Use of Economic Criteria for Highway Investment Planning

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● ROAD AND bridge building—one of the finest manifestations of man's ingenuity and peaceful, constructive endeavour—is team work par excellence. It represents a most complex productive effort, extending from the gathering of the basic data through the survey and planning work right to the payment of the final bill and to the settlement of the last legal claim. In this process use is continually being made of a great many experts in different fields: of surveyors, draftsmen, location and soils engineers; of highly skilled specialists in the various construction phases; of traffic and safety experts; of appraisers; statisticians, geographers, planners, financial and legal talent; above all of decision-makers throughout.

What part can economic analysis play in this process? This paper attempts to appraise critically some of the basic economic assumptions, ideas, and working techniques which might be used in this intriguing sphere of highway planning and finance. To maintain logical continuity, the discussion follows decision-making in investment planning, step by step, from broad, general issues down to detailed technical problems.

BASIS OF INVESTMENT DECISIONS

A private entrepreneur's decision to invest in a factory of other productive asset will arise from the expectation that such investment will prove profitable. The business man will carry out the new venture when the anticipated returns from the investment are at least equal to the costs of borrowing the necessary money. Hence, the incentive to all private investment arises from all business men's assessment of the profitability of investment related to the rate of interest on money for investment.

Keynes (1) called the expected profitability of new investment the "marginal efficiency of capital." In this connection "marginal" refers to the returns from producing one more capital asset (the marginal one). Logically, the entrepreneur or promoter, confronted with a whole range of possible new projects, will choose the one which can be expected to yield the highest rate of return over cost. Therefore, the marginal efficiency of capital will denote, at any given moment of time, the highest net rate of return from the most promising of all projects to be found in the entire economy. In ordinary language it might be called the expected annual profit rate on the most promising of all real investments.

It is, firstly, important to appreciate the dynamic nature of Keynes' concept of marginal efficiency of capital and the way in which it provides a link between the present and the future. Many entrepreneurs and potential promoters of capital investment schemes will simultaneously turn their attention to a great variety of ventures. They will, by market research, forecasts or by sheer guess-work, try to foresee the future and the performance of the projects under consideration. They will reject ventures which show a combination of high risk, slow maturing and low returns, in favour of those with the opposite characteristics. In interaction, each entrepreneur individually and all of them collectively will therefore in effect establish a system of project priorities at any given time, with the most profitable venture taking top place and all the others being ranked according to their merits. Investment funds will then be borrowed and the projects carried out until the expected rate of profit from the least profitable scheme equals the rate of interest at which capital can be attracted. In equilibrium, the marginal efficiency of capital, expressed in percent per year, will be equal to the rate of interest on money.

It is important, secondly, also to note the inherent tendency to self-adjustment of this process. The business promoters will compete, as it were, for a necessarily limited number of feasible new projects. The supply of worthwhile ventures at any

time depends on a great variety of technological and environmental factors: for example growth of population and markets, the rate of technical progress and innovation, trends in income, employment and purchasing power. As over time more and more new projects are realized there will be a tendency for the marginal efficiency of capital to decline; but then growth and technological progress may again provide better investment opportunities and hence raise the schedule for the marginal efficiency of capital. On the whole, however, the marginal efficiency of capital will adjust downward to the money rate of interest, itself determined by factors which need not enter into discussion at the moment.

Thirdly, it is important to appreciate the monopolistic nature of the investment planning process. Whatever project the entrepreneur contemplates, it must be something which his competitors cannot emulate, at least not for the time being. The venture may involve the introduction of an entirely new commodity or service, in which case the entrepreneur will attempt to protect his monopolistic position by patents and commercial strategy. If the product or service sponsored by him is not entirely novel, he will at least endeavour to create a 'mental' monopoly, by advertising, introduction of a brand name and so on. In addition he will attempt to build spatial or functional monopolies, by seeking government protection and licensing, supply and sales franchises and exclusive rights within a territory, or by oligopolistic maneuvers.

The net profits that accrue to the entrepreneur or his firm are the result of many heterogeneous factors: gains from risk-taking and uncertainty-bearing; the presence of a favourable market and technological environment; outstanding managerial and organizational ability; and perhaps a good deal of luck, bearing in mind Goethe's maxim that only the able enjoy consistent luck. But always there will be a strong element of monopoly present in the process which determines investment and, in interaction with the rate of interest, the marginal efficiency of capital.

PLANNING OF INDIVIDUAL PROJECTS

A synthesis of the general investment process with the planning of individual projects must now be attempted. In other words, it remains now to describe how a list of worthwhile projects might be drawn up and how the profitability and performance of each one of them might be judged.

Basically, the prospective entrepreneur will select from equally risky alternative ventures, for first consideration, 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 over time. This implies that he has knowledge of net returns (that is, gross revenues less costs) over the planning period for a number of ventures.

How can the most profitable combination of price, cost and output for an individual project be achieved? This problem, demonstrated in Figure 1, resolves itself into the process of maximizing the difference between total gross revenues and total costs, in other words maximizing net revenues; if that position is reached then the most advantageous outputs (quantities of goods or services) are also being produced.

On the revenue side, fundamentally, one will have to assume the presence of one very important aspect of monopolistic market strategy: "price discrimination," also called "charging what the traffic will bear," or euphemistically, "differential pricing," the term preferred by A.M. Milne (2) in his excellent textbook on transport economics.

Assuming that this can be done, through market analysis, motivation research or experimentation, the entrepreneur will attempt to assess the potential maximum benefits derived by each user or group of users from the consumption of the new product, and the total quantities of this product provided cumulatively at each point. These benefits can at the same time be taken to represent the maximum differential charges which can be extracted from each user, as long as the basic condition "benefits offered are at least equal to prices charged," is satisfied.

Curve DBM in Figure 1 represents such an assessment of marginal differential benefits and prices charged. It shows that gross revenues will be maximized if total quantities OM of goods or services are supplied and charges identical to the ordinate values of the benefit (marginal revenue) curve DBM are imposed. Total gross re-

venue—which is the integral of the demand function—will tend to become equal to the area under the arc DBM as the number of users approaches infinity.

Is Perfectly Differential Pricing Permissible?

Gross revenues are charges multiplied by quantities; in this case the sum of an infinite number of rectangles, each of a height corresponding to price charged and with an infinitesimally small base representing quantity consumed (Fig. 1). It is sometimes argued that such a rate policy, with infinitely small variations of prices charged, would not only be unethical, but also at least impractical. The latter contention may be true

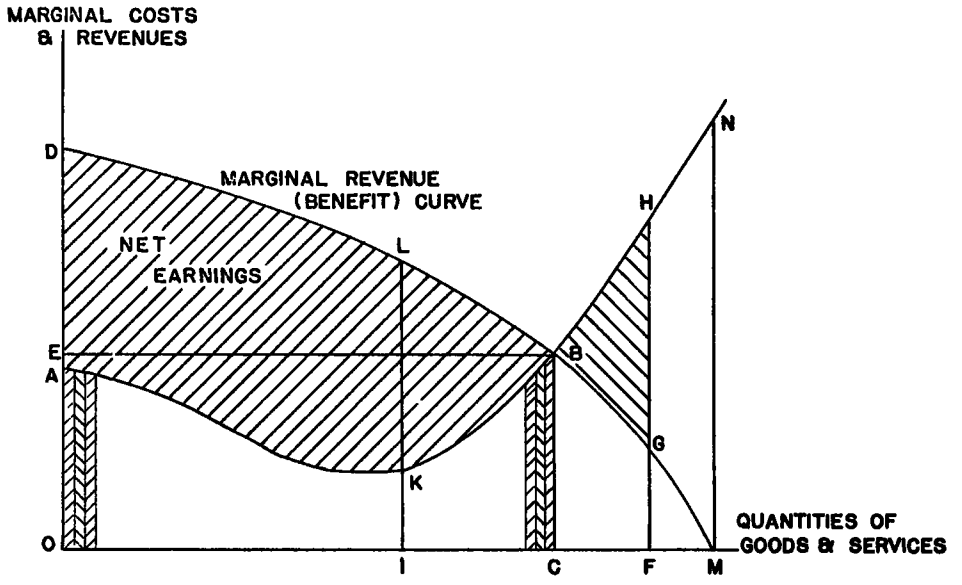

Figure 1.

and in the real world it may be more convenient to let rates go down in definite "steps". As a matter of fact, many electric power companies employ rate structures 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 the revenue maximization formula. 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. Analytically, one might accommodate this phenomenon by calculating gross revenues net of collection costs. Diagrammatically then a whole series of marginal gross revenue curves would be obtained, one for each pricing system adopted, consisting of a series of "steps" and in the extreme case consisting of a straight line. The one marginal revenue curve which encloses the largest gross revenue area—and hence the one with the greatest number of steps—will represent the best solution.

Very little remains of the other arguments against differential pricing once the 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 on as many occasions as possible by all sellers of goods and services. Whenever feasible it is presented as a price reduction and advertised as "quantity discount," "loyalty discount," "off-peak inducement toll" and the like. Another method would be to vary service qualities, including differing treatment in the granting of credit facilities, while holding direct money prices constant.

Only because generations of economists have been brought up on the quite unrealistic assumptions of pure and perfect competition have we come to regard the uniform market

price, set at the marginal cost level, as the rule rather than the exception. Partly this has been due, as Schumpeter (3) points out, "...to the specific bias of the economic theorist that has nothing to do with political preference, the bias for easily manageable patterns." One learns slowly that the so-called imperfections, the monopolies, duopolies, oligopolies, are all-prevasive, that advertising, control of entry, licensing, government regulation, brand names, special service features, credit terms, even such market strategy as the opening of a retail store in a particularly favoured location, are all very logical attempts to create little economic "niches" which are sheltered from the chill winds blowing across the desolate market place of pure and perfect competition.

It is very important for the subsequent discussion of specific highway problems to accept the principle of differential pricing (which is really the same as differential benefit assessment), at least as an investment planning tool. A quotation from Milne may give this principle of discriminatory pricing, which is so particularly important in the field of transport economics, some further theoretical respectability: "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 can be expressed in the form that no traffic should be charged a price which it will not bear when, at a lower price, the traffic would be prepared to move. 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. 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 (3)."

Further proof how economies can be brought about by differential pricing will be provided in the following sections. (Judging from information contained in studies by Owen and Dearing (4), Dearing (5), Duzan (6) and others, toll roads in the United States appear to apply differential pricing. This point is pursued in detail by Kuhn (7), Chapter IV "Toll Road Model—Final Consideration.")

Cost Analysis and Output Determination

By contrast from the marginal benefit (and differential price) curve DBM in Figure 1, the marginal cost curve ABN requires only brief explanations. Due to the amazing interest taken in the United States in marginal cost pricing (or incremental cost charging) of highway services and the great volume of literature produced on the subject, little needs to be said on the topic.

No significance should be attached to the way the marginal cost curve ABN is drawn in Figure 1; it is assumed here that marginal costs of providing the first few quantities of goods or services 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 it is further assumed 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—(This is a somewhat unrealistic assumption, but the main line of reasoning presented here does not depend on it. The theoretical problems posed by indivisibilities of factors of production, fixed and variable costs, etc. can be resolved fairly easily (8).)—and thus implying that infinitely small additions to output requiring infinitely small incremental cost doses are possible—a smooth marginal cost curve will be obtained.

The most advantageous output to be produced and consumed, from the entrepreneur's point of view, will be determined by the intersection of the marginal cost and revenue curves (at point B in Figure 1) and will be quantity OC. Marginal costs associated with the production of the different quantities of output are identical to the ordinate values of the marginal cost curve. Total costs will tend to become equal to the area

OABC under the curve AB as the number of goods or services supplied approaches infinity.

If the cost and revenue conditions depicted in Figure 1 prevail, the entrepreneur will choose to supply OC quantities of goods or services, since he cannot increase his net earinings 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 goods or services, is equal to the benefit enjoyed by the additional user of that last unit of output. 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 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 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 goods or services are being offered and consumed no user could possibly be worse off than prior to the operation of the new factory or facility, since benefits will be equal to charges. Users are not compelled to buy the new goods or services and their choice is a purely voluntary one. They cannot be 'overcharged' since the slightest over-all increase of the rate schedule over and above the maximum level of the benefit schedule would presumably induce them all to refrain from the purchase of the goods and services offered.

Is output OC the optimum one from the community's point of view? Will adoption by the 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 entrepreneur, by pursuing ruthless "charge what the traffic will bear" 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 "under-employing" 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 all demands for the proposed goods and 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 units of production 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 entrepreneur 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 1, 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, 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 1) 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.

Desirability of Investment Decision

It is important at this point in the analysis to obtain a reliable answer to the question whether or not the entrepreneur or entrepreneurs will plan the investment of productive resources in the most efficient and socially most worthwhile way. It may help to briefly recapitulate the conclusions previously arrived at:

1. In an economy where there is freedom of investment planning, entrepreneurs will promote projects which promise returns in excess of the rate of interest on money for investment. Since ventures which show the highest relative returns at equal risk will logically be selected first, an order of project priorities based on expected profitabilities will be established.
2. This process is continuous and self-adjusting. The entrepreneurs will be 'competing' for the necessarily limited number of investment opportunities, the 'supply' of which is determined by technical innovation and progress, the extent of the market, population and income growth, geographical expansion, etc. The marginal efficiency of capital—the expected rate of return from producing the most promising additional capital asset at any one time—will have a tendency to decline. There will be no more investment once the marginal efficiency of capital falls to the level of the prevailing interest rate.
3. For purposes of project selection entrepreneurs will carry out demand and cost studies for all proposed ventures. Differential charging, made possible by the monopolistic characteristics inherent in the situation, will be applied whenever practicable. Thus gross revenues will be determined by the maximum charges which can be extracted from the purchasers of various output quantities. Then costs associated with the various output levels will be ascertained.
4. The output at which marginal costs exactly equal marginal revenues (themselves equal to the benefits conferred upon the user of the marginal unit of goods or services) will be the most profitable one from the entrepreneur's point of view. At this point the expected net revenues (that is, the difference between gross revenues and costs) from the proposed project will be maximized.

Once these preliminary steps have been completed each entrepreneur individually and all entrepreneurs collectively will have compiled lists of profitable ventures. These will be arranged in order of logical priorities, for example by relating net revenues either to capital investment, or to total costs. (A good discussion of highway priority calculations and appropriate arithmetical methods is contained in a paper by van Glinstra Bleeker (9).) Entrepreneurs will select the projects with the highest priority rating, that is, those promising to yield the highest (marginal) efficiency of capital, for most immediate implementation. Projects from which lower returns are expected will be carried out subsequently until finally the marginal efficiency of capital invested in new ventures will have been brought down to the rate of interest on investment money.

Thus in the sequence of events as described, 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. The so-called "unreasonably high rate of profits" is, therefore, in the planning stage, nothing but an indication that exceptionally good investment opportunities exist within the economy.

It is certainly most desirable from the community's point of view that entrepreneurs should invest in those projects, and select those particular output levels, which promise to yield the greatest benefits relative to costs. For the economy as a whole aggregate investments will then also produce maximum benefits relative to costs; thus the desired objective for the allocation of scarce resources for productive purposes will be fully met.

PRIVATE VERSUS PUBLIC INVESTMENT ACTIVITIES

Having established the economics of the purely private investment process, it now remains to introduce investment activities of the State. Two problems arise: not only must public investment planning per se be analysed, but the conflicting desires of private and public agencies in allocating scarce resources to promising capital investment projects must be reconciled.

To deal with the latter problem first, one can very crudely state that the most efficient allocation of investment resources will be achieved when all projects—regardless of their private or public characteristics—are assessed on their merits in the same way and are carried out in order of expected rates of net return. In other words, public projects should compete, as it were, on equal terms with private ones and logical priorities for all of them should be based on the expected efficiencies of capital for the various ventures.

Such an approach, although useful as a starting point, represents gross over-simplifications. It ignores the institutional setting and behaviour of private and public agencies and unrealistically implies either the complete planning of all investment by the State, or the voluntary and successful adoption of private enterprise behaviour by public authorities. It further presumes that the returns from a public investment project can be measured and compared directly with those from a private venture—again an entirely untested condition.

The problem of the proper delimitation of private and public spheres of influence in economic life is perhaps one of the most pressing at the present time and should certainly receive more attention in economic research than in the past. (It should be noted that recently an expansion of the supply of public goods and services, rather than of private ones, has been advocated by Galbraith (10) and others. It is argued that in North America man is approaching the limits of physiological needs, that the greatest gains in standards of living can be made in the area of things consumed in common and that therefore the wealth-producing machinery of the modern economy should be used increasingly for the provision of needed social facilities and services.) It is impossible, within the limited scope of this paper, to do the question justice. At the same time, as will be shown in the next section, highway provision clearly is a proper function of public authorities, and therefore an attempt must be made to at least sketch the basic theoretical framework. Since, except for the technical features, there is nothing special about highways from the economic theory point of view, the following remarks generally pertain to what might be called "the economics of public works" and apply with equal force to the planning of investment in public airports, docks and harbours, sewage systems, water works and the like.

It is self-evident that society as a whole cannot at any time use up—whether by current consumption or by capital investment—more goods and services than the economy produces; in effect, for the entire economy, output and income must be equal. At any given level of employment total income is necessarily equal to incomes created by production of investment goods and services plus incomes created by the production of consumers goods and services. Investment is total current output less output of consumption goods. Similarly, savings are total aggregate income less consumption expenditures. Therefore investment must be equal to savings, because both are in turn equal to output (=income) less consumption.

As Keynes shows, investment has a key role in the economic process. If investment falls short of savings then there will be a reduction in output and a fall in employment until, with lower savings put aside from lower incomes, aggregate investment again equals aggregate savings. Conversely, if investment increases, then income will increase until savings out of the higher incomes will once more be equal to higher investments. It is usually assumed that the volume of aggregate savings is a fairly predictable and stable function of national income. Investment, on the other hand, because it requires predictions about the unknown future and is based on such dynamic factors as the state of business confidence, population growth, technical progress, etc., is autonomous and subject to violent, erratic fluctuations.

Most governments are now dedicated to policies of full employment. To individual enterprise wage payments are just like ordinary variable costs which do not have to be met once there is no employment. To society as a whole, on the other hand, payments to labour—either in form of wages or welfare support—go on regardless of the degree of employment and they are therefore really like unavoidable fixed costs. If so, the argument goes, it is better to let workers contribute to national income by productive employment, than to let them be idle. Or, more concisely, it is argued that the marginal cost to the economy of employing otherwise idle labour is zero or almost zero.

In addition there are, of course, many humanitarian, political and social reasons for pursuing the economic objective of full employment.

From the foregoing discussion it will have become clear that there is a fundamental difference between private and public investment planning: as private investment autonomously and erratically moves up and down, the State (provided the bureaucratic apparatus is in possession of the facts) will normally attempt to adjust its own public works programs in such a way that full employment is attained. Thus, as private investment goes down, public investment will normally be increased, and conversely. This process can be fairly well accommodated within our earlier concept of a mixed priority list of worthwhile private and public investment projects: as through a decline in the businessmen's confidence and promotional fervour, etc., more and more private ventures drop out, the opportunities for the realization of public projects will become greater. This is, of course, the idea behind the so-called 'shelf of public works'—quite a sound one whatever the practical drawbacks of this device may be. The limiting cases, at full employment, will be all public and no private investment, or, at the other extreme, only private and no public investment at all. But normally, in a free society, both forms of investment will be represented in varying degrees and this brings with it all the complications of a mixed system.

Great difficulties of measurement arise when one begins to compare the net returns from a public investment with those of a private project. How could one ever hope to assess in identical units of measurement the social returns from, for example, a new court house and from a new steel plant? In the latter case money net returns, based on money gross revenues less money costs at the optimum output level, will be the appropriate index. But although the costs of constructing the court house can be stated in money, it would be very difficult to directly translate the social advantages flowing from the administration of justice and the maintenance of law and order into dollars and cents.

Conceptually the steel plant and the court house are poles apart, but very serious efforts should be made to reduce the analytical gap between them. From the entire community's point of view it would be advisable to broaden the very narrow cost and revenue concepts used in the steel plant planning process, by including social costs (those which the entrepreneur escapes and imposes on the community at large, that is, smoke and noise nuisance, deterioration of a residential neighborhood, etc.). Similarly, some ways and means might be found to calculate more accurately the true returns from social investments. Usually little analytical difference is found between private and public investment planning in the field of transportation and this may be particularly true of highway provision. (An analytical toll road 'model', discussed in Chapters II, III and IV by Kuhn (7) can be used to demonstrate the great similarities between private and public highway investment planning, provided the toll road entrepreneur has a wide enough planning horizon and the highway authority is acting efficiently.) In this way, by empirical and theoretical research, social and private planning criteria might eventually be made more compatible thus leading to a more efficient allocation of scarce resources.

There still exist difficulties on the money (or resources) supply side of investment planning. It was shown earlier that private investment will normally continue until the marginal efficiency of capital declines to the interest rate level. In terms of Keynesian economics, the interest rate is determined by "liquidity preference" (the desire of people to hold cash for a number of motives, rather than to tie it up in investments) and the amount of money. Since the amount of money is set by the monetary authorities and normally cannot be influenced by private enterprise forces, the rate of interest becomes a price or reward for the "not-hoarding" of cash and equates the demand for ready money with the supply.

The circumstances are quite different in the case of public bodies. In the first place they can and do expand or contract the amount of money by printing bank notes or by withdrawing them from circulation. Secondly, the State can by taxation simply withdraw from the private sector funds which would have been used for consumption or investment. It can then, thirdly, either increase or decrease its own ordinary or capital spending, frequently without balancing tax receipts and government disbursements.

Consequently, whereas private enterprise is subject to money market forces in its investment planning, the State does not experience automatic checks and controls to the same extent. As an over-all policy, as was mentioned before, the objective of full employment will normally be pursued. However, even so the freedom of action of the State within those given terms of reference are very great; thus during a recession taxes might be reduced, or government spending be increased, or the amount of money be enlarged, or these methods be used jointly with differing emphasis.

In the last analysis reliance has to be put on a blend of political and economic forces to bring about rational solutions in this very complex field of public finance. The anguish of the taxpayers felt when remitting money to the income tax department—somehow collectively expressed—may be just as effective a force as the "liquidity preference" of private individuals in the Keynesian model of the economy. The desire to avoid large budget deficits and/or inflationary price trends will also constitute powerful restraints to State action. Efficiency of government operations and spending, finally, may best be promoted by vigilant parliamentary control, by informed criticism and by the evolution of better economic, planning, statistical and accounting tools. A useful first step in the right direction would be for government departments to show expected net social and money returns for each major public investment project that lends itself to such analysis. Only those ventures which show anticipated net returns in excess of the prevailing rate of interest should be considered for implementation.

THE ECONOMIC PROBLEMS OF PUBLIC HIGHWAYS

The general investment process, both in the public and the private sphere, has been described in some detail in order to fully understand the political, institutional and economic framework within which road investment planning has to operate. Next the rationale of public, rather than private, provision of highways must be established.

Should Highway Provision Be a Public Function?

It can be observed in the world at large that the provision of roads and streets is overwhelmingly entrusted to public bodies. There are some exceptions, especially a number of toll roads and bridges, but even those are subject to a great degree of State control or support. The institutional arrangements vary, from the ubiquitous government highway departments to the public authorities in the United States, or the Crown Corporations as these organizational devices are called in Canada and the United Kingdom. But essentially all these highway organizations are creatures of the State.

There are compelling reasons for this state of affairs and these should be examined.

Prevalence of Monopolistic Conditions

In practice the public highway and street system enjoys a largely unchallenged monopoly position. Admittedly, there is some competition on certain segments where the otherwise captive motorist customer can turn to air, rail, water transport and in rare instances to toll roads. However, on most sectors, particularly in the sphere of urban arteries, residential streets and sidewalks, local access and farming roads, development and mining highways, there are no substitutes whatsoever to the public road.

The proposition can therefore be accepted that public highway authorities exercise a very wide degree of monopoly power and that, indeed, this monopoly power is probably greater than that of a private monopoly which tends at least to be limited by the threat of potential competition, public control or nationalization. The prevalence of monopoly conditions means that one will have to employ monopoly theory and that it would be misleading to introduce spurious comparisons with competitive situations into analyses of highway economics.

Absence of Market in Highway Sphere

Linked to the existence of monopoly conditions is the fact that there is no real market in which highway services are sold and bought. Reasons are: firstly, the lack of compulsion for the monopoly supplier to sell his services since revenue would be forth-

coming from general fiscal funds in any case; secondly, the fact 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 that one is confronted with the absence of all the economic checks, balances, controls and procedures which are normally associated with the working of the market mechanism. To find practicable substitutes for these market forces is one of the key issues in highway economics.

The System Aspect of Public Highways

The "system" aspect is one of the most important characteristics of public highways; yet it is a concept which is very difficult to define and which has received relatively little attention in the literature.

By a system it is meant 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 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 load can be distributed more widely over many generating plants; peaks of demand for electricity on 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, however, whole districts can be served by one main connection from the power plant, mass consumption at low unit costs for all users becomes possible. Similar considerations apply to almost all other public or publicly regulated enterprises—sometimes called "natural monopolies"—such as water, gas, sewerage, urban transportation, telephone and railway systems.

The same principles fit the public road system: as 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 are 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 economically more advanced countries practically every house, farm and place of work has road access and almost every citizen draws to some degree on road services every day.

Does the Integrated Public Road System Possess Inherent Demand and Supply Advantages?

From the users' point of view, the services rendered by a well-developed public highway system are 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 allows users to choose freely from a great variety of routings and at any moment of time—given knowledge of conditions—users will tend to follow the most rational traffic flow pattern, that is, 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: large commercial vehicles, farm trucks, delivery vans and passenger cars will all be users of the highways, thus contributing jointly to the costs of construction and maintenance of the roads 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.

On the supply side the economies of scale and operation to be reaped from treating highways as an integrated whole, rather than as so many road bits and pieces, are also very important. 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.

It might be noted that sometimes in the past the negative aspects of the system characteristics of highways seem to have received undue attention. This may partly be due to some misunderstandings and misapplications of economic theory. Instead of assessing and promoting the economies of joint use of highways by trucks, vans, buses and automobiles, a formidable amount of research work has been devoted to the punitive aspects, such as the minute economics of cost allocation between one vehicle and another. This does not detract, of course, in any way from the great contributions such analyses are making to engineering knowledge.

Furthermore, it appears to be misleading to ignore the Tremendous economic advantages to be derived from an integrated road system and to express concern that certain secondary roads and streets "are not paying their way"; surely, the contributions these subsidiary feeder facilities are making to the system as a whole cannot be ignored. (For appropriate assessment techniques see (7), pp. 196-202.)

Finally, some very real system economies to be reaped from the free flow of traffic, taxed and regulated in a reasonably uniform way, have been lost in many instances by a veritable jungle of weight, size, safety, licensing, rate and taxation provisions. Some of the objectives promulgated, such as dipstick laws, corridor area concepts, regional boundary control and the like, seem to belong more appropriately to the era of petty European principalities than to the motor age and the great North American Continent. Due to determined efforts over many years this "balkanization" of highway transport has been reduced considerably, but many people would claim that there is still great scope for improvements in the interest of the highway system as a whole.

To conclude: 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 being operated separately. The ultimate economic limits of the system will be reached when the last (marginal) network extension or improvement will yield benefits which are equal to the costs attributable to the marginal project.

Highways Operated "In The Public Interest"

Very closely linked to the system concept is the fact that roads are supposed to be operated by government bodies "in the public interest." It is difficult, though, to derive precise working rules from so vague a concept. Broadly speaking, promotion of the public interest means that available resources are used in such a way that they yield the greatest aggregate benefits relative to costs for the community at large. This definition compels an answer to such questions as "What exactly are 'aggregate benefits'?"; "How are they to be measured?"; "What do costs mean in this connection?".

As soon as one sets out to promote the public interest one leaves behind cash profit maximization, the basic motive guiding the actions of private entrepreneurs. From the economics of private enterprise and the profit-making firm, such as described under the headings "Basis of Investment Decisions" and "Planning of Individual Projects" and illustrated in Figure 1, one must turn, for better or for worse, to the so-called "economics of welfare." (This term, originally coined by Professor Pigou of Cambridge, is now generally accepted. Basic works on the subject are by Pigou, Little, Baumol, Phelps-Brown, and others.)

New Investment Planning Methods and Criteria

This implies that the planning horizon must now be set as wide as possible—certainly

wider than that of the private entrepreneur; the reasons are, firstly, that the promotion of the public interest is entrusted to a self-perpetuating, permanent body and secondly—if perfect knowledge of the future is assumed—that public interest should know no time limits, but only priorities.

It further follows that activities or works which create external economies must be promoted and those which cause external diseconomies must be discouraged. Finally, works which are too big for individual enterprise must be undertaken as long as they are economically worthwhile; in that case the State performs a 'catalyst' function.

In short, the maximization of social benefits and the minimization of social costs within a very wide planning horizon must be the aim of highway development. Highway investment must be conducive to economic growth and development generally. Hence, highway investment criteria must be equally applicable to an urban expressway project, to an inter-city highway, or to resource development roads in the Yukon or in Central Africa. The state of economic development is a relative term: City slums or densely settled but congested industrial regions may be just as 'under-developed' in the economic sense as pioneer areas with unexploited resources. The economic criteria for highway investment planning must therefore be comprehensive enough to lead to the maximization of net returns on social capital in all these varied situations.

This calls for a redefinition of the working variables employed in "Basis of Investment Decisions" and "Planning of Individual Projects" and in Figure 1 of this paper. All activities external to the private entrepreneur, which were favourably or unfavourably influenced by his activities, are now internal to the economy as a whole and hence of direct concern to the highway department. Hence all benefits attributable to and all costs caused by public highway provision must be taken into account in road investment planning. Examples of factors to be taken into account are given below.

Highway Benefits (Curve DBM in Figure 1).—Savings in time, cost, inconvenience, etc., realized by road users directly.

Transportation cost, production cost and distribution cost savings accruing to the entire economy.

Employment-creating effects of highway investment.

Beneficial effects on land use, growth of secondary industries, development of natural resources, tourist trade.

Increases in the range of choice for users by opening new possibilities of travel, products, etc.

Enlargement of supply and marketing areas for products and services.

All other social benefits.

Highway Costs (Curve ABN in Figure 1).—Direct costs incurred by highway department.

Highway dust, fumes, noise.

Accident costs.

Detrimental effects on land use, values, etc.

All other social costs. (The more rapid depreciation in the value of existing fixed assets, e.g. railway installations, due to the introduction of a highway facility is not a true social cost factor, but belongs to the category of historical costs and is therefore irrelevant.)

Practical Problems of Cost and Benefit Measurement

Briefly, in common sense terms, highway planning—like all other economic planning—must therefore 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 should serve some wider economic, social and political purposes beyond the mere mechanical conveyance of vehicles from one point to another.

With some justification the criticism can be put forward that such broad definitions of highway costs and benefits are unrealistic, simply because there are no measuring techniques available to match these wide definitions. Admittedly, there will be practi-

cal difficulties in assessing all benefits and all costs to a great degree of accuracy in all circumstances, but this does not mean that the aims should not be set high. One must start off with the 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 the highway investment decision making. It should then be the prime aim to narrow down further the scope of guesswork by improving the measuring techniques.

First Progress Report of the Highway Cost Allocation Study (11)

It appears that the Highway Cost Allocation Study, which is currently being conducted in the United States, proceeds 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 inquire 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 (12)." 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. As soon as one takes the next step and tries 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, one moves into the realm of economics. As the First Progress Report points out, 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 basic vehicle operating test and engineering data. The field for fruitful inquiries widens even more when one takes 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 paper 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 themselves 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. 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 inquiries in this field should remain unopened.

PUBLIC HIGHWAY INVESTMENT PLANNING—FINAL CONSIDERATIONS

The scene is now set for the completion of the highway investment analysis. The vexing problems of the proper delimitation of spheres of government activity and those which should rightfully be reserved for private enterprise were touched upon earlier. Let it be assumed now that the levels of both total taxation and of total government expenditure are optimum, in the sense that a higher or a lower level of either would result in an economically less advantageous situation, or in politically less preferred circumstances, for the community 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 contribution 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 from government outlay in all other spheres.

As a concession to reality one has to admit right at the outset that a large proportion of government outlay, because of the familiar difficulties of measurement, will not be subject to the economic cost/net return calculus and will thus presumably be determined by collective political judgment. It may well occur that in this economic-political sphere of government budgeting each department will be vying with the others for fund allocations and all will have as their opposing counterpart the Ministry of Finance which tries to keep the taxes down.

Going further, two divisions within one department may be competing with each other for funds, for example the one responsible for airport development with the highway department or the waterways authority. How are the inherent conflicts of interest to be resolved? Pseudo-competition, as "an excellent antidote to bureaucracy and vested interest," between the various agencies concerned with transportation in the United States has, for example, been suggested by Pagrum (13). Little (14), on the other hand, favours the over-all planning approach provided the central board adopts suitably efficient policies.

Similar problems and their solutions are, of course, also to be found in the sphere of private enterprise. A comparable dilemma exists when the budget of a large company is to be allocated between, say, advertising, research, new production facilities and so on. In the final analysis the department which can most effectively "sell" its proposals will obtain the largest fund allocation. Similarly, inside government: The agency which succeeds in presenting the most convincing case will likely get the largest budget allocations. 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 allocations of funds for highway purposes—have been so eminently successful in the United States and elsewhere. (The first Canadian needs study, prepared with the help of the Automotive Safety Foundation of Washington, D.C., was completed by the Ontario Department of Highways in 1956. It has been most successfully implemented and extended since then.) It is suggested that any improvements in the technical quality and competence of plans prepared by the highway department, whether in form of a full-scale needs study or otherwise, should influence government policy in favour of road spending. The adoption of efficient planning, management and housekeeping arrangements within the highway department will therefore in most cases also result in the allocation of desired funds. In that way the public authority finds itself in a situation rather comparable to that of a private company which has to attract capital in the money market by showing proof of successful and efficient operations.

Road Revenue-Expenditure Equation as Guide to Public Policy

It has been seen that highway budget allocations will be partially or completely subject to political decisions. Would it be possible, though, to let actual or potential road user revenues determine the highway budget allocations? Could one not, by drawing on the example of public utilities, run highways as a self-supporting activity and stipulate that the highway authority spend no more and no less than it intends to collect?

If we employ revenues collected from road users in form of motor fuel taxes, license fees and other imposts as the criterion for the "social profitability" of highway expenditures, then the underlying assumption is that the existing imposts are related to benefits and that they are at the "ideal" level. As Winch (15) shows, these assumptions are inadmissible: Firstly, user revenues do not always measure benefits; for example, certain road improvements may actually decrease tax receipts although project benefits may be great; secondly, highway account deficits may either mean that taxes are too high and therefore discourage traffic which might otherwise pay project costs, or that taxes are too low so that users pay less than their share although they might be willing to pay more.

On the theoretical level of discussion, therefore, no a priori reasons exist to believe that: (a) highway user revenues should determine highway expenditures, (b) deficits indicate the curtailment of road spending, and (c) surpluses dictate increases in road expenditures.

In practical terms it is also interesting to note that this allegedly ideal balancing of road expenditures and road revenues is by no means universally practised. In Europe highway tax receipts generally greatly exceed expenditures. In Great Britain, during the period 1948 to 1955, fuel tax and vehicle duty revenues of about £ 1,680 million accounted for nearly 800 percent of highway expenditures, which were only £ 219 million. Good arguments could be put forward for increasing road expenditures in Great Britain—on social investment grounds—and also for lowering road user imposts—on taxation grounds. But it would not follow that balancing the outlays and revenues would be either good investment policy or good taxation procedure. Also, it does not necessarily follow that in Canada, where road user revenues fall considerably short of road expenditures, urgently needed highway and bridge projects should be cancelled, or that license fees and fuel tax rates should be raised.

Proper Sequence of Decisions in Highway Sphere

It is suggested that the determination of the magnitude and priorities of road projects must come first. How this might be done by means of cost and benefit analyses has already been discussed at length. The proposed highway development program, complete with cost and benefit estimates, must then be reconciled with the claims for funds of other government departments. Within the over-all limits imposed by (a) total planned public expenditures, (b) expected revenues, and (c) the government's fiscal policies, all projects which promise to yield net social benefits over and above social costs should be considered. Since the total proposed expenditures on worthwhile public projects may exceed total budgeted government expenditures, a proper sequence of priorities must be worked out. Government priority planning procedures will resemble closely those employed, for example, by the entrepreneurs when calculating project priorities, except that in the public sphere costs, benefits and other variables are interpreted in the widest social sense.

In other words, all the techniques and analyses described earlier as applying to private investment planning, will basically be valid. The only changes in Figure 1, for example, will be that the horizontal axis now denotes "quantities of highway services" and the vertical one "marginal social costs and benefits." Hence curve DB can be called "marginal social benefit curve," curve AB "marginal social cost curve" and the difference between the two "net social benefits" or "net social returns." Again, projects yielding the highest net returns relative to capital investment or to total costs will be given first priority consideration.

Subsidiary Highway Planning Decisions

Once worthwhile projects have been selected in this way and have been given appropriate priorities, many subsidiary technical and managerial problems have to be settled within the basic framework of the main investment decisions. An example of such secondary planning problems is the precise determination of the appropriate highway design and construction standards according to the weight, volume, speed, dimensional, etc., characteristics of the traffic to be served (see (7), Chapter III, for a three-dimensional diagram analysis illustrating these problems).

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 including interest on money invested over the project planning period will be chosen. Appropriate methods for arriving at solutions are analytically fairly simple and need not be discussed here.

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. (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 traveled northwards on Highway 400 from Toronto towards Barrie, but 12 times as many vehicles, a total of 8,700, traveled 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 (16)." In addition to these repeated fluctuations there will be a long-term secular growth (or a secular decline) of traffic. If one will 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 output 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" (17) demonstrates ably how the different demands for highway services which arise when "time" is introduced can be reconciled and how the most economical final output solution can be found. The guiding basic principle is that of cost minimization and utility (in our case, benefit) 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 benefit) 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 (18)." And: "Thus by this method of totalling unnecessary costs of sub-optimum solutions at each time one can calculate the best compromise solution, and the problem of the peak can be solved mathematically (19)."

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 (19)." 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 4-lane divided highway and construction of only a 2-lane road now, with the second 2-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 (20)."

By extending these analyses it will also be possible to work out, for example, solutions which apply simultaneously for different choices of traffic routing, as well as for various traffic peak and growth situations. Planning of highway systems can also be expedited in this way. However, enough has been said to indicate the general nature of the methods which can be used. (The mathematically inclined student of highway planning problem should refer to Studies in the Economics of Transportation (21), Part I, for further detailed discussions of the subject matter.) 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: "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 (22)."

It now only remains to discuss highway pricing as the appropriate tool for the attainment of the desirable levels of output allowed for in the investment planning phase. This is done in the following section.

SOME NOTES ON PRICING OF HIGHWAY SERVICES

In the preceding parts of this paper economic analyses and techniques were evolved which will enable an entrepreneur or a highway department to achieve optimum investment, priority and output solutions. In conclusion some attention must be given to the closely related sphere of highway pricing problems. Since pricing of highway services is a subject fraught with controversy, a careful and systematic approach is indicated.

In connection with the over-all allocation of funds for highway purposes, it was decided earlier to treat the provision of public roads and streets as one of a number of government functions. In particular, no direct fiscal or bookkeeping link between road expenditures on the one hand and road user revenues collected by the government on the other hand was established. Subject to some other criteria still to be discussed, there therefore exists 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 the highway pricing analyses.

It was seen earlier 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 "marginal cost-pricing rule" shall be referred to in the future, which, when applied to extreme output values, determines the optimum quantities of services to be rendered. The marginal cost-pricing rule does not restrict one very 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 the price for highway services exceeds this ceiling, then traffic will be lost and the 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, the 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, there is freedom to set highway prices as desired, since thus there will be no interference 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 far afield into political, legal, fiscal and—in connection with the conept of "equity"—pseudo-ethical spheres. They are strictly extraneous objectives as far as this analysis is concerned and they shall therefore be subordinated to the two prime rules which were 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. This opens up the very wide field of competition in transport which cannot be discussed here; may it suffice 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.

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, the second interpretation of taxation equity shall be used for the subsequent discussion.

Other Objectives

Various other taxation objectives can be encountered in practice. There is the public utility approach, which calls for an over-all balancing of revenues and expenditures, but may leave freedom of charging for individual service units to the management of the enterprise. Sometimes subsidization of some users is prescribed for social or political reasons. Yet, another approach calls for the simulation of private enterprise behaviour in similar circumstances. Finally, there is pricing on the basis of benefits received; 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."

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, one 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 paper; 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.

It is assumed 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. The results of the various pricing policies will be judged entirely in the light of these objectives.

Case 1: Simulation of Private Enterprise Behavior-Monopoly

Possibility (a)—Dissimilar Charging (Figure 2).—This simply calls for "charging what the traffic will bear", following the procedures of the private entrepreneur. Output is optimum OD, net revenue is ABC.

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.

Possibility (b)—Uniform Charging (Figure 3).—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.

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.

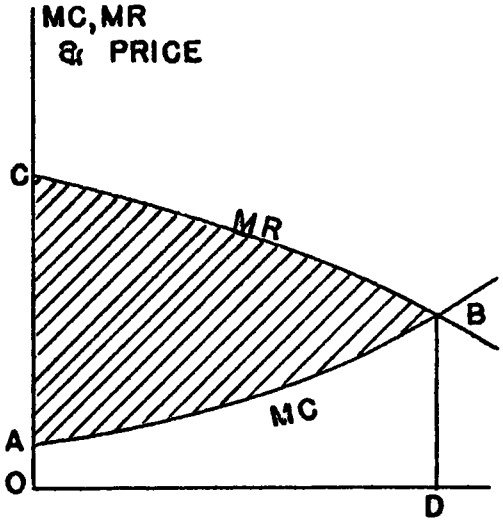

Figure 2.

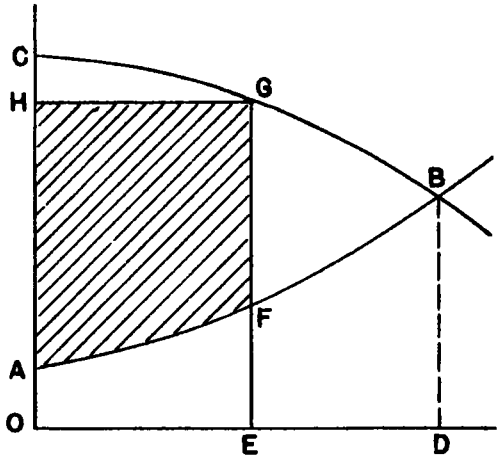

Figure 3.

Case 2: Simulation of Private Enterprise Behavior-Competition

Possibility (a)—Optimum Output (Figure 4).—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 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 (Figure 5).—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.

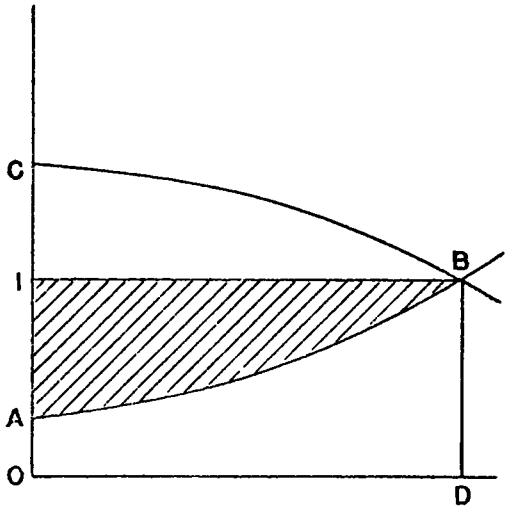

Figure 4.

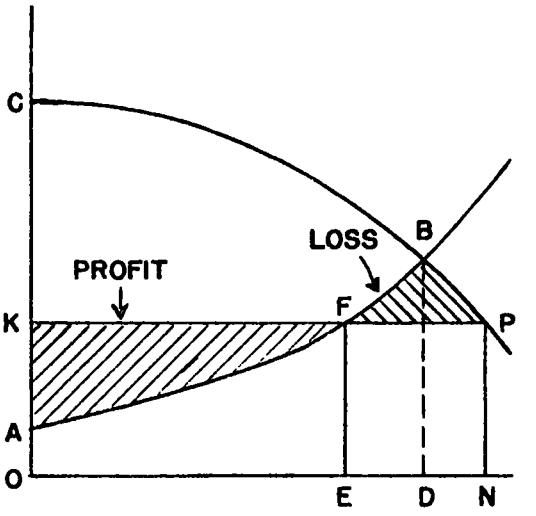

Figure 5.

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.

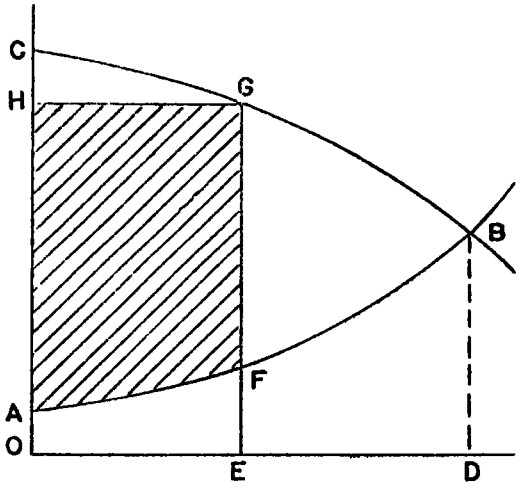

Figure 6.

Possibility (c)—Price Level Too High (Figure 6).—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.

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 (Figure 7).

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 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.

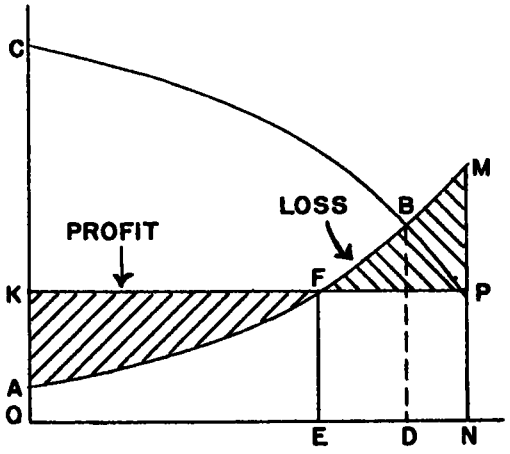

Figure 7.

Possibility (b) —Decreasing Marginal Costs (Figure 8). —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.

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.

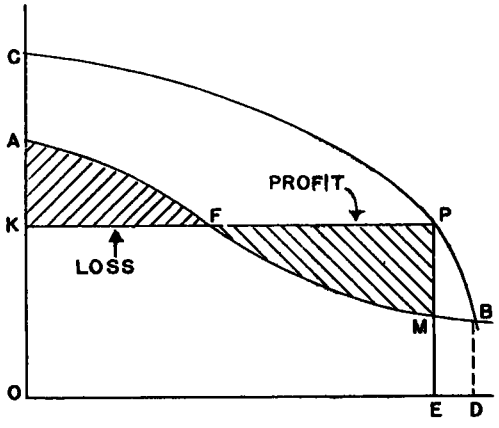

Figure 8.

Case 4: Public Utility Approach—Differential Charging

Possibility (a) —Optimum Output (Figure 9). — 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.

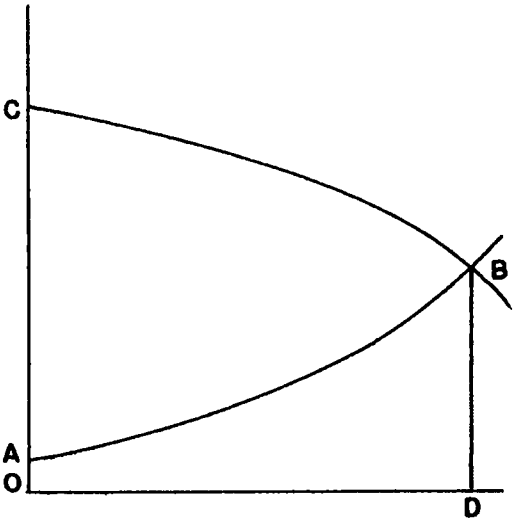

Figure 9.

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 (Figure 10).—The two objectives of maximum output (that is, 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" (that is, in proportion to "what the traffic will bear").

Solution.—Determine the proportionate relationship of magnitude of total revenues which could be collected under a perfectly dissimilar charging regime (that is, size of area OCBL) to total costs incurred when providing maximum output OL (that is, size of area OAFBML). Let one 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 actual 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.

Results and Objectives Achieved.—Maximum output, putlic utility requirements, subsidization of users (that is, encouragement of maximum use of a public service), charging in proportion to benefits received, charging in proportion to "what the traffic will bear."

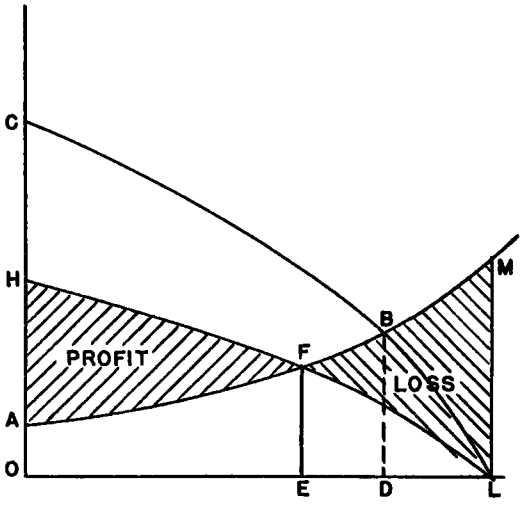

Figure 10.

Objectives Not Achieved.—Optimum output, charging on the basis of costs, competitive neutrality, maximization of government revenues.

Some Observations on Pricing Possibilities

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 2), as well as Case 2(a) (Figure 4) and Case 4(a) (Figure 9) 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; vet 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 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? It is known 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 one realistically bases his policies on the assumption of monopoly, rather than on a 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 generally known as the "incremental cost method."

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, one will 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 one will be back to a perfectly dissimilar charging regime and Case 1(a) (Figure 2) 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 which might be raised, to "homogeneity of service units", apply 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 3 to 8 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 Case 1(a).

Finally, charging on the basis of average total costs is occasionally suggested. Case 3(a) (Figure 7) and Case 3(b) (Figure 8) 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 (that is congestion) will be encouraged when marginal costs are above average total costs (Figure 7); optimum use of the highway plant will be discouraged when marginal costs are below average total costs (Figure 8).

The Public Service Approach

Taking an entirely different approach, one might also ask: why have any specific pricing and taxation policies for highways at all? Could one 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 all citizens are pedestrians and nobody owns a vehicle, or alternatively in countries where all persons are owners of automobiles.

The First Progress Report 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." (pp. 10-11). In terms of the present diagrammatical representation, the public service approach would lead to maximum output OL (Figure 10), 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.

The 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.

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