sometimes charging on the basis of costs is regarded as equitable, in which case the "competitive neutrality" requirement is also satisfied. Sometimes taxation equity is interpreted as implying equal charging for all service units regardless of costs. Since the cost charging case is already covered under the "competitive neutrality" objective, we shall use the second interpretation of taxation equity for our subsequent discussion.

<u>Other Objectives</u>

Various other taxation objectives can be encountered in practice. There is the <u>public utility approach</u>, mentioned a number of times in this study, which calls for an overall balancing of revenues and expenditures, but may leave freedom of charging for individual service units to the management of the enterprise. Sometimes <u>subsidization of some users</u> is prescribed for social or political reasons. Yet another approach calls for the <u>simulation of private enterprise behaviour</u> in similar circumstances. Finally, there is <u>pricing on the basis of benefits received</u>; the last objective is sometimes interpreted as "equalization of charges for all service units", sometimes as "charging what the traffic will bear".

Usually a number of these objectives are combined when solutions to highway taxation problems are sought. Thus the First Progress Report remarks with reference to experience in the United States:

> "Each State, when confronted with the mounting need for funds to modernize its highways, has found it necessary to review its road-user tax structure from the double standpoint of productivity and equity."(127) (underlining supplied)

In Canada, in the most recent investigation of highway pricing problems, objectives of highway investment requirements, of government revenue maximization, of equity, of charging according to cost, and of equalization of charges for all service units, were all simultaneously emphasized as desirable. The relevant recommendations of the investigation body, the Select Committee on Toll Roads and Highway Financing, Province of Ontario, read in part as follows:

> "The Committee recommends an acceleration of the present highway programme and that the gasoline tax in Ontario be increased to provide additional funds for the Province for this purpose ... The Committee recommends that registration fees for all types of vehicles be reviewed in order to achieve greater equity in accordance with cost responsibility ... recommends that the government review the tax rate per gallon levied on fuels other than gasoline with a view to equating the tax contribution for vehicles of the same size and weight ... recommends that licence fees be adjusted to reflect weight of vehicles and distance travelled

of various classes of vehicles ... "[128]

These introductory remarks and definitions will have shown what a great variety of highway pricing policy objectives can be pursued. Some of these objectives conflict with each other, others can be reconciled. It is absolutely essential in any consideration of road user taxation problems that the policy objectives are stated clearly; only in this way can appropriate solutions be found.

Equipped with preliminary working definitions and bearing in mind the two prime rules which satisfy optimum output requirements, we can now proceed to a demonstration of possible pricing policies which could be adopted by a public highway authority.

Possible Pricing Policies of Highway Authority

The analytical apparatus and the diagrammatical techniques employed in the subsequent section are the same as those used throughout this study; they therefore require no special introduction. Likewise, the concepts "costs" and "benefits" -- unless otherwise stated -- are to be interpreted as "social costs" and "social benefits", as defined earlier. This means that "pricing of highway services", or "charging for highway services" does not only include the imposition of fees on direct road users, but also covers taxation of other direct and indirect beneficiaries, such as adjacent land owners.

We assume that the highway authority or other government body responsible for the highway function, has complete freedom of charging in any fashion it desires for the services it provides and that it is only bound by the objectives it sets itself. We shall judge the results of the various pricing policies entirely in the light of these objectives.

Case 1: Simulation of Private Enterprise Behaviour - Monopoly

Possibility (a) - Dissimilar Charging

This simply calls for "charging what the traffic will bear", following the procedures of the toll road operator in our model. Output is optimum OD, net revenue is ABC.

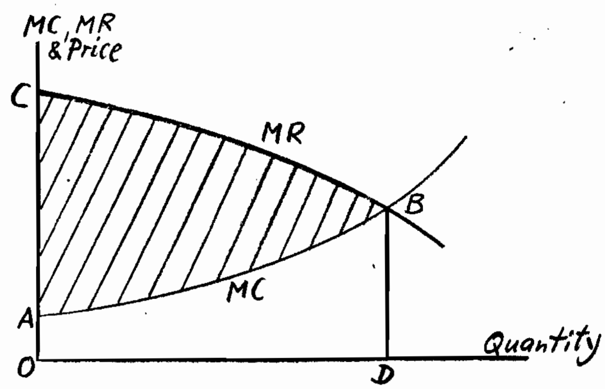

Fig.29

Results and Objectives Achieved:

Optimum output, maximization of government revenues, equity in the sense that each user pays "what the service is worth to him".

Objectives Not Achieved:

Public utility requirements (since excessive profits are being reaped), competitive neutrality, charging on the basis of costs, equalization of charges for all service units.

Case 1: Simulation of Private Enterprise Behaviour - Monopoly

Possibility (b) - Uniform Charging

In this case the highway authority will fix output and uniform price in such a way that the area between the marginal revenue and marginal cost curves is maximized. Output is sub-optimum OE, price is OH, net revenue is AFGH.

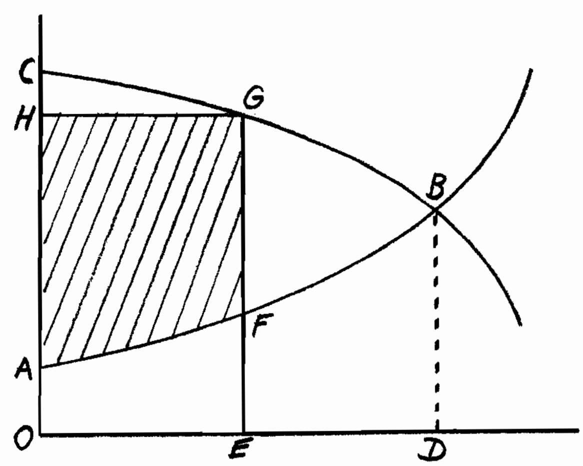

Fig.30

Results and Objectives Achieved:

Large -- although not maximum -- government revenues, equalization of charges for all service units.

Objectives Not Achieved:

Optimum output, public utility requirements, competitive neutrality, charging on the basis of costs.

Case 2: Simulation of Private Enterprise Behaviour - Competition

Possibility (a) - Optimum Output

This objective calls for a uniform market price, determined by assuming competition -- a highly unrealistic working basis. Hence the pseudo-market price may coincide with the optimum level

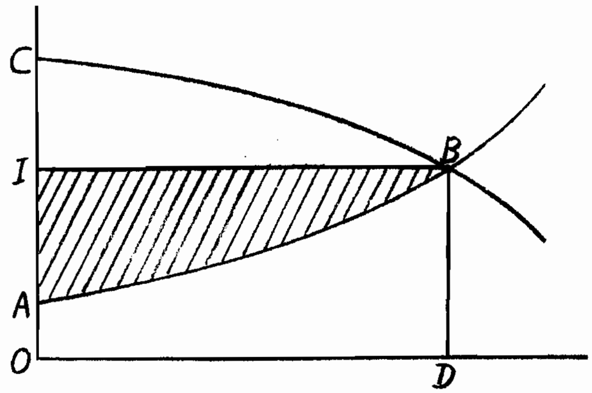

Fig.31

DB = OI (Possibility 'a'), may be below optimum level (Possibility 'b'), or may be above the optimum price level (Possibility 'c'). Under Possibility (a) output is optimum OD, price OI and net revenue IAB.

Results and Objectives Achieved:

Optimum output, moderate government revenues, equalization of charges for all service units.

Objectives Not Achieved:

Public utility requirements, competitive neutrality, cost charging.

Possibility (b) - Price Level Too Low

Price set too low at, say, level OK. Output is determined by intersection of assumed market price with marginal revenue curve at point P; hence output is supra-optimum ON. There may be a net profit or a net loss, depending on whether area KAF is greater or smaller than area FBP.

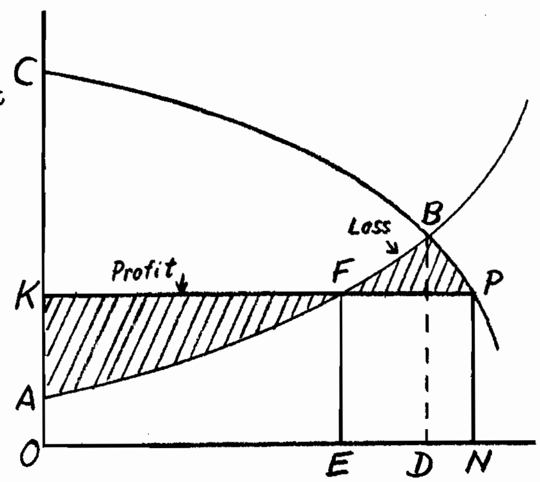

Fig.32

Results and Objectives Achieved:

Equal charges, subsidization of some users, encouragement of use of public services.

Doubtful: size of government revenues, public utility requirements.

Objectives Not Achieved:

Optimum output, competitive neutrality, charging on the basis of costs.

Possibility (c) - Price Level Too High

Price set too high at, say, level OH. Output determined by intersection of assumed market price with marginal revenue curve at point G; hence output is sub-optimum OE. Net revenue is AFGH. Results may conceivably be similar to those of Case 1(b) - non-discriminating monopoly.

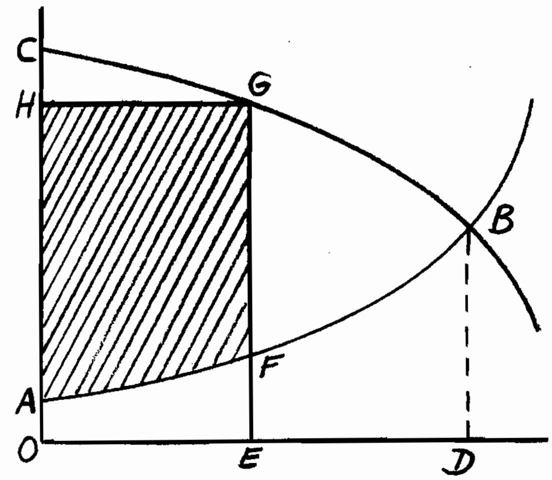

Fig.33

Results and Objectives Achieved:

Large government revenues, equalization of charges.

Objectives Not Achieved:

Optimum output, public utility requirements, competitive neutrality, charging on the basis of costs.

Case 3: Public Utility Approach - Equal Charging

Possibility (a) - Increasing Marginal Costs

This public utility approach calls for a balancing of revenues and expenditures. This concept of "reasonable profits" permitted to be made by the public utility, is merely a modification and requires no special explanations. Price will be set in such a way that profits AKF earned on service units OE are exactly balanced by

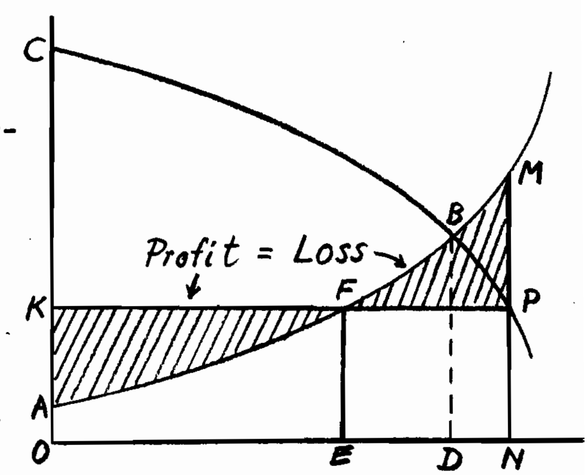

Fig.34

losses FPM sustained through provision of "unremunerative services" EN.

Results and Objectives Achieved:

Public utility requirements, equalization of charges, encouragement of use of public services beyond output OD, subsidization of (presumably deserving) users of output quantities EN.

Objectives Not Achieved:

Optimum output, maximization of government revenues, cost charging, competitive neutrality.

Possibility (b) - Decreasing Marginal Costs

The requirement of equal charging, coupled with decreasing marginal costs in the critical output range, leads to sub-optimum output OE. It is a case which has received considerable attention in the theoretical literature. Revenues balance expenditures, with losses AFK cancelled out by profits FPM.

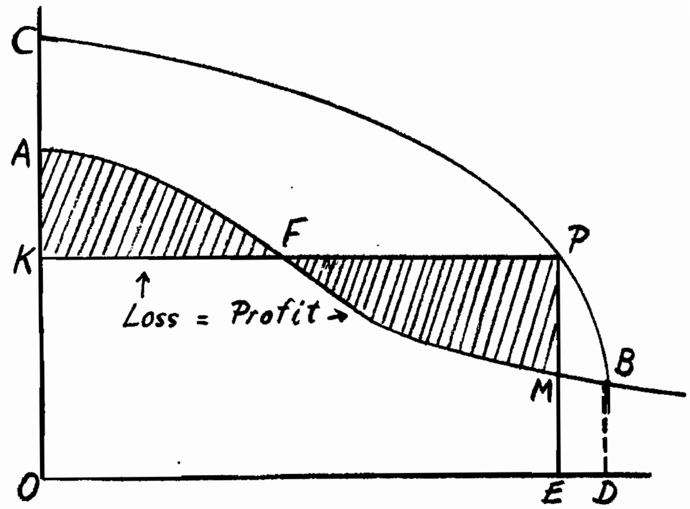

Fig.35

Results and Objectives Achieved:

Public utility requirements, equalization of charges, subsidization of some users.

Objectives Not Achieved:

Optimum output, maximization of government revenues, cost charging, competitive neutrality.

Case 4: Public Utility Approach - Differential Charging

Possibility (a) - Optimum Output

The most logical way to achieve both optimum output and a balancing of revenues and expenditures is by charging exactly according to marginal costs. The so-called "incremental cost method" proposes this approach.

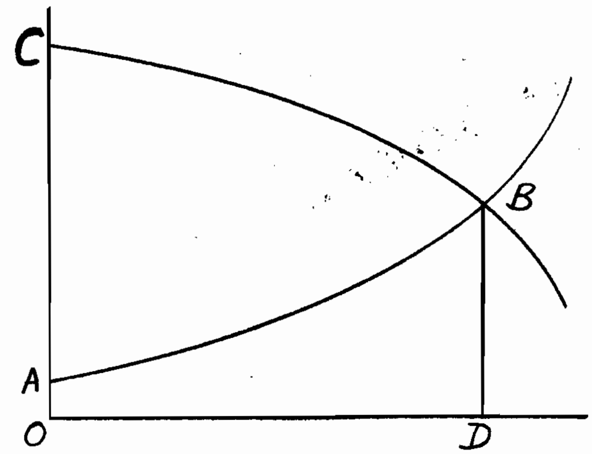

Fig.36

Results and Objectives Achieved:

Optimum output, public utility requirements, charging according to costs, competitive neutrality.

Objectives Not Achieved:

Maximization of government revenues, equalization of charges.

Possibility (b) - Maximum Output

The two objectives of maximum output (i.e. serving all users however small a charge they can pay) and balancing of revenues and expenditures can be achieved in a number of ways. An "equity" notion is introduced here by fixing charges "in proportion to benefits received" (i.e. in proportion to "what the traffic will bear").

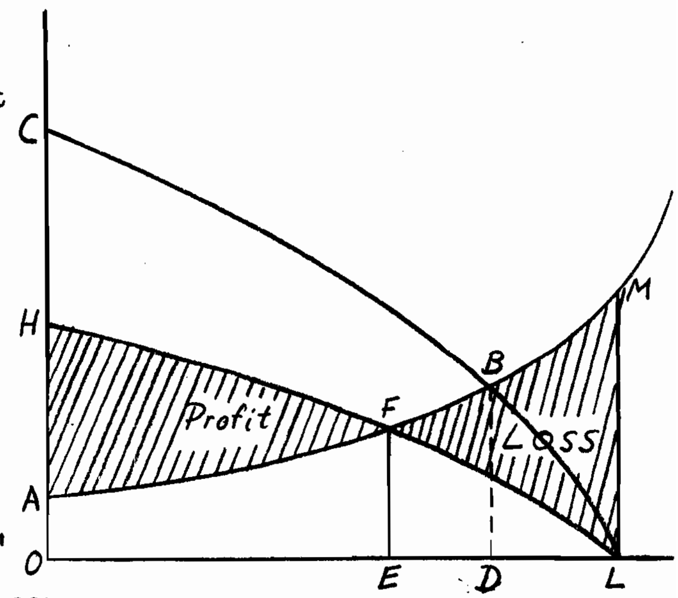

Fig. 37

Solution: Determine the proportionate relationship of magnitude of total revenues which could be collected under a perfectly dissimilar charging regime (i.e. size of area OCBL) to total costs incurred when providing maximum output OL (i.e. size of area OAFBML). Let us assume that the ratio of total costs to total revenues is 4 to 5. Now fix all charges at four-fifths of the theoretically possible maximum level; this procedure provides the <u>actual</u> price curve HFL. Output is maximum OL, total revenues OHFL are equal to total costs OAFBML, profits HAF on service units OE exactly balance losses FLM on service units EL; users of service units EL are subsidized.

<u>Results and Objectives Achieved</u>:

Maximum output, public utility requirements, subsidization of users (i.e. encouragement of maximum use of a public service), charging in proportion to benefits received, charging in proportion to "what the traffic will bear".

<u>Objectives Not Achieved</u>:

Optimum output, charging on the basis of costs, competitive neutrality, maximization of government revenues.

<u>Some Observations on Pricing Possibilities</u>

What conclusions can be drawn from the foregoing demonstration of the various possibilities for pricing policies? In the first place there seems to be a great variety of choice for the public authority. It should be emphasized in this connection that additional models and combinations of objectives could, of course, be readily devised. Secondly, even if the public authority conforms with the prime rules established earlier, in order to satisfy investment and output requirements, optimum output can be achieved in three different ways. Case 1(a) (Figure 29), as well as Case 2(a) (Figure 31) and Case 4(a)

(Figure 36) are equally satisfactory from that point of view.

In order to arrive at a definite solution, the three possible cases have to be judged in the light of other criteria. Case 1(a) yields maximum government revenues and might therefore be preferred for fiscal reasons, provided there is not too much political resistance to an all-out "charge what the public will bear" regime. It appears that this is the prevailing situation in the United Kingdom, where road transport is an extraordinarily lucrative source of government revenues; yet road users in Great Britain -- and this is just a very general observation not based on detailed study of conditions prevailing in that country -- appear to object more to the crass inefficiencies of the road plant and the obvious underinvestment in highways, than to the high level of motor fuel taxes and license fees.

Case 2(a) does not seem a practicable possibility, since it would be a great coincidence indeed if the pseudo-market price happened to be set at exactly the right level. How would a public authority, in practice, determine what the price level would have been if there had been several competing providers of highway services? We know that there will never be a number of competing toll roads linking two towns, just as there will never be different electric circuits, water systems and telephone connections in one house, installed by competing companies. Hence it will be better if we realistically base our policies on the assumption of monopoly, rather than on the nebulous competitive ideal.

Case 4(a), finally, appears to meet more objectives of public pricing policy than any other solution. It is also the approach which is most frequently advocated in the United States. It is known as the "incremental cost method" and will be examined as such later in the chapter.

Benefit Charging, Value of Service, Average Cost Pricing

Very briefly some other pricing methods should be mentioned which occasionally come up in discussion. "Charging according to benefits received" is probably the best known of these. Unfortunately, the advocates of this approach frequently do not explain what they mean by "benefits". Are benefits to be assessed in accordance with utility measurements or a hedonistic calculus? Will the luxury-car owner pay more than the driver of an old farm truck? Does a truck load of timber accommodated on the highway represent greater highway benefits than a bus filled with sightseers? Does the rich man receive greater benefits from highway use than the poor man and hence pay higher charges, or does it work the other way? Can benefits conferred when a vehicle travels on a poor gravel road be compared to those of travel by the same vehicle on a modern expressway?

Obviously, as economic theory tells us and common sense confirms, no satisfactory answers can be given to these questions. Utility, or benefits, cannot be measured directly as a sort of psychic or physical reality, independent of external observations. If, however, we assess benefits by the most convenient observable effect -- namely by the amount of money users are prepared to give up in order to avail themselves of these benefits -- then we are back to a perfectly dissimilar charging regime and Case 1(a) (Figure 29) applies without any modifications.

Occasionally the proposition is put forward that benefits are proportionate to the number of service units received by individual users. Highway services, under this approach, are supposed to be homogeneous benefit units as measured by ton-miles, vehicle-miles, passenger-miles, axle-miles etc., and would be sold by the highway authority at a standard price, in much the same way as loaves of bread are sold by the baker. All the objections raised to "homogeneity of service units" in Chapter III apply, of course, to this proposition. Proportionality of benefits to service units by itself does not provide any guidance for the fixing of the actual (uniform) price level; therefore this version of the benefit approach is usually coupled with some other objective, such as "expenditures must equal revenues". Depending on the circumstances, the cases illustrated by Figures 30 to 35 apply. Rather surprisingly, the benefit method of pricing is sometimes confused with a pure cost approach.

Charging on the basis of the "value of the service" is also encountered in the field of transportation. It is a term which dates back to the earlier days of the railways and was really used as a substitute phrase for "charging what the traffic will bear". It was and is regarded as the more expedient term, since it does not carry the same strong suggestion of discriminatory monopoly pricing. Complex railway rate tariffs and pseudo-scientific rate theories have been built around the "value of service" principle, with goods commanding high wholesale or retail prices being charged higher railway tariffs than less highly priced merchandises in otherwise identical circumstances. Charging on the basis of the value of the service can be likened to benefit charging; it is covered by our Case 1(a).

Finally, charging on the basis of average total costs is occasionally suggested. Case 3(a) (Figure 34) and Case 3(b) (Figure 35) illustrate average cost pricing. In neither case will optimum output be achieved by average cost pricing. Depending on the configuration of the marginal cost curve, excessive use of the highway plant (i.e. congestion) will be encouraged when marginal costs are above average total costs (Figure 34); optimum use of the highway plant will be discouraged when marginal costs are below average total costs (Figure 35).

<u>The Public Service Approach</u>

Taking an entirely different approach, we might also ask: why have any specific pricing and taxation policies for highways at all? Could we not regard the provision of highways as a public service, to be rendered free to all, and dispense with road user taxes and imposts on other beneficiaries altogether? This approach might very easily be justified in cases where it is important to encourage road transport for development reasons or where the benefits conferred by roads and streets are widely and uniformly distributed throughout the entire economy. There exists no rationale -- apart from revenue collection considerations -- for specific highway pricing policies and imposts in countries where <u>all</u> citizens are pedestrians and nobody owns a vehicle, or alternatively in countries where <u>all</u> persons are owners of automobiles.

The <u>First Progress Report</u> considers the public service approach in the following way:

> "The proposition that there should be no road-user taxes, as such, is worth examining, at least as a point of departure. Considered by itself, general tax support of highways might not be inherently unjust, even under modern conditions. The use of the automobile is almost universal, except in large cities. As for commercial vehicles, freight trucks and combinations distribute and deliver the food, clothing, building material, household goods, and general merchandise of the Nation. The benefits and savings their operators derive from highway improvements are distributed in large part to their customers; for if this were not so their business would not increase. The same is true of buses within their more limited sphere of operation. Thus the provision, out of general revenues, of roads adequate to support the heavier weights of commercial vehicles would not of itself, in the absence of competitive conditions, severely violate principles of equity." (128)

In terms of our diagrammatical representation, the public service approach would lead to maximum output OL (see Figure 37), with almost all benefits presumed to be social benefits and social costs presumed to be very small. There would be no government revenues accruing from the highway function and no "rationing" of highway services by means of user imposts and other levies would take place.

Our discussion throughout has emphasized the many possibilities which exist for pricing policies. The various choices which confront a public highway authority have by no means all been described, but the ones dealt with in this chapter may serve as representative cases. There can be no conclusion that one approach is "right" in all situations and that another method has only defects and no merits. All the economist can do is to point out the various ways in which different policy objectives can be achieved most efficiently.

Competitive Neutrality in Transportation

By contrast to the last-mentioned "public service" concept, which would dispense with road user taxes altogether, advocates of the "competitive neutrality" approach to transportation problems rely heavily on highway user imposts as a means of achieving their particular objectives.

What are these objectives? No attempt can be made here to cover exhaustively so vast a field as competition in transport, but a greatly simplified summary of the main aims of competitive neutrality will be sufficient for the purposes of our study. The different transport media -- pipelines, water, air, rail and road transport -- are seen as competing with each other over a wide range of their services. Assuming users' free choice among these competing services, the best distribution of traffic, at the optimum and most preferred combination of costs and quality, will be achieved when all services are rendered at true economic cost. If this is so, then the amount of money any user gives up to buy a transport service unit, will be equal to the costs of rendering that particular service. Since this rule applies to all transport agencies and all service units, the most preferred output combination will be produced at minimum cost to the community as a whole.

If, however, so the argument goes, some services are sold at less than true economic costs, then the consumption of these services will be artifically expanded, traffic will be diverted from another transport medium which could have performed the service more efficiently to the less efficient medium, the optimum competitive pattern is distorted and total transport costs needlessly increased. If only all forms of transportation had to cover their full costs of operation -- so the advocates of the "competitive neutrality" approach say -- and if only every single service unit were sold at cost, then the total national transportation task would be performed most efficiently and at minimum cost. State subsidization of one carrier to the detriment of his competitors, sales of service units at less than cost to some users, whilst other users are charged more than costs -- all these imperfections distort the competitive neutrality ideal.

At the present time this general argument has been applied with great vigour to competition for long-distance freight haulage between the railways and the trucks. It is claimed that heavy commercial vehicles enjoy public highway services which are being provided free, or at least well below cost, whereas the railway companies have to pay for the operation and maintenance of their tracks out of their own pockets. Hence long-distance truck traffic is artificially expanded and long-distance rail traffic suffers a competitive disadvantage.

Analytically it should be noted that the competitive neutrality approach calls for two things: (i) balancing of revenues and expenditures by each form of transportation and by each carrier; (ii) charging to each individual user in accordance with costs. Objective (i) is, of course, in line with the familiar public utility aims, but objective (ii) necessitates the pricing policy illustrated by Case 4(a) (Figure 36). To re-state the rail-versus-road argument in practical terms: it is not enough if road users as a whole pay fully for highway costs, since (say) passenger cars may still be "subsidizing" heavy commercial vehicles; therefore also each vehicle group, and ultimately each individual vehicle, must pay its appropriate share of highway costs.

The two objectives are stressed in the <u>Preliminary Report</u> of the Royal Commission on Canada's Economic Prospects:

> "In 1953, provincial government revenues from gasoline taxes and licence fees amounted to 89% of the expenditures on highways by provincial governments in that year. But these revenues amounted to only 64% of the total expenditures by federal, provincial and municipal governments on highways, rural roads and urban streets. Highway construction expenditures have continued to increase since 1953 and the expectations are that this trend will continue. As these expenditures are related in very large measure to the numbers, the speeds and the weights of the vehicles in operation, we suggest that the owners of these vehicles should be required to pay an even higher percentage of the total costs involved than they are doing at the present time.
>
> In this connection it should be emphasized that a substantial proportion of the increased costs is necessitated by the heavier construction of highways and bridges which is now required to accommodate the heavier classes

of trucks. It is important, therefore, that studies be made to determine the taxes and licence fees which the owners of passenger vehicles and the operators of different classes of commercial vehicles should be charged respectively, having regard to the proportion of total costs which should reasonably be allocated to each of them. If the owners of vehicles in any category are paying less than their appropriate share, the owners of other vehicles may be paying more than their fair share. And <u>if trucks in the heavier classes are being under-charged, this gives them a competitive advantage vis-à-vis the railways at a time when public subsidizing of railway revenues may be fast approaching</u>. Quite obviously a situation of this kind makes little sense in terms of the most efficient use of our national resources."[129] (underlining supplied)

It should be noted in passing that there is an inconsistency in the penultimate sentence of the quotation from the <u>Preliminary Report</u>. If it is not in the interest of "the most efficient use of our national resources" to give trucks a competitive advantage vis-à-vis the railways by having them subsidized -- via low road user taxes -- by other vehicle categories, then it should be equally undesirable to give the railways a competitive advantage over the trucks by subsidizing them from the public purse.

This theme cannot be fully developed here; in any case a full discussion of the problems raised by the Gordon Commission in its <u>Preliminary Report</u> should be postponed until the final document and the special report on transportation become available.

The whole issue of competition in transport could provide a most fascinating subject for prolonged research, but this would be far beyond the limited scope of the present study. However, in order to get the relevant problems into perspective, an attempt will be made to enumerate briefly, with reference to Canadian conditions, the requirements for the achievement of true competitive neutrality.

Can Competitive Neutrality Be Accomplished?

To demand that all transport agencies should currently pay their own way and that all users should currently be charged on the basis of costs, is to pick out but two of a number of requirements for the achievement of true competitive neutrality. To build up the theoretically ideal basis, we have to satisfy ourselves that (i) there is equality of promotion in transportation and (ii) there is neutrality of past and current policies of taxation, pricing, management, supervision, regulation, statutory obligations etc. affecting the various agencies.

The first step towards the desired aim would be to place all transport agencies and activities under one supreme co-ordinating body. In Canada this would mean that highway transport and the provision of roads and streets -- at present provincial and municipal responsibilities -- would have to be put under federal jurisdiction.

Next, stock would have to be taken of existing assets used by transportation agencies. There are three possibilities. A strict accounting approach would call for a historical investigation into past investment in transport facilities; government aid subsidies, land grants etc. would be debited to each agency, the repayment of debts, the rendering -- in the public interest -- of services at less than cost etc. would be credited. The remaining debt -- if any -- plus interest charges accumulated over the years, would be charged in some fashion to present and future users of each transportation agency. Thus motorists would have to pay for the "highway debt" incurred over the years (i.e. excess of government road expenditures over revenues collected from users, plus interest on unamortized portions)* in form of higher current and future highway user imposts. Similarly, users of the services of the Canadian National Railways and Canadian Pacific Railways would be charged for the economic debts incurred in the past by these companies through the acceptance of land grants, mineral rights, subsidies etc. Of course, the same procedure would also have to be applied to airport users, shipping and users of pipelines.

Since this historical accounting approach may prove too cumbersome, an alternative would be to assess the current capital value of all transportation assets; the value would be based on the net revenue generating capacity of, for example, the highway network, the railway plant, canals and so on. Since this method too might prove rather complicated, as a last resort all by-gones could be declared by-gones. Thus there would be no highway debt, no railway debt and all forms of transportation, as of a certain date, would start with a clean slate. Even the Canadian Pacific Railway would

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* Such a calculation of highway debts was actually attempted for the period 1889-1957 by the Select Committee on Toll Roads and Highway Financing, Province of Ontario.(130) The so-called "highway deficit" came to exactly $211,598,000. No explanation was provided why road expenditures prior to the appearance of the first automobile in Ontario in 1901 should be charged to today's generation of motor vehicle owners. There was also no estimate of the present capital value of the existing highway plant in Ontario, an item which might well amount to several billions of dollars.

be relieved of their obligations to the holders of debentures and shares, since otherwise they would suffer a competitive disadvantage in that respect.

With the problem of existing assets put out of the way, the organizational structures of all transport agencies would have to be purged of non-transport elements. This would be vital, in the interest of pure and perfect competitive neutrality, because otherwise there might be cross subsidization of different economic activities. Thus the railways would have to divest themselves of their interests in hotels, telegraph services, steamships etc.; the Canadian Pacific Railway~~s~~ would have to sever their links with Consolidated Mining and Smelting Co., and other industrial interests, truckers would have to give up operating freezing plants and warehousing.

Next, a federal watch-dog agency would be appointed which -- equipped with all information -- would see to it that each and every user of transport paid charges fixed in accordance with costs, not more and not less. The Royal Commission mentioned in its <u>Preliminary Report</u>[129] that heavy commercial vehicles should be charged appropriate shares of highway costs. If we rid ourselves of the notion that there is something special about highways because of the divided ownership of track and vehicles, it is easy to see that now every train, every railway consignment, must also pay its appropriate share of track, terminal and all other costs. If this is not done then our entire plan, designed to accomplish a perfectly neutral, competitive situation, would be imperilled since one train, one segment of the railway network might be subsidizing another.

We now would have to devise some rules for new government investment. Obviously, if users of the St. Lawrence Seaway are charged tolls which will permit the writing-off of the capital investment over fifty years, and users of airports or highways are required to write off these facilities within (say) twenty years, then the Seaway users enjoy a competitive advantage. But how would one account for different degrees of physical durability of assets created by government investment? Obviously some very difficult problems would have to be solved before competitive neutrality in that respect could be achieved.

Finally, a whole mass of economic policy, regulatory and fiscal details would have to be cleared up. For example, sales and excise taxes levied on one type of transport equipment (say automotive accessories) would also have to be levied on, for example, aircraft parts. Labour legislation, safety provisions and other regulations would have to be adjusted to ensure equal treatment for all transport media. There should also be no state-financed research which favours one mode of transportation. The State would further have to refrain from influencing the current operation of transport enterprises one way or another; for instance, there should be no compulsion for any one agency to do things in the "national interest" -- a euphemistic phrase used to compel enterprises to render services which are clearly unremunerative on ordinary commercial grounds; on the other hand the State must not favour one transport medium with lucrative contracts, such as the carriage of mail at high rates, or the conveyance of defence materials, if other media are not offered equal chances.

Even if all these truly tremendous practical obstacles to the achievement of competitive neutrality could be removed, some major economic problems would still have to be solved. In transportation there does not exist just one single market in which all media compete; on the contrary, transportation services are rendered in a multitude of individual markets, some competitive, some monopolistic in nature; there are markets which exist regionally and also markets which have grown up around a specialized service. As we had occasion to point out several times before, there is no such a thing as a "homogeneous unit of transport service". If this is so, how can competitive neutrality ever be achieved, when each carrier, each medium, is confronted with different market characteristics, different elasticities of demand for the particular services rendered and different degrees of monopoly?

We must draw the inevitable conclusion from our preceding discussion that there is no reason to believe that pure and perfect competitive neutrality can, in practice, be achieved in the realm of transportation. There may be some countries in the world where conditions are favourable for the implementation of appropriate policies, but Canada is certainly not one of them. An actively pursued public transportation policy has always been one of the most important features of Canadian history. Without it the country, as it is today, would not exist. The economist is confronted by a historical legacy of complex relationships, by a most intricate pattern of regulation, subsidization, help and hindrance, which it is impossible to disentangle since the whole economy, the distribution of population and the location of industry has grown up around it. It can only be accepted as given.

The Incremental Cost Method

The foregoing discussion may have removed much of the incentive to pursue highway pricing policies aimed at the achievement of competitive neutrality. This removes one of the most important policy objectives mentioned earlier and thus further widens the choice of pricing approaches which could conceivably be pursued by a highway authority.

Despite the fact that different conditions and policy requirements may call for entirely different approaches, it is important, from the point of view of our analysis, to test at least one pricing approach in the light of conditions encountered in the real world. In this way we can bring our analysis to a logical conclusion.

For the purpose we shall choose the incremental cost method. There are several reasons for subjecting this particular pricing technique to detailed scrutiny. In the first place we saw before (see Case 4(a) - Figure 36) that the incremental method achieves more policy objectives than any other technique; in particular, it satisfies our prime rule which calls for the attainment of optimum output and it even conforms to the requirements of competitive neutrality; from the point of view of road users it is probably the most favourable of all approaches, except for the public service method, since all surplus accruing from the provision of highways is passed on as a "consumers' surplus".

Secondly, the incremental cost method has received much favourable attention in the United States; elaborate and extremely costly road tests, such as the AASHO,[131] are being conducted in order to obtain empirically the necessary cost data. Adoption of the incremental method in Canada has been advocated on several occasions. Hence, a brief discussion of the problems posed by this pricing concept may be of topical interest.

At the outset two points should be made clear. Firstly, the incremental cost concept constitutes a theoretical pricing policy and should not be confused with an actual technique of collecting imposts from road users; the latter is a practical problem which will be dealt with after the incremental cost concept itself has been explained. Secondly, we shall only discuss very briefly the most important features of the concept, since the subject has been exceptionally well covered by other writers.*

Some specifically Canadian viewpoints may be of interest. Gordon D. Campbell, who is the Engineer-Observer of the Canadian Good Roads Association on the AASHO Test Road Project, generally accepts the incremental cost method, but recommends that development roads be financed from general fiscal funds.(132) The Canadian Tax Foundation in its Taxes and Traffic(133) draws attention to the incremental cost theory as one of several solutions and points to the practical obstacles which stand in the way of its implementation.

The Canadian Trucking Associations, in a major paper on questions of highway finance(134), generally accept the pure cost approach to road user taxation, but stress the immense practical difficulties which make it questionable whether true costs can be assigned to vehicle categories, let alone individual vehicles. The Automotive Transport Association of Ontario(135) concurs with these views of

*See the appended bibliography on the incremental cost method.

the Canadian Trucking Associations; both organizations favour the so-called "cost function analysis" which consists of a breakdown of highway costs, by means of an accounting analysis of existing records, into items assignable to all vehicles, to heavy vehicles exclusively and to the public highway function generally.

William G. Scott, as spokesman for the railway industry in Canada,[136] stresses the competitive aspects of highway finance and proposes either a cost approach (incremental cost method) or a benefit solution (gross ton-mile concept). The latter is covered by our Case 2 (Figures 31 to 33).

What, then, is the incremental cost method? Basically it attempts to assign to each vehicle the costs occasioned by it. No objections can be raised against this very fundamental principle. However, doubts must be felt when the subsequent methodological steps are taken.

The incremental method usually defines a "basic" road as one which would be adequate to accommodate the "basic" vehicle, normally a passenger car. Sometimes, the basic road is taken to represent the highway standard which existed before the motor vehicle age. In any case, all vehicles are supposed to share in some proportion the costs of this basic road. The additional costs of providing and maintaining successively enlarged and improved facilities are then shared by the heavier and larger vehicles to which these costs can be attributed. Thus the heaviest and largest vehicle would be responsible for part of the costs of the basic road, it would share to some extent in the costs of all successive increments for medium-sized vehicles and it would finally be responsible for the entire cost of the last "cost step", if it alone requires it.

In this way, the incremental cost method faces the well-known problems of the assignment of joint costs. Are the costs of the basic road and of all successive joint cost "steps" to be distributed with reference to mileage travelled or benefits received? Some arbitrary decisions obviously have to be made. In this connection Winch points to a serious defect of the incremental method, under the valid assumption that the "basic" road of the pre-motor vehicle age is a cost responsibility of the community:

> "Instead of arguing that the community should pay what highways would cost them in the absence of motor vehicles and motor vehicles the rest, we could argue that motor vehicles should pay what it would cost them for a road system not used by the community and the community the rest. The incremental half of each of these arguments is valid but the allocation of joint costs entirely to the other group is not.
>
> Highway costs can therefore be divided into three categories: those incurred entirely for the benefit of motor vehicles which should be borne by motor vehicle users; those incurred entirely for the benefit of the community, which should be borne by the community; and those which are joint costs and yield benefits to both. The incremental cost principle applies to the first two types and is valid. It does not apply to the joint costs and gives no guidance how this group, which is normally the largest, should be divided."(137)

Many other unsatisfactory features of the incremental method could be cited. How can, for example, the costs of the conversion of a road from two to four lanes be allocated to any one class of vehicles? Or, how can costs of administration, of safety features and of road expenditures incurred for aesthetic purposes be distributed rationally between, say, passenger vehicles, commercial vehicles and the community as a whole?

Drawing on the analyses pursued in this study, all the complications illustrated by means of the three-dimensional diagram technique apply, of course, fully. The cost problem posed by a vehicle of a certain weight, (or desiring to inflict a certain number of load applications per period of time on the highway), and travelling at a certain time in a certain direction -- thus causing certain traffic volume costs -- simply cannot be handled by the incremental cost method or by any other pricing technique currently advocated.

On a very practical plane of discussion we might expect that the railways, which after all have fewer variables and fewer complications to contend with in their costing problems, would lead the way in uncovering the secrets of cost allocation and rational pricing. There is no evidence that this is so; on the contrary, it appears from a recent judgment of the Board of Transport Commissioners that the Canadian National Railways are unable to supply cost figures pertaining to their operations:

> "The Canadian National stated that it was unable to supply any figures of the all-inclusive cost of operations, because so many arbitrary assumptions as to the application of the overhead costs would have to be made that it would be impossible to arrive at a fixed conclusion in the matter." (138)

If the railways, which are not plagued by such highway problems as divided ownership of track and vehicle, heterogeneous traffic use, and community share in road costs, have not been able to perfect their costing methods to any significant degree, then it is obviously unreasonable to expect great advances in this respect in the highway sphere.

We might finally ask ourselves whether it is really important to determine precisely and accurately the costs of providing highway services for each individual motor vehicle or vehicle category. We saw before that we had no particular stake in the "charging according to costs" approach, since the optimum output can also be achieved by other means, for instance by perfectly dissimilar pricing. One of the most important propositions this study attempted to establish was the crucial role of pricing according to marginal costs at the critical (or extreme) values. Apart from this one point in the cost universe we are not particularly interested -- as far as investment, priority and output planning are concerned -- in cost data for the intermediate ranges.

Even if "competitive neutrality" was a cause espoused by us, there are good reasons to believe that the significance of charging on the basis of costs is not very great. In the first place, competitive agencies -- as the quotation from the judgment of the Board of Transport Commissioners shows -- may also not be aware of their cost structure, or may not wish to charge according to costs. Secondly, once we deduct the community share of highway costs, the range of possible inaccuracies of cost shares assignable to vehicles shrinks accordingly. Thirdly, there are all the difficulties of matching the theoretically perfect pricing policy -- if it exists --

by the perfect user charge collection system. The problems associated with the last point will be discussed in the next section.

<u>User Charge Collection Problems</u>

What do we expect of a good user charge collection system? Firstly, we want to keep the costs of the "social transfer" of claims on resources from the taxpayer to the government at the absolute minimum. This means that the administrative costs of collection, bookkeeping and enforcement of the system we choose must be low. Secondly, we desire that the tax collection system fulfil the particular functions set by our pricing objectives; if our objective is maximization of government revenues, then our collection system must be capable of producing these large revenues; if we charge on the basis of costs, then the system must be smoothly adjustable to the particular cost data provided; finally, the collection system must be capable of rationing consumption to optimum output, since this is our prime objective.

What pricing tools are available? In Canada motor fuel taxes and special fees, normally associated with the licensing of the vehicle and increasing with its size and weight, are used in all ten provinces. In some of the United States so-called "weight-distance taxes" are in vogue; these are imposts on mileage travelled which vary with the weight of the vehicle. Sometimes special taxes on automotive equipment, for example tires, are rated as road user taxes. There can also be toll collections at bridges, tunnels or at highway toll gates. Finally, in accordance with our wider interpretation of benefits conferred by highway provision a variety of financial tools can be employed to collect revenues. Taxes on benefiting land can be imposed; alternatively land can be bought by the highway authority prior to the construction of the facility and then be disposed of later at a profit. Enterprises connected with the highway function, such as gasoline stations, roadside restaurants, motels etc., can be charged special fees or franchises can be sold to them.

Let us now see how the various pricing tools which are available perform their functions. The motor fuel tax and the vehicle license are extremely good revenue producers and the costs of collection and administration are very low. The vehicle licensing system is extremely efficient as a tool of rationing consumption of highway services to the optimum values of weight service, if we think of it in terms of maximum vehicle weight permitted on the road; it is not suitable for the rationing of the number of load applications per unit of time, if that is our criterion of weight service.

Neither the motor fuel tax nor the licensing system can ration the consumption of highway services to the optimum traffic volume values. It would be difficult to introduce the necessary "time" dimension, unless one licensed vehicles for travel at certain hours of the day or days of the week; probably a case could be made for licensing commercial vehicles, at especially low off-peak rates, for night travel only. Toll charges imposed during peak traffic hours to prevent congestion might be possible. Winch suggests such a system at strategic spots, for instance, at bridges, tunnels etc., which would have a beneficial effect on the distribution of traffic flow over time within a certain area of influence.

In a way the motor fuel tax incorporates an automatic traffic volume rationing device, since fuel consumption and hence tax payments increase under congested traffic conditions. However, the additional fuel tax charges are very small compared to the marginal social costs imposed by the presence of one more vehicle on a congested road or street. Hence there is a social loss caused by the failure of the user charge collection system effectively to reduce demand for road services to the optimum level. Apart from building road facilities to peak traffic requirements -- if by doing so a net gain of social benefits is obtained -- and apart from adopting Winch's scheme of imposing special rush-hour tolls, there seems to be little that could be done to remedy the situation.

Weight-distance taxes are generally poor revenue producers and the costs of administering and enforcing them are relatively high. Since the authorities are largely forced to rely on mileage records submitted by the operators -- who are also the taxpayers -- the incentive for evasion is great. Weight-distance taxes may perform a useful function by rationing the number of load applications per unit of time, but they are useless as traffic volume rationing devices; in fact it is very difficult to think of many good reasons why they should be used at all by public highway authorities.

Toll charges suffer from high collection costs and from the very restricted scope of their application; the reasons for this were discussed at the conclusion of our toll road model analysis. In Canada sales taxes on automotive equipment are generally not regarded as belonging to the category of road user charges.*

*Certain sales taxes on automotive equipment now form part of the federal highway financing programme in the United States.

It is suggested that great scope exists in the sphere of land taxes, land sales and taxation of subsidiary highway service operators. As was shown in this study trends in land values can be assessed and attributed to highway improvements. There is no reason why private profit conferred by road provision should not be turned into public revenues, if it is the policy aim to tap indirect and transferred benefit sources for fiscal purposes. Land transactions by public authorities, used for many years with great success by some authorities in Canada and the United States, could be turned into a lucrative source of public revenues. Using the reverse approach, advance purchases of right-of-way for highways to be constructed years later, has saved a number of highway departments millions of dollars.

A strong case can be made for the imposition of special fees on operators of subsidiary service establishments. This should not only be done to collect revenues, but especially to cover at least the social costs inflicted by these enterprises. Roadside restaurants, motels, gasoline stations definitely diminish the value of a long-distance highway, since they constitute a safety hazard, demand special access features and distract the attention of drivers by use of advertising signs. In the case of primary highways and other important routes a complete ban on all roadside establishments and advertising signs should be imposed, since the social costs caused by them would probably be found to outweigh by far any benefits or revenues derived from them.

Pricing of Highway Services - Conclusions

The main conclusion which emerges from the discussion of highway pricing problems is the fact that there are so many possible policies which can be pursued by a highway authority. It is very important that the objectives of public policy be clearly stated, so that they can be carried out efficiently. The desired aim of optimum output can be achieved in a number of ways, of which the incremental cost solution is one. After discussion of this approach it was found that it does not meet a number of theoretical and practical desiderata. Motor fuel taxes and vehicle license fees were found to be lucrative sources of revenue, easy to administer and satisfactory in some respects as consumption rationing devices. However, no simple methods are envisaged which would solve the peak traffic problem. More use of imaginative commercial policies might be made in the field of subsidiary highway activities.

There can be no recommendations for the adoption of a particular pricing policy and a particular system of user charge collections. This once more underlines the desirability of separating highway investment policies from the subordinate problems of pricing and revenue collection. The attention of highway authorities should be turned first to investment planning and priority determination. The social losses of making wrong or belated decisions in this vital sphere will far outweigh the possible social losses caused by distortions of the competitive pattern.

TABLE 1

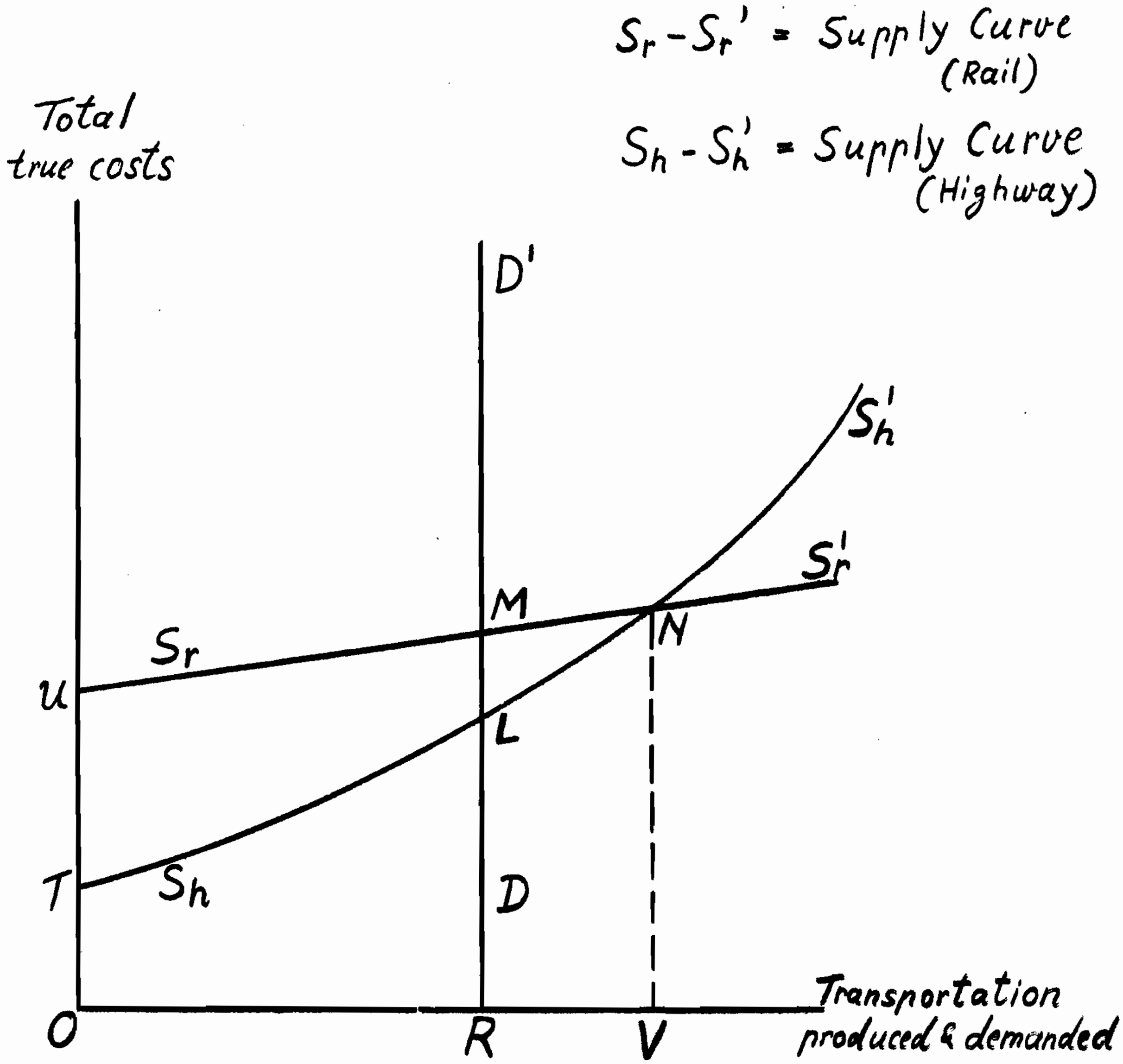
COST CATEGORIES

	RAIL TRANSPORT	ROAD TRANSPORT
A. FIXED COSTS:		
(1) Plant	Land right-of way	Land right-of-way
	Legal costs	Legal costs
	Grading, drainage, track and rails	Grading, drainage, sub-base, base course, surface
	Tunnels, bridges, terminal facilities, permanent structures	Tunnels, bridges, terminal facilities, permanent structures
	Signalling and safety facilities	Guard rails, road signs, other safety facilities
	Planning, surveying, engineering, labour and all other costs resulting from construction of the railway line	Planning, surveying, engineering, labour and all other costs resulting from construction of the road
(2) Vehicles	Locomotives	Tractors
	Freight cars	Trailers
	Repair, maintenance and storage facilities	Repair, maintenance and storage facilities
	Fuel storage	Fuel storage
(3) Other fixed costs	Taxation, insurance, legal and license fees attributable to the ownership of the assets listed above	Taxation, insurance, legal and license fees attributable to the ownership of the assets listed above
B. VARIABLE COSTS:		
(1) Plant	Current maintenance and repairs	Current maintenance and repairs
	Replacements, periodic maintenance, inspection	Replacements, periodic maintenance, inspection
(2) Vehicles	Repairs, wages, fuel, oil, water, spare parts, superintendence, etc.	Repairs, wages, fuel, oil, batteries, tires, spare parts, superintendence, etc.
(3) Other variable costs	Management, administration, taxation, legal and license fees attributable to the operation of the assets listed above	Management, administration, taxation, insurance, legal and license fees attributable to the operation of the assets listed above

COST CATEGORIES

Table 1 (Cont'd)

	RAIL TRANSPORT	ROAD TRANSPORT
C. INTEREST AND DEPRECIATION	Depreciation Interest on investment	Depreciation Interest on investment
D. OTHER COSTS (for instance):	Terminal costs, handling charges, estimated costs of loss or damage to goods and equipment	Terminal costs, handling charges, estimated costs of loss or damage to goods and equipment
	Quality of service considerations	Quality of service considerations
	Time costs, such as the costs of working capital tied to the goods in transit	Time costs, such as the costs of working capital tied to the goods in transit
	Costs of adjustment of production or marketing schedules to the irregularities, speed and other characteristics of traffic flow	Costs of adjustment of production or marketing schedules to the irregularities, speed and other characteristics of traffic flow
	Flexibility of routing and scheduling, adaptability of plant and equipment to changing situations	Flexibility of routing and scheduling, adaptability of plant and equipment to changing situations
	"Social" costs and nuisance costs (smoke, fumes, noise)	"Social" costs and nuisance costs (fumes, noise)
SUB TOTALS	....	....
DEDUCT	Scrap value of plant and equipment at the end of planning period	Scrap value of plant and equipment at the end of planning period
TOTAL TRUE COSTS	TOTAL TRUE COSTS OF RAIL TRANSPORT	TOTAL TRUE COSTS OF ROAD TRANSPORT



$S_r - S_r'$ = Supply Curve (Rail)
$S_h - S_h'$ = Supply Curve (Highway)
Total true costs
D'
S_h'
S_r'
M
N
S_r
U
L
T
S_h
D
Transportation produced & demanded
O
R
V

Figure 2

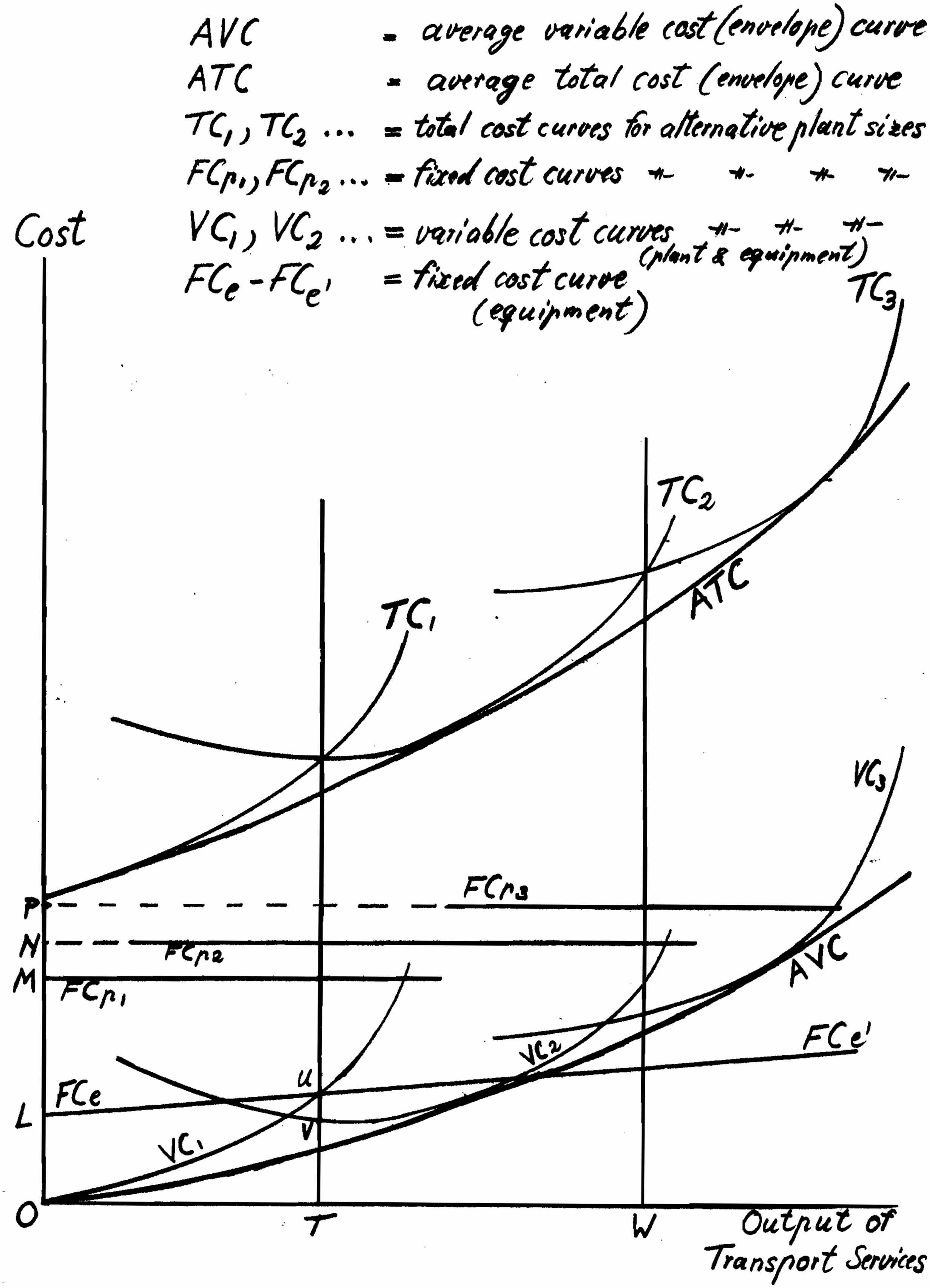

AVC = average variable cost (envelope) curve
ATC = average total cost (envelope) curve
TC1, TC2 ... = total cost curves for alternative plant sizes
FCp1, FCp2 ... = fixed cost curves " " " "
VC1, VC2 ... = variable cost curves " " " (plant & equipment)
FCe - FCe' = fixed cost curve (equipment)
Cost
TC3
TC2
ATC
TC1
VC3
FCp3
P
N
FCp2
M
FCp1
AVC
FCe'
VC2
u
FCe
L
v
VC1
O
T
W
Output of Transport Services

Figure 3

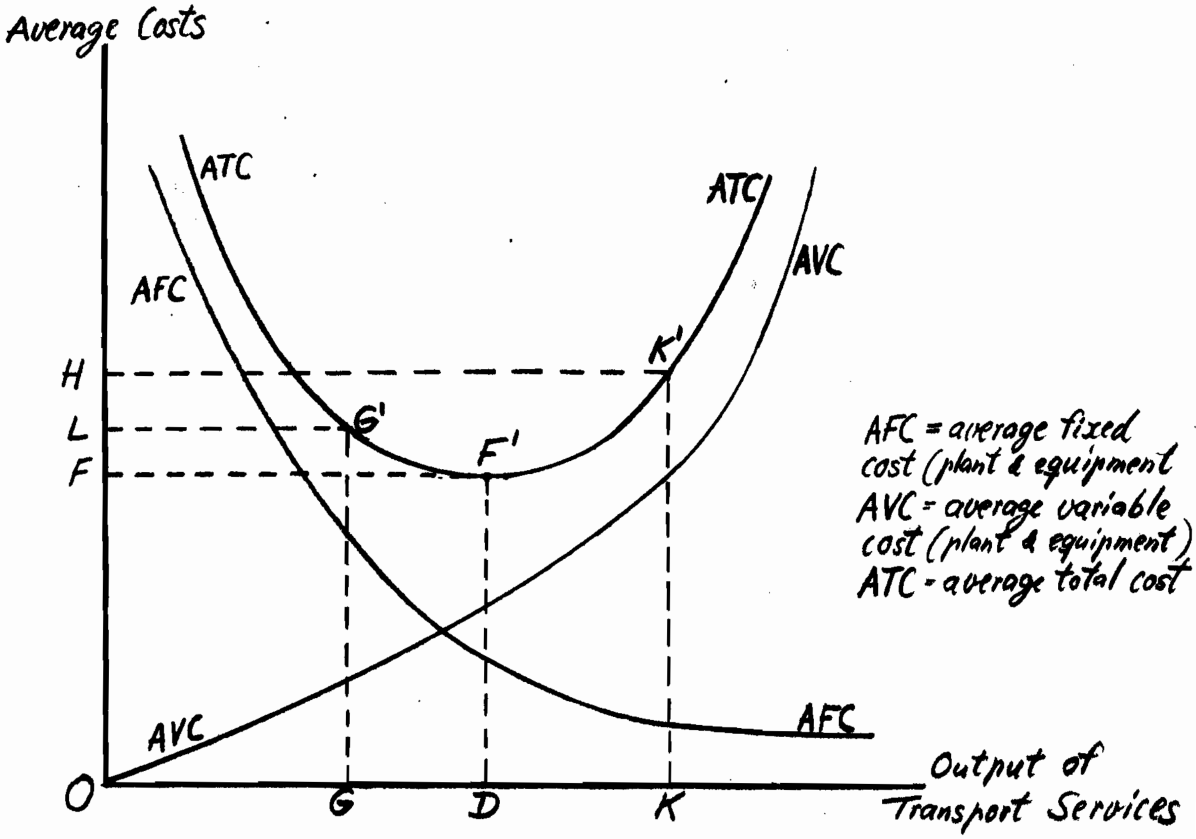


Figure 4

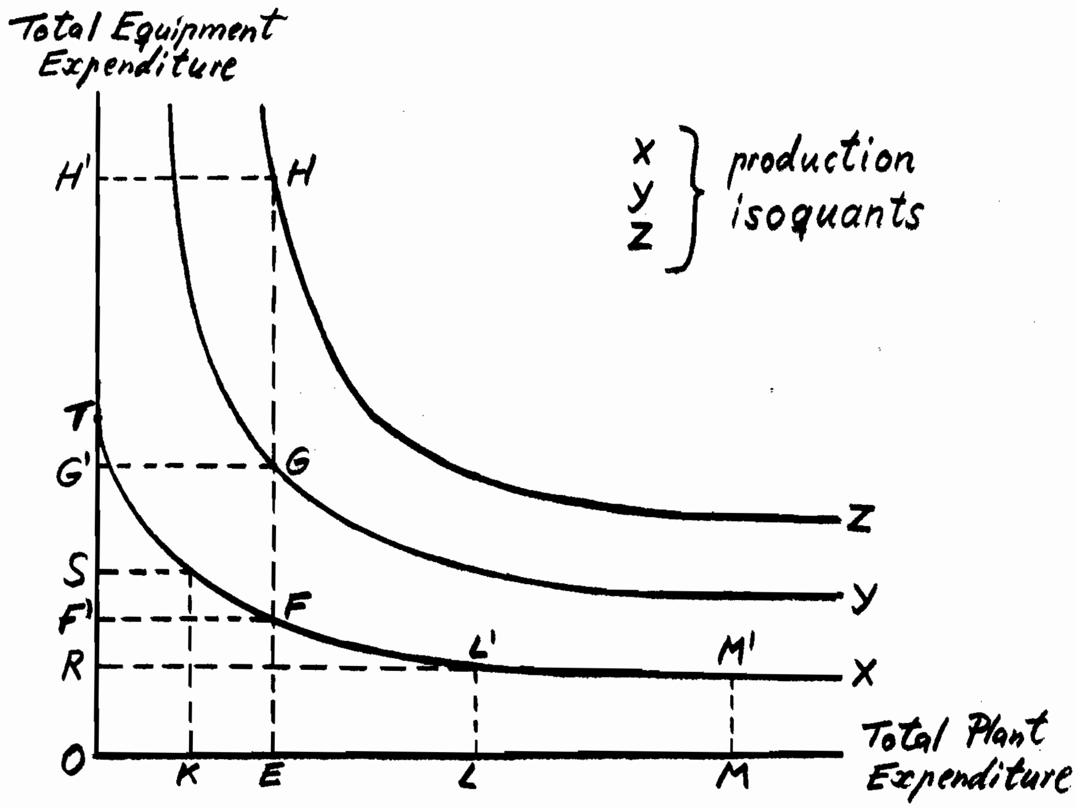


Figure 5

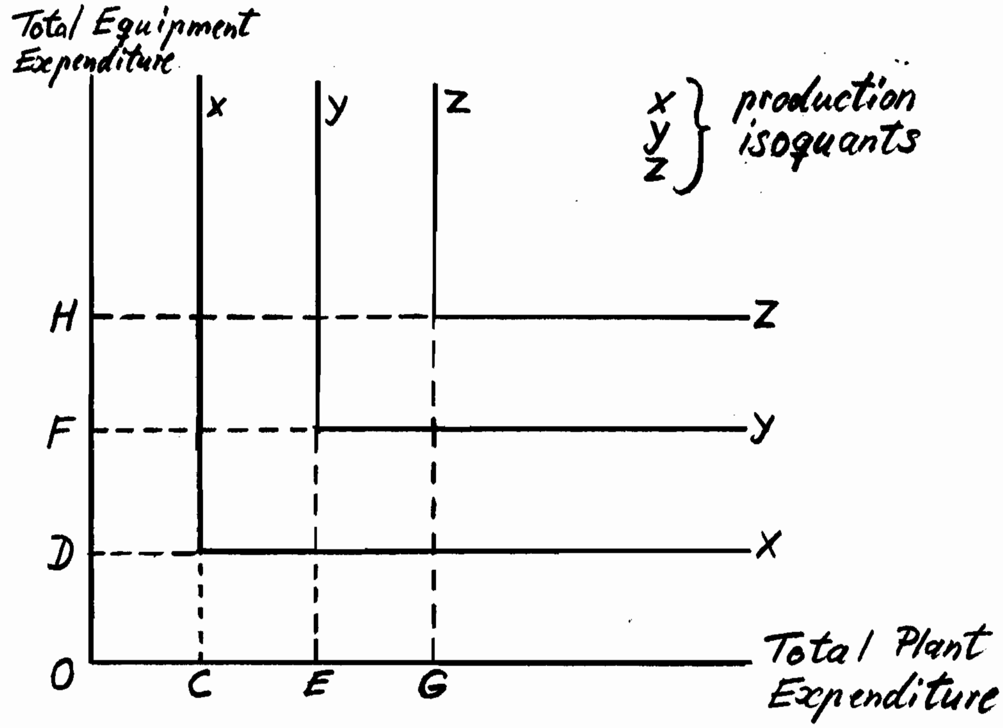
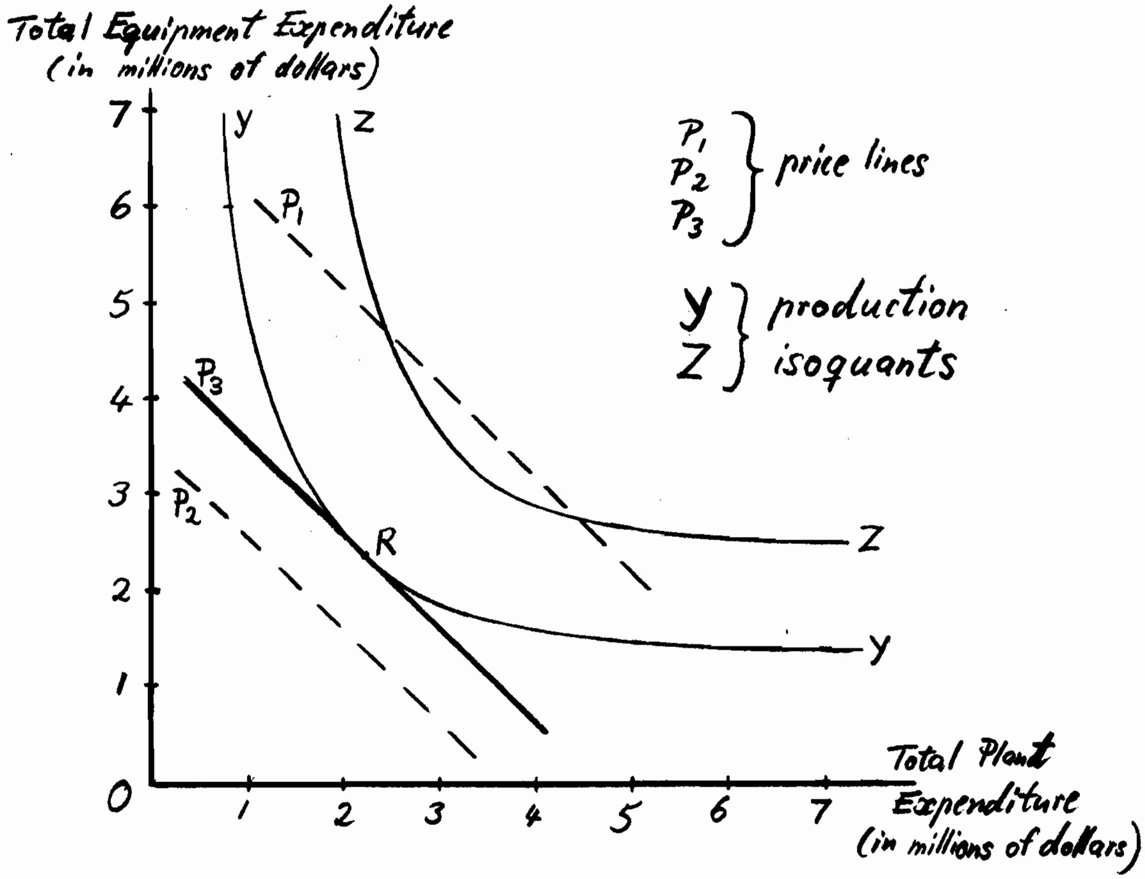


Figure 6



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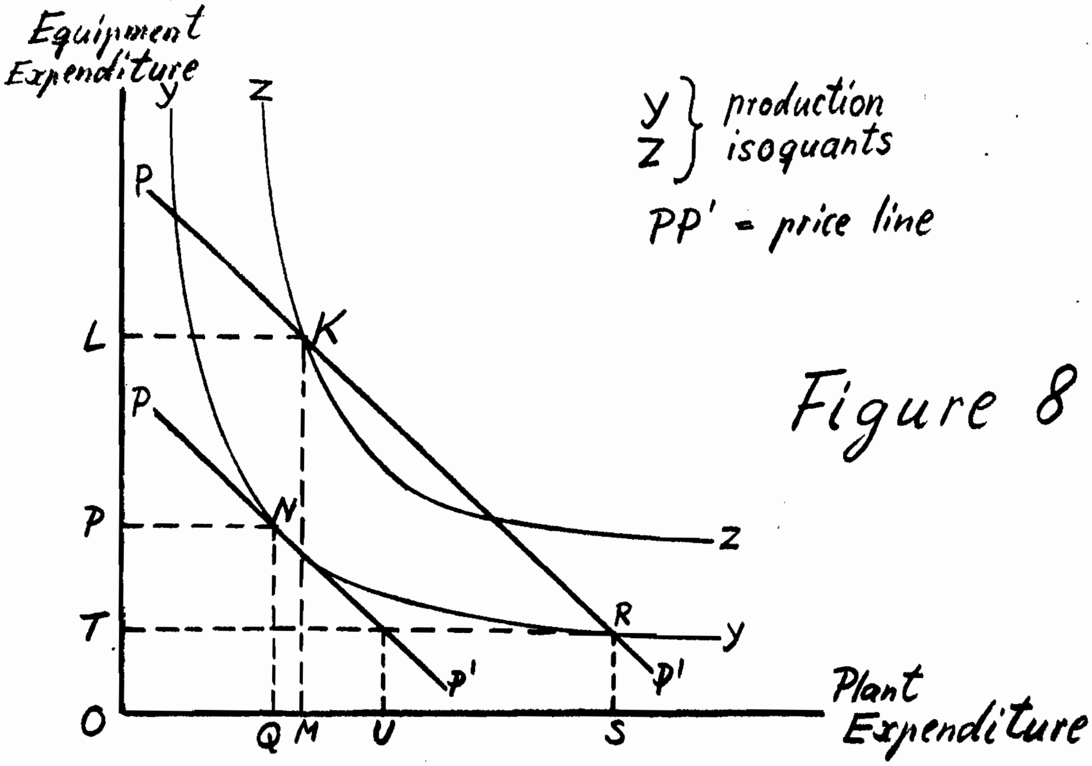


Figure 8

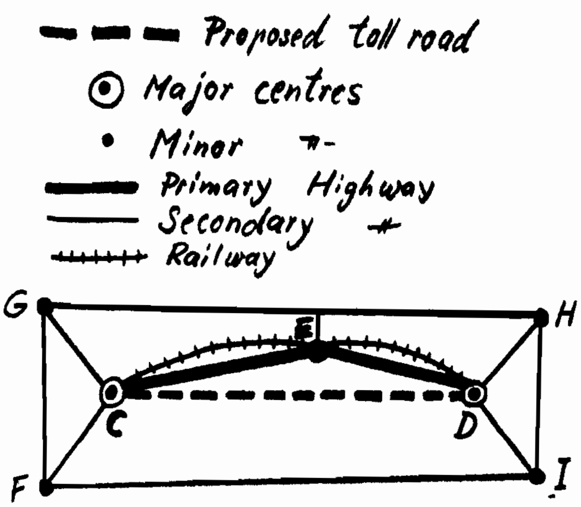
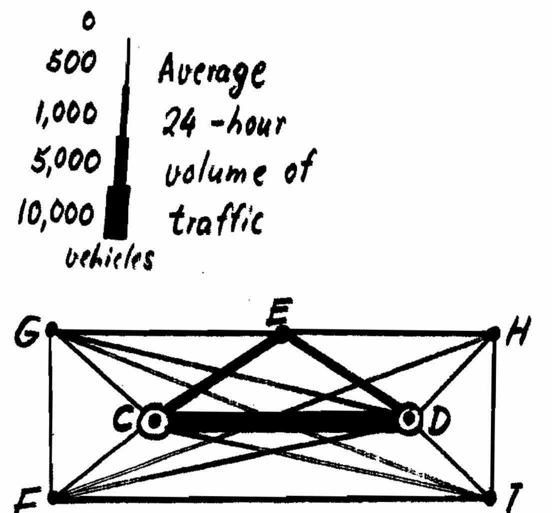
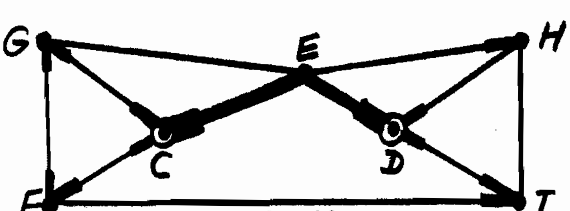


Figure 9



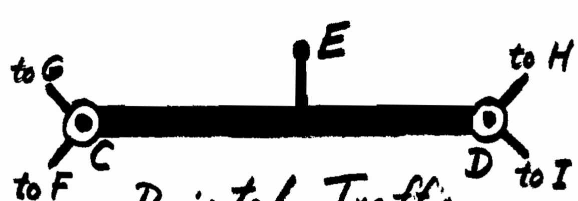
Travel Desire Lines (from origin-and-destination survey)

Figure 10a



Results of Traffic Volume Count

Figure 10b



Projected Traffic on Toll Roads

Figure 11

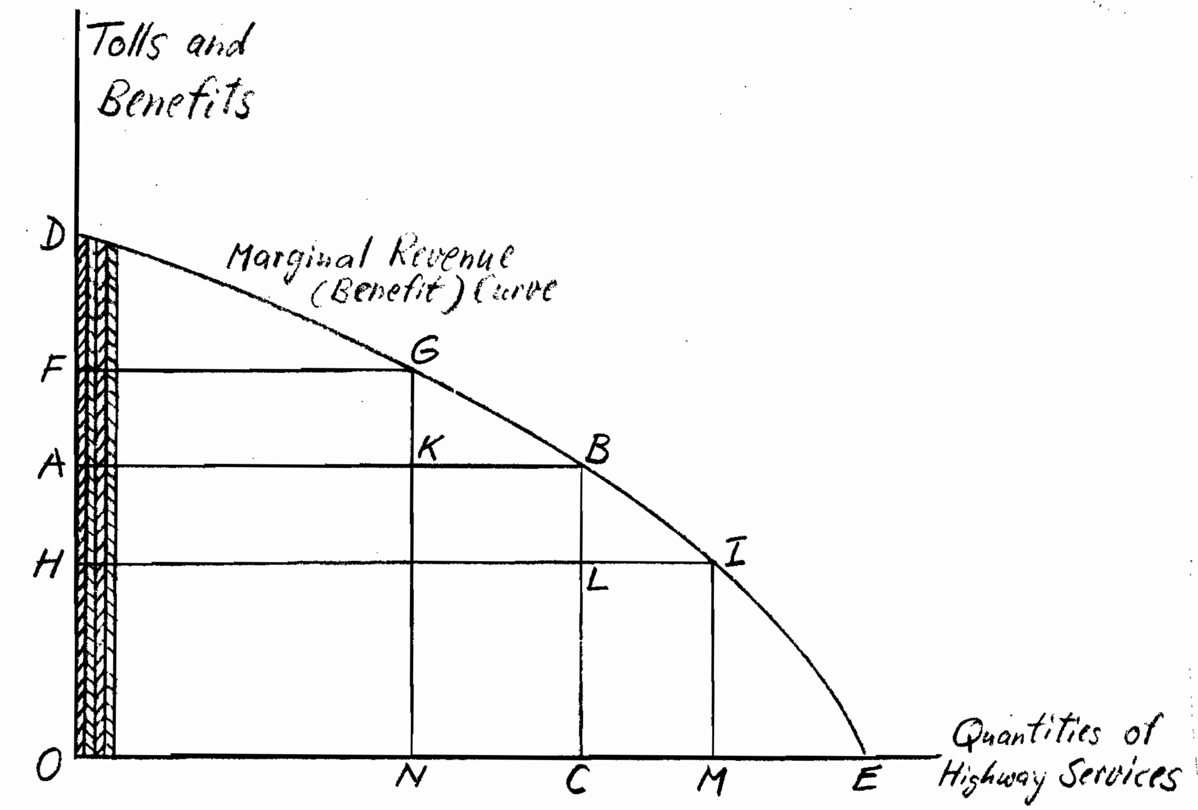


Figure 12

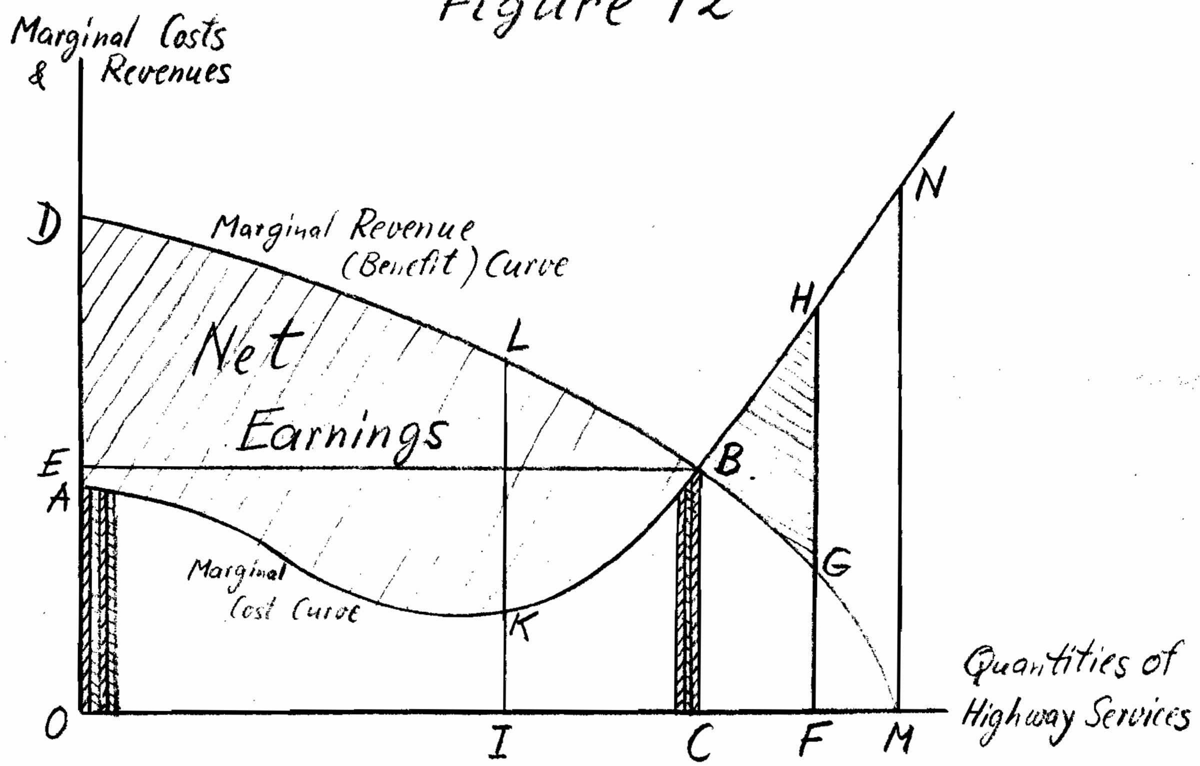


Figure 13

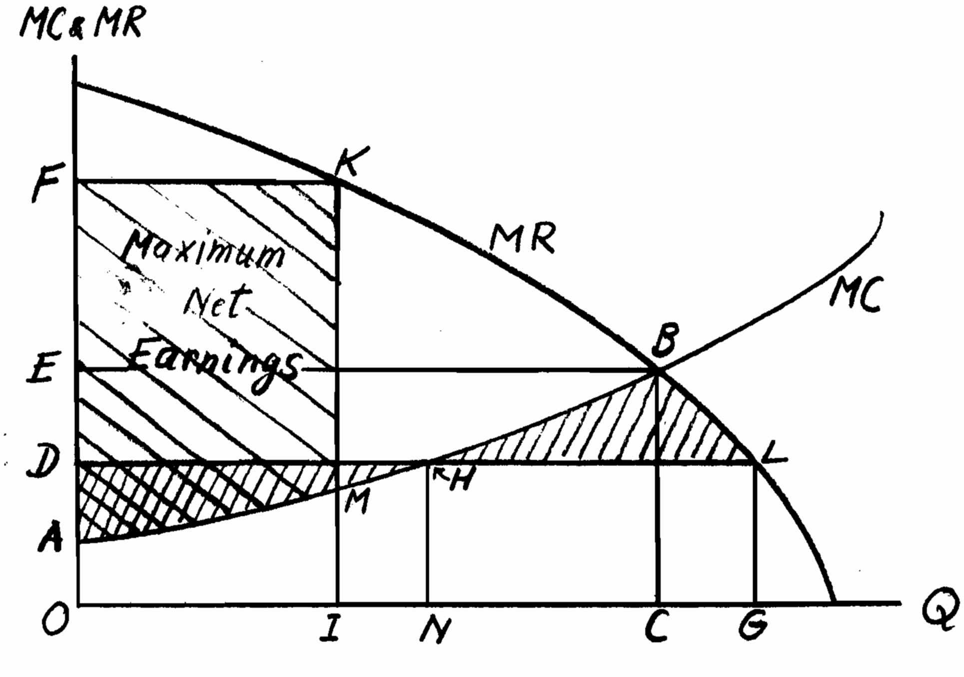


Figure 13a

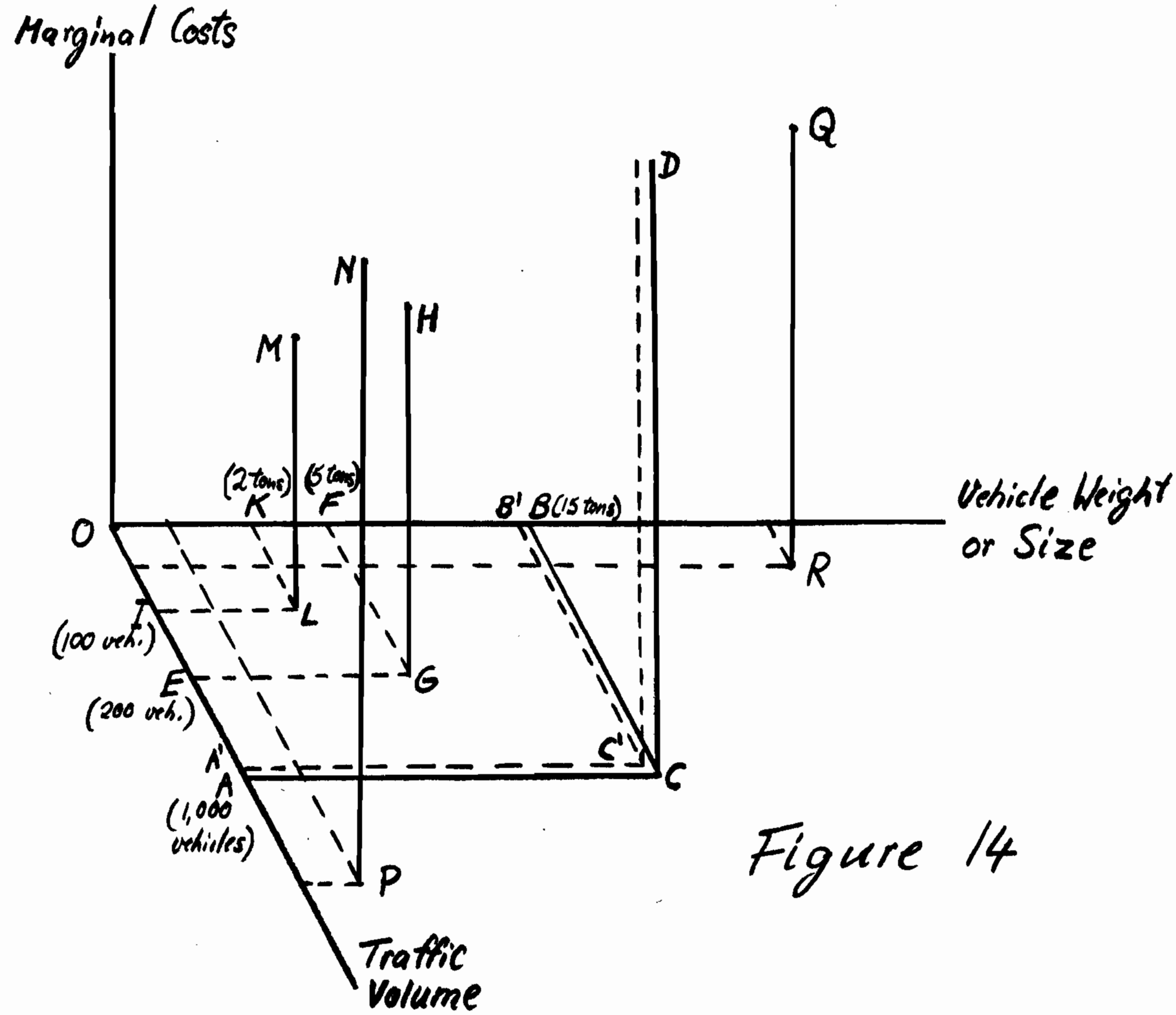


Figure 14

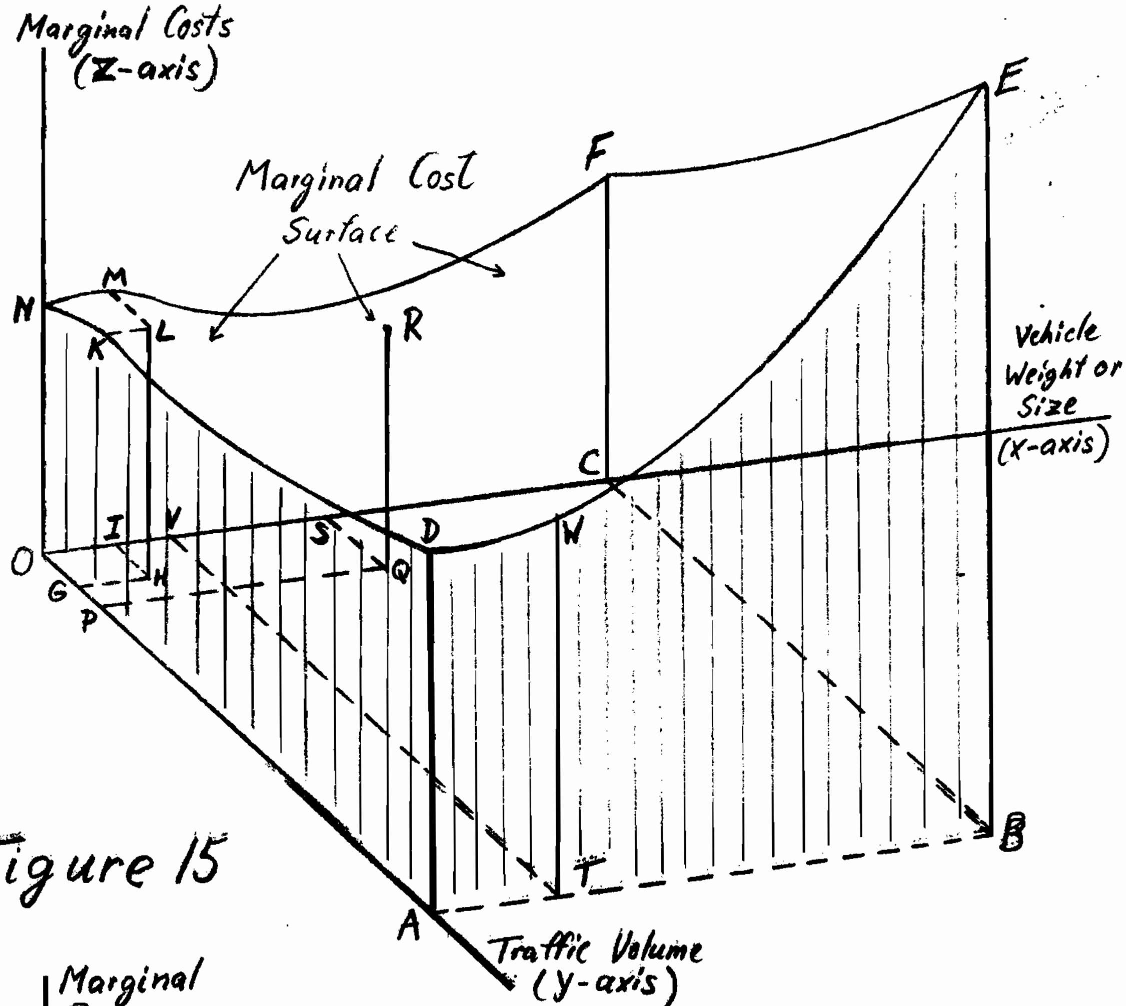


Figure 15

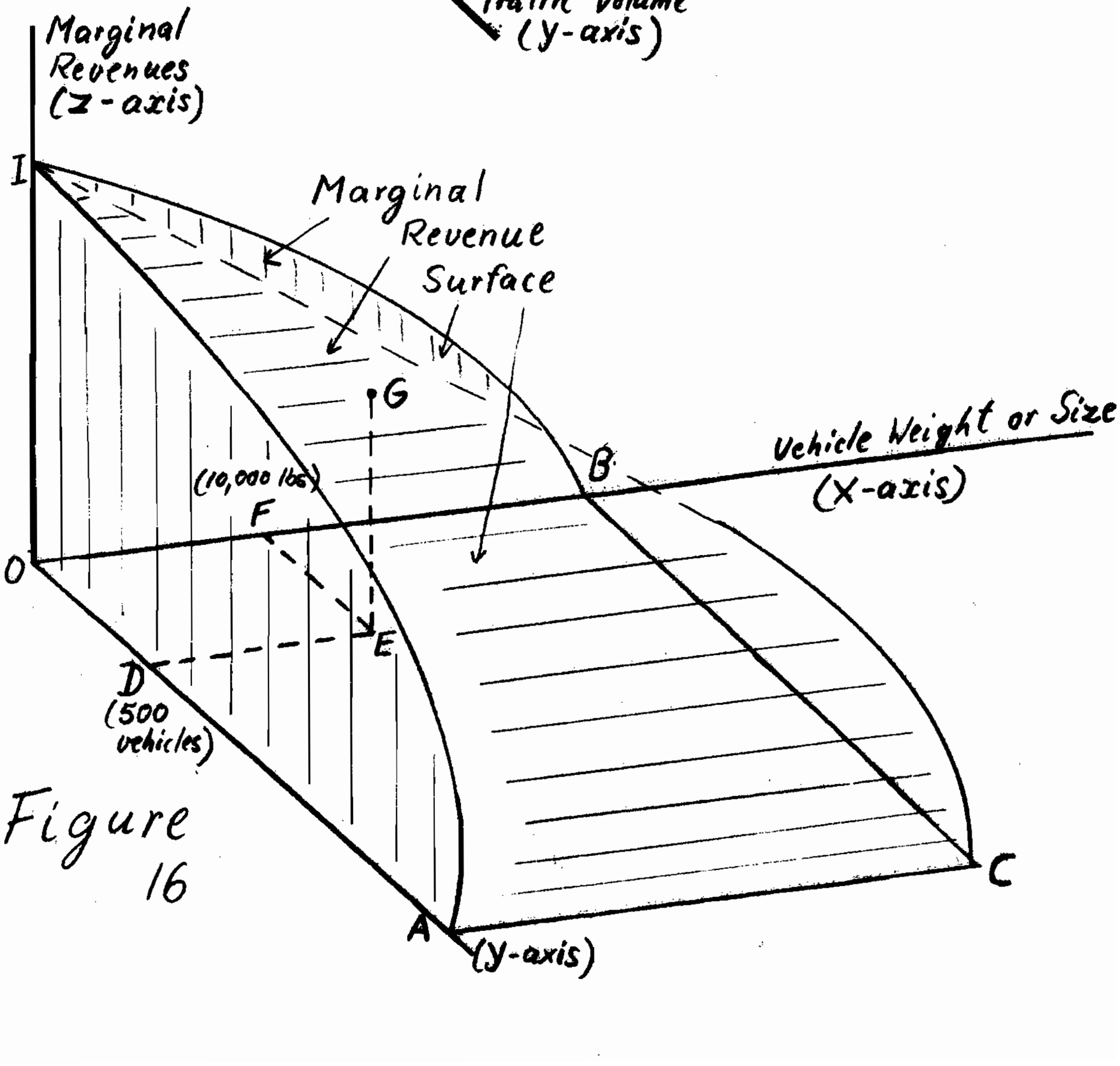


Figure 16

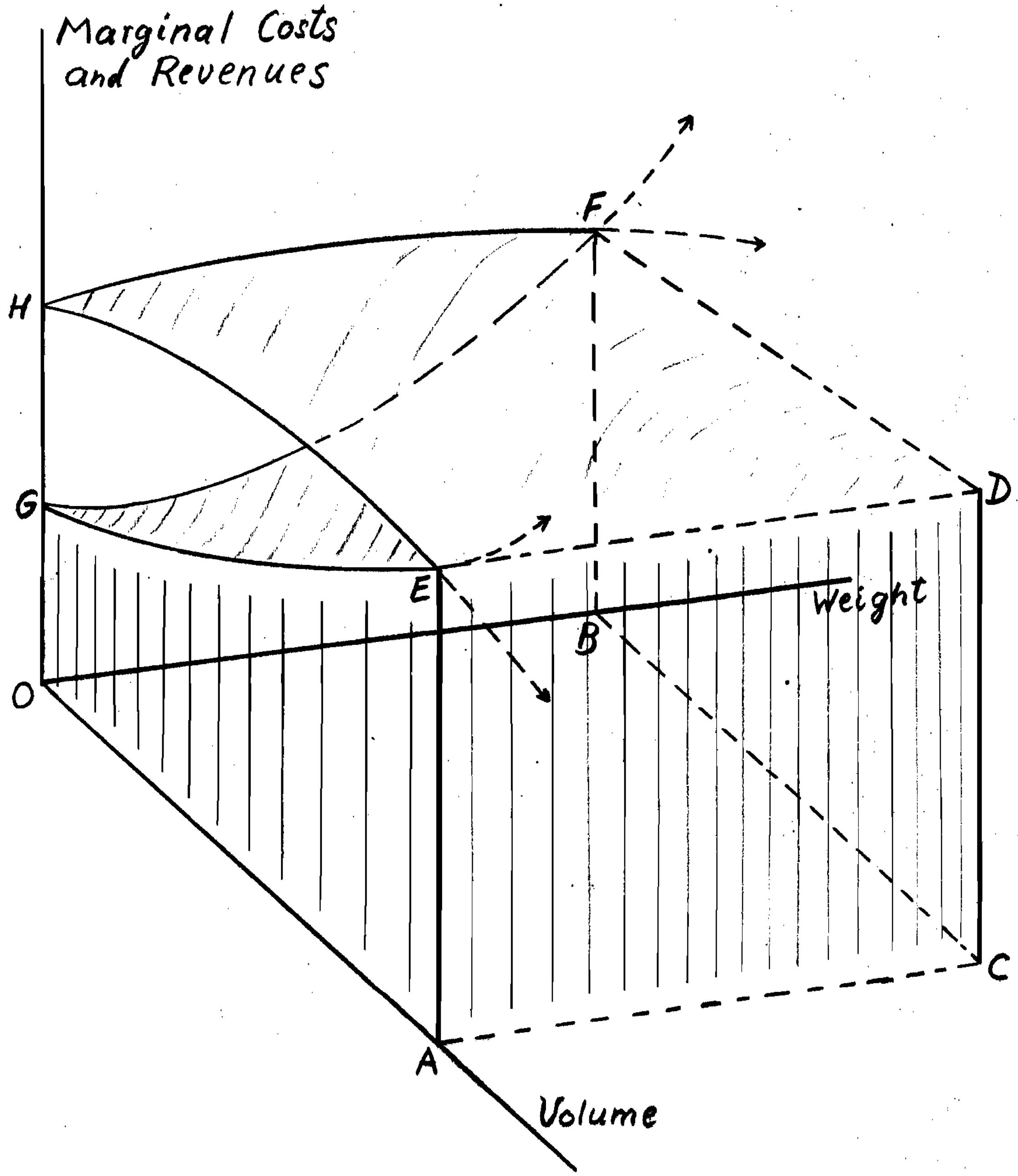


Figure 17

TABLE 18

Percentage Gain in Land Values, 1950 over 1945, in Each of Four Areas Investigated in Gulf Freeway Study, Houston, Tex.

(Corrected for Changes in the Value of the Dollar)

Area	Relative Land Values 1945	Relative Land Values 1950	Percentage Increase in Value, 1945 to 1950
	%	%	%
Areas close to freeway:			
Area 1	100	221	121
Area 2	100	178	78
Areas remote from freeway:			
Area 3	100	105	5
Area 4	100	126	26

Source: A Study of Land Values and Land Use Along the Gulf Freeway, Houston, Tex., Texas State Highway Department, 1951, Austin, 1951. Quoted from: United States Government, First Progress Report of the Highway Cost Allocation Study, Washington, D.C., 1957, Table 22, p. 111.

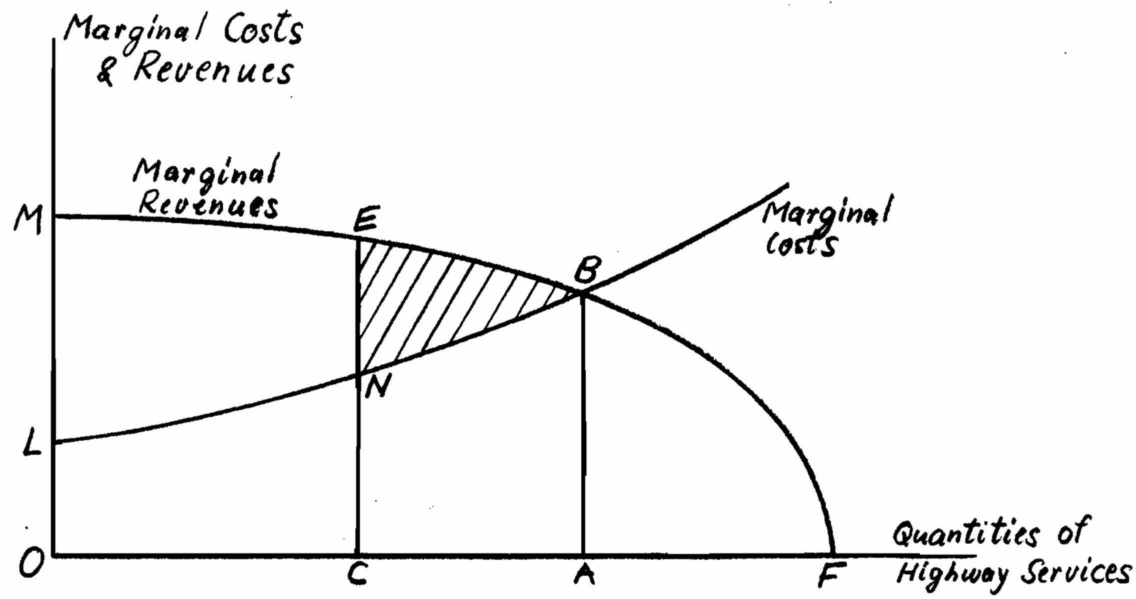
TABLE 19

Changes in Property Values in New York Area

(in millions of dollars)

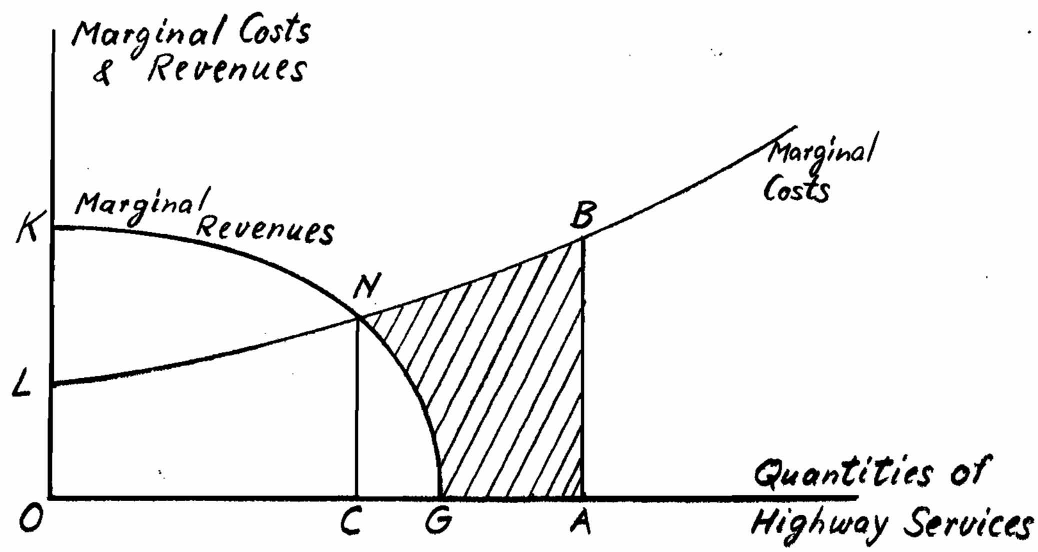
	Value at Time of Construction $ mill.	Value 1953 $ mill.	Increase %
Grand Central Parkway (constructed 1925)			
Influence Area	4.4	93.2	2038
Control Area	141.5	850.8	501
Henry Hudson Parkway Manhattan Section (constructed 1935)			
Influence Area	397.5	415.9	4.6
Control Area	1,484.2	1,367.6	- 7.9
Henry Hudson Parkway Bronx Section (constructed 1935)			
Influence Area	21.9	44.3	102.0
Control Area	99.3	76.5	-22.8
Shore Parkway Brooklyn (constructed 1939)			
Influence Area	61.7	108.7	76.2
Control Area	487.8	581.5	19.2

Source: The Influence of Public Improvements on Property Values, Office of the New York City Construction Coordinator. Quoted from David M. Winch, The Economics of Highway Planning, The London School of Economics, 1957, p.172. (Title supplied)



Rush-Hour Traffic Situation
(Optimum Plan One = Output OA)

Figure 20



Midnight-Hour Traffic Situation
(Optimum Plan Two = Output OC)

Figure 20a

Figure 21

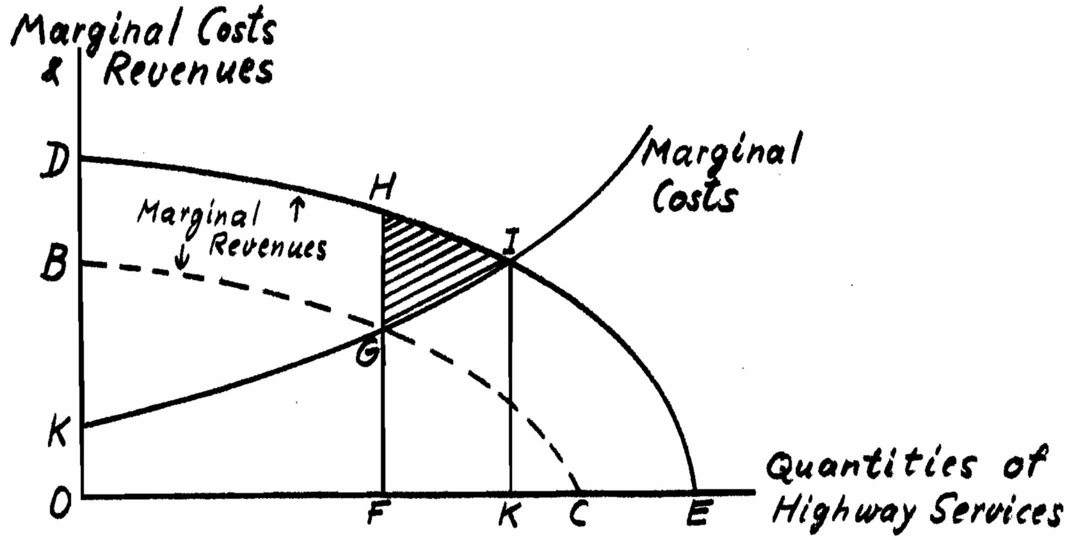


Figure 22

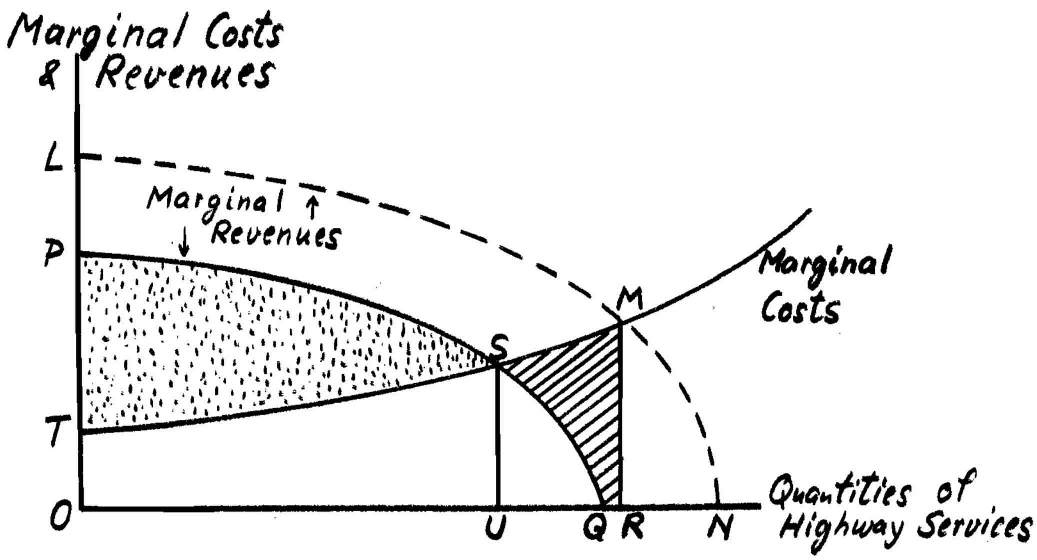


Figure 23

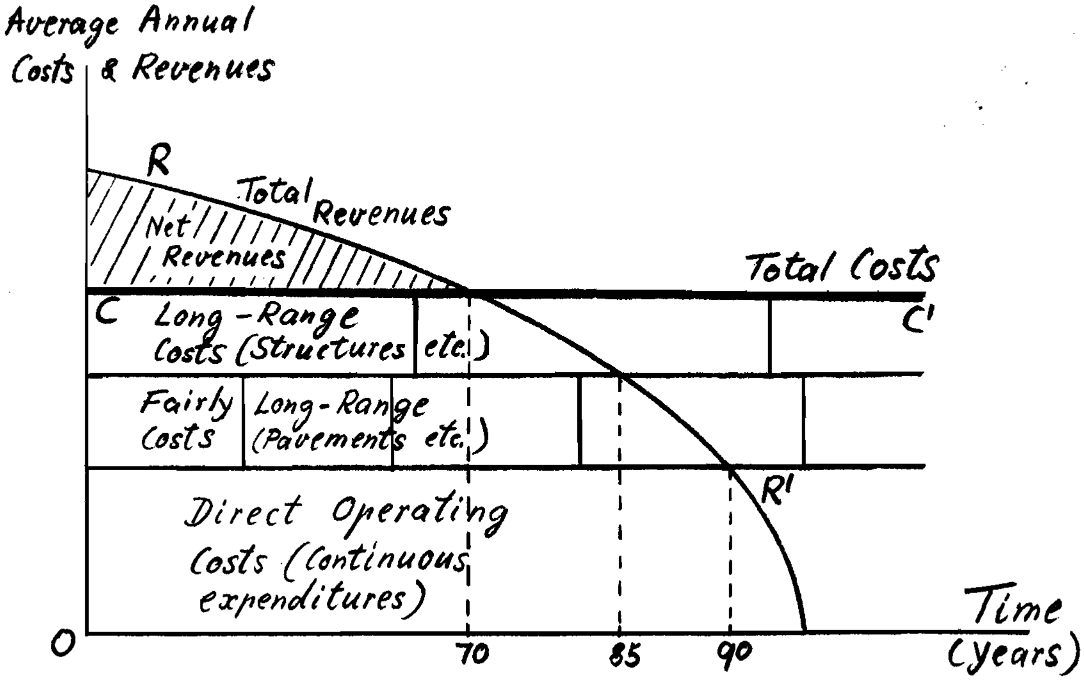


Figure 24

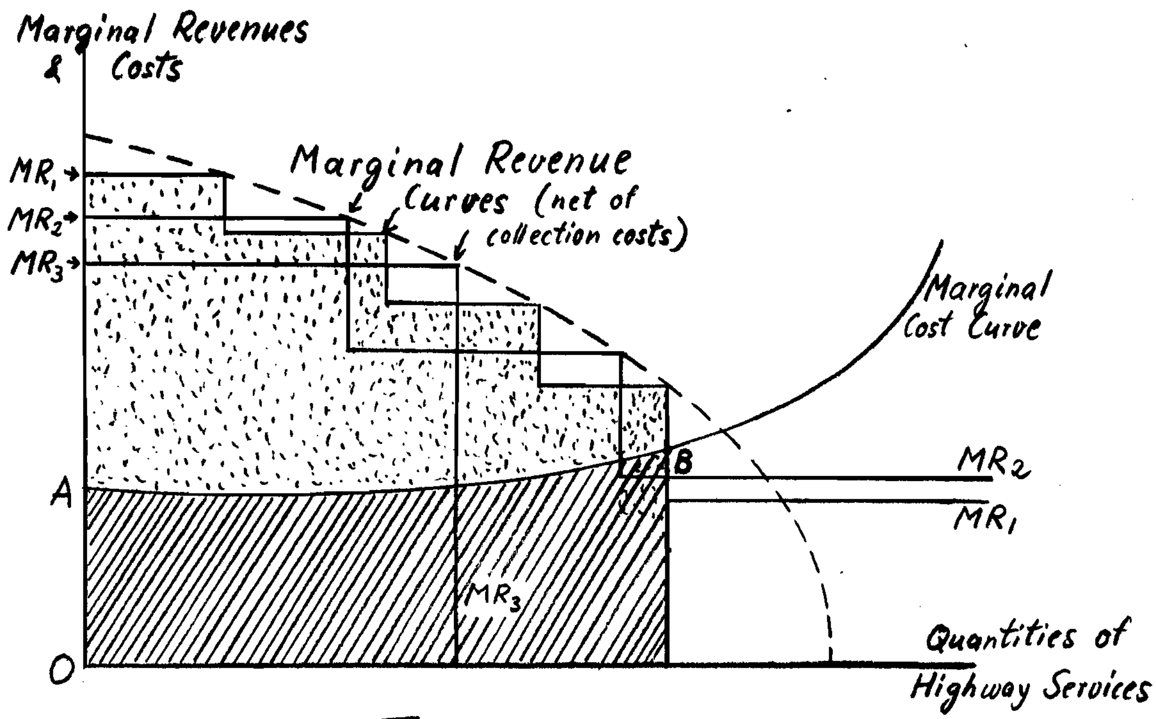


Figure 25

TABLE 26

COMPARISON OF TRAFFIC GROWTH RATES IN ONTARIO AND IN THE UNITED STATES

(All figures represent average increases compounded annually for the period shown in headings)

	Ontario			U.S.A.		Selected States (a)	
	1945-55	1956-66	1966-76	1945-55	1956-66	1945-55	1956-66
Population	2.8	2.5	2.3	1.7 (b)	1.6 (d)	0.5-3.0	0.5-2.5
Vehicle Registration	9.3	5.8	4.7	7.3 (c)	2.5 (e)	2.0-8.0	2.5-3.5
Vehicle Travel	11.0	6.0	4.8	9.3 (c)	-	6.0-9.5	4.0-4.5

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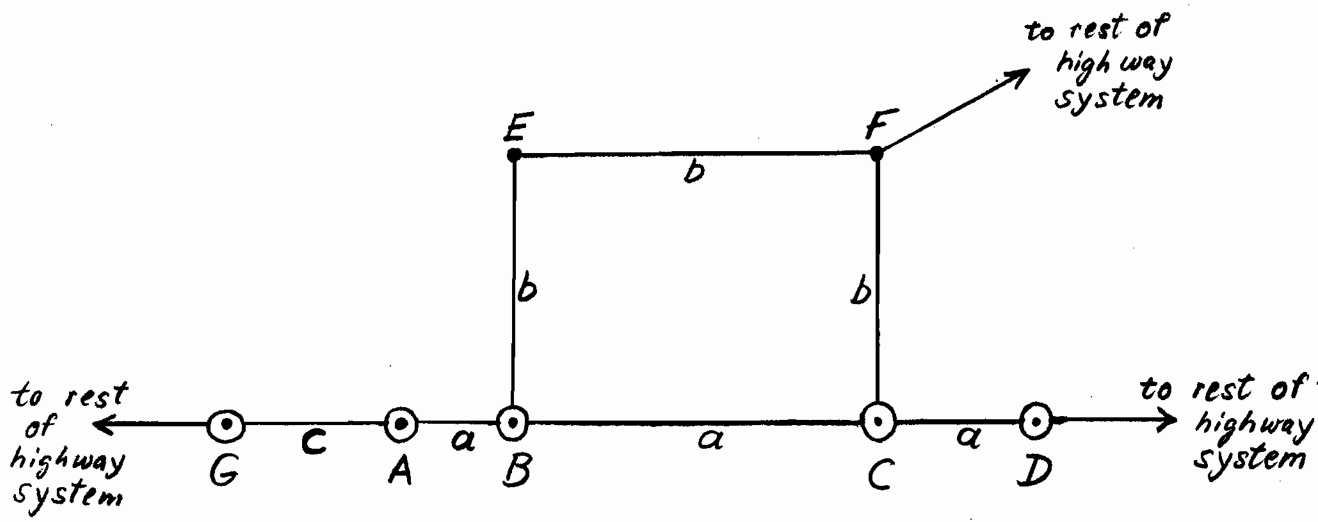

Figure 27

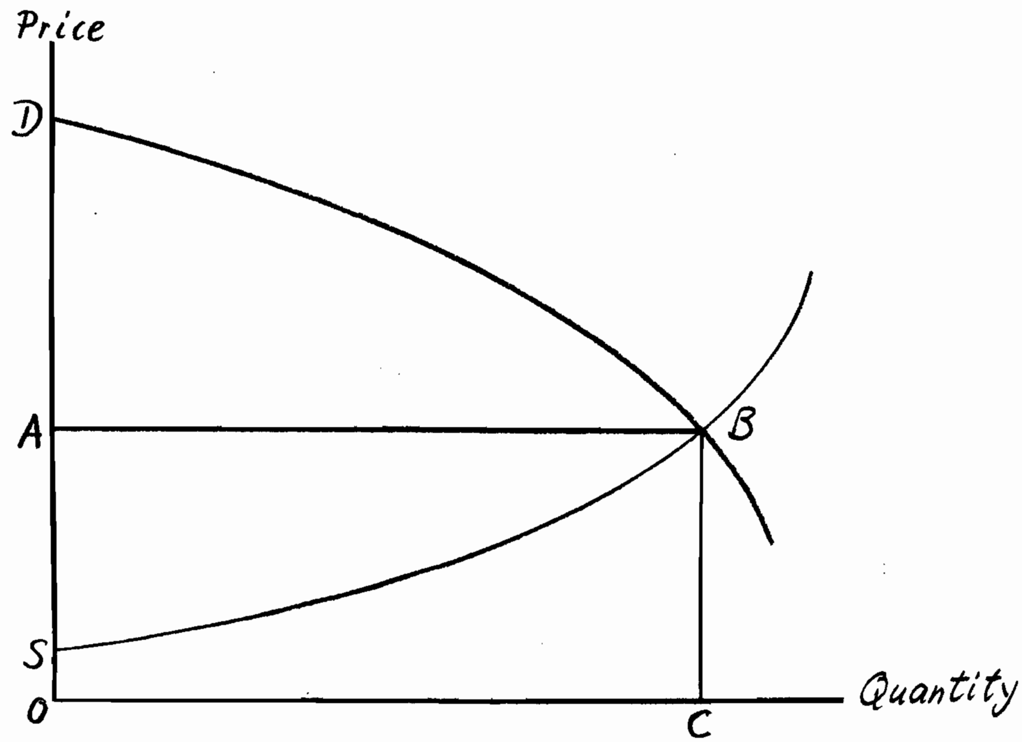

Figure 28

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