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ROUND TABLE 80

SYSTEMS OF ROAD INFRASTRUCTURE COST COVERAGE

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

PARIS 1989

ECONOMIC RESEARCH CENTRE

REPORT OF THE EIGHTIETH ROUND TABLE ON TRANSPORT ECONOMICS

Held in Paris on 9th-10th February 1989 on the following topic:

SYSTEMS OF ROAD INFRASTRUCTURE COST COVERAGE

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

THE EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT (ECMT)

The European Conference of Ministers of Transport (ECMT), an inter-governmental organisation established by a Protocol signed in Brussels on 17th October 1953, constitutes a forum for the Ministers of Transport of 19 European countries[1]. The work of the Council of Ministers is prepared by a Committee of Deputies.

The purposes of the Conference are :

a) to take whatever measures may be necessary to achieve, at general or regional level, the most efficient use and rational development of European inland transport of international importance;

b) to co-ordinate and promote the activities of international organisations concerned with European inland transport, taking into account the work of supranational authorities in this field.

Major problems which are being studied by the ECMT include: transport policy; the financial situation and organisation of railways and road transport; problems concerning inland waterway transport and combined transport; development of European trunk lines of communication; problems concerning urban transport; the prevention of road accidents and co-ordination, at European level, of road traffic rules and road signs and signals; traffic trends and long-term traffic forecasts.

Moreover, the ECMT organises Round Tables and Symposia. Their conclusions are considered by the competent organs of the Conference, under the authority of the Committee of Deputies, so that the latter may formulate proposals for policy decisions to be submitted to the Ministers.

The ECMT is equipped with a computerised documentation centre.

The Secretariat is attached from an administrative point of view to the Secretariat of the Organisation for Economic Co-operation and Development (OECD) which publishes and distributes its publications.

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ROAD PRICING:
THE POLITICAL AND STRATEGIC POSSIBILITIES

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ROAD PRICING:
THE POLITICAL AND STRATEGIC POSSIBILITIES

SUMMARY

Oxford, September 1988

1. OVERVIEW

The purpose of this report is to assess the state-of-the-art in road pricing theory and application, and to draw conclusions which will be useful for policy development. There are two key questions which have been raised by the ECMT. These are:

1) Why road pricing has not worked, and

2) How it could be made to work, given the changing situation in relation to available technologies, and policies on private financing and regulation.

Before addressing these issues, we consider the arguments in favour of road pricing and the range of technical issues which have to be faced in any attempt to implement a system of road user charges.

First, however, we should ask the question, what is the objective of road pricing? Or rather, what are the objectives of road pricing? For, at present, there is a strange and paradoxical consensus among a wide variety of different disciplines and interest groups, all apparently in favour of road pricing but for quite different reasons.

We can distinguish three lines of argument:

-- The first says that traffic delays are caused by an excess of unnecessary or avoidable journeys, made because the effective cost of travel is too low. If motorists were made to pay for the costs that their journeys impose on other travellers, some journeys would be deterred and speeds would increase. Thus road pricing is to be supported as a way of deriving clearly perceived and accurately set charges which correspond with costs. This would replace some or all of current motor taxation, which is imperfectly related to the costs imposed by travel;

-- A second argument focuses on the inadequacy of the present road infrastructure provision. If there were more roads, travel would be easier. The money raised in a road pricing system would simultaneously indicate where there was an economic demand for more roads, and provide the funds to construct them;

-- A third argument sees road pricing as a tool for achieving a balanced and consistent treatment of all aspects of an urban transport system, not only roads. The revenues from road pricing would be used for whatever purpose gave the maximum benefit -- provision of car parks, new rail lines, subsidies to bus services, etc., thereby improving overall transport efficiency and the mobility of non-car owners as well as car owners.

In ideological terms, road pricing has been described as a tool for using competitive market principles in transport; or as a tool for implementing considerations of social cost accounting. It is a way of avoiding subsidies, or a way of financing them.

But, in the quarter of a century since it was declared that road pricing was technically feasible, virtually every attempt to implement it seems to have caused both political opposition and technical confusion. It has been described as the most successful theoretical contribution of economists to transport, and the least successful political contribution. We shall argue that this perception is, partly, untrue. In fact we are now in the middle of a very rapid growth of experimental policies and schemes which are not usually described as "full" road pricing systems, but nevertheless make substantial moves in that direction.

However, the political barriers are still substantial, and have not fully been recognised. In this report we shall aim to discuss some of the more important political and strategic questions, especially those that are inherent to the whole road pricing argument as it has developed over the last century and a half, as well as practical issues of implementation. We conclude that the prognosis is good, but what emerges is a form of road pricing that augments rather than replaces traditional transport policies.

2. THEORETICAL DEVELOPMENTS AND POLICY IMPLICATIONS

Our starting point is the developing theoretical basis for road pricing, not only because this provides the rationale, but also because we argue that many of the political difficulties faced by road pricing derive directly from the way in which some important theoretical questions have been recognised but then often ignored. What we, do therefore, is rehearse part of the now traditional case for road pricing, as it has developed historically and currently, but adding a "commentary" on the policy implications at each stage of the argument.

2.1. The foundation of the argument in 1844

It was a French engineer, Dupuit (1844), who laid the foundations for road pricing (and indeed much of welfare economics) by a simple proof that the utility to society of a bridge was always more than the tolls which could be collected from its users. His argument has not been bettered by later and more complex treatment, so we repeat a section of it here:

> "We want to know the utility of a footbridge which is being used free of charge at the rate of 2 080 000 crossings annually. Suppose that a toll of FF 0.01 would reduce the number by 330 000, that a tax of FF 0.02 reduces it by (another) 294 000 and so on. We then say that for 330 000 crossings the utility is about FF 0.01 and that for the next 294 000 crossings the utility is about FF 0.02.

Dupuit then draws up a table of the utility that would be obtained at every possible level of charge from zero to that figure (FF 0.15) at which there is no demand, and continues:

> "Thus FF 102 000 francs would be the absolute utility to society of the bridge. We can find the relative utility by deducting the costs of maintenance and the interest on the capital expended in construction. If this latter sum were to reach or exceed FF 102 000 the construction would have produced no utility, the difference expressing the loss which would have been made. Such is the calculation to be made in the case where crossing is free of charge. If there is a toll we must take only the figures below that of the charge. Thus for a toll of FF 0.05, for example, the absolute utility of the bridge is expressed by the sum of the ten last figures or FF 66 000; the utility lost, by the sum of the first five, or FF 36 000: the product of the toll would be 770 000 crossings at FF 0.05 or FF 38 500. With this toll, then, the possible utility of the bridge would be distributed in the following manner:

To the toll collector	FF 38 500
Derived by those crossing the bridge (FF 66 000-FF 38 500)	FF 27 500
Loss of utility arising from the 1 310 000 crossings which would have been made but for the toll	FF 36 000
Total	FF 102 000

> "As the toll increases, so does the utility of the bridge diminish in proportion; it becomes zero when the toll equals FF 0.15, at which price no one crosses the bridge; it is therefore possible for the loss of utility to rise to as much as FF 102 000."

Policy commentary

There are three points of importance to policy analysis in Dupuit's treatment:

1. The utility to users is measured by reference to what they are prepared to pay (but is not equal to what they do pay);

2. There is a loss of utility incurred in charging a toll, derived from the crossings which are deterred;

3. The utility gained by the "toll collector" must be included.

These three points all focus attention on the inherent, inevitable, distributional aspects of pricing. Dupuit was well aware of indirect and distributional consequences:

> "Without entering into the details of these indirect effects, it can readily be shown either that their measurement is included in the above formula or else that they are merely changes in the distribution of wealth which it is not for us to take into account, because the losses and gains counterbalance each other. When we say that we are not to take them into account we are speaking only with respect to the calculation of utility. The State, on the contrary, must concern itself very seriously with them. A new means of communication is opened; while it has a utility of ten million for society as whole, yet it causes one million to pass from Peter's pocket into Paul's. Although this may at first be merely an individual misfortune, it will have repercussions on the wealth of society which the State has an interest in preventing, redressing or mitigating."

Overall, the argument tends to justify lower, not higher, charges. These are not necessarily zero: Dupuit provides for the need for

> "a revenue sufficient to cover the cost of upkeep and interest on capital"

but tolls should not be more than this, i.e. in general they should be less than they would be if set at a profit-maximising level.

Almost the entire framework of the economic argument for road pricing and, implicitly, the likely political sensitivities are contained in this argument. The one crucial exception is the issue of congestion, which was introduced later.

2.2. Theoretical elaboration, 1890-1964

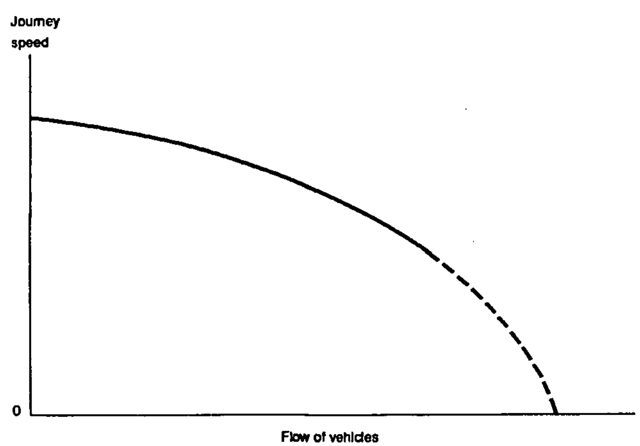
Marshall (1890) pointed out in a footnote that where unit costs increased as the level of production rose, marginal costs would be higher than average cost and a "producers" surplus would be created. While not applied to roads, it provided a necessary link to the welfare economists of the 1920s, especially Pigou (1920) who developed the general case for marginal cost pricing, and Knight (1924) who advocated the imposition of congestion taxes as a means of alleviating congestion and encouraging the more efficient use of road space.

In the following forty years the case for road pricing was built. There have been many surveys of the case, broadly all using the same structure in a more or less sophisticated form. It is necessary once again to outline the argument here, but for the purpose of this paper concentrating on those elements which will have policy implications or difficulties.

Traffic flow relationships

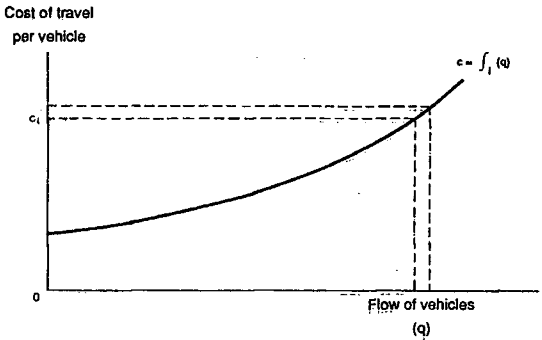
One of the fundamental aspects of traffic flow is that the average speed of vehicles on a link (a stretch of road without junctions) will be lower, the greater the flow of vehicles, as illustrated in Figure 1. Consideration of the form of this relationship was given by Smeed and Wardrop (1964) and Wardrop (1968).

Figure 1. **DIAGRAMMATIC SPEED-FLOW CURVE**



This relationship can be used to calculate journey times on each link of a route since journey time is the reciprocal of journey speed. Such time forms an important part of the total cost incurred by each driver in making a journey. Since some other costs (petrol, vehicle depreciation) will also tend to be greater in slow-moving congested traffic, the general shape of the cost curve, including all costs, is likely to be close to the specific shape of the journey-time curve. This is shown in Figure 2.

Figure 2. **DIAGRAMMATIC COST-FLOW CURVE**



Where c_i is the cost to a driver of travelling on link i ; depending on the amount of traffic on that link (q_i) the relationship can be written

$$c = f_i \ (q)$$

The attempt of each driver to minimise his own costs of travel (or at least those that he is aware of, his "perceived costs") will be satisfied in the situation where any two routes from an origin to a destination will have equal journey costs, and will not be greater than the cost of travelling on any alternative possible route.

Beckmann, McGuire and Winsten (1956) showed that this equilibrium situation is equivalent to that where a minimum is found to the sum of the areas under the cost curves for each of the links on a network, i.e. where

$$\sum_i \int_o^{qi} f_i(q)\,dq$$

is minimised.

Economic interpretation of this process

The process by which such an equilibrium might be obtained, and its economic interpretation, is of some importance.

Consider two alternative routes j and k, the links of each having their own cost-flow curves of the form shown in Figure 2. There is some initial distribution of traffic between the routes. A typical link of route j has an initial flow of q_j, and if $\triangle q$ corresponds to one vehicle, each vehicle bears a cost $\triangle qcj$. The total cost incurred by all vehicles on the link is $q_j c_j$.

Each driver will consider whether to change from one route to another; a change will take place under the following conditions:

a) A driver considering a change will look at the cost he bears on his existing route compared with the cost he would bear on the alternative; he thus compares $\Sigma' \triangle qc_j$ with $\Sigma'' \triangle qc_k$ where Σ' sums over all links in the first route and Σ'' the links in the second route. He will change from route j to route k if

$$\Sigma' \triangle qc_j > \Sigma'' \triangle qc_k.$$

b) If he then sees a third route where $\Sigma''' \triangle qc_l$ is even smaller, he will change to that one, and so on.

c) All drivers are making similar decisions about whether to change routes.

d) Thus every change that is made is from a larger to a smaller sum, therefore reducing the total

$$\sum \int_o^{qi} f_i \ (q) d_q$$

for all links in the network.

e) Changing only ceases when there exists no further opportunity for reducing this sum of the areas under the cost curves, i.e. when it is at a minimum, and when $\Sigma q.c$ is equal on all alternative routes.

While the sum of the areas under the cost curves has been minimised, however, this sum is not equivalent to total cost. An extra driver joining a flow of q_i vehicles per unit time on a particular link, joins a situation where each of the q_i drivers already there experiences a cost of c_i, the total cost being $c_i q_i$.

The cost he himself bears, in joining the flow, is $\triangle q \ (c+\triangle c)$, a cost slightly greater than that which each driver previously bore. In addition, each of these drivers must also bear this same new cost, the total cost now being the area of the new, bigger rectangle, given by $(q + \triangle q)(c+\triangle c)$.

Thus the new arrival has added to the total cost two elements: (a) his own cost $\Delta q(c+\Delta c)$; (b) an extra cost imposed on all other vehicles of Δcq. We may call the former element his "private" cost, the latter the "social" cost of his journey.

It can be seen that this private cost is equal to the area of the vertical strip in Figure 2, the social cost to the area of the horizontal strip, to first order in small quantities. It is necessary to distinguish carefully not only between marginal and average costs, but also between these and private and social costs.

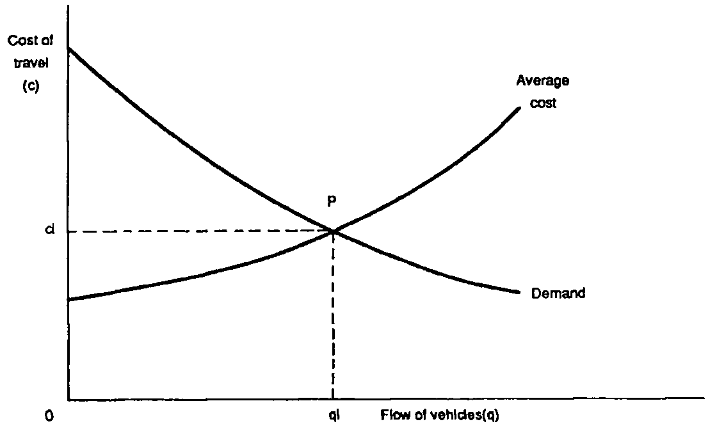
For the individual driver, the extra cost he incurs is virtually the same as average cost -- in joining the stream, or making an extra journey, he himself incurs an extra cost only very slightly higher than the average cost before he joins. It is only when both his costs and the extra costs of all other drivers are considered that the marginal cost of his journey is greater than the average cost which all drivers pay out.

<u>Taking account of the price elasticity of travel</u>

Consideration will now be given to the amount of travel on a whole network where costs of travelling increase with flow and the total amount of travel is a decreasing function of the cost of travel.

Two curves can be specified, as shown in Figure 3; the flow (q) here being a suitable measure of the total amount of travel (such as vehicle miles per unit time) and the cost curve being calculated by aggregating all the cost-flow curves on the individual links on the assumption that traffic will be distributed over the network in the way described above.

Figure 3. **COST AND DEMAND FOR TRAVEL**



Then $q = f_1(c)$ may be taken as the equation of the demand curve and $c = f_2(q)$ as that of the average cost curve.

Since f_1 and f_2 are respectively decreasing and increasing functions, it is clear that the two equations can only both be satisfied at the point P with cost = c_i and flow = q_i, when there will be no incentive for any change to be made in the amount of travel so long as the two functions remain as they are.

To summarise the argument at this stage; the total amount of travel on the network will be determined by the intersection of the aggregate market demand curve and the aggregate cost curve. The distribution of that total on each link of the network will be determined in accordance with the quest of drivers to minimise the sum of the areas under the cost curves for the separate links.

The theoretical case for road pricing

Since a high traffic flow is associated with a low speed and therefore longer journey times, a number of investigations have been made into the theoretical implications of reducing the number of vehicles using congested roads in order to increase speed. What are the circumstances under which such a policy can result in an increase in total social welfare?

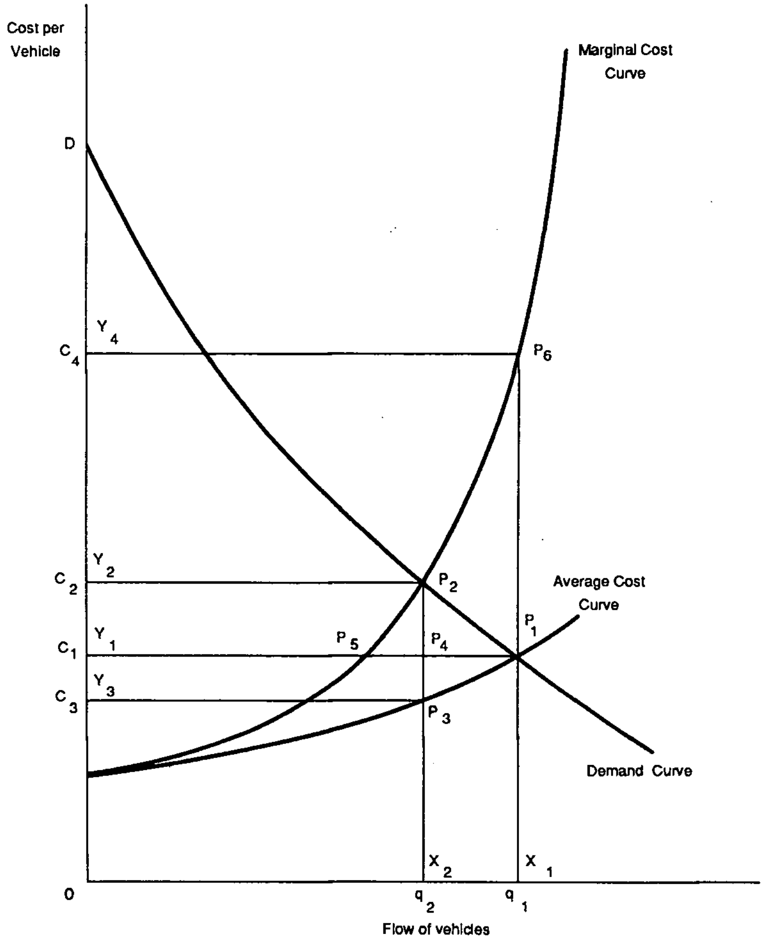
The approach outlined by, for example, Beesley and Roth (1962), the Smeed Report (HMSO, 1964), following roughly the analytic framework of Pigou (1920), Walters (1954 and 1961) and Beckmann et al. (1956), may be summarised in Figure 4, which shows the relationship between flow (q), average costs (c_a) and marginal costs (c_m).

The demand curve may be specified by the equation $c_a = g(q)$. The average cost curve will be given by $c_a = f(q)$. The marginal cost curve, which shows the addition to total cost of additional vehicles, is then given by differentiating total cost with respect to flow, thus

$$c_m = qf'(q) + f(q)$$

Traffic flow, left to find its own level by the intersection of demand and average cost curves, will reach equilibrium at point p_1, giving a flow of q_1 and cost c_1 per vehicle. The total cost incurred by all vehicles will then be q_1c_1.

Figure 4. **AVERAGE COST, MARGINAL COST, AND THE FLOW OF VEHICLES**



The consumer surplus will be

$$\int_{o}^{q1} g(q)\,dq - q_1c_1.$$

Suppose a toll is now exacted, by means of a suitable metering system, which varies according to the level of congestion obtaining and has the effect of raising the cost facing each motorist to the level of his marginal (greater than average) cost. The perceived cost and demand curves now intersect at point P_2; flow will be reduced to q_2, outlay by each driver increased to c_2. Total outlay is now c_2q_2.

The total outlay may be more or less than it was previously, depending on the shape of the curves, but the new apparent consumer surplus

$$\int_{o}^{q2} g(q)dq - q_2c_2$$

must be less than the old consumer surplus since $q_2 < q_1$.

2.3. Policy difficulties inherent in the classical statement

We can see, with hindsight, that the theoretical case for road pricing was bound to raise some political difficulties -- although these were rarely given full attention at the time.

We can list three aspects of importance:

1. Perception: There are two necessary conditions for road pricing to work. First, the system must "internalise" external costs, i.e. make the driver pay for the costs he imposes on others. This was well appreciated. But secondly, the form of charge must be perceived and understood by the motorist as well as being reasonably closely related to the level of congestion obtaining.

2. External costs: The existence of external costs has one effect (among others) which will be particularly important: financial cost will not generally be equal to financial revenues. A subsidy or a surplus is inherent to the system. For that reason, simple comparisons with a "market" may be misleading: a profit maximising road-providing company would not set its prices at the social optimal any more than a government agency was doing.

3. Distribution: Consider two groups of drivers. First there are those who no longer make the journeys they did previously: their welfare has clearly decreased. Secondly, there are the drivers who are still making journeys. The real resource costs of their travel has reduced, but the amount each journey costs them is clearly more (by $c_2 - c_1$ each) than before, and the consumer surplus that they experience themselves is clearly less [by a total of $(c_2 - c_1)q_2$]. Thus we seem to have achieved two groups of people both of whom are worse off as a result of road pricing. This is why the description of the toll collected as a transfer payment is crucial, since unless the money raised is used in such a way that somebody benefits, no social improvement has been made. (It should be pointed out in addition that even

if this condition is fulfilled, and the money is used for purposes which are clearly worthwhile and which result in a larger consumer surplus elsewhere in the economy, there is still an ambiguity in theoretical terms as to whether a welfare improvement has resulted, depending on whether the test of possible or actual compensation is applied.)

This latter difficulty has been addressed in two ways. First, it has frequently been the practice of authors on road pricing to describe the effective welfare increase as depending on the return to vehicle owners (for example, by reduction in road tax) of the amount collected. Thus the Smeed Report (HMSO 1964):

> "assumed that the introduction of road prices would be accompanied by a corresponding reduction in existing taxes."

In particular circumstances, it has been argued that the more efficiently this assumption is implemented the more the original benefits of road pricing may be eroded. Thus Sharp (1966) estimated that if drivers receive back the money in the form of reduced general motor taxation, they may decide to "buy back" up to a third of the road space they originally vacated.

Secondly, it is observed that the difficulty, in part, arises from simplifications in the classical statement: there is only one class of traffic -- private cars -- they can all have the same value of time. As soon as we allow the existence of cars, lorries and buses all using the same road and with different values of time, then there will be at least some classes of road user who benefit directly from a reduction in generalised costs of travel even if taxes are not reduced and transport investment is not increased. For example, drivers with high marginal utilities of time and low marginal utilities of money will benefit from the increase in speed by a greater amount than the extra money cost of travel.

However, while this ensures that there will always be direct as well as indirect beneficiaries of road pricing, it means that in all conceivable situations some people will be better off and some worse off; in other words, the distribution of income and welfare will have changed.

2.4. New theoretical concerns in the seventies and eighties

Four developments are worthy of attention:

1. Detailed traffic theory

From Else (1986) and others has developed a line of argument intended to be helpful, but on occasion proving the opposite. The speed flow curves used in Section 2.2 are greatly over-simplified. In practice, a speed flow may have a "backwards-sloping" section in which the clarity of the optimum charge is muddied. Worse, detailed consideration of the behaviour of queues at intersections indicates, for example, that the first vehicle in a queue is causing more delay than the end vehicle. Theoretically, each vehicle should be charged at a different rate. This may or may not be a correct interpretation of the economic concept of the "marginal" vehicle but, in either case, it is quite incapable of practical implementation and is also inconsistent with the necessary condition for road pricing, that drivers should be faced with a well-perceived charging structure that is capable of influencing their behaviour.

The effect of this sort of detailed traffic engineering argument may well have been to cause despondency about the hopelessness of ever being able to implement a sensible system.

2. Wider definition of "social costs"

In the classical argument, "social costs" are the costs imposed by one driver on another. Road pricing is justified by reference to only one class of road user, and only one or two simple costs (money and time). Increasingly, the concept of social costs has been widened to include other important external costs, especially time delays to other classes of road user (bus passengers, pedestrians and separate consideration of commercial vehicles, emergency services, etc.) and accidents: visual, noise and atmospheric pollution. The more classes of external costs that can be included, the greater the potential advantage of road pricing -- though the more difficult to have confidence in the precise estimates of optimum user charges.

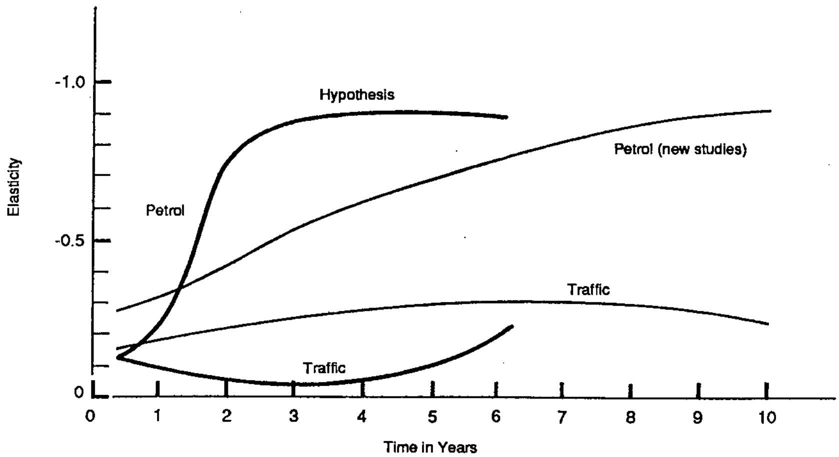
The effect of this argument has been to increase the case for road pricing qualitatively, but sometimes to reduce its clarity as a broad (and more realistic) definition of social costs seemed to involve greater problems of estimation. Certainly the confidence with which the actual optimal level of charge could be set was reduced, at the same time as the required level was probably increased.

3. The traffic-generating effects of roads

Mogridge (1986) and others have argued that the provision of new roads may generate sufficient extra traffic that speed improvements may only be temporary. This does not <u>of itself</u> weaken the case for road pricing, but does weaken the link between the revenue collected and optimal expenditure on roads (Mogridge argues, for example, that urban rail investment is likely to have a bigger effect on road speeds than would road investment).

The effect of this argument (like the previous one) is to require a more integrated and comprehensive planning framework that can deal with all modes of transport and their interactions, rather than seeing road provision as a self-contained problem.

Figure 5. **EVIDENCE UP TO 1988 COMPARED WITH DIX & GOODWIN'S HYPOTHESIS, 1982**



4. <u>Short term/long term effects</u>

The development of empirical evidence on short- and long-term demand elasticities has proceeded, with considerably better information than was previously available. Figure 5 and Table 1 (from Goodwin, 1988) indicate that elasticities may be substantially higher than had previously been thought, but only after some years. This means that the full benefits of road pricing may take some years to realise, and any budget constraints approached on a year-to-year basis would cause distortions.

The effect of this argument is to require transport authorities to take a longer-term view than has often been the case.

Table 1

SUMMARY OF ELASTICITIES FROM 85 REFERENCES 1980-1988

Demand	With respect to:	Elasticity		
		Short-term	Long-term	Not distinguished
Petrol	Petrol price	-0.27	-0.73	-0.48
Traffic	Petrol price	(-0.13)	(-0.30)	-0.39
Car ownership	Petrol price			-0.21
Car ownership	Car prices			-0.87
Traffic	Tolls			-0.45
Passengers	Bus fares	-0.3	- 0.65	-0.41
Passengers	Tube fares	-0.2	- 0.4	-0.2
Passengers	Rail fares	-0.7	- 1.1	-0.65
Passengers	Petrol price			+0.34
Car ownership	Public transport costs			+0.1

Peak period commuting in towns has elasticities of half (or less) as great as off-peak. "Long-term" is typically in the range 5-10 years, but <u>may</u> be more.

3. PRACTICAL ISSUES INVOLVED IN THE IMPLEMENTATION OF A ROAD PRICING SYSTEM

At the same time as the improvements in theory were appearing to make road pricing more complex and demanding, there was also a gathering of experience of the practical problems that have to be solved in the implementation of a practical system, which we now consider.

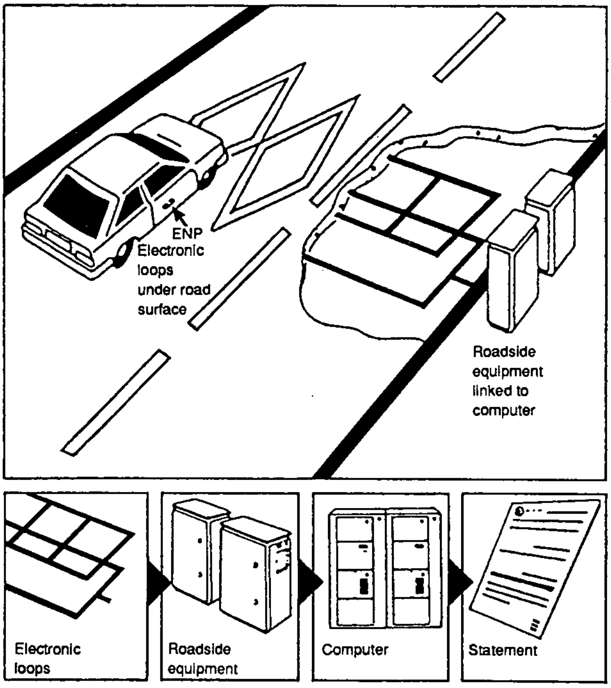
3.1. Method of charging

The United Kingdom Ministry of Transport study into road pricing (HMSO, 1964) examined two basic approaches to vehicle charging: off-vehicle and driver-operated meter systems. In the former, each vehicle has some form of identification number which is read by sensors at various points in the road network, and persons are then charged for passing each point or for the time spent (travelling) between detectors. With the driver-operated meter, there is a continuous charge for time spent within designated areas; some form of hybrid might also be possible, in which meters are switched on and off automatically on entering and leaving designated areas. Given the technology of the early sixties, the study team came out strongly in favour of a driver-operated meter as being cheaper, more flexible, more reliable and better able to reflect the philosophy behind road pricing than an off-vehicle system. Twenty years later the balance had swung in the other direction in the Hong Kong Electronic Road Pricing Demonstration, which used a passive, off-vehicle system, on the grounds that it was cheaper and less prone to tampering.

A third charging option -- and the one which has been most widely used on tolled roads and in area licensing schemes in Singapore, Bergen, etc. -- is a manual system, where charges are either collected on site or permits are purchased in advance and displayed on the vehicle. The former has serious implications for congestion and the latter severely restricts the spatial and temporal complexity of the road pricing scheme.

The technology of the experimental Electronic Road Pricing (ERP) scheme in Hong Kong is described in Catling and Harbord (1985), and illustrated in Figure 6. Each vehicle was fitted with an Electronic Number Plate (ENP), which was welded to its underside and transmitted a unique identification code when interrogated by a pair of power and receiver loops embedded in the road surface. Roadside equipment monitored the performance of the loops, decoded the ENP signal and transmitted the data to the Control Centre. Here data were rigorously checked and validated before being passed to the accounting system, which estimated charges and was able to send out bills at regular intervals. In a fully working system, each vehicle would be required to have an ENP: if not, "illegal" vehicles can be identified by the system and can be detected either in manual checks or through a video recording of the vehicle and its licence plate number. In trials of the system, the equipment worked extremely well, with a failure rate significantly better than required by the specification.

Figure 6. **TECHNICAL OPERATION OF THE ELECTRONIC ROAD PRICING SCHEME DEVELOPED FOR HONG KONG**



Source: "A Fair Way to Go" (Hong Kong Government Information Leaflet)

Although considered technically superior by the Hong Kong consultants, the off-vehicle system has a number of consequences for the way in which road pricing can be implemented;

-- All vehicles have to be fitted with an ENP, including those which rarely use an ERP-controlled area of the country, thereby adding to the scale of the set-up problem and to the difficulty of containing the system;

-- The use of loops in the road as the means of detection makes it more difficult to introduce extensive changes to the system and favours some type of point rather than continuous pricing system;

-- There is little information, at the time a car journey is being made, as to the ERP cost of the journey and, because charges may be collected some weeks after the journey is made, the link between journey and cost may be weakened;

-- Because of the lack of immediate association between travel and price, and the need for taxis to travel in charged areas without passengers, there are problems of deciding how to pass on the congestion charge to taxi passengers.

The question of method of payment is an important one, since it is through the payment system that we seek to influence behaviour. The analogy often used is with a telephone bill (where there are different charges according to distance and time of day), but there the objective is not to make individuals aware of the cost of individual calls! It is very likely that telephone behaviour on pay phones is very different than where there is a monthly or quarterly bill, and it is the former frame of mind which we are trying to create, not the latter. With regular billing the road pricing charge for individual journeys is unlikely to be fully perceived, especially when another household member or a company pays the bill. As against this, the occasional payment of a large sum of money might bring home the true cost of regular car journeys in congested conditions in a way which a daily charge might not. In the Hong Kong system, the intention was to reinforce daily awareness of cost by distributing publicity illustrating the cost of travelling by car in certain space/time zones, and through displays of charges at ERP sites.

Accepting the technical feasibility of road pricing -- which was established in the Hong Kong study beyond reasonable doubt (for that particular type of system) -- there are three further issues to be decided:

a) Which vehicles to charge for the use of roads;

b) How to vary charges by time of day;

c) How to distribute charges across the city (areas, direction, etc.).

We consider each in turn.

3.2. Exemptions for certain vehicles or persons

From a theoretical viewpoint, there is no reason why all vehicles should not be charged the economic or social cost of the journeys they make in congested conditions, but in practical applications to date the main costs have been borne by private motorists, with buses and goods vehicles being exempt. Costs per bus passenger would probably be quite low at peak times, but there has been a reluctance to impose the charge because of the wish to encourage travel by this more space-efficient mode;

similarly, there are concerns about increasing manufacturing costs if goods vehicles were charged -- though the impact of such charges on some firms might well be less than the inefficiencies which arise through the present restrictions on loading and unloading in congested areas, and so might lead to net cost reductions.

The main problem is caused by taxis which, both in Singapore and Hong Kong, were originally excluded from the scheme, but experience has shown that they need to be included because of the high cross-elasticities of demand between cars and taxis in such densely populated areas; given the substantial use of taxis by non-car owners, however, it is probably expedient to charge taxis at a lower rate than cars, which would encourage some transfer from car to taxi, but this would be offset by transfers from taxi to other public transport modes at the lower end of the market.

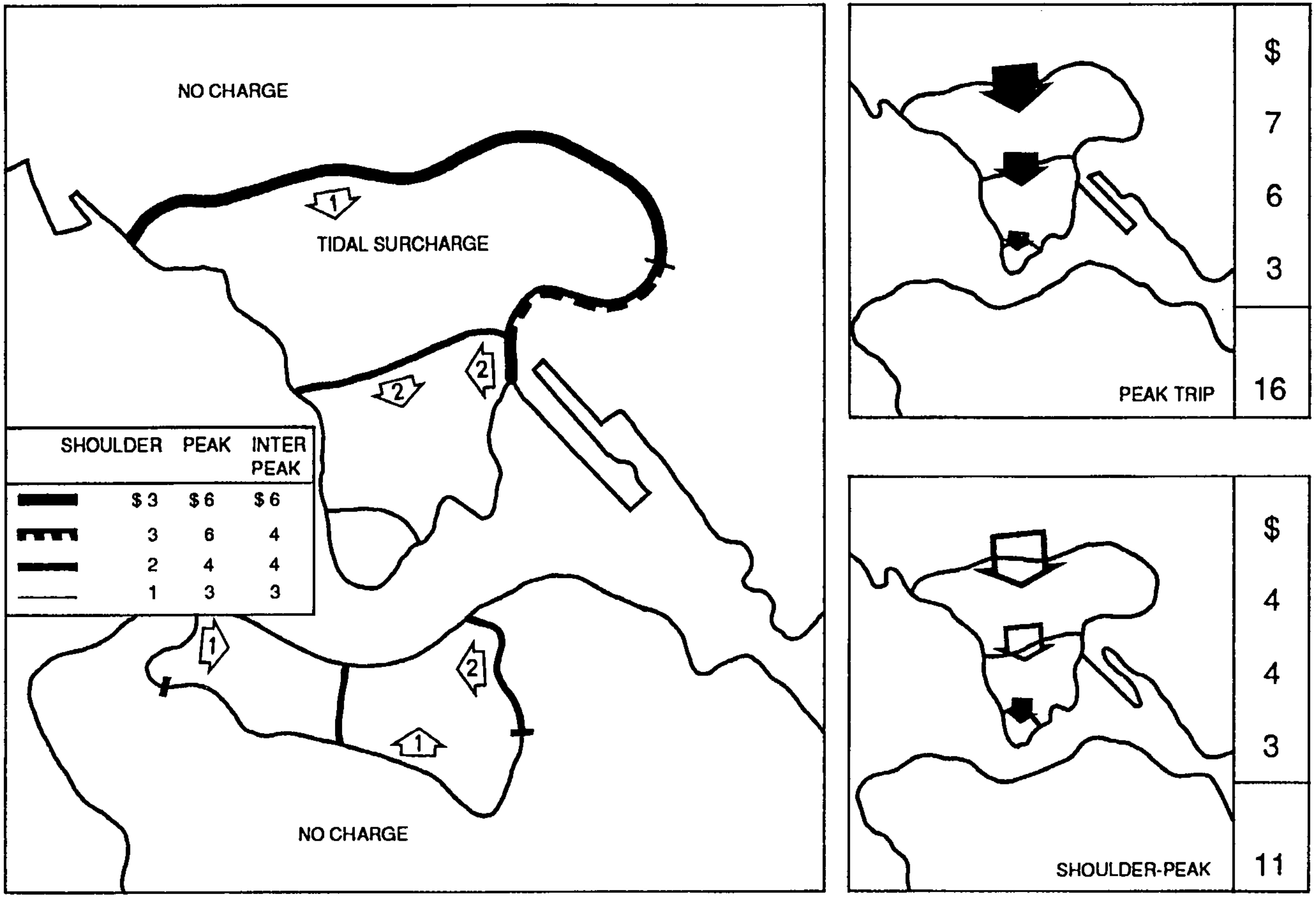
Pressure for exemptions also comes in another form, from particular groups of people who feel they are unfairly disadvantaged by road pricing or have a special right to road space in the affected area. Examples include local residents -- who are exempt from access restrictions in many schemes such as the no-car area in Florence -- and disabled drivers. Local business people, too, may argue that they have as much right to special treatment as the local delivery driver.

3.3. Temporal pattern of charges

Traffic conditions change continually over the road network and vary from day to day. It would be possible electronically to measure variations in traffic flow minute by minute and vary charges accordingly, but this would not be practical or desirable from a behavioural viewpoint: motorists would be accelerating past charging points as prices were about to change, or doing U-turns, and would have no clear idea of the cost of travel before they set out -- which is the time when the travel decision is taken (aside from minor variations of route). The constraint is thus one of comprehensibility, stability and simplicity: patterns of charges, once established, should remain in force for months at a time and the range of charges should be simple enough for the motorist to understand and remember.

Balancing these considerations in Hong Kong led to a six-period charging system, based around morning and evening peak charges, an inter-peak charge, an off-peak (zero) charge and shoulder charges to stagger the rise from the off-peak to peak charges. There was also provision for special charges, perhaps levied during road works or on days when heavy traffic loads are anticipated (e.g. race days in Hong Kong). Because of the way in which the charging system would work spatially, however, the price graduations are much finer than this six-fold system would indicate. This is illustrated in Figure 7.

Figure 7. **CHARGING STRUCTURE "B" DEVELOPED FOR THE ASSESSMENT OF ELECTRONIC ROAD PRICING IN HONG KONG, WITH AN EXAMPLE OF THE VARYING CHARGE FOR THE SAME JOURNEY AT DIFFERENT TIMES OF DAY**



Source: Adapted from "Electronic Road Princing Pilot Scheme: Results Brief & Consultation Document", Hong Kong Government.

Politically, it is probably desirable that there are periods of the day or week when road pricing charges are set to zero, so that motorists are offered times at which journeys could be made without incurring penalties. Apart from enhancing the public acceptability of road pricing in general, it would be a recognition that there are times -- in some countries at least -- when car use is more "essential" because:

a) The public transport system is offering a very low level of service;

b) Travel on foot or by public transport is considered to be unsafe by some groups of the population.

These two factors tend to argue for zero changes in the mid- and late evenings and on Sundays.

3.4. Spatial pattern of charges

An off-vehicle system for registering road pricing charges means that continuous charging is very difficult to implement, because if a vehicle is incorrectly matched (e.g. correctly recorded as entering but not picked up when leaving the charged area) it could erroneously incur a very high charge. The Hong Kong experiment was based on a point data capture system, but the information collected could be used to create a number of different spatial charging structures. For example:

a) Link charges. Motorists would be charged for using certain links of the road network, perhaps where capacity is especially restricted, or where there is a concern to limit traffic for environmental reasons.

b) Junction charges. ERP loops would be laid at major junctions to control traffic levels over the area of the network. This is probably more efficient than a) especially if some turning movements could be exempt.

c) Cordon charges. Motorists would be charged for entering or leaving a designated area -- similar in concept to Singapore (though with scope to vary charges by time of day and direction).

d) Boundary charges. Similar to cordon charges, but charging lines extend right across travel corridors, so there is little scope for switching route to avoid the charge -- unlike a) to c) where, to varying degrees, route switching is an option.

e) Zonal charges. Conceptually this is quite simple but is difficult to achieve in practice. A combination of a Cordon/Boundary and a Junction or Link configuration would be used to charge motorists for journeys made within and between zones -- rather like the present public transport fare structure in London.

Structures c), d) and e) all have the potential disadvantage of leading to serious congestion and parking problems on the outer edge of the boundary, as people drive as close as possible to the toll site and then complete their journey on foot or by public transport. At the very least, this suggests the need for a co-ordinated system of parking controls and other traffic management measures within a kilometre or two of a boundary -- unless these are located along significant natural barriers such as major rivers.

After considerable investigation of alternatives, the ERP study team in Hong Kong opted for three schemes for evaluation purposes, based on a system of boundary charges. This well suited the geography of the territory, where there are some natural water boundaries and few roads with spare capacity so that route switching was not an option to be encouraged.

The intermediate charging system (Scheme B) developed for Hong Kong is shown in Figure 7. Here charges vary according to time of day, section of the boundary line and the direction of travel. By travelling at different times in the two directions, considerable variations in charges will be incurred and (as noted earlier) total charges may fall in between two or more pricing structures if a journey is begun in one time period and completed in another. The system appears to offer a very acceptable compromise between the need for simplicity of comprehension and sophistication of the charging structure; scheme B was designed to operate with only 115 toll sites.

3.5. Other aspects

This section has discussed just a few of the practical considerations involved in implementing a road pricing scheme. Little has been said, for example, about the sophisticated accounting systems or the design of the electronic toll sites. There are also more general issues concerning the level of road pricing charges, which relates to the overall objectives of the scheme; we return to this issue in later sections.

4. POLITICAL INTEREST IN ROAD PRICING

4.1. Factors behind United Kingdom policy interest

Both the theoretical and practical concerns developed within a political context and, not surprisingly, this has had a substantive effect on the way in which they were perceived. This was different in the situation of the sixties, and the more recent interest in the eighties.

a) The nineteen sixties

There were several reasons for the interest at this time in road pricing as a means of limiting traffic congestion:

i) By the late fifties traffic in many capital cities was growing rapidly and road network conditions were deteriorating fast; there were fears that traffic in the capital would "grind to a halt" unless something were done (Hart, 1976).

ii) There was a growing realisation that full motorisation in large urban areas could not be achieved without destroying the fabric of the city, so that some form of vehicle restraint would be essential. This argument was advanced strongly in "Traffic in Towns" (HMSO, 1963), which had a considerable influence on planning in Britain and some other European countries.

iii) Even where road construction was felt to be a long-term solution, money was not available to construct urban roads on a large scale; at this time, priorities in the United Kingdom were on modernising the railway network and building inter-urban motorways.

iv) Economists were beginning to have more influence on transport investment decisions, with the use of cost-benefit analysis to give priority to motorway building (e.g. London-Birmingham Motorway: Beesley and Reynolds, 1960) and justify construction of urban underground systems (e.g. the Victoria Line: Foster and Beesley, 1963); this provided an opening for other economic "solutions" such as congestion taxes.

v) More specifically, the concept of charging motorists for using road space to park their vehicles was beginning to be accepted, so that charging for moving vehicles too might be viewed as a logical development of the application of prices to control use of scarce resources.

b) The nineteen eighties

Two additional elements have been added to the policy debate in recent years:

i) Private road funding

For reasons quite unconnected with road pricing, there has in some countries, including the United Kingdom, been much greater interest in providing "private" or reserved roads (tunnels, bridges etc.)

to be funded by some sort of toll whose function would be to reward capital, not to establish optimal levels of traffic. Thus the Adam Smith Institute (1983), whose main interest has been the development of privatisation, deregulation and the functioning of the private market and competition, argued in favour of road pricing both to ration available resources and also:

"to provide a system of direct funding for the maintenance and construction of roads in Britain...this means that there will be a direct correlation between the revenue a road earns, the maintenance required, and improvements to critical sections of the road system."

This argument is very different from that of Mogridge summarised above, and may be contrasted with an argument of the International Union of Railways (1987), which concluded that "the internalisation of transport costs would almost certainly lead to a swing in demand towards the railways."

Thus we see a regrowth of interest in road pricing, but essentially on private market principles, not social costs. This argument has not yet been taken to its logical conclusions -- privately owned roads operating on a commercial basis -- except in the special case of some limited road construction and, as a reversal of Dupuit, some tolled bridges and tunnels. But it seems likely to arise as a political possibility in the future.

ii) New technology

The recent period has also seen the development of in-vehicle electronic equipment designed for purposes quite distant from road pricing. Nevertheless, the equipment itself can be as easily multi-purpose as, for example, the use of home computers for games, word processing or calculation. This has not escaped media attention, as is shown in a commentary by the London Evening Standard (15.4.88) on a new route navigation system:

"The new Autoguide vehicle navigation system launched experimentally in London this week could be worth 'an extra M25' to the capital if and when it is up and running, according to Transport Secretary Paul Channon.

With this system a car receives infra-red signals which advise on the best route to a prescribed destination, and also pinpoints its own position and progress.

Road casualties could be cut by 500 a year, journey times shortened by 10 per cent, and annual mileage among regular London road users reduced by 6 per cent, he suggests.

At current prices it would cost the motorists £250 to buy the Autoguide transceiver and up to £50 a year to give it access to the central computer which constantly monitors the traffic situation -- cheap at the price if it made such a difference.

But cynics are convinced that this wonder system -- devised by Government scientists as part of a Europe-wide search for door-to-door navigation -- would provide the perfect basis for electronic road pricing in London.

Since each vehicle in the system has its own input into the computer's assessment of traffic volumes and speeds, boffins could easily add a logging system to record the London mileages of cars equipped with the system.

Their owners could then be sent monthly bills for London road usage -- a form of that supplementary licensing of which the anti-car environmentalists and social theorists have long dreamed as a deterrent to so-called unnecessary motoring in the capital.

This is nowhere in the scenario, asserts Mr. Channon. But neither he nor his advisors have satisfied troubled members of the road lobby."

It is interesting to speculate that the very large amount of research currently planned in DRIVE, designed primarily to provide better route guidance and enhance safety, may in the event result in equipment which could very easily accommodate almost any conceivable road pricing system.

4.2. Developments in other countries

There has been a renewal of interest in road pricing in several countries, motivated by a range of different policy interests. For example:

-- In Stockholm, there was a detailed study of road pricing twenty years ago which, like many other areas, then died for lack of support. However, recent regrowth of interest has focused on environmental advantages rather than the traditional traffic engineering or economic conditions.

-- In The Netherlands, current thinking envisages use of a combination of different tools. Five new tunnels are to be financed by private capital, paid back by charging road users. Concerning the main existing infrastructure, there is a plan to institute electronic road pricing by 1996, making more money available for both roads and public transport. One interesting innovation -- which may help to solve one of the problems experienced in Hong Kong -- is the plan to have a "dual price mechanism". Motorists would choose either to have a bill at the end of the month or to use a pre-paid card (similar to a telephone card) whose value is cancelled with use in the car. Declared policy priorities are to give better facilities for freight and commercial vehicles.

-- In Japan, a recent study (Sakashita and Fukuta, 1987) included both public transport and road prices within the same model, and concluded that the optimal result included both a lump sum tax and cross-subsidy from private to public transport. Such cross-subsidy on its own was the second best solution, and the tax on its own was third best. An increase in paring charges was also found efficient (though one commentator on the study concluded that in Japan "Electronic Road Pricing is technically possible but institutionally impossible").

-- In Bergen a manual system of area licensing is in use, to finance the construction of new roads in the area (Larsen, 1988). In Oslo there is a plan for area licensing, also largely aimed at raising money for road investment. Using microwave (not loop) technology, information would be read from moving vehicles at relatively high speeds from portable locations, with a system that has the added advantage that foreigners can pay cash and there are claims that the in-vehicle equipment cost could be as low as £10 a car.

4.3. Public hostility towards road pricing

Despite the technical arguments in favour of road pricing, the main obstacle to its successful implementation has been public opinion -- or rather, the views of pressure groups who may or may not reflect broad public feeling. In Hong Kong, for example, debate and media coverage was dominated by members of the ten per cent of the car-owning population, some of whom would lose out, rather than by the ninety per cent of non-car owners who would have benefited (Borins, 1988). Whether representative or not, however, there has generally been a negative "public" reaction to the idea of road user charges; so much so, that only a few substantial schemes have been introduced so far, and in special situations:

i) Where there is strong political leadership (e.g. Singapore), or

ii) The scheme is presented primarily as a revenue-raising device linked to hypothecated spending on new road construction (e.g. Bergen), or

iii) Where some form of traffic restraint -- but not usually price-based -- has been accepted because of severe congestion and/or environmental problems (e.g. Athens or Florence).

From discussions with members of the public in London, Hong Kong (Jones, 1984), Adelaide and elsewhere, it is evident that public concern hinges on similar sets of issues. In particular, there are concerns about:

-- The "unfairness" of the system, which gives more wealthy drivers access to road space that hitherto was regarded as equally accessible to all;

-- A number of concerns about the practicability of the scheme (ranging from the reliable operation of the technology to the comprehensibility of the scheme);

-- In some cities, worries that an already overloaded public transport system would not be able to cope with the additional passengers that would result if motorists were persuaded to leave their cars behind;

-- A mistrust of authority, in two senses:

a) Whether road pricing would not just become another convenient method of raising taxes in an inelastic market where people feel they have little choice but to pay up.

b) Concerns about invasion of privacy and misuse of information in situations like Hong Kong, where the proposed system would track vehicles across a network.

Public discussions have also suggested a number of issues which might help to increase acceptability of road pricing -- at least as one option in the debate on urban traffic problems:

a) Although road pricing is generally not a very popular notion:

i) It is often seen as fairer than a complete ban on certain types of traveller or vehicle;

ii) It is usually recognised that some restraint has (or eventually will have) to be tried.

b) Any restraint on car traffic would need to be linked explicitly with improvements in public transport, as part of an overall package. In public relations terms, this probably requires something highly visible such as new routes or lower fares, rather than just notional higher frequencies on existing services.

c) Responses are often inconsistent and ill-conceived. There is a need for public debate and education to overcome two common misconceptions:

i) It is believed that while motorists would be attracted out of their cars by an "alternative" policy of lower bus or tube fares, they would not be put off by higher road charges. (Again, this strengthens the psychological case for fare reductions to gain public acceptability for road user charges;)

ii) People are not usually able to see the benefits of road pricing to road users other than car drivers, in terms of faster journey times for buses, or a more pleasant environment for other travellers.

d) Support for road pricing is usually higher in the denser areas (where conditions are worse) and among professional drivers who have to tolerate congested conditions; one option might be to try and gain the support of these groups before launching a general public debate.

e) It is important that practical issues such as boundary problems, payments systems and any exceptions are well thought out in advance: once the idea of road pricing was accepted by respondents as a serious subject for discussion, attention quickly switched to these more detailed issues.

f) Urban residents perceive two main traffic problems: congestion and lack of parking for residents. Road pricing would not necessarily alleviate the residents' parking problem -- indeed, in Hong Kong electronic road pricing was promoted as a management technique that would allow higher car ownership levels! Possibly, in conjunction with traffic restraint, some road space could be transferred from moving to stationary vehicle use, to show an advantage in this respect too.

g) Even though the introduction of road pricing might be felt to be premature, there was some support for the idea that it was prudent to at least investigate the options at this stage. However, road pricing was viewed very much as a complement to, rather than substitute for policies such as improved public transport.

5. A ROLE FOR ROAD PRICING

Either explicitly or implicitly, road pricing can only form one element of a package of measures designed to tackle urban traffic congestion -- and only then if the public perceive it as a "necessary" tool for traffic management. This is likely to arise either where it is marketed as a "total system", with the money raised being hypothecated for road building or public transport support; or where congestion is so bad that there is an acceptance that drastic restraint measures are called for.

In an appendix to this report, we review a range of strategies for reducing urban congestion. It is evident that there is a wide range of methods for achieving this, both through direct restraint of car traffic and by encouraging drivers to switch to other modes or times of travel. It is also clear that no single measure offers the "best" solution, and that the most promising results are likely to be obtained using a combination of approaches.

There is a wide variety of restraint measures, apart from road pricing, many of which appear to be highly successful. At the local scale, physical or regulatory restrictions can achieve significant reductions in travel levels, though sometimes with undesirable effects outside the restricted area. General control on car ownership and use can be exercised through road licence tax and fuel tax, and traffic levels in areas of high traffic attraction can be contained by using parking controls. All these methods tackle congestion indirectly, however: they may achieve results that are adequate and the degree of inefficiency involved may be politically preferable to the introduction of a road pricing scheme. But where traffic pressures are extreme, road pricing has a number of advantages.

Developments in South-East Asia over the last decade have demonstrated that we are now at a point where road pricing is technically and financially feasible (offering rates of return of over 300 per cent, Dawson, 1986) and capable of achieving the desired reductions in traffic levels. Singapore and Hong Kong offer two different approaches, the former providing a low-tech solution to control traffic congestion in one specific area and time period (with encouragement for traffic re-routeing) and the latter a high-tech solution where congestion is poly-centred and a temporal redistribution is required rather than a spatial one.

The comprehensive evaluation in Hong Kong clearly demonstrates the advantages of a full road pricing system over the policy of car ownership restraint which is used in several countries with severe traffic problems (Dawson and Brown, 1985). In particular, road pricing:

a) Provides a more appropriate temporal as well as spatial control on traffic: whereas a 20 per cent reduction in peak traffic from car ownership restraint would lead to similar levels of reduction off-peak, the same level of peak restraint through road pricing would enable traffic levels in the evenings and at weekends (when there is spare capacity) to increase by a corresponding amount;

b) Enables higher levels of car ownership to be absorbed than if the latter were the prime means of restraint. It is estimated that in 1991 the Territory could accommodate 275 000 licensed cars with road pricing, but only 200 000 without such a scheme.

Benefits are also substantially higher at around £70-90 million per year, compared with £30 million for car ownership restraint, for a cost of around £5 million per year (1985 prices).

The Hong Kong experience further demonstrates two cautionary points. First, that road pricing is not a substitute for other policy measures. It requires a good public transport system; the use of local traffic management measures to ease bottlenecks, give priority to buses, etc.; a strong parking control policy; and some flexibility in activity timings (in Hong Kong's case there is little work flexi-time, but shops stay open well into the evening, facilitating a degree of travel re-scheduling).

Secondly, road pricing is very unpopular with the motoring public and so, politically, is a policy of last resort. If a criticism can be made of the Hong Kong demonstration, it is that not enough resources were put into the public relations aspects of the study; although the 90 per cent of non-car owning households would have benefited from the scheme (through faster bus journeys, and in some cases the chance to own a car), the disbenefits that would be experienced by some of the 10 per cent of car-owning households dominated the discussion. In addition, some concerns were more widespread and related to a general mistrust of government: would information on vehicle movements throughout Hong Kong really be kept confidential?; and could any government resist the temptation of using road pricing as a general revenue raiser rather than as a device for redistributing existing motoring taxes (as had been promised by the Government)?

The message from Hong Kong and cities such as Kuala Lumpur (which rejected a Singapore-type solution) is probably that the proposals were premature, but that under some conditions road pricing would become acceptable. In Hong Kong traffic congestion is perceived to have eased in recent years, because of the effects of the high annual car tax and some recent increases in road and rail network capacity; once motorists perceive a serious congestion problem they are more likely to accept the need for a road-pricing-type solution. Evidence in related areas shows that the imposition of a new charge always results in a public outcry, but that if it "works" it is soon accepted. This principle has applied in most cities with regard to payment for on-street and off-street parking spaces (though people will opt for a free space where possible), and in Hong Kong the doubling of the cross-harbour tunnel toll (as a congestion control measure) was opposed less vociferously once it succeeded in reducing substantially tunnel queues and variability in journey time (these traffic benefits were relatively short-lived, however, as the economy expanded and traffic levels increased).

One theoretical objection to road pricing from a social viewpoint is that it favours people with higher incomes who are able to pay the high charges. While rationing by price may be regarded as socially or politically undesirable for an essentially public good such as road space, the alternative of congestion not only increases community costs in general, but discriminates against people who are short of time -- instead of rationing by price we have rationing by time. Both rationing mechanisms have their strengths and weaknesses; and writers such as Else (1986) and Starkie (1986) have argued that a better social and political compromise might be to have alternative networks in the city that are time- or price-rationed -- just as in France, Italy or Japan, motorists have the option of using motorways for inter-urban journeys and paying substantial tolls, or travelling "free" on the old road network. In a city such as Tokyo, for example, the high price/high level of service network could be delimited using the urban expressways and some major distributor routes, with a link-based charging system.

An often forgotten aspect of road pricing is the measure it provides of the importance to motorists, in money terms, of the journeys they make over the road network. Road pricing schemes could thus be designed explicitly both as a means of traffic restraint and as an indicator of demand for new road space -- plus a means of paying for it. The supplementary licensing scheme introduced in Bergen, Norway in January 1986 is designed primarily with this second objective in mind. A further aspect of importance -- although least well documented -- is the long-term effect of road pricing schemes. In a travel context, there is evidence to suggest that long-term price elasticities are higher than short-term ones, with respect both to petrol prices and bus fares (Goodwin, 1988), as people make more fundamental adjustments to their stock of capital goods and life styles. Apart from changes in travel patterns, we might expect to see road pricing leading to land-use changes. In the case of local pedestrianisation schemes, retail turnover often increases rather than decreases after the scheme's introduction, because of improvements to the environment. Road pricing is unlikely to confer such benefits over a wide area and it is probable, on balance, that it would add to pressures for decentralisation: in most North American and Western European cities this is probably perceived as undesirable, but in some very rapidly growing and crowded cities it may indeed be welcome.

We are thus beginning to see something of a divergence concerning the primary objectives of road pricing, on a geographical basis. In North America and parts of Western Europe, car ownership levels are already high, and congestion has been held within tolerable limits by traffic management, selective road building and public transport improvements, and a general process of city decentralisation. Particularly in North America, it is thought unlikely that road pricing will be adopted as a traffic restraint measure (Higgins, 1986; Elliot, 1986). Conversely, in Asia, South America and Africa, car ownership levels in most countries are still very low, public transport provision is usually good, cities are growing rapidly and pressures on the road network are likely to increase substantially; in such cases road pricing may be both an appropriate measure to control traffic levels and one that in time will become politically acceptable. Japan and parts of Western Europe lie somewhere between these two stereotypes.

On the other hand, some of these more car-saturated European or North American cities may come to apply road pricing for other reasons; we have already noted Bergen's use of a supplementary licensing system to finance new road construction. While traffic congestion itself may not be seen generally as sufficiently serious to warrant a full road pricing system, the growing environmental problems in some cities might provide the motivation, given that environmental improvements often require some major restraint that is needed to increase speeds on a road network (see Section 2) -- especially since vehicle charges could be related to engine characteristics and revenues used to repair damage caused to buildings and the health of the population. In such cases it would probably be necessary to widen the net of road user charges, to include goods vehicles and buses too: Rome, for example, now has the highest concentration of carbon dioxide in the world, and a number of firm restraint measures are being considered.

6. THE IMPLEMENTATION OF ROAD PRICING: AN ASSESSMENT

It is becoming clear that "road pricing" is no longer a single concept or policy, but a label attached to a wide range of different strategies that may be followed. This is, indeed, what is likely to make it successful.

6.1. A framework for development

A gathering of researchers concerned about the issue recently met in Oxford (1) and proposed the following approach which may be taken as a summary of the main themes in this report:

a) The problem. There is no longer a single dominating interpretation of the urban transport "problem". Some people put priority on relief of congestion in order to reduce the cost of time delays for passengers, cars, freight and public transport. Others stress environmental issues including pollution, as well as accessibility for non-car users. Road pricing can offer solutions for each of these problems; but they will be different solutions derived from different political assessments, requiring different price structures and charging levels.

b) Objectives. For the same reason, a variety of different objectives may be served by a road pricing system. These include:

- -- Economic optimisation by marginal social cost pricing;
- -- Reduction of traffic;
- -- Moderation of mode split;
- -- Provision of money for transport purposes;
- -- Institution of an information-providing system.

c) Policy alternatives. There are at least three radically different policy lines which are compatible with road pricing, namely:

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1. International Conference on Dynamic and Activity Based Approaches, Oxford Conference on Travel and Transportation, July 1988. This section acknowledges the views of participants in the Conference, and Carina van Knippenberg who summarised the discussion, though in this report we have added our own comments also.

i) Raising funds to increase road capacity;

ii) Rationing existing infrastructure to make optimal use of it, without providing for substantial increases;

iii) Improving the quality and reducing the price of public transport.

d) Reactions. Relatively little attention has been paid to the detail of travellers' behavioural responses to road pricing, yet these are central to the whole case. Reactions will include altering: time of day of travel; route; mode (including walking); origin-destination patterns and location; trip generation and suppression, consolidation, switching between members of a household. All these effects will vary in importance for different journey purposes, and in the short or long run.

e) Implementation. Practical issues to be resolved include:

-- Site location;
-- Optimal (or maximum politically acceptable) charges;
-- Selection of priority classes of traffic;
-- Fraud and enforcement;
-- Privacy and security;
-- Consistency with public transport capacity and objectives;
-- Indirect effects (e.g. employer refunding);
-- Monitoring and flexibility.

f) Research. There is no point in continuous repetition of the same sort of research studies. Nevertheless there will clearly be a case for:

-- Econometric assessment of charging levels;
-- Modelled forecasts of results (using tools that are capable of handling especially the constraints on household and individual adaption in the short run, and the dynamic transition from short- to long-run effects);
-- Market research to ensure that the total package of policy measures offered will be well received by the public.

6.2. Conclusions

Two questions were raised at the beginning of this paper:

1. **Why has road pricing not worked?**
2. **How could it be made to work?**

Our view is that the first question is phrased too harshly. It is strictly true that, so far, the sort of completely comprehensive, rational, optimal road pricing scheme based on marginal social cost outlined in the early studies, has not been fully implemented anywhere. Yet there have been many attempts to get good second-best systems based on practical interpretation of the logic of road pricing, and their importance should not be underestimated.

The case for road pricing depends on both the existing and likely future land use, traffic and environmental pressures, and the objectives of the politicians and planners in each city. It is possible that the range of acceptability of road pricing might be extended if dual price- and time-rationed networks were devised. Although few full-scale road pricing schemes have been implemented, we can conclude that:

-- Road pricing is better able to restrain traffic levels in congested areas than parking controls or car ownership restraint;

-- Road pricing enables higher car ownership levels to be absorbed than would otherwise be possible in a city;

-- Road pricing provides an indication of the economic demand for road space and a source of revenue for future road building or improvements to other parts of the transport system, or environmental improvements;

-- Road pricing schemes will be most effective when introduced in conjunction with other forms of restraint, where a good public transport system already exists or improvements are credibly planned as part of the road pricing package, and there is some scope for activity re-scheduling.

Road pricing has come a long way in the last twenty-five years. Instead of asking "Is it feasible?", we can now point to a strong economic and technical case for road pricing as one of a number of urban transport management measures. In behavioural terms too it clearly "works", but more practical experience of road pricing is needed before the approach will be assessed as dispassionately by the public as the pricing of on-street parking spaces is now viewed. Research can help, by further investigation of some of the theoretical and practical issues discussed in this paper. Above all, what is necessary is a better appreciation of the socio-political environment in which transport policy is formulated and implemented.

ANNEX

A REVIEW OF THE EFFECTIVENESS OF VARIOUS MEASURES TO CONTROL URBAN CONGESTION

Road congestion can either be reduced by increasing capacity or by lowering demand at peak times. Aside from constructing new road space, it should not be forgotten that significant increases in capacity can be achieved by introducing a number of traffic management measures, such as:

-- Urban clearways, along with loading/unloading and parking, are barred at peak periods;

-- One-way streets, which increase link capacity and reduce the number of conflicting movements at junctions;

-- Area traffic control systems, which enable traffic light settings to be adjusted to bring the pattern of capacity more in line with the pattern of demand.

Here we assume, however, that road capacity is fixed and we are seeking ways of containing, redistributing or reducing demand, rather than increasing supply.

We can identify five broad demand strategies for limiting traffic congestion:

1. Restraints on the use of motor cars (both road pricing and physical restraints);

2. Restrictions on the ownership of motor vehicles;

3. Restraint through parking controls;

4. Attracting motorists out of their cars, through improvements to alternative transport systems;

5. Activity rescheduling, to spread more evenly the demand for travel over the day.

1. Controls on ownership

Car ownership levels can either be regulated directly or controlled through the imposition of high levels of taxation. In Bermuda, for example, there is a limit of one small car per household, while in Japan residents of larger urban areas have to demonstrate that they have a residential parking space before they can purchase a car. Much more common, however, is a policy of high taxation on ownership, through a first registration tax and an annual licence fee. Apart from providing a source of government revenue, such taxes are used directly to restrict the level of car ownership in countries such as Hong Kong, Singapore and Korea (although, as the latter has found, this causes problems once a domestic car industry becomes established).

The effects can be quite dramatic: in Hong Kong a trebling of annual licence fee and a doubling of first registration tax in 1982 led to a 25 per cent drop in car ownership over the following two years (Dawson and Brown, 1985). The problem is that as a means of controlling traffic in congested areas, it is a very blunt instrument: it is the least intensively used cars owned by poorer people which are given up first. The inappropriateness of the policy measure can be seen in Hong Kong, where a 14 per cent reduction in licensed cars in the first year (from 1982 to 1983) led to a nearly 20 per cent drop in traffic in the uncongested New Territories and very little change in traffic levels on the most congested parts of the network -- in some areas traffic continued to increase (Transpotech, 1985).

In a situation of rising incomes and increasing population, however, the effectiveness of such fiscal constraints are constantly being eroded, as is evidenced in Singapore where there has been strong upward pressure on car ownership levels in the last few years (Cochrane et al. 1986). Also, there is some evidence both in Singapore and Hong Kong that some people may have registered small goods vehicles at reduced tax rates and then used them mainly for private travel purposes.

2. Restrictions on the use of cars

Controls on car use are much more varied, ranging from various forms of taxation on use to restrictions on when or where vehicles can be driven. Taxation can be applied to a range of variable costs of use, such as tyres and spare parts, or petrol. The problem with the former is that they may lead to lower standards of maintenance without significantly reducing use -- and in fact aggravate congestion by increasing the number of breakdowns and accidents.

Petrol tax is widely used as a general revenue-raiser and in some cases as a means of relating payment to use (i.e. recovery of road track costs) or to control congestion. It is probably a reasonable proxy for payment of the road track element of costs -- and countries such as the United Kingdom and The Netherlands have given serious consideration to raising road building and maintenance revenue in this way, rather than through an annual licence fee (e.g. Dix and Goodwin, 1981) -- but it does not closely match the external costs of congestion. Although petrol consumption does increase for most vehicles in crowded conditions, the majority of mileage is not generated at the busiest times or places. Some indication of this is again evident from the Hong Kong road pricing assessment (Harrison, 1986) where road pricing charges would affect about 50 per cent of car journeys, but only around one third of car mileage, because average trip length is greater in the rural areas. In the United Kingdom too, the petrol shortages in 1973-74 led to much larger reductions in traffic in the evenings and at weekends than during the day.

Some consideration has been given to varying fuel taxes for different areas of a country or different classes of user, but there are problems of leakage from one group/area to another, and such a system cannot differentiate between times of day of travel. Further, a high fuel tax would tend to encourage purchase of smaller and more fuel-efficient cars, but this would not necessarily affect congestion levels -- it could actually reduce capacity slightly if vehicle performance dropped significantly.

Controls on moving vehicles are of two types: those which bar movements on parts of the network at specific times or places, and blanket restrictions on car use throughout an area. Although such measures restrain traffic, they are often introduced for environmental reasons, rather than to control congestion per se. Many cities now have pedestrianised areas, from which most vehicles are restricted for much of the day, and in a few places such as Gothenburg (Elmberg, 1972) there are more elaborate measures to discourage through traffic from entering an area. The more physical forms of restraint tend to be self-enforcing and can be very effective locally, but may add to traffic problems in adjoining areas and may take many years to implement.

A variant on the complete banning of vehicles at certain times or places is to control the volume of traffic entering a link in order to avoid densities reaching a critical level, either through metering or by limiting vehicle types (e.g. reserving a lane for buses and car pool vehicles on a freeway). This capacity optimisation technique has been quite successful, but attempts to extend the idea to use a time penalty as a general means of restraint have not been successful or well received. In Nottingham, for example, such a scheme was abandoned because motorists were not prepared to wait for long periods at red lights and incur time penalties (Vincent and Layfield, 1977).

Occasionally the closure of a link of a network for repair, or because of sewage or underground railway construction, provides an opportunity to monitor how motorists would respond if faced with a deliberate restraint policy. One example is provided by the closure of a road bridge in Central York (Dawson, 1979), where the monitoring study did find evidence of significant shifts in travel behaviour. The main effect was route switching (to other bridges) but followed closely by changes of at least ten minutes in the time of travel; there was no evidence of mode switching by motorists. Many motorists appeared to have some flexibility as to the timing of their journey (except for school escort trips), and for shopping and personal business trips there was some evidence of considerable changes in the timing and destination of travel. In the case of morning peak journey-to-work departures, there was a general shift towards an earlier start time; this preference for an advance of the working day is corroborated by other studies dealing with the impact of flexi-time on work travel patterns (Section 4.5).

A few cities, such as Lagos (Ogunsanya, 1984) and Athens (Matsoukis, 1985), have introduced some blanket restrictions on car use, by limiting the proportion of the car stock that can be used in the city on a given day, by banning vehicles with different licence plates on alternate days (i.e. last digit odd/even in Lagos and 1-5/6-0 in Athens). New Zealand introduced a similar scheme for weekend travel during a period of petrol shortages (Johnston et al. 1983). Although some reductions in traffic level have been achieved in the short term, these have not usually been as substantial as hoped for, because motorists postpone trips, pool cars and switch to taxis rather than buses. Over the longer term, people buy second cars, even forge number plates and change travel behaviour in ways which makes the scheme ineffective.

Evidence from "road pricing" studies

Despite high taxes on car ownership in Singapore, congestion was becoming very serious in the central area, and in 1975 the Government decided to introduce an Area Licence Scheme (ALS) to reduce the number of private cars entering this area by charging an entry fee in the morning peak period (now widened to 7.30 a.m. -- 10.15 a.m.) for cars carrying less than four occupants. Low-occupancy vehicles are required to purchase and display a special licence disc valid for one day or one month; taxis are charged at a reduced rate. As part of the scheme, other changes were made in the provision of transport supply including:

-- Upgrading of roads around the edge of the cordon area, to provide a by-pass route;

-- Increases in central area parking charges, to further discourage use;

-- Provision of park and ride facilities, with cheap parking at the periphery of the restricted area and a shuttle bus service penetrating it.

Details of early results from the ALS scheme are provided in Holland and Watson (1978); these have largely been sustained since (see Behbehani et al. 1984) and demonstrate that very significant changes in the level and pattern of traffic can be achieved through direct pricing of moving vehicles.

During the morning restricted period, the total number of private cars entering the licensed area fell by over 70 per cent in 1975; by 1982 this had risen slightly to 64 per cent below pre-ALS flows. Among people who had previously driven to work in the restricted area, approximately two-thirds of displaced drivers changed their mode of travel, and the other third modified their travel time to avoid the restricted period -- in most cases by advancing the trip to before 7.30 a.m. Of those who changed mode, approximately equal numbers switched to buses, or joined or formed a car pool; over time, with changes in the composition of the labour force, the percentage travelling by bus has increased. For people previously travelling through the restricted area, the proportion of trips made in a car fell only slightly (from 53.5 per cent to 50.0 per cent), but more of these were in car pools; most motorists either changed journey time or detoured around the restricted area.

Part of the success of the scheme lay in the willingness of the Government to modify elements of it in the light of experience. The initial cut-off time of 9.30 a.m., for example, resulted in considerable congestion at the end of the charging period, until this was extended to 10.15 a.m. Similarly, park and ride did not prove a success and buses were redeployed on routes directly linking housing estates with the restricted area. One unexpected limitation of the scheme was that the morning restrictions had very little impact on evening peak travel, which has remained highly congested and is now double the morning flows. Clearly, to achieve its objective, road pricing charges have to be applied throughout the working day.

A similar pattern of responses was forecast in a study of the likely impacts of introducing electronic road pricing in Hong Kong; the study used a mixture of exploratory social research, stated-preferences surveys and disaggregate modelling techniques (Harrison et al. 1986). Motorists who modified their behaviour in response to road congestion charges were likely to change mode or change time of travel, in the ratio 2:1. Both Singapore and Hong Kong have rather special conditions, however, which may mean the results are not directly transferable to other cities; the road networks are particularly crowded (over the whole Territory of Hong Kong, there is one vehicle for every 3.5 metres of road) and the public transport networks offer a range of alternatives with high levels of service. In less extreme situations we might expect the pattern of responses to be modified to some extent.

Such differences were observed in a stated-preference study of motorists' probable responses to a peak period surcharge on cross-river facilities in the New York area (Levinson et al. 1980); this covered both work and non-work journeys and asked for responses to different toll increases on only one, and all river crossings, respectively. Where route switching was an option, this was about twice as popular as changing mode or the time of travel. But when this option was removed, then "take public transport" was slightly more popular than "change time of travel", with "not make trip at all" a close third (and particularly applicable to non-work journeys). Changing travel time appeared least sensitive to price increments, while use of public transport was particularly sensitive to price of car travel. There are thus some interesting similarities and differences compared with the South-East Asian experience.

The limited evidence suggests, therefore, that road pricing would lead to significant modifications in travel behaviour and produce the necessary reductions in congestion, as well as providing large net savings to all road users (in the Hong Kong case, of the order of £70-85 million a year).

3. Restraint through parking controls

Probably the most widely applied and successful means of restraint (in both engineering and political terms) has been the development of parking controls. In the early days of parking management the method was seen primarily as a means of increasing road capacity, but in many cities it has successfully made the transition to being a method of restraint, which is both time- and space-specific and imposes a charge which (unlike fuel tax) is related to a specific trip.

There are several aspects to parking control, including the number of spaces, the charge, the times of day at which parking is permitted and the maximum duration. In areas with high demand for car use, capacity restraint seems to be more effective than price restraint (i.e. the worry of not being able to get a space is more important than its cost). Certainly in Hong Kong, which has the highest density of cars in the world, motorists reported being more deterred from using their cars by the absence of spaces rather than, say, the cost of parking or the level of traffic congestion (Jones, 1984).

Some of the ways in which a parking capacity constraint might affect travel in one London suburban town centre were explored in a recent survey of motorists who parked in the Outer London area of <u>Kingston</u> town centre (Bradley et al., 1986). Respondents were asked what they would do on the next occasion if they had found they could not park at all in the centre at that time on that day. They were offered five responses:

i) Travel by bus;
ii) Travel by another mode (rail, walk, etc.);
iii) Travel to another centre;
iv) Travel at another time of day;
v) Postpone or cancel the trip (travel less often).

For work journeys, mode switching was the predominant response, followed by time switching -- though, implicitly, we are talking about quite major changes in travel time (if small adjustments, say of fifteen minutes, were included the proportion opting to re-time would probably be much higher). For non-work journeys, "re-timing", "change destination" and "trip suppression" were relatively more common responses. Overall, "shop/other" appeared to be the most flexible activity. The response "none possible" was highest for part-time work journeys, with 17 per cent reporting no alternatives.

Despite its apparent success, however, there are a number of significant limitations of parking control as a means of restraint:

- -- Public authorities often have direct control over only a small proportion of spaces;

- -- Where parking is scarce, policies usually favour the short-term parker (to use the space more efficiently and allow customers access to local businesses); but this increases the volume of movement on the road network and so may increase traffic levels through the day;

- -- Shortages of parking spaces may increase local traffic levels because of:

    i) Motorists cruising and looking for a space.

    ii) An increase in serve-passenger trips: four trips replace two as people are dropped off and picked up, instead of attempting to park.

    iii) The use of the road network as a mobile parking lot: in Hong Kong some companies reported employing chauffeurs who would drive around while the executive was in his meeting if no nearby space could be found, and similar practices have been reported in the United Kingdom for short duration shopping trips.

- -- Parking difficulties may also lead to high levels of illegal parking (either staying too long or parking on restricted sections of road) and so cause enforcement problems. In this respect, the use of wheel clamps seems to be a more effective deterrent than parking fines, because of the delay and inconvenience it imposes on the busy motorist, but clamped vehicles may themselves be a cause of congestion;

-- Finally, parking restraint only affects terminating, not through traffic. As the former is more effectively controlled, the reduction in congestion may cause long-distance traffic to re-route through the area.

Some of the limitations of parking policy can be seen in Central London where, as public parking controls have been tightened, a greater proportion of traffic in the area either has a private parking space or is through traffic -- the released capacity thus being taken up by traffic not affected by such controls.

The ineffectiveness of parking restraint as an efficient control on congestion is evident in a study carried out by the United Kingdom Transport and Road Research Laboratory which concluded that, in terms of a full cost benefit assessment, parking restraint achieves only at 35 per cent of the benefits of a full road pricing scheme (Maycock, 1972). Supplementary licensing along the lines introduced in Singapore has about 70 per cent of the benefits of a full scheme.

4. Improvements to alternative modes

Rather than "forcing" motorists off the road network, another approach is to encourage them to leave their cars at home by providing an alternative transport system which is more attractive than using the car. Such a philosophy has a much higher level of public support than a policy of restraint, but it is usually much less effective -- people think it will encourage others to change their behaviour, leaving the road freer for them!

During the 1970s in England, for example, a series of bus demonstration projects were carried out to show how bus improvements and priorities could attract people from their cars. In some cases patronage did rise substantially, but most of the generated traffic came from non-car owners. Heggie (1977) reviews much of the evidence and concludes that:

-- Bus priorities (in the form of bus lanes or intersection priorities) lead to relatively small improvements in mean travel time (i.e. savings of one to three minutes) and have very little effect on patronage, with no evidence of a shift from car driver to bus modes;

-- Fare reductions can stimulate bus travel, but very little of this represents diversion from the car; most is generated travel or diversion of walking trips;

-- Bus service innovations such as express buses or dial-a-ride services may attract significant numbers of passengers but, again, few are former car drivers;

In most cases, even park-and-ride services have not been as attractive to motorists as originally envisaged.

These conclusions seem very discouraging in terms of the bus providing a serious competitor to the car in urban areas, although some of the experiments (e.g. free fares in Rome) lasted only a few days.

The attractiveness of rail and underground services seems much greater and more certain. Cities with a significant rail network also tend to be larger and have more severe congestion and parking problems; however, it is difficult to separate out the relative importance of these "push" and "pull" factors. Certainly in London, though, when large changes in public transport costs were introduced the cross-elasticities between car and underground seemed to be quite high. Between 1981 and 1982 (when the fares doubled), underground commuting decreased by 14 per cent and private car trips increased by a similar amount; the following year, when LT fares were cut and the zonal fare system was introduced, underground commuting increased by 14 per cent and private car commuting decreased by between 9 per cent and 15 per cent ("Transport Data for London").

Bus and rail represent extremes in terms of investments and what is not yet certain is how successful intermediate options are at attracting motorists (e.g. air-conditioned mini-buses, buses running on separate rights of way, or light rail systems). Preliminary observations of a new busway in Adelaide, for example, indicate that patronage has been considerably higher among motorists than anticipated; but they have tended to use it like a railway, preferring to drive to the stations on the busway and parking there rather than picking up a (lower frequency) busway service from their local stop.

Mogridge (1986) suggests that the public transport networks are of more fundamental importance than is normally realised, because average road speeds in big congested cities are in equilibrium with the average direct-journey speeds achieved on the appropriate mass-transit network, both within and to the city centre. He argues, therefore, that the public transport system is the key influence on road network congestion and improvements to the former would be more successful at reducing congestion, than new road building or the imposition of road pricing. Anecdotal evidence from the Hong Kong study (Jones, 1984) lends support to this notion, with senior business people reporting taking the mass transit railway to meetings where this resulted in shorter journey times than travel by car.

There are clearly limits, however, as to how far public transport trips can substitute for car trips (at least in the eyes of motorists), either spatially, temporally or by journey purpose. A study carried out for London Transport in the mid-seventies into the possible effects of petrol rationing on motorists' travel, found that although most work journeys would continue to be made, about one-third of the other journeys which could no longer be undertaken by car would be suppressed entirely; these tended to be the longer social/recreational journeys, made during off-peak periods. Only about one-half of the trips no longer made by car would transfer to public transport (Heggie, 1977).

We have already noted the incentives for car pooling that have been introduced as part of some traffic restraint measures. Other modes which compete in part with car use are walking and cycling. Walking is still the dominant mode of travel in many cities (e.g. Mitchell and Stokes, 1982), although often neglected in traffic studies. Recently the bicycle has seen something of a revival in some European and North American cities, helped by a network of priorities and a positive public attitude towards the environmental and physical exercise benefits to be gained from more widespread use of this mode (Brog and Otto, 1981; Quenault, 1981).

5. Re-timing of destination activities

A final approach to the problem of congestion is to use the existing road space more efficiently by spreading travel demand over a wider time period. The spreading of the peak occurs already, as people choose to modify time of travel from their personal optimum to save on in-vehicle time, but the process can be helped by changing the times at which activities start and finish, or by allowing some leeway in these times.

The introduction of flexible working hours is the best example of activity-led re-scheduling. Perhaps surprisingly, a review of flexible work hour studies (South Australia Energy Research Associates, 1983) concluded that:

> "The main benefits which have been seen to flow from a more flexible approach to working hours have not been transport-related. Temporal flexibility in the work place is commonly advocated first and foremost as a counter to declining productivity and decreased job satisfaction."

Nevertheless, such schemes do appear to have significant impacts on peak travel, including:

1. A spreading and flattening of peak traffic on both the road and public transport networks;

2. Association with 1), faster in-vehicle travel times (sometimes offset by longer waits for public transport users who now travel outside peak periods) and more comfortable journeys by bus or train, with a higher probability of obtaining a seat;

3. Mixed effects on mode choice, depending on local circumstances;

4. A marked and consistent shift towards earlier start and finish times.

The introduction of flexible work hours at government offices in Ottawa had a dramatic impact on the distribution of arrival and departure times (Transportation Research Board, 1980). There was a reduction of peak loads in excess of 50 per cent and a tendency to arrive earlier and depart earlier than before. Studies in the United Kingdom have found similar results. Following the introduction of flexi-time at a large government office in north-east England (employing some 10 000 people) peak fifteen-minute vehicle movements declined by about 35 per cent, which was sufficient to eliminate local congestion. The scheme also enabled the bus company to reduce peak vehicle requirements in the area by 20 per cent (Traffic Advisory Unit, 1978). A study in north-west London also found that peaks were flattened and start times brought forward after the introduction of flexi-time (Foyster and Durrant, 1979) -- but here this had the unfortunate effect of making the new (lower) office peak coincide more closely with the commuting peak on the nearby arterial road network.

The extent to which people are willing to change their work hours is limited in some countries by restricted shop opening hours or the fixed pattern of school hours. In the United Kingdom we find that about twice as many children are taken to school by car as return home by that mode, because work and school start times coincide, whereas in most cases finish times do not. Any change in school hours, therefore, would affect a proportion of work journeys as well and because of this any attempt to separate morning work and school peaks is likely to spread traffic less than would be expected from a simple examination of journey purpose profiles. Despite this cautionary note, time management of land uses seems to offer considerable potential for spreading traffic peaks and making better use of both private and public transport networks (e.g. see Jones et al. 1987).

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BELGIUM

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INCOME AND EXPENDITURE IN BELGIUM'S ROAD SECTOR:
AN ATTEMPT TO DRAW UP A ROAD ACCOUNT FOR 1986

SUMMARY

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PREFACE

Given both the existing budgetary constraints and the current endeavours to establish an integrated transport policy, it is clearly of interest to the Minister of Public Works and to the Road Fund to have a sufficiently precise idea of the situation with respect to the Belgian road account, the aim being to determine all the various items of income and expenditure with respect to the infrastructure and road traffic for all users in Belgium.

This analysis is therefore being carried out in order to estimate the degree of financial autonomy of this mode of transport or, more precisely, to determine whether or not the income exceeds the expenditure, as is often asserted.

The paper as such may be developed further at a later date.

INTRODUCTION

In Belgium, road traffic plays an increasingly important role each year in terms of services supplied, investment, employment, technology and exports.

As at 31st December 1986, the road vehicle population totalled 4 035 077 units, with cars accounting for 3 360 313 or 83.3 per cent.

The total increased by 7.6 per cent from 1981 to 1986, the growth in the number of cars being about the same (7.1 per cent). Moreover, the forecasts of the Bureau du Plan indicate that this growth will continue up to the year 2000.

Accordingly, Belgium is producing nearly 1 million motor vehicles each year, some 10 per cent of European output, at a total value of BF 300 billion. Over 10 per cent of the production is exported.

The number of jobs directly or indirectly dependent on motor vehicles is nearly 800 000.

While these macro-economic data are important in themselves, attention must also be drawn to the fact that the road sector produces tax revenues which totalled more than BF 200 billion in 1986, or more than 15 per cent of the central government's overall tax revenues [1].

It therefore seems important to us to stress this factor as there is tight control of public funds at the present time and any government expenditure is subject to careful scrutiny.

However, while the tax revenues are high, the expenditure on roads must also be determined with sufficient precision, so our aim is to ascertain both income and expenditure in the road sector as rigorously as possible.

The computation of the road account is based on the determination of the items of income and expenditure generated by the infrastructure and road services.

This can be done in accordance with a conventional approach whereby the ratio is established between the amount of direct income and expenditures in connection with this mode of transport (Part 1).

With a view to making fuller use of the findings, it would seem to us that the calculations should be broadened to include indirect income and costs (Part 2).

Considerations in connection with indirect income and costs might be examined in greater detail, but that is not our purpose here. In the overall computation of the road account, only the most representative factors, the least open to question, will be included.

It would also seem important to comment on the results obtained since they will be partly the outcome of estimates (see comments and conclusions).

Lastly, with a view to establishing an integrated transport policy and making use of the results of the enquiries on the basis of the same methodology, the same calculations should be carried out for the other modes, namely the railways and inland waterways.

It is along these lines that we should subsequently like to extend our research.

I. DIRECT COMPUTATION OF THE ROAD ACCOUNT

In order to draw up a State road account, it is first necessary to determine, as fully as possible, precisely which income and expenditure items are to be included:

1. INCOME

To calculate the yield of taxes specific to the road sector, account must be taken of the revenues arising from the purchase of vehicles and their ownership and use, irrespective of whether these revenues accrue to the State itself or to others. What do such revenues consist of?

Account will initially be taken only of factors relating to motor vehicles, i.e. almost 85 per cent of the vehicles on the roads [2], and the data will subsequently be extended to cover road traffic as a whole.

1.1. Taxes on the purchase of vehicles

VAT and luxury tax

The tax system in force relates to the purchase of cars and breaks, the user being the person employing the car or break for his personal use or for business activities other than the sale of such vehicles.

In practice, the VAT on sales in Belgium is calculated on the price actually paid to the seller, account being taken of any reductions granted at the time of delivery. The rate of VAT is 25 per cent.

Cars (but not breaks) with an engine cylinder capacity exceeding 3 000 cc or a rating of over 116 kW are also subject to a special tax of 8 per cent on luxury goods which is calculated with reference to the same amount as that used as the basis for VAT [3].

Vehicle registration tax

A vehicle cannot be used on public thoroughfares without being registered, at which time the registration tax has to be paid [3].

The following bases have been adopted to calculate the tax revenues arising from VAT on car purchases:

For new cars:

-- Number of new registrations by type of vehicle, which can be obtained each day from the Ministry of Communications (Transport Department);

-- Calculation of an initial annual average price of the selling prices in force for each category of vehicle, no account being taken of optional equipment;

-- Calculation of a representative amount of 25 per cent VAT and, where applicable, an additional luxury tax of 8 per cent.

For second-hand cars:

-- Extrapolation of the data from the INS national accounts under "Private consumption -- second-hand cars";

-- Application of the VAT rate.

The amounts calculated for 1986 were respectively BF 31 billion for new cars and BF 5 billion for second-hand cars plus 8 billion in registration tax revenues (figure provided by the FEBIAC), or a total of BF 44 billion.

This amount is therefore a minimum since no account has been taken of the VAT on optional equipment at the time of purchase which is very attractive to the public.

There is still some uncertainty as to the precise figure for registration tax revenues.

1.2. Road taxes

The road tax varies according to the taxable horsepower of the vehicle [4].

The scale is reviewed each year in the light of changes in the index.

A supplementary tax has been in force since 1st July 1983 for cars, brakes and minibuses equipped for LPG.

Road tax data are published each year by the Ministry of Finance and are given in the breakdown of current income.

Revenues in 1986 totalled BF 20 520 billion [5].

1.3. VAT and excise duties on motor fuels

Each year the Fédération Pétrolière records the deliveries for domestic consumption of oil products [6]. As the unit is the metric tonne, the statistics on ordinary and extra petrol, diesel and LPG have to be converted into litres.

Since the average annual prices, including VAT, of these products are published in the annual report of the Fédération Pétrolière, the amounts of VAT on motor fuels can be calculated, the rates per litre being:

-- BF 5.046 for ordinary petrol
-- BF 5.286 for extra petrol
-- BF 3.676 for diesel
-- BF 2.164 for LPG.

The same approach is adopted for excise duties, the rates per litre being:

-- BF 11.20 for ordinary and extra petrol
-- BF 5.25 for diesel.

Overall, tax revenues arising from motor fuel consumption therefore amounted to BF 30.8 billion for VAT and BF 56.926 billion for excise duties, i.e. a total of BF 87.768 billion [7].

1.4. Taxes on insurance premiums

The "Union Professionnelle des Entreprises d'Assurance" keeps records of the total value of motor vehicle insurance premiums, the last figure available being for the year 1985.

For all insurance companies together, the premiums for third-party liability in 1985 amounted to BF 48.490 billion (of which BF 39.738 billion for passenger transport and

BF 1.317 billion for two-wheelers), and therefore to BF 7 434 560 for hire or reward transport, while the premiums for complementary motor vehicle insurance totalled BF 14 700 033.

As the value of premiums has increased by 5 per cent per year since 1980, the two preceding amounts can be estimated for 1986 at BF 50.915 billion (BF 43.109 and BF 7.806 billion) and BF 15.435 billion.

These amounts include the annual tax on insurance policies.

As regards motor vehicle insurance policies it should be pointed out that, while the specific taxes amount to only 9.25 per cent with respect to both compulsory third-party or complementary insurance, it is in fact mainly the supplementary contributions which increase the tax burden.

Table 1 shows the real tax situation [8]:

Table 1

	Pure tax	Contribution		Red Cross	Total
		INAMI	Fund for Handicapped		
	%	%	%	%	%
Third party -- motor vehicles (+ two-wheelers, passenger transport)	9.25	10	7.5	0.25	27
Third party for taxis for transport for hire or reward	9.25	5	7.5	0.25	22
Complementary motor vehicle insurance	9.25	--	7.5	--	16.75

The following tax revenues will be obtained:

	BF billion
-- Third party (two-wheelers + passenger transport):	11.639
-- Third party (transport for hire or reward):	1.717
-- Complementary motor vehicle insurance:	2.553
	15.909

This amount is broken down between pure taxation and resources for the INAMI, the Caisse d'allocations pour handicapées (fund for the handicapped) and the Red Cross.

1.5.,1.6.,1.7. Tax yield from maintenance and repairs and sales of spare parts, accessories, tyres

The data published by INS provide the statistical sources for the activities under these three headings. Unfortunately the most recent data are for 1984, so these figures have been adjusted in the light of the increase in the total motor vehicle population from 1984 to 1986, growth in the consumer price index and the increase in the number of cars during the same period, all figures being taken from the INS yearbooks.

The amounts obtained were as follows:

-- Maintenance and repairs: (including spare parts and accessories)	36.489 x 103.87 x 106.2 = 40.251 billion
-- Sales of spare parts:	43.485 x 103.87 x 113.4 = 51.221 billion
-- Sales of tyres:	10.863.3 x 103.87 x 113.4 = 12.796 billion

Given that these amounts do not include VAT and that VAT rates are respectively 19 per cent for the first two items and 25 per cent for sales of tyres, the following amounts for tax revenues were simple to calculate (in BF billions):

-- Repairs and maintenance:	7.648
-- Spare parts:	9.731
-- Sales of tyres:	3.199
Total	BF 20.578 billion

It should again be pointed out here that the amount for this item can be considered to be a minimum in view of the existing tax evasion.

1.8. Car radio tax

The amount here is published in the records for the ways and means budget, and in 1986 these taxes totalled BF 1.6 billion [9].

1.9. Fines for traffic offences

Fines in 1984 were estimated at BF 2.2 billion [10].

Given the increase in the motor vehicle population from 1984 to 1986 (3.87 per cent) and the fact that the fine has increased from BF 500 to BF 750, the figure for 1986 is estimated to be BF 3.4 billion.

1.10. Technical inspection

The Ministry of Communications (Transport Department) publishes the number of technical inspections carried out each year. The minimum price amounts to BF 610, including VAT at 19 per cent, so the tax revenue can be calculated to be BF 152 million for 1986.

1.11. Driving permit

The driving permit has a tax stamp attached to the value of BF 500, the tax being levied by the commune. The number of driving licences issued is published each year by the Ministry of Communications after a certain time-lag.

In order to update the amount, the accurate figure for 1984 has been adjusted to take account of the increase in the motor vehicle population between 1984 and 1986.

The revenue for 1986 therefore totals BF 70 million.

1.12. Customs duties

Foreign trade data are published annually in the INS yearbooks, and customs duties on imports from outside the EEC are recorded for the different types of car. It is assumed that only a marginal number of cars are imported into a non-EEC country with Belgium as the final destination. The customs duties for 1986 totalled BF 2.222 billion.

1.13. Miscellaneous income from taxes and charges

Parking meters:

The figure for income from parking meters is not known but the cost of operating them has been estimated to be about the same as the charges collected.

Tax on car prototypes

Approval of driving schools

The above two sources provide income of some BF 152 million [11].

1.14. Summary of income from motor vehicle traffic in 1986

	BF (billion)
1. Tax on vehicle purchase (VAT and registration tax)	44.000
2. Road tax	20.520
3. VAT and excise duties on motor fuels	87.768
4. Insurance premiums	15.909
5., 6., 7. Tax yield from maintenance and repairs, purchases of spare parts and tyres	20.578
8. Car radio tax	1.600
9. Fines for traffic offences	3.400
10. Technical inspections	0.152
11. Tax on driving permits	
12. Customs duties	2.222
13. Miscellaneous income from taxes and charges	0.152
Total	BF 196.301

1.15. Total income from the road sector

Since the car population accounted for 83.26 per cent of the total number of vehicles in 1986 [12], overall income for that year is estimated at BF 214 billion insofar as this new total is obtained by means of extrapolating the values under those headings relating solely to the tax revenues generated by the motor vehicle sector (items 1, 2, 5, 6, 7, 11, 12 and 13 in the above list).

This may seem to be a somewhat summary working method but it will be retained since it involves only a small overall percentage.

2. EXPENDITURE

Expenditure on the road sector must be determined at the level of the central, regional and communal authorities.

2.1. Central government expenditure

According to reports by the Chamber of Representatives of 3rd December 1986 (pp. 47 and 48), as set out with reference to the public works budget for 1986, the Road Fund expenditure was as follows (in BF millions):

-- Personnel (chapter 51)	2 615 [13]
Operation (Chapter 52, excluding Article 525.01)	385
-- Financing:	
Expenses (Article 525.01)	1 000
Interest (Article 525.02)	52 823
Amortization (Article 560.01)	49 399
Total	106 222
-- Investment and maintenance Liquidation (Chapter 53)	27 878
-- Miscellaneous	112
General total	BF 134 212 million

2.2. Expenditure by regional authorities

Given the responsibilities of the regions with regard to subsidised works, they can participate in the financing of roadworks carried out by the communes, works which relate to road construction and improvement but also to allied activities such as draining.

The Flemish-speaking region estimates the amount spent on roadworks in 1986 at BF 1.6 billion [14].

The Walloon region estimates the amount of such work at BF 0.455 billion [15].

The remaining difficult problem is to determine the amount for the Brussels region.

2.3. Expenditure by the communes

The information currently available as regards the use of communal budgetary resources cannot be used as a basis for determining the overall amount allocated to roadworks, so reference will be made to the funds allocated by the "Crédit Communal" to such works.

In 1986, total subsidies amounted to BF 0.430 billion and total loans for roadworks to BF 8.642 billion.

2.4. Summary of expenditure (in BF billions)

-- Central government expenditure			134.212
-- Flemish region:	1 600		
Walloon region:	455		
Brussels region:	--		2.055
-- Communes:			9.071
Total		BF	145.338 billion

This overall amount for expenditure in the road sector must be regarded as an underestimate because it does not include expenditure by the communes from their own budgets or expenditure by the Brussels region, although such expenditure does not attain sufficiently high levels to make our findings invalid.

3. THE BELGIAN ROAD ACCOUNT

In the light of the foregoing estimates, the Belgian road account can be set out as follows;

$$\frac{214 \text{ billion}}{145 \text{ billion}} = 1.48 \text{ or } +/- \ 1.5$$

In other words, for every franc spent on the road sector by central, regional and communal authorities, the State receives BF 1.50 for the overall road transport services supplied.

That is the conclusion to be drawn from the direct computation of the Belgian road account.

II. COMPUTATION OF AN OVERALL ROAD ACCOUNT

Section I concerning the direct computation of the road account adopted a sectoral viewpoint and, with a view to covering the impact of the existence of the road sector on the economy as a whole, the object now is to describe developments at the level of the income as accounted for this time by the tax revenues from the Road Fund loans and also at the level of expenditure in terms of the cost of road accidents. It would seem essential to take account of these externalities.

1. TAX REVENUES FROM ROAD FUND LOANS

The previous section (paragraph 2.1.) showed that the interest credited to the expenditure account of the Road Fund Budget totalled BF 52 823 million in 1986.

The rate of witholding tax on income from movable assets is 25 per cent and on this basis, the State's tax revenues would amount to BF 13.205 billion. However, this estimate is not very reliable as the actual rate is that calculated for household incomes as a whole.

Accordingly, with reference to the average rate of tax on households [16] of 18.6 per cent, it can be seen that public purse receipts amount to BF 9.825 billion.

However, this amount is an underestimate since it is clearly not low-income households that contribute to the State Funds, so a higher rate of tax must in fact be adopted. For want of a better estimate, the average of the two preceding results will be adopted, i.e. BF 11.515 billion.

2. THE COST OF ROAD ACCIDENTS

Road traffic accidents are a source of substantial economic losses and great physical and mental suffering. The costs to which they give rise cannot be ignored, and these have been calculated precisely by Mr. P. Dubus for 1983. These socio-economic costs include [17]:

-- The cost of medical and hospital care given to casualties;

-- Material damage;

-- Mental suffering of casualties and close relatives;

-- Expenditure on road policing, emergency services (fire brigade, civil defence and red cross);

-- Legal costs to be borne by those liable;

-- Lost production both now and in the future owing to the death or incapacity to work of members of the labour force involved in accidents;

-- General expenses of insurance companies.

It should be noted that no account has been taken of the time wasted for road users who are not involved in the accident (time wasted through congestion and provisional deviation of traffic). Nor is account taken of costs relating to preventive measures.

2.1. Number of road accident casualties

The numbers of road casualties are published in the INS statistical yearbooks with a breakdown by slightly injured, seriously injured and killed. The data for 1983 are shown in Table 2.

Table 2

	Killed	Seriously injured	Slightly injured	Total
Men	1 507	12 624	37 097	51 228
Women	583	5 603	23 539	29 725
Total	2 090	18 227	60 636	80 953

The 1986 statistics for the three types of casualty are respectively 1 943, 17 584 and 62 632, a total of 81 812 road accident casualties which therefore shows a 1 per cent increase on the figure for 1983.

Since this increase is attributable to a rise in the number of slightly injured, it will be assumed that the cost of road accidents remained the same over the period 1983 to 1986.

2.2. Cost of medical, pharmaceutical and hospital care

These costs were estimated by the INS (after a time lag) on the basis of the average cost of care given to persons injured while working in public transport undertakings, and a price index has been used in the calculations.

Expressed in 1983 prices, the average cost per casualty for medical, pharmaceutical and hospital care can be estimated to be as follows:

- -- Killed: BF 106 000
- -- Severely injured: BF 179 000
- -- Slightly injured: BF 10 000

These amounts are multiplied by the number of casualties shown in the general table and the overall total is BF 6 090 million.

2.3. Material damage

The amount for claims met by insurance companies is estimated at BF 15 215 million [18].

The amount of material damage for which compensation is not paid is estimated to total about BF 16 000 million.

Accordingly, the total cost of material damage caused by road accidents in 1983 can be estimated to be about BF 31 215 million.

2.4. Mental suffering inflicted on casualties and close relatives

Mental suffering is evaluated on the basis of the compensation granted in this connection by Belgian courts in recent years [19].

The amounts given below are averages and may differ appreciably from those recorded in individual cases.

Expressed in 1983 prices, the average cost of mental suffering per casualty can be estimated as follows:

-- Killed:	BF 400 000
-- Severely injured:	BF 100 000
-- Slightly injured:	BF 5 000

In the case of those killed, the amount shown represents the average compensation granted to spouses, parents, children and relatives according to the family status of the person killed.

The amounts given for injured persons are estimates of average compensation awarded for the suffering undergone, for the increased efforts to be subsequently made owing to permanent incapacity and for any detrimental effects from the aesthetic standpoint.

These average amounts for each case are multiplied by the number of casualties to give an overall estimate of BF 2 962 million.

2.5. Expenditure for road policing and emergency services

Road policing is done by two separate units, the communal police in the communes and the "Gendarmerie" on state roads and motorways [20].

The data obtained from the Ministries gives the 1983 expenditure as:

Communal police:	BF 4 384 million
Gendarmerie:	BF 4 314 million
Total	BF 8 698 million

The emergency services are provided by the fire brigade, civil defence and Red Cross, expenditure by these services with respect to road accidents in 1983 being estimated as follows:

Fire brigade:	BF 1 109 million
Civil defence:	BF 498 400 million
Red Cross:	--

The overall cost for such services was therefore BF 9 807 million.

2.6. Legal costs

On the basis of data provided by the Ministry of Justice, legal costs in connection with road accidents in 1983 are estimated at BF 2 394 million.

2.7. Lost production as a result of deaths and injuries

Incapacity for work affecting a member of the labour force corresponds to a loss of production for the community, a loss that may be definitive in the case of death or certain severe injuries, or temporary with possibly a lower working capacity owing to disablement.

The production losses taken into consideration relate to the following:

- -- Remunerated production by members of the labour force;
- -- Non-remunerated production by housewives;
- -- Non-remunerated production other than that of housewives and performed for the person's own account.

Taking account of non-remunerated production is fully warranted, since the decisions handed down by the courts confirm that the compensation is to be paid for any reduction in the general capacity of the casualties: the extra occupational and post-occupational activities of casualties (household activities, etc.) also have an economic value and proper compensation must be paid for their loss.

Where death is involved, account has to be taken of total losses of production.

An estimate is therefore made of the average loss of production per casualty. Future losses of production are calculated at discounted present value as from the year the accident occurred.

The calculations take account of the age structure of casualties, their average rate of activity by age group and their level of experience at the time of the accident [21].

2.8. General expenses of insurance companies

According to the annual report of the Insurance Control Office, the general expenses of insurance companies for the third-party liability -- self-propelling land vehicles branch -- totalled BF 10 807 million in 1983.

To these general expenses must be added those relating to the guarantees associated with third-party motor insurance i.e. those relating to the vehicle itself and to the occupants. As there are no published data, these general expenses are estimated to be 25 per cent of the amounts paid and held in reserve for claims in 1983, i.e. BF 2 700 million.

Accordingly, the general expenses for the year 1983 may be estimated to be:

-- Vehicle third-party:	BF 10 807 million
-- Associated guarantees:	BF 2 700 million
Total	BF 13 507 million

2.9. Estimation of the socio-economic cost of road accidents in 1983

The costs relating to production losses, medical care and mental suffering are determined by multiplying the costs per casualty, as set out under II. 2.2. by the number of casualties shown in Table 2.

The costs relating to material damage, road policing, emergency services, legal costs and general expenses of insurance companies have also been taken into account and totalled up.

Expressed in 1983 prices (Table 3), the marginal socio-economic cost of road accidents occurring in 1983 is estimated at BF 106.5 billion, which is equivalent to 2.5 per cent of Belgium's gross domestic product.

Table 3

ESTIMATED SOCIO-ECONOMIC COST OF ROAD ACCIDENTS
OCCURRING IN BELGIUM IN 1983
(BF billions AT 1983 PRICES) [22]

	BF billion
1. Medical care	6.090
2. Material damage	31.215
3. Mental suffering	2.962
4. Road policing, emergency services	9.807
5. Legal costs	2.394
6. Production losses	40.533
7. General insurance expenses	13.507
Marginal socio-economic cost	106.508

Given the very slight increase in the number of injured over the period 1983 to 1986, essentially as a result of more slightly injured persons, the overall cost is considered to be unchanged and is the substantial sum of BF 106.508 billion in 1986.

3. ADJUSTED COMPUTATION OF THE ROAD ACCOUNT

In the direct computation of the Belgian road account, the amounts obtained were as follows:

-- Income: BF 214 billion
-- Expenditure: BF 145 billion

When account is taken of the external effects, the new amounts are:

-- Income: BF 225 billion
-- Expenditure: BF 251 billion

These further enquiries therefore enable us to conclude that the road sector covers about nine-tenths of its expenditure out of its own income.

III. COMMENTS AND CONCLUSIONS

1. Our first approach consisted of drawing up a "direct" overall road account covering all income and expenditure directly ascribable to the road sector, the aim being to determine the extent to which the sector is in financial equilibrium or, in other words, to see whether road traffic as a whole covers the costs that the services generate.

The enquiries showed that in 1986, for each franc received from the government or other funding authorities (regions and communes), the activities themselves generated income of BF 1.50.

However, this finding calls for a number of comments:

a) As regards income, the methodology selected ensured that the receipts were never overestimated;

b) On the other hand, as regards expenditure, the total amount given may be considered to be smaller than it actually is since certain data are not available, namely the expenditure in the Brussels region and the expenditure in the communes as a whole, the overall total of which should nevertheless not be very high, given the well-known state of finance in the communes;

c) The sharp cut-back in the funds allocated to public works in 1986 and the very marked underestimate of the amounts for maintenance work had the effect of making the income/expenditure ratio more favourable.

Attention will have to be focused on preserving road sector assets in the future, so it will be advisable for real expenditure to increase and grow at a faster pace than that forecast for road traffic and, accordingly, that of the tax revenues from it.

The income/expenditure ratio will therefore deteriorate.

2. The aim in our second approach was to include in the analysis those factors external to the sector proper and, accordingly, to adopt a more general economic standpoint. For example, account was taken of the income arising for the State owing to the considerable indebtedness of the road funds.

Moreover, the cost to the community of road accidents, usually estimated at BF 70 billion, was recently calculated to be over BF 100 billion for 1986 on the basis of more detailed and updated analysis.

The second approach led us to the conclusion that the sector covers nine-tenths of its expenditure by means of its income.

The comments set out in paragraph 1 remain valid, and we may add that it is generally recognised that the road sector is not set up solely with a view to commercial viability since it also aims to meet a number of general economic objectives.

For instance, by providing services to the increasing number of places which do not have rail services, the road network plays an essential role in opening up the regions both economically and socially.

Although these advantages are acknowledged by all, they are not taken into consideration in the road account.

Similarly, no account is taken of most of the income that the communes obtain from the road network such as, for example, the higher tax on property to which there is access by road, conveyancing fees and the tax on real estate profits resulting from an improvement in road infrastructure.

All these factors are difficult to estimate but an attempt might be made at a later date.

Account might also be taken of the tax spin-off from the activities of the 800 000 workers depending directly or indirectly on the road sector and also from the BF 107 billion cost of road accidents.

However, it is considered that the work would be devoted to other purposes, public transport for instance, if it did not go into the road sector.

Lastly, there are clearly other external costs that might have been taken into consideration, such as the detrimental effects on users (traffic congestion) and on people living in the area crossed by the road infrastructure (noise and air pollution, visual intrusion, land use, etc.) or even to the community as a whole (energy conservation, regional development) [23].

At the present stage of our work, there is no method sufficiently reliable to enable us to make such estimates. Accordingly, as stated in the introduction, we have used in our road account those explanatory variables that call for the least caution and which also have the merit of being the most representative.

NOTES AND REFERENCES

1. In 1986 current and capital income totalled some BF 1 430 billion.

2. The main source of the information is FEBIAC, but the estimating methods are those of the authors.

3. The deductible VAT and luxury tax is limited to 50 per cent. The non-deductible part of VAT is taken into account in business expenses where applicable. No deduction can be made for the vehicle registration tax.

4. See Annex 1.

5. General statement of budgetary income and expenditure for the 1987 financial year, page 4.

6. See Annex 2.

7. See Annex 3, table drawn up by the FEBIAC on the basis of the above data.

8. See "Revue générale de fiscalité -- dossier 'auto et fiscalité'", Ced Samson -- 85-12 bis.

9. See "Budget des voies et moyens, document parlementaire" No. 4/1 603/1 85/86 of 30th September 1986, p. 119.

10. Estimate by the CEPSA -- Institut de Sociologie de l'ULB.

11. See reference 10, page 115, Article 36 01/2 and 3.

12. See Annex 4.

13. This amount may in fact be multiplied by two if account is taken of the personnel coming under the Public Works Department who are also engaged in activities relating to the road network.

14. Figure supplied by the Private Office of Mr. Pede, Minister for the Flemish-speaking region responsible for subsidised works.

15. Figure supplied by the Private Office of Mr. Aubecq, Minister for the Walloon region responsible for subsidised works.

16. See the 1986 Report by the National Bank, page 108: in 1986, as a percentage of GDP,

Direct taxes represented:	18.6%
Indirect taxes:	12.0%
Social security contributions:	15.1%
Fiscal and similar revenues	45.7%

17. See "Calcul des coûts externes des transports terrestres -- coûts des accidents de transport -- cas de la Belgique" (Calculating the external cost of land transport -- transport accident costs -- case study of Belgium) by Dubus, P. for the International Union of Railways (UIC), May 1986.

18. See "Rapport annuel sur les activités et sur la situation des entreprises d'assurances en Belgique", Office de contrôle des assurances.

19. Published in the "Journal des Tribunaux".

20. Data obtained from the Ministry of the Interior.

21. In this connection, see the detailed calculations done by Dubus, P. in Annex 1.1, pp. 1 to 16 of the study already referred to.

22. Partly adjusted totals taken from the study by Dubus, P.

23. See "Infrastructure cost allocation: some specific aspects", ECMT, Council of Ministers, October 1983.

ANNEXES

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Annex 1

AMOUNT OF ROAD TAX

Horsepower	cc or cm3 cubic capacity	Road Tax (1) (12 months)	Extra (2) 10 per cent	Supplementary road tax (12 months)	A payer	
					Vehicle without LPG	Vehicle with LPG
1	2	3	4	5	3 + 4	3 + 4 + 5
4 and under	100 -- 750	1 572	157	3 600	1 729	5 329
5	751 -- 950	1 968	197	"	2 165	5 765
6	951 -- 1 150	2 832	283	"	3 115	6 715
7	1 151 -- 1 350	3 708	371	"	4 079	7 679
8	1 351 -- 1 550	4 572	457	6 000	5 029	11 029
9	1 551 -- 1 750	5 448	545	"	5 993	11 993
10	1 751 -- 1 950	6 312	631	"	6 943	12 943
11	1 951 -- 2 150	8 196	820	"	9 016	15 016
12	2 151 -- 2 350	10 068	1 007	"	11 075	17 075
13	2 351 -- 2 550	11 940	1 194	"	13 134	19 134
14	2 551 -- 2 750	13 824	1 382	8 400	15 206	23 606
15	2 751 -- 3 050	15 696	1 570	"	17 266	25 666
16	3 051 -- 3 250	20 568	2 057	"	22 625	31 025
17	3 251 -- 3 450	25 428	2 543	"	27 971	36 371
18	3 451 -- 3 650	30 288	3 029	"	33 317	41 717
19	3 651 -- 3 950	35 160	3 516	"	38 676	47 076
20	3 951 -- 4 150	40 020	4 002	"	44 022	52 422
21	4 151 -- 4 350	42 204	4 220	"	46 424	54 824
22	4 351 -- 4 650	44 388	4 439	"	48 827	57 227
23	4 651 -- 4 850	46 572	4 657	"	51 229	59 629
24	4 851 -- 5 050	48 756	4 876	"	53 632	62 032
25	5 051 -- 5 250	50 940	5 094	"	56 034	64 434
26	5 251 -- 5 550	53 124	5 312	"	58 436	66 836
27	5 551 -- 5 750	55 308	5 531	"	60 839	69 239
28	5 751 -- 5 950	57 492	5 749	"	63 241	71 641
29	5 951 -- 6 150	59 676	5 968	"	65 644	74 044
30	6 151 -- 6 350	61 860	6 186	"	68 046	76 446
31	6 351 -- 6 650	64 044	6 404	"	70 448	78 848
32	6 651 -- 6 850	66 228	6 623	"	72 851	81 251
33	6 851 -- 7 150	68 412	6 841	"	75 253	83 653
34	7 151 -- 7 350	70 596	7 060	"	77 656	86 056
35	7 351 -- 7 650	72 780	7 278	"	80 058	88 458
36	7 651 -- 7 850	74 964	7 496	"	82 460	90 860
37	7 851 -- 8 150	77 148	7 715	"	84 863	93 263

1. For vehicles with engines exceeding 20 horsepower the tax is fixed at BF 40 020 + BF 2 184 per horsepower over 20.
2. An extra 10 per cent is added to the road tax and goes to the communes and the Brussels region.

See "Revue générale de Fiscalité -- Dossier 'auto et fiscalité'". Ced Samson -- 85-12 bis.

Annex 2

OIL PRODUCTS STATISTICS FOR BELGIUM

Period: Year 1986
Unit : 1 000 metric tonnes

Nomenclature	Imports	Processed in refineries	Net output	Deliveries for domestic consumption	Exports	Ships fuel tanks
Crude oil	23.262	23.223	-	-	5	-
Natural gas	6.786	-	-	6.419	235	-
Intermediate products	3.451	3.515	562	-	536	-
Motor spirit (1)	1.173	64	4.906	2.720	3.296	-
Aviation spirit	7	-	17	3	21	-
Spirit type jet fuel	-	-	138	64	85	-
Kerosene type jet fuel	190	10	1.127	522	735	-
Tractor kerosene (TVC)	-	-	-	-	-	-
Kerosene	10	-	73	73	26	-
Gas oils (2)	4.922	552	9.319	8.528	4.486	311
Light fuel oil (+ heavy gas oil)	78	-	156	34	43	337
Residual fuel oil	3.990	294	6.732	2.750	5.258	2.271
Petroleum gases						
- Liquefied 1. Butane	88	-	252	64	191	-
- Liquefied 2. Propane	109	-	249	223	96	-
- Liquefied 3. Mixtures	5	-	19	76	8	-
- Uncondensable	-	-	1	1	-	-
Residual petroleum pitch	-	-	232	217	-	-
Petroleum coke	233	-	-	233	-	-
Tars	90	-	666	294	390	-
Lubricants (3)	572	-	10	203	379	22
Petroleum jelly	-	-	-	-	-	-
Paraffins	3	-	-	3	-	-
White spirit	19	-	260	52	226	-
Special spirits	15	-	101	25	88	-
Feedstocks for the chemicals industry						
-- Liquefied gases 1. Butane	-	-	-	66	-	-
-- Liquefied gases 2. Propane	-	-	-	-	-	-
-- Liquefied gases 3. Mixtures	-	-	-	-	-	-
-- Uncondensable gases	-	-	-	-	-	-
-- Naphtha	1.135	-	998	1.414	583	-
-- Other liquid or solid products	-	-	-	67	-	-
Sulphur	6	-	111	120	1	-
Naphtha for uses other than in the chemicals industry	-	-	-	1	-	-
Other products	155	-	251	180	152	-
Totals	12.800	920	25.619	17.932	16.064	2.941
1. Including ordinary petrol.	-	-	-	252	-	-
2. Including diesel oil for road vehicles.	-	-	-	2.663	-	-
3. Including motor oils.	-	-	-	75	-	-

Annex 3

CALCULATION OF VAT AND EXCISE DUTIES ON MOTOR FUELS

	Ordinary petrol	Extra petrol	Diesel	LPG
Deliveries for domestic consumption				
. in metric tonnes	252 000	2 468 000	2 663 000	76 000
. in litres (1)	345	3 269	3 133	141
Average price per litre	25.23	26.43	18.38	10.82
VAT per litre	5.046	5.286	3.676	2.164
Duties per litre	11.2	11.2	5.25	--
Total VAT (1)	1 742	17 279	11 517	305
Total excise duties (1)	3 866	36 611	16 448	--
Total revenues (1)	5 608	53 891	27 965	305

General total: BF 87 768 million

1. In BF millions.

Source: Data supplied by the Fédération pétrolière on the basis of calculations by the FEBIAC.

Annex 4

THE VEHICLE POPULATION AS AT 31ST DECEMBER IN EACH YEAR

Type of vehicle	1981		1982		1983		1984		1985		1986	
	Absolute figures	%	Absolute figures	%	Absolute figures	%	Absolute figures	%	Absolute figures	%	Absolute figures	%
Cars	3 138 677	83.66	3 163 506	83.55	3 195 094	83.46	3 235 060	83.43	3 278 789	83.36	3 360 313	83.26
Vans	144 533	3.85	149 332	3.94	155 435	4.06	161 567	4.17	171 071	4.35	181 820	4.51
Agricultural tractors	125 469	3.35	128 507	3.39	130 931	3.42	133 642	3.45	136 087	3.46	138 299	3.43
Motor cycles	114 513	3.05	119 063	3.14	123 178	3.22	124 760	3.22	124 286	3.16	130 454	3.23
Lorries	110 248	2.94	108 502	2.87	106 232	2.78	105 076	2.71	104 684	2.66	105 052	2.59
Special vehicles	33 064	0.88	33 056	0.87	32 817	0.86	32 684	0.84	32 528	0.83	32 678	0.81
Road tractors	28 428	0.76	28 142	0.74	28 408	0.74	28 969	0.75	29 887	0.76	31 198	0.77
Civil engineering equipment	19 992	0.53	20 166	0.53	20 343	0.53	20 439	0.53	20 621	0.52	20 968	0.52
Agricultural equipment and cultivators	17 681	0.46	17 947	0.47	18 185	0.48	18 543	0.48	18 735	0.48	18 767	0.47
Buses and coaches	18 910	0.51	18 299	0.48	17 452	0.46	16 947	0.44	16 550	0.42	16 250	0.41
Total	3 751 515		3 786 520		3 828 076		3 877 687		3 933 238		4 035 799	

Source: FEBIAC 1986 Financial Year, p. 44.

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DENMARK

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SUMMARY

Copenhagen, December 1988

INTRODUCTION

Let us initially define a beneficial infrastructure project as one which has a positive present value at the rate of discount interest which meets the demand of the responsible investing authority (say 6 per cent) or, correspondingly, as one which has an internal rate of return which exceeds that interest rate.

Let us further add the requirement that a beneficial project must have either a neutral or a positive effect on the environment. Unlike the economic criterion mentioned above, this is to a very large extent an absolute requirement. Whereas the economic evaluation may be the result of summing a number of positive and negative efects, the environmental criterion leaves very little scope for trade-offs between positive effects on some recipients and negative effects on others. Today, negative effects are largely not acceptable to any extent, regardless of positive overall effects in economic as well as in environmental terms.

The purpose of this paper is to give an illustration -- by means of reference to the Scandinavian Link project -- of the difficulties involved in achieving public and political acceptance of infrastructure projects which, in both economic and environmental terms, are clearly beneficial. Some of the causes of the difficulties will be indicated and some ideas as to how they may be overcome will be discussed.

In a European perspective the infrastructure problem will without doubt be the most serious issue of transport policy in a few years. Transport volumes of goods and persons are increasing rapidly. Bottleneck situations will soon be the rule rather than the exception if the lack of decisiveness concerning particularly projects of international importance is not soon replaced by a large-scale investment effort. This effort must, however, be directed towards the transport system as a whole, to assure that it is well balanced in environmental terms.

In recent years, environmentalists in Scandinavia and elsewhere have, of course, suggested that the problem of insufficient capacity in the transport system be avoided rather than solved. In other words, transport volumes should be prevented from growing by enforcing radical changes in production and distribution patterns, and subsequently -- which is rarely recognised -- through decreased standards of living.

This paper assumes that governments will continue to accept (and even promote) increased economic activity.

1. THE SCANDINAVIAN LINK PROJECT

The Scandinavian countries are geographically situated on the fringe of Europe. Not only do long distances separate them from Central Europe -- the movement of people and goods between the individual Scandinavian countries, and between Scandinavia and the Continent, usually also demands one or more ferry crossings.

The Scandinavian Link project is a proposal for reducing this handicap. If during the next ten years we expand our motorway and rail system and establish permanent transport links, it will be possible to create a transport system capable of fulfilling the more exacting requirements for speed, reliability and punctuality which industry will then be demanding. In addition, development opportunities for tourism will be greatly enhanced both inside Scandinavia and between Scandinavia and the rest of Europe.

The Scandinavian Link project is a plan for an overall transport system able to be completed by the year 2000 at the latest, and several years earlier in the case of the key sections. The plan is based on existing infrastructure, projects already approved or scheduled, and totally new projects.

The Scandinavian Link proposals cover the transport corridor (road and rail) from Oslo via Gothenburg to Malmoe, continuing via a permanent link to the Copenhagen Airport (Kastrup) where it will connect with the existing Danish motorway and rail network.

From there, road traffic to the Continent can use either the direct ferry route between Roedby and Puttgarden or the fixed link across the Great Belt to Funen and Jutland, continuing to Hamburg by motorway. The ferry route is about 140 km shorter, but the crossing takes one hour excluding waiting time.

Rail passenger traffic between Copenhagen and Hamburg is expected to continue via Roedby-Puttgarden, with freight traffic crossing the Great Belt.

Apart from the improvements in this transport corridor already scheduled for the years ahead, additional investment will be as shown in Table 1.

Table 1

MSEK	Denmark	Sweden	Norway	Total
Öresund Bridge	4 900	4 400	--	-9 300
E6 Motorway	-	4 000	1 800	5 800
Railway	-	3 800	1 800	5 600
Total	4 900	12 200	3 600	20 700

Under this proposal the E6 would be upgraded to motorway status from Oslo via Gothenburg to Malmoe where this was not already the case. The route spans a total distance of 587 Km, of which 225 km is already motorway. There are 79 km of motor expressway, some half of which is ready for upgrading to motorway. 283 km will be replaced by a new road which will be around 30 km shorter than the existing route. Finally, a new bridge will be built across Svinesund on the border between Norway and Sweden.

Railway improvement is required along the same route to boost capacity and speed. This will involve widening to dual-track, mostly along the existing alignment.

A fixed link will be built between Malmoe and Copenhagen in the form of a 4-lane motorway and dual-track railway. The railway will serve long-distance traffic as well as local traffic between Malmoe, Kastrup and Copenhagen.

Construction of a fixed link across the Great Belt has now been commenced. It will be ready for rail traffic in 1993 and for cars and lorries in 1996.

2. ECONOMIC BENEFITS OF THE SCANDINAVIAN LINK PROJECT

Proximity to the Continent is important for travel and freight transport alike. Both tourism and business trips by car and train will increase when travelling time between Scandinavia and the Continent is substantially reduced. Motorists travelling from e.g. Oslo, Stockholm or Helsinki to destinations on the Continent will be able to achieve average time savings of around two hours due to the improved infrastructure, principally the permanent link across the Öresund.

The increase in transport punctuality generated by fixed links will be at least as important as a reduction in average journey time. Long delays occur regularly on Öresund ferry services, particularly in summer but frequently too on Fridays or Sundays all year round. This causes great irritation to travellers, complicating the planning of both leisure and work schedules.

Clearly the risk of delays and the need to book reservations has a significant bearing on the volume of traffic, especially local traffic, in the Öresund region. A fixed link across the Öresund would generate wider cultural and commercial relations not only between Malmoe and Copenhagen but also between Southern Sweden and Zealand.

Both within Scandinavia itself, and between Scandinavia and the Continent, passenger train journeys will be shortened considerably as a result of the establishment of fixed links and the introduction of high-speed trains. Journey times between e.g. Oslo or Stockholm and Hamburg will be reduced from 13-14 hours to 7-8 hours.

Like private cars, freight lorries will receive an immediate transport time reduction of around two hours on journeys between Oslo, Stockholm or Helsinki and the Continent. The permanent Öresund link alone will provide time savings of approximately one hour.

Where lorries are concerned, the shorter travelling time will enable industry to deliver more quickly, and thus provide improved service to customers on the Continent. Just as important, however, is the fact that fixed links, motorways and an up-to-date freight transport system will lead to increased reliability in delivery schedules.

Freight trains will enjoy the greatest time saving if the improvement in infrastructure is supplemented by an efficient freight transport system. Some examples of possible transport times in the year 2000 are shown in Table 2.

Punctuality must be assured before industry can introduce streamlined materials control and production based on the "just-in-time" principle. The importance of the Scandinavian Link project to industry's competitiveness cannot be gauged therefore merely by assessing the time saving for goods in transit. Implementation of the Scandinavian Link project is also one of the prerequisites for ensuring that companies can enjoy full benefits of rationalisations made possible by optimal logistical solutions.

Over the next ten years, industry will introduce a range of production system changes which are closely related to the associated material flows. For example, mean batch size is expected to shrink by 30 per cent, while capacity utilisation of production plant increases from 80 per cent at present to an average of 85 per cent.

Table 2

Hours*	Oslo	Stockholm	Helsinki	Copenhagen
Hamburg	16 (29)	19 (28)	42 (49)	6 (9)
Cologne	21 (45)	23 (43)	46 (65)	11 (25)
Paris	39 (62)	41 (61)	64 (82)	28 (43)
Zurich	47 (70)	49 (68)	72 (91)	37 (51)
Rome	61 (84)	63 (83)	86 (104)	51 (65)

* Current transport time shown in brackets.

These changes will have a major impact on the so-called logistical parameters. A few examples are given below:

-- Consignment sizes will be reduced by 25 per cent;

-- The time interval between order issue and receipt (lead time) will be reduced by 30 per cent;

-- Punctuality will be improved by 30 per cent.

-- Transport frequency will be increased by almost 50 per cent.

For each of the parameters, typically one-fifth to one-third of the changes may be attributed to improvements created by the Scandinavian Link project.

Table 3

	Öresund Bridge	Öresund Bridge + E6 Motorway	Öresund Bridge + E6 Motorway + High-speed train
Present value MSEK (6 %)	3 800	4 400	13 700
Internal rate of return (%)	9	8	10

Traditionally, the socio-economic significance of an infrastructure project is assessed by a cost-benefit analysis in which the building and operating costs of the project are compared with benefits to users in the form of time savings and reduced operating costs. Such an analysis has been performed for three sub-projects in the overall Scandinavian Link project, as shown in Table 3.

It will be seen from the table that the fixed Öresund link provides a good rate of return, and if the yield on alternative investments is 6 per cent, project implementation will provide a social benefit of MSEK 3 800 at 1987 prices. The addition of a motorway between Malmoe and Oslo will slightly augment this benefit, corresponding to an internal rate of return of around 7 per cent for this sub-project.

As will be seen from the table, the present value (benefit) is increased substantially by the addition of a high-speed, efficient rail freight system. However, assessment of this system is somewhat uncertain, particularly as regards the degree to which lorry transport will switch to combined transport.

It must be stressed that the profitability calculations only take account of the immediate benefits in the form of time savings and cost savings for people and freight. To these must be added the massive benefits to industry which will be made available through improved logistical solutions. For the 20 companies or divisions which took part in the Scandinavian Link logistics study, it is estimated that the improvements proposed by the Scandinavian Link project will increase gross profits by MSEK 680, or 12 per cent of turnover.

Besides these purely economic benefits, the establishment of a motorway will lead to substantial improvement in road safety on the Oslo-Malmoe route. In monetary terms, this alone will increase the socio-economic value of the road by MSEK 600 to MSEK 1 500.

3. CONSEQUENCES FOR THE ENVIRONMENT

In recent years the citizens of the Scandinavian countries have become increasingly conscious of the risk of environmental damage posed by manufacturing, transport, energy provision and other human activity. So, in preparing the Scandinavian Link project, a study was naturally made of the environmental effects, particularly air and noise pollution.

Cars, lorries, ferries, diesel trains and power generation for electrical locomotives all produce environmental effects which affect the well-being of human beings and plants. As part of the Scandinavian Link project, an analysis has been performed charting air pollution from road and rail traffic as a function of total air pollution, and its effect on the environment.

Table 4

	CO			HC			NOx		
	Old E6	New E6	Diffe-rence %	Old E6	New E6	Diffe-rence %	Old E6	New E6	Diffe-rence %
Car	103.6	91.8	-11.4	12.6	12.1	-3.7	36.3	46.8	28.9
Heavy lorry	16.1	8.9	-44.6	3.3	3.4	-4.7	39.3	31.9	-18.7
Lorry + trailer	49.9	31.8	-36.3	6.3	6.2	-1.5	96.9	76.0	-21.6
Bus	1.8	1.7	-6.0	1.1	1.0	-7.4	12.5	10.5	-16.4
Total	171.4	134.2	-21.7	23.3	22.7	-2.1	185.0	165.2	-10.7

The analysis consisted of an assessment and comparison of environmental effects in alternative traffic situations in the year 2000. The reference "alternative" reflects the environmental situation expected at that time, based on traffic growth forecasts for the existing infrastructure and including changes already sanctioned or scheduled. Improvements which will result from statutory requirements for the catalytic cleaning of petrol engines and improvements to diesel engines have also been taken into account.

As a part of this analysis, the Swedish Road and Traffic Institute (VTI) carried out a detailed study on the Gläborg-Rabbalshede section in collaboration with the Swedish Transport Research Commission (TFK). Analysis was performed using VTI's computer program VETO, which is based on the input of detailed data concerning:

- -- Vehicle types;
- -- Road geometry;
- -- Unevenness profile;
- -- Weather conditions;
- -- Driving pattern.

The results of VTI's calculations show that although a new road is expected to generate a small increase in total traffic volume (2 per cent), vehicle-kilometers will fall by 8 per cent as the new route will be approximately 1.7 km shorter than the existing road. Annual emission of pollutants in tonnes was calculated as shown in Table 4.

The results show a reduction for all types of emission under review. CO (carbon monoxide) emission is expected to be reduced by 20 per cent, primarily on heavy lorries and lorries with trailers. HC (hydrocarbon) emission will be reduced by 2 per cent, despite some increase from heavy lorries. NO_x (nitric oxide) emission is also expected to fall, despite the fact that the emission factor for NO_x and cars will be around 45 per cent greater on the motorway than on the existing road.

The standard of the E6 is particularly poor in central and northern parts of Bohus County and on a number of other individual sections. The uneven traffic flow provides adverse emission, and traffic is also routed through the towns. Upgrading these sections to motorway status will often shorten the road, with a positive effect on emission. This particularly applies to heavy through-traffic, a larger proportion of which will switch to the motorway than in the case of cars. Road shortening, coupled with a more even traffic flow, will result in major improvements on these sections, as illustrated by the Gläborg-Rabbalshede example.

The environmental effect, measured as emission volume, is generally found to vary only very slightly between the various alternatives. This is naturally due to the fact that changes in infrastructure principally affect long-distance traffic. However, such traffic represents only a very limited proportion of total traffic, normally only between 10 and 20 per cent. Local traffic represents by far the largest proportion.

Furthermore, it is important to remember that the calculations only show the volume of air pollution which is due to traffic. A wide range of other sources (heating, industry, etc.) also contribute to pollution. For Scandinavia generally, long-distance airborne pollution from abroad is the biggest culprit.

Finally, it must be stressed that a general lowering of the emission levels is expected during the period up to the year 2000. Falls of 65 per cent are expected for sulphur (SO_2) and 30 per cent for nitric oxide (NO_x). In addition, by the end of the century, legislation on private cars and tougher regulations on heavy lorries are expected to lead to a reduction of HC and CO emissions to 35 per cent and 60 per cent, respectively, of the 1985 level.

4. THE DILEMMA OF INFRASTRUCTURE POLICY

The problem of providing sufficient infrastructure capacity in both quantitative and qualitative terms to meet the increasing transport needs of the future has direct bearing on the capacity for future economic growth and trade in Europe, and thus -- in the final analysis -- on the role which Europe will be able to play on the world scene.

The Scandinavian Link project is an illustration of the fact that solutions are available, but that the various national authorities hesitate to make the necessary decisions. Despite the fact that we are dealing with projects which meet both environmental and economic requirements, the decision-making process is so protracted that enormous potential benefits are forsaken.

There is a clear need to deal consciously with these issues at national and international level. As the major obstacles seem to be in the fields of environment and economics, solutions must be found in these fields.

5. THE ENVIRONMENTAL ISSUE

If we reject the idea of solving environmental problems caused by increased traffic flows simply by preventing economic growth and increased trade, we have to accept that measures must be taken to transfer considerable volumes of transport to means which are less polluting and require less space than road transport. Proposals for new road infrastructure should, therefore, generally be put forward as part of a package containing other measures which alleviate the growth in road traffic.

It will be necessary to deal with the environmental issue in infrastructure as a question of managing the entire transport system rather than just reacting automatically to growth in road traffic. Massive transfers of traffic from road to rail cannot, however, be undertaken uncritically.

Such massive transfers would generally only be possible through direct government intervention of a nature which is inconsistent with market economy principles or by levelling heavy burdens in the form of taxes or traffic restrictions on road transport. Both types of measures would lead to loss of efficiency in the transport system and thus to a sharp increase in total transport costs.

Even if such radical and costly measures are rejected, major increases in the market share of railroads can certainly be achieved by means of real improvements in the quality of rail transport. These quality improvements can, however, only be achieved in an economically viable sense by means of high-speed trains on a highly concentrated network connecting large urban concentrations. The Scandinavian Link project includes proposals for a combined goods transport system based on high-speed block trains operated in a closed system between 10-15 terminals in Scandinavia and a similar number of terminals on the Continent.

Such a system for combined transport would be highly efficient and very attractive to industry. Considerable quantities of goods would be transferred from road to rail, but environmentalists would have to accept certain "trade-offs" among various environmental effects. For instance, the price of reducing emission from lorries would be to increase noise levels from goods trains running at higher speeds and greater frequency. Secondly, the system derives its benefits from large-scale transport between industrial centres. Environmentalists generally oppose increases in urban concentration.

The important conclusion is that in a time when most governments recognise the need to reduce pollution generally (and from road traffic in particular), it is most often not sufficient to demonstrate that a road project is neutral in its environmental effects. Either the project itself or accompanying projects must have directly positive environmental consequences.

6. THE ECONOMIC ISSUES

The other set of obstacles in the decision-making process is of an economic nature. In some instances there is a problem of sheer magnitude, in others it is rather a question of sufficient identity between those who pay for a project and those who stand to gain.

The problem of magnitude is typically found where a small country is to undertake a large single project. Irrespective of a project being generally recognised as a beneficial investment, it might be found to be of such a scale as to be difficult or impossible to deal with for the investing authority.

An example is the Great Belt Link in Denmark, which is now under construction. Although successive examinations had proven the project to be very advantageous from a cost/benefit point of view, there were serious concerns that the macro-economic effects in the construction period of about eight years could not be sustained by the Danish economy.

It was, however, found that these concerns could be dismissed. Despite the size of the project (almost 20 km and about 18 000 MDKK in construction costs), the effect on the economy in any one year would not amount to more than 1 per cent of GNP, and that the slight inflationary pressure to be expected can be dealt with.

The long-term effect on the balance of payments is clearly positive, even if the net effect in the construction period is negative. In the "worst" year, a contribution to the deficit in the payments balance of about 3 000 MDKK is expected, as compared to current deficits at the level of about 20 000 MDKK. The positive long-term effects stem largely from savings on energy costs which are reduced to about one-fifth of the fixed link.

In 1978, another Great Belt project was, in fact, given up for reasons of its general economic effects. It had been the intention to finance the project directly through the state budget, which in those years suffered from major deficits. Further increases in these deficits could not be accepted, but neither was there a political will to consider other sources of finance, indicating perhaps that the overriding economic effects were considered to be at least as important as the question of financing.

There is, however, no doubt that lack of financial resources often is the most important obstacle to a project being carried out. The problem may, actually, be more accurately described as the lack of sufficient identity between the party bearing investment costs and the party reaping the benefits.

In an international context, this problem is typical for transit countries who will often hesitate to invest large sums in infrastructure which is largely to the benefit of non-nationals -- and which may even result in increased pollution to be borne by nationals.

Within a given country, the question posed is typically whether the taxpayer as a whole should bear the costs of a project which is only to the benefit of a minority.

However the problem is formulated, the key to the solution in such cases is for the project to be capable of generating revenue. Whether this revenue is used to service loans or is absorbed directly by e.g. the state treasury, is a separate issue.

The important question in the first instance is whether the services yielded by the project are so defined and limited in nature as to make it possible to put a price on these services that users are willing to pay. Competition from existing infrastructure or e.g. ferry routes, will often make it difficult to set a price which is considered sufficient.

The second question is whether pricing of infrastructure use is generally thought to be acceptable, or whether the overriding opinion is that transport infrastructure is a public good, which should be made available free of charge. Except for certain recent experiences in Norway, the Scandinavian countries have no tradition for user fees on roads. It is, however, generally accepted that the Great Belt Link and eventually the Öresund Link will be paid for by user fees.

The Scandinavian Link project does not include specific proposals on financing, but the shareholders behind the Consortium have declared themselves to be willing to participate with equity or loan capital, should the governments involved find this desirable.

Recent developments in Swedish transport policy have opened certain possibilities in this direction. It has been declared in a government policy statement that alternative sources of finance may be considered where certain projects otherwise could not be carried out. This has led local authorities along the E6 route from Gothenburg to the Norwegian border (Bohus County) to propose upgrading of the E6 to motorway or expressway standard, financed partially through user fees.

The project is a combination of new road and upgrading of existing road in such a way that it will not generally be possible for users to choose between using the new road against fees or the existing road free of charge. As it is not considered acceptable for local traffic to be obliged to pay tolls, a means of collecting revenue without charging for local traffic had to be devised.

Furthermore, the traffic levels are rather low on certain sections, so that collection of fees at all interchanges would entail costs which were much too high compared to revenue.

The solution proposed to collect tolls in only two places; both new bridges. In the north, tolls will be collected on a new bridge across Svinesund, which also constitutes the border between Norway and Sweden. In the south, tolls will be collected on the proposed bridge across Sunninge Sund on which traffic will bypass Uddevalla, the major town in the region.

Without placing charges on local traffic to any considerable extent and with administrative costs being kept very low, this proposal makes it possible to finance about half of the total project costs by user fees. The remainder is to be financed through the state budget, with the possibility of spreading the burden on the taxpayers over, say, twenty years by a specific bond issue.

Based on the positive experiences from the Channel Tunnel project, German, Danish and Swedish banks have recently expressed interest in financing the construction of a link across the Femern Belt between the southern Danish islands and Northern Germany, on a purely commercial basis. The project is of about the same magnitude as the Great Belt or the Öresund, that is a crossing of about 20 km.

Compared to the route across the Great Belt and Jutland, distances between the Scandinavian Peninsula or Copenhagen and e.g. Hamburg would thus be shortened by about 150 km. The ferry across the Femern Belt takes about one hour plus terminal time, which varies greatly according to weekday and season. The European Community have granted financial support for studies to be undertaken by the Scandinavian Link Consortium into the viability of this project. It is expected that the study will be carried out in co-operation with industrial and financial interests in Germany.

7. CONCLUSIONS

The lack of decisiveness, in particular concerning infrastructure projects of international importance, stems from political problems related to environmental impact and economic problems related to the issue of identity between user and payer. Furthermore, the lack of a "federal" authority in Europe with cross-national powers in questions of infrastructure investment means that no individual body is assigned the responsibility of promoting and carrying out projects which are essentially of broad European interest.

An attempt has been made to describe the environmental and economic problems by reference to the Scandinavian Link project, and to indicate some possible solutions.

The final point to be made is that -- in the absence of a body holding e.g. regional or European authority and responsibility -- progress in infrastructure development is dependent on initiatives by other parties with a direct interest in this development.

In recent years, cross-border integration in European business and industry has been proceeding at a pace which by far exceeds political integration at the community level. There is no doubt that this process will accelerate towards and beyond 1993.

With the subsequent increase in trade and thus the physical movement of people and goods throughout Europe, the business community will have a growing interest in the development of international infrastructure. It must therefore be expected that business interests, to an increasing extent, will be seen as promoters and developers of large-scale infrastructure projects.

The business interest may be specific and related to profits from construction and operation of a project or it may be more general and related to the cost savings and service improvements to be achieved as a result of improved infrastructure. The Channel Tunnel and the Scandinavian Link are, respectively, examples of these two types of business interest.

In any case, the question remains as to whether governments in Europe will be able and willing -- in a more systematic manner -- to deal with this challenge from an increasingly integrated business community.

FRANCE

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SUMMARY

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THE TOLL SYSTEM ON FRENCH MOTORWAYS

France is neither the first nor the only country to use tolls to finance its motorways, but it is the country that has made the most systematic use of them for this purpose and has accordingly drawn a series of different lessons from this experience as regards both the overall system of financing by means of tolls and the relevant methods of collection. This paper will first describe French motorway policy in general and then set out the technical and commercial aspects of toll collection (establishment of the level and structure of tolls).

1. FRENCH MOTORWAY POLICY

Some fifty years ago, before the explosion of car ownership, French schoolchildren were taught that their country had the finest road network in the world since, with a population density of about 100 per km^2, France had a very close-knit network of well-maintained surfaced roads totalling some 800 000 kms in length which were managed partly by central government (around 10 per cent) but mainly by the local, departmental and communal authorities.

This was unfortunately not true for long, because the rapid growth in motor vehicle traffic from the late 1950s soon gave rise to traffic flow problems and bottlenecks on roads with only one lane in each direction and no bypasses around towns, that is to say almost all the roads in the national network.

The traffic forecasts at the time therefore showed the need for a motorway system on the major axes, as already existed in many neighbouring countries such as the Benelux, Italy and Germany. However, the financial resources needed to complete such a programme were beyond the means of the central government budget, which at the time had to meet increasing demands for expenditure on social matters, energy, education and agricultural conversion programmes, in addition to military expenditure. It was found that sources of funding other than taxation would be required to complete the motorway programme, so the decision was taken to raise loans with security provided by the collection of tolls from users, all the operations being assigned to companies licensed by the public authorities to construct the motorways by raising the loans and then to maintain and operate these motorways.

Accordingly, a little over thirty years ago the government awarded the first concessions for toll motorways to the SEMs (sociétés d'économie mixte -- mixed economy companies). These companies were set up with only modest equity capital in which the local authorities participated, usually with a majority holding.

Towards the mid-way point around 1970-73, a number of concession-holding companies of a more private nature were set up, essentially by entrepreneurs and banks, whereby new ideas and methods were introduced, thus developing an experiment in which there was a clear distinction between the virtues and weaknesses of structures with public interests, on the one hand, and private interests on the other in the field of public service concessions. Three private companies succumbed and were merged with the older SEMs owing to the difficulties involved in ensuring a balanced operation in the short and medium term -- inherent in concessions for long periods of over thirty years -- aggravated by the successive crises of 1973 and 1979 which resulted in both an increase in the interest rates on loans and slower growth of traffic.

Finally, then, the whole structure of toll motorway concessions in France is organised around nine concession-holding companies:

-- A private sector: COFIROUTE;

-- A national mixed economy company: STMB;

-- Seven SEMs of different sizes making up the so-called "public" sector (see Table 1).

The SEM sector operates 85 per cent of the network in service and includes the oldest motorways for which concessions were granted, more particularly, Lille-Paris-Marseilles-Nice. The SEMs are associated in the Union des Sociétés Françaises d'Autoroutes à Péage (USAP) and can make calls:

-- For the issue of loans and management of the corresponding debt, on a public organisation named the Caisse Nationale des Autoroutes (CNA) which is run by the Caisse des Dépôts et Consignations (CDC);

-- For the provision of current financial requirements in each financial year, on the CDC and on a diversified banking system;

-- For the provision of particular technical or administrative services -- with a view to consistency and efficiency -- on the suppliers of common services: SCETAUROUTE and the SCET;

-- For the export of motorway know-how, on GIE-TRANSROUTE, set up with the holding company of the

CDC -- Caisse des Dépôts-Développement -- (C3D), and SCETAUROUTE.

In addition, another public organisation, Autoroutes de France, likewise run by the CDC, provides resources on a provisional basis to balance the financial situation of the SEMs by arranging for the companies showing a surplus to make priority repayment of the advances granted by the government and to advance funds to companies showing a deficit. By means of loans it provides any funds that may be needed to ensure a balance in the whole sector.

The system as a whole is set out in Figure 1 which shows the links between these different bodies.

2. FINANCING

The balance to be struck in setting up the operation may be outlined as follows:

-- The State grants the concession-holding company the right to collect a toll for a period of some 35 years under conditions specified in the contract at an initial rate and with annual increases which are usually proposed by the company but are fixed by the government itself. Given the general economic requirements, the toll is never left entirely to the initiative of the concession-holding company (although this would be one of the basic requirements for a purely private business contract);

-- The State retains ownership of the infrastructure and the land involved, which has major consequences as regards funding, the concession-holder's accounts and, more particularly, the tax treatment;

-- The concession-holding company undertakes to find the resources to finance construction within the framework of the initial financial arrangements whose equilibrium is based on a forward-looking feasibility study, while the State undertakes to provide financial assistance in various forms:

. Construction grants or advances out of the central government budget;
. Annual operating royalties, whether repayable or not;
. Guarantee of a more or less substantial proportion of the loans, especially if they are issued abroad.

In some cases there are also advances or grants by local authorities -- usually at regional level -- interested in seeing a link completed quickly.

-- For its part, the concession-holding company:

- Provides what is usually a quite small amount of capital in view of the scale of the investment involved, other than in the case of private concession-holders (at least 10 per cent of the equity);
- Floats loans in accordance with an initial contractual plan and with specific State authorisations weighed up in the light of general financial constraints;
- Can mobilise advances from private shareholders which earn a given rate of interest.

The financial equilibrium of the concession depends on a large number of parameters: first, general parameters arising from the economic situation of the country concerned and, secondly, parameters specific to the concession.

-- General parameters:

- Inflation;
- Rates of interest for the loans during the construction period;
- The period of amortization of these loans and any deferral arrangements;
- Rates of exchange to be applied in the case of loans issued abroad.

-- Specific parameters:

- Final cost of construction;
- Volume of traffic when entering into service;
- Annual rate of growth in volume of traffic over the operating period;
- Changes in the toll rate over the operating period;
- Changes in annual operating costs, excluding financial costs.

Tests of the sensitivity of a concession's financial equilibrium to the impact of these main parameters show just how delicate the equilibrium is.

It has been observed that the equilibrium is particularly sensitive to the evaluation of the initial volume of traffic, the subsequent growth and, more especially, the rates of the toll and changes in them in response to the pattern of inflation.

Although it would be very difficult to quantify precisely the relationship between rates of use and toll rates, since this is specific to each individual link and highly dependent on the conditions governing the choice of competing routes, the general form of the curve displaying the interaction between these two factors is shown in Figure 2, with a range of least sensitivity between A and B.

The result, which has a direct impact on the financial return on infrastructures as considered here, is that the optimum revenue -- usually lower in the initial years than the concession-holder's total operating expenditure, including financial costs -- is produced at M, as shown in Figure 3, in a section of the curve where traffic is still very sensitive to the toll rate.

Only in exceptional cases is a system of rates adopted whereby the financial equilibrium, i.e. between revenues and expenditure, can be established at the outset. Rates established on the basis of marginal cost -- the most readily justifiable from the standpoint of economic criteria since it results in the optimum use of resources and would meet the requirements of users most effectively -- would give rise to a substantial deficit. If a purely private sector approach is to be adopted, the rate of toll should be that which maximises revenues. However, this would not meet the requirements of the public authority making the concession which wishes to obtain the highest economic return.

Accordingly, the rate adopted will usually be between A and B so as to take advantage of this area where traffic shows a low sensitivity to the rate. In France, this level is at present averaging about FF 0.30 per kilometre and is comparable -- although lower -- than those found in a number of ECMT countries which use this system of financing (for example, Italy and Spain) (see Table 2).

The concession-holding companies are, by definition, in debt since their investment is financed by loans. On average, some FF 62 of each FF 100 collected in tolls goes to the amortization of loans, FF 31 to motorway maintenance and operation and FF 7 to central and local government taxes.

Taking an initial investment totalling FF 101 000 million in constant francs, equivalent to about FF 160 000 million at present value, the debt currently amounts to FF 57 700 million broken down as follows:

-- Loans on the French market	FF 36 400 million
of which short- and medium-term loans	FF 1 350 million
-- Loans on the foreign market	FF 9 400 million
of which EIB	FF 3 100 million
-- Advances by central and local government and the ADF....	FF 11 900 million

Depending on the methods of amortization and the accounting rules adopted, the companies' operating accounts will be in balance more or less rapidly. This is already the case for COFIROUTE which is paying off on the duration of the concession and distributing dividends. It is not yet the case for the SEMs which are paying off on the term of the loans and carrying forward their operating deficits each year pending their absorption in the future, necessarily before the end of the period for which the concession is granted.

As at 31st December 1987, the amounts carried forward, or deferred expenditure, totalled FF 33 700 million, which may be compared with annual revenues in 1987 of some FF 11 000 million.

However, while the SEMs have not as yet met all their commitments in terms of amortization and the relevant reserve funds, most of them are showing or are about to show a profit on the operating account. Thanks to two years of particularly high rates of some 10 per cent growth in traffic (1986 and 1987), the public organisation "Autoroutes de France" will have virtually no need to call on external resources, since it would seem that it can now simply offset the deficits of some by the surpluses of others, provided that toll rates keep strictly in line with the rate of inflation.

3. MOTORWAY PROGRAMME FROM 1988 ONWARDS

While the lag with respect to equipment has now been almost eliminated where traffic requirements are concerned, a great deal still has to be done to meet the demands as regards opening links to the regions and promoting local economic development in view of the fact that the road plays a fundamental role in France insofar as it handles 90 per cent of passenger traffic and 60 per cent of freight.

Accordingly, in 1988 a new master plan for national roads was drawn up together with a ten-year motorway programme which is to provide some 2 800 kms of new motorways.

Financial simulation models have shown that the funding of this programme is compatible with the financial prospects for the existing concession-holders with no calls on the State budget.

For the private companies, the capacity to construct new motorway sections depends on the financial resources available and also on the possibility and ability to pay a proper return on capital, thus calling for a balanced operating account in the immediate future.

For the SEMs, the capacity of the concession to construct new motorway sections depends on the existing and future resources prior to the end of the period for which the concession is granted and on the need to establish a balanced operating account once the accumulated deficits have been absorbed, account being taken here of the need for each company to strike an internal balance between the old and new sections and of the similar process carried out by the ADF between the SEMs.

In short, it is in fact the surpluses from sections in service for a long time which provide the funds, without State aid, for new motorway sections of value from the standpoint of regional development but on which there is less traffic and therefore a smaller financial return than on the old network.

The cost of the programme in current francs, assuming a price increase of 4 per cent per year, totals FF 128 billion (at current prices) which covers:

-- New construction	FF 100 000 million
-- Renewal of fixed equipment	FF 8 000 million
-- Investment in motorways in service	FF 10 000 million
-- Financial costs	FF 10 000 million

The investment would be financed by:

-- Loans	FF 112 000 million
-- Capital and various advances ...	FF 16 000 million.

After the cash surpluses have been used for the new programme and the advances of the Autoroutes de France have been repaid by the SEMs, the financial situation of all the companies should be in balance again towards the year 2000. The SEMs will be showing taxable profits at different dates according to the company but ranging from 1997 to 2008, which is compatible with the concessions terminating in 2015.

4. ADVANTAGES AND DRAWBACKS OF TOLLS

The public now fully accepts the idea of tolls but the introduction of the system was initially debatable and led to consideration of the advantages and drawbacks, a subject of much controversy and a great many studies (1).

The arguments may be summarised as follows.

Tolling modifies the choice of users since it has a dissuasive effect on some (avoidance owing to the toll), thus preventing them from benefiting from the best possible traffic conditions. By and large, according to economic theory the toll should be fixed at a very low level which corresponds to the marginal social cost.

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1. For example, the OECD report: "Toll financing and private sector involvement in road infrastructure development" (1987).

From this standpoint, however, motorways are financed by means of taxation and, in practice, taxes are not optimal (current taxes also distort the choice of users) and entail a disutility in the form of the psychological resistance of taxpayers (2).

Financing by users is, moreover, a good way of showing them their preferences and preventing them from misusing public infrastructures. It may also be considered to be fair that those who benefit from a service should pay for it.

Lastly, it is a guarantee of good management to ensure decentralised management of both the construction and operation of a motorway by an independent agency that has to show a profit.

A toll system costs money, however, both initially to set it up and then to operate it. Recent studies tend to show that the additional cost of construction is between 2 and 8 per cent of the initial cost and that operating expenses amount to 8 to 10 per cent of toll revenues.

5. ORGANISATION OF THE TOLL SYSTEM

5.1. General characteristics

The French motorway system, in the form of concessions, so far consists of inter-city link motorways mainly constructed in open country and starting on the periphery of urban areas. Only at a few particular points does it connect up with the very dense network of other surfaced roads.

The motorway network is primarily used for quite long journeys (the average run is estimated to be over 200 kms) and is well integrated with the motorway networks of neighbouring European countries since its design and equipment were planned accordingly.

There are therefore a number of basic characteristics which have a decisive influence on the operation of this network and on the organisation of the toll system:

- There is often some discontinuity in the vicinity of major urban centres (Paris-Lille-Lyons-Marseilles-Strasbourg-Bordeaux);

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2. The already old Rationalization of Budgetary Choices for Motorways study (1974) had explored the consequences of this factor.

-- The points of access from the ordinary road network (interchanges) are quite widely spaced, more particularly because the authorities have worked on the principle of always leaving the user a choice between a toll motorway and a toll-free parallel road that is well maintained and equipped;

-- The motorway system has been specifically designed with long-distance journeys in view, equipped with service areas every 40 to 50 kilometres and rest areas every 10 to 15 kilometres. These areas provide particular services for travellers and their vehicles, but also offer relaxation and information, details about the regions crossed and about its art and culture.

5.2. The "closed" toll system

This system is the most stringent although apparently more complex and, in fact, calling for higher investment.

It calls for the separation of part of the motorway, irrespective of the configuration (linear, star-shaped or mesh) by means of barriers right across the carriageway so that vehicles entering and leaving the motorway at interchanges between these barriers can be controlled and the toll to be paid is based on the exact distance travelled (See Figure 4).

The barriers are usually very wide, averaging some 18 to 20 lanes, with twice as many exit lanes as entrance lanes during a normal period. The distance between them depends on the importance of the region crossed and in France ranges between 100 to over 650 km (average 200 km).

The interchange points have at least two or three lanes (five on average), some of which can be used in either direction as at the barriers. The distance between interchanges obviously differs according to the region, ranging from 10 to 30 or more kilometres and averaging 20 km.

The functional value of grouping the toll buildings and equipment in a single unit has led to the adoption of the "trumpet-shaped" interchange which differs from the conventional "diamond-shaped" interchange where there is no toll system. This involves constructing an additional cross-over road where it is necessary to connect up with a road cutting across the motorway (See Figure 5).

The additional cost of the investment specifically owing to the need to collect the toll is therefore attributable in the case of the closed system to:

-- The construction of the barriers across the road;

-- The use of trumpet-shaped interchanges instead of diamond-shaped ones and the installation of toll booths.

Only extreme or average estimates can be made since the calculations essentially depend on the length of the closed system, distance between interchanges, the density of traffic flows and toll collection methods.

Example 1: Fairly short closed section in a densely populated area:

Length:	100 km (between barriers)	
Distance between interchanges:	10 km	
Cost of barrier:		FF 45 million
Additional cost of interchange:		FF 20 million

Additional cost owing to toll system:

$$\frac{45}{50} + \frac{20}{10} = 0.9 + 2 = \text{FF } 2.9 \text{ million/km}$$

or $\frac{2.9}{35}$ # 8 % of the cost of the infrastructure.

Example 2: Very long closed section in a sparsely populated area:

Length:	600 km	
Distance between interchanges:	30 km	
Cost of barrier:		FF 35 million
Additional cost of interchange:		FF 15 million

Additional cost due to toll system:

$$\frac{35}{300} + \frac{15}{30} = 0.1 + 0.5 = \text{FF } 0.6 \text{ million/km}$$

or $\frac{0.6}{25}$ # 2 % of the cost of the infrastructure.

Where the French network is concerned, with its 16 closed systems, the additional cost of investment averages some 5 per cent.

There were 4 800 kms of motorway in service in 1987, nearly 4 000 km or 5/6 being in the closed system and including:

-- 39 barriers right across the carriageways;
-- 220 booth terminals on interchanges.

5.3. The "open" toll system

Where the link-motorways are to be constructed for the purpose of approaching or crossing densely populated built-up areas, there is a strong temptation to use these new roads for shorter and more regular journeys (daily commuting, for example). Pressure on the government from local political and economic authorities has sometimes resulted in tolls being dispensed with for certain sections used for short local trips.

This gives rise to the "open" system in which a flat rate toll is collected only at certain places on the motorway either at a barrier or an interchange, as shown in Figure 6.

The flat-rate tolls collected are not based on a standard kilometric rate since they may be applied for journeys of different lengths.

Lastly, the design of the system sometimes involves quite short distances (20 km, or an average of 36 km) between the barriers across the carriageways, which is an increasingly intolerable constraint for long-haul traffic. The driver has to stop often to pay small amounts.

The additional cost of investment is essentially attributable to the barriers across the carriageways and, in some exceptional cases, the booth terminals at interchanges.

In the average case of a barrier with ten lanes every 36 km -- average spacing -- the estimated additional cost of FF 22 million amounts to 2.5 per cent of the cost of the infrastructure, but can be more if the distance between barriers is shorter and there is a large volume of traffic (see Figures 7 and 8).

5.4. Flow capacity and toll collection equipment

The types of equipment described in the preceding paragraph meet the requirements for the flow of traffic according to the toll collection methods used.

Average daily traffic over the year totals 19 000 vehicles per day, some 20 per cent of which are lorries. There are very marked seasonal variations, however, and some 40 per cent of the annual traffic on the network in Southern France is during the summer period. The well-known traffic peaks on certain sections create difficult capacity problems for the motorways and also for management of the toll system.

The toll structure is based on the categories of vehicles shown in Table 3.

The automatic toll collection equipment at present consists of:

- Basket-type recipients for coins, used in the open system;

-- ISO2-type readers of credit cards issued by the banks (Carte Bleue, Eurocard-Mastercard, Access, Eurochèque, Crédit Mutuel), by trade associations (TOTAL, DKV, UTA), or by the companies themselves (season tickets or special cards).

Some of the motorways also have terminals which in addition process microchip cards to debit the toll.

All operations can be performed manually in the toll booths by the attendants who are there around the clock (3 x 8-hour shifts).

In a closed system the exit flow which can be handled is around 160 to 200 vehicles per hour per lane, depending on the type of equipment used. The average breakdown of the operations is as follows:

. 70 per cent by means of cash;
. 15 per cent by means of bank cards;
. 15 per cent by other cards and season tickets.

The inflow lanes handle about 300 to 400 vehicles per hour, a toll card being taken by the driver on entering.

The breakdown of methods of payment in the open system is more or less the same as that for the closed system and the flow per lane ranges from 180 to 300 vehicles per hour depending on the type of equipment and the amount collected. It is important to achieve a suitable mix between automatic toll lanes and manual lanes so as to ensure the optimum exit flow.

The rates of flow given are not, of course, achieved systematically, especially at the interchange terminals where it is not easy to vary the number of lanes open.

Monitoring devices are combined with the collection equipment so as to prevent fraud, keep track of the operations in detail and compile statistics.

5.5. Toll collection costs

In addition to the managerial staff of each company, toll operation calls, on average, for:

-- 0.5 to 1 person per kilometre in the closed system;

-- 1.1 to 2 persons per kilometre in the open system,

depending on the particular characteristics of the sections and the traffic handled.

Leaving aside investment and structural costs, toll collection costs in France average FF 190 000 per kilometre

-- all systems together -- whereas FF 170 000 are required for maintenance and safety. These amounts have to be increased by some 30 per cent if structural costs are taken into account.

The closed system, which calls for a double check (entrance and exit) for each trip, would seem to be the more costly. The range of costs per operation are as follows:

- -- FF 2 to 3 in the closed system;
- -- FF 0.7 to 1.70 in the open system.

In fact, the average distance travelled in the closed system (and therefore the average revenue per operation) is very much greater than that in the open system, so the toll collection cost accounts for a smaller percentage of revenues in the closed system.

The average toll in the closed system is about FF 40, of which 5 to 7 per cent covers the cost of collection.

The average toll in the open system is about FF 12, some 10 per cent of which covers the cost of collection.

5.6. Progress made since the beginning

The main progress made with toll collection since the outset has served to speed up the collection process -- and therefore the flow of traffic -- and raise the productivity of the equipment. For example, the improvements include:

- -- The number of categories of vehicle in the toll system has been reduced from over 12 to 5;
- -- More efficient and selective coin machines have been introduced;
- -- Equipment for the automatic determination of the category of vehicle has been provided (automatic measurement of the number of axles and the height of the front axle cap);
- -- Entry cards for the closed system are no longer issued manually;
- -- Since 1987 general use has been made of equipment for processing ISO2-type magnetic cards which have replaced punch cards;
- -- Bank cards are now accepted and the process for handling other credit cards or season tickets has been harmonized;
- -- The companies' computerised toll equipment has been modernised;

-- More reliable systems of handling cash have been adopted, and in several cases the money is sent directly through compressed air tubes to the safes of terminals;

-- Steps have been taken to prevent fraud.

Steps have also been taken towards improving the working conditions of the attendants (more efficient equipment in the booths, greater comfort during working hours, security, etc.).

6. COMMERCIAL POLICY WITH RESPECT TO TOLLS

The commercial policy of concession-holding companies with respect to toll collection cannot be compared with that of an ordinary commercial company, the essential reason being that a toll is not a price from the legal standpoint but a fee for the use of an infrastructure in the public domain. Vis-à-vis the manager of the motorway, the user is therefore in the same position as the user of any toll-free road.

In this particular context, the rates are fixed by the State on proposals by the companies for both the initial amount on entry into service or annual increases. Furthermore, the concession contracts specify a number of rules concerning maximum rates and the relationship between those applied to lorries as compared with light vehicles (ratio of no more than 2.5).

Tolls on French motorways have dropped in value by 25 per cent over the past ten years. Completion of the new 2 800 km programme will depend on their being maintained at the same level in real terms.

The fact remains, however, that in paying the toll the user clearly expects particular consideration and services from the concession-holding company. A commercial policy is therefore adopted in this connection, although certainly less freely than in the case of motorway services and information of an artistic and cultural nature. Co-ordination is ensured by government departments backed up on the initiative of the companies by associations set up by them.

The commercial policy as regards tolls therefore primarily concerns the following:

-- Facilitating payment of the toll by speeding up the process and reducing the psychological impact;

-- Adopting suitable systems of subscription for season tickets.

As already pointed out in Section 2 above, French tolls would seem to be fixed at a level whereby small variations of some plus or minus 10 per cent, for example, have no appreciable impact on the volume of traffic, a fact attributable to the fundamental value of the motorway for medium and long-haul journeys, together with the conditions as regards safety and comfort. The situation is unlikely to be the same in built-up areas.

Moreover, while the average rate per kilometre is now FF 0.31, the differences between top and bottom rates have been narrowed down and do not exceed a ratio of 1 to 1.8 (FF 0.26/km to FF 0.48/km) after having reached 1 to 3 around 1980. It is accepted that the rates for motorways constructed in geographically difficult areas -- where the cost may be as much as three times that of the average cost in flat country -- may be increased by 40 per cent.

6.1. Faster and "painless" collection of tolls

a) Payment of the toll in cash, with all that this implies in terms of preparations by the user in view of the frequent need to provide change, is clearly the longest and most difficult method.

   Moreover, the collection, counting and transfer of cash are a major constraint on motorway management and are difficult to keep entirely under control (fraud -- security).

   Thanks to electronic funds transfer systems, the use of cash has been reduced to 70 per cent of the operations which account for some 60 per cent of the amounts paid. As these systems progress, the percentage will certainly be brought down to 50.

   As in the French system at present, however, this type of payment in cash will continue to be used for a long time. Steps have been taken to improve the automatic cash recipients (open system) and more widely introduce payment systems in the toll booths offering a number of possibilities and allowing for a dialogue with the user.

b) Electronic funds transfer, seldom used initially, has been developing considerably over the past decade and has become particularly important since the general acceptance of ISO2-type magnetic cards throughout the French network in 1987, thus providing for payment by bank cards (Carte-Bleue, Visa, Eurocard-Mastercard, Access, Eurochèque, Crédit Mutuel), after negotiation with the banks, and by various types of card issued by the concession-holding companies or by suppliers of services (oil companies, DKV or UTA, etc.).

The cards issued by the concession-holding companies are for particular categories of user and are either specific to one or more companies or can be used throughout the network. The latter include:

-- For lorries: inter-motorway card;
-- The departments of central government or local authorities: official cards.

A number of companies have introduced a "free-way card" for drivers of light vehicles who often use motorways, especially for professional reasons. In all cases the accounts are kept by the operating companies which bill the user on the basis of particular contractual arrangements each month.

Experiments have been carried out with smart cards to which banking establishments will no doubt be moving at some time.

It may be noted that electronic funds transfer already makes it possible to eliminate some of the cash problems on the spot and, at European level, simplify payments as most of the cards are accepted everywhere.

c) Rapid or tele-tolling is the ideal form of collection and is a subject of active research and experiment since, once the equipment is installed, the operation is carried out automatically without the vehicle having to stop.

Such a procedure would now seem inevitable in order to establish the right conditions for toll payment without interrupting the flow of traffic, especially in the case of very dense urban or suburban traffic in which road users are making relatively short journeys of, say, half an hour where a delay of a few minutes is very important, whereas it is negligible for a journey of several hundred kilometres.

Tele-tolling should therefore permit very high levels of traffic nearing the maximum capacity of the infrastructure, i.e. 2 000 vehicles per lane per hour.

Moreover, space is scarce in urban areas and the size of the toll terminals cannot be increased at will. Normally, a flow of 4 000 vehicles per hour would call for a 150 metre-wide terminal accommodating about twenty toll booths.

Given that the new motorway programme decided on by the French Government aims to speed up the construction of a number of urban or suburban motorway sections by means of toll revenues -- while at the same time the traffic carried by motorways on the main arteries has been increasing at the particularly high rate of 10 per cent or more since 1986 -- the motorway concession-holding companies in France, in collaboration with the Ministry for Equipment and the Union des Sociétés d'Autoroutes à Péage (USAP), initiated a competition in 1985 to encourage industry to develop a season-ticket system for users of road infrastructures for which tolls are charged, a system that was subsequently called tele-tolling. As a result, specifications were drawn up for a system of very high-frequency exchanges between the infrastructure and the moving vehicle.

When invitations to tender were sent out by those responsible for the DRIVE programme, the USAP approached the comparable Italian and Spanish associations with a view to ensuring a sufficient degree of harmonization to make the equipment compatible. In the light of current progress with respect to vehicle design and driving systems, the project also takes account of a number of other objectives relating to:

- Driver guidance systems;
- Road user information systems;
- Various safety systems for drivers.

The aim is to complete the relevant prototypes and bring the equipment into industrial production by 1991.

A number of field tests have been carried out or are now in hand which differ somewhat in practical design but have the same objective in view and provide information on the operation of such systems, for example, with respect to:

- Automatic recognition of vehicle registration plates (SAPRR -- motorway A42 to Dagneux-Beynost);

- Very high frequency systems for vehicle identification in accordance with existing systems [SANEF -- motorway A4 to Coutevroult (in situ trials), ACOBA -- motorway A64 to Biarritz, AREA -- motorway A43 to l'Isle-d'Abeau-Les Chesnes].

These experiments relate to the open system, for which the problem is not easily solved.

d) <u>A reduction in the number of toll-booth barriers right across the carriageway</u>. This approach remains exceptional because it is very costly, and only two barriers have so far been shut down in the open systems on the Paris-Caen (SAPN) and Lyons-Marseilles (ASF) motorways.

6.2. Introduction of season tickets

The use of season tickets, i.e. giving users specific means of payment together with a reduction, is a source of difficulties for operators. In some countries this practice is not adopted. It is in fact very difficult to differentiate -- at any rate in the case of link motorways -- between reductions that can reasonably be offered to certain categories of user because the loss of revenues is largely offset by greater use of the infrastructure and those reductions which are too generous. One cannot really speak of inequality of treatment because season ticket schemes may be subscribed to by both French and foreign drivers.

Two of the main categories of motorway users benefited rapidly from the season ticket system with the consent and even the encouragement of the authorities in view of the political dimension of the problems arising, namely:

- Road hauliers;
- Users making many short trips in the vicinity of urban centres.

a) Season tickets for road hauliers (See Figure 9)

Owing to both established habits and reluctance to pay the toll, road haulage operators were, for some time, hesitant to benefit from the advantages gained by using the motorways.

So as to encourage them to use the most up-to-date infrastructures most suitable for them, the concession-holding companies proposed season ticket arrangements allowing reductions on an increasing scale in line with the mileage clocked by their fleet of vehicles. Each company calculated the reductions on its network which were as high as 30 per cent (averaging some 20 per cent). In addition there were the effects of the reduction in the axle tax granted for journeys on motorways. In short, the tolls paid by carriers for 38-tonne lorries were quite close to those for light vehicles. It should be pointed out that such a situation is quite illogical from an economic standpoint whereby vehicles would be required to pay according to wear and tear on the carriageway and the difficulties to which they give rise for motorway operation.

More recently, as the network has been growing, the companies have been getting together to set up a joint season ticket system with cards valid for the French network as a whole, namely CAPLIS (Carte d'Abonnements Poids Lourds Intersociétés).

The commercial policy of the companies is of course more readily applicable to other aspects of making the hauliers welcome and providing specific services (haulage and customs clearance centres, restaurants, hotels and various facilities).

b) Specific season tickets for short journeys

As already pointed out, while the French concessionary motorways are usually used for medium and long-distance journeys, there are exceptions which are catered for by the open system. Accordingly, exceptional tariff conditions are offered to such users.

There is quite a wide range of exceptional conditions as they cater for particular cases that often differ, such as:

-- Reductions when displaying a season ticket;
-- Purchase of credit cards entitling the driver to a number of trips paid for beforehand at a reduced price;
-- Flat-rate arrangements for any number of trips over a given period (system to be avoided).

There are also facilities entitling drivers to pass through a toll barrier in the open system or reductions for a specific journey which includes a number of separate tolls.

In most cases the journeys are between home and work in the vicinity of large built-up areas. However, this type of season ticket arrangement applying to light vehicles involves only a very small amount of business.

7. FUTURE TRENDS

The implementation of the new national master plan for roads, which will be virtually completed where motorways are concerned in the first few years of the 21st century, will mark an appreciable change in the pattern of French motorways. The two main new characteristics as regards toll motorways are:

-- The establishment of a close-mesh network of motorways covering the whole country and no longer only radiating outwards from Paris but with many transversal links between towns of over 100 000 inhabitants (see Figure 10);

This network will form an integral part of the European system of major traffic arteries. It should be noted that the rules governing the French toll system and the methods of collection involve no discrimination since:

. Toll-free parallel routes remain available to all users;
. The same rates are applied to everyone, irrespective of nationality. In addition, the season-ticket arrangements, more particularly for lorries, are also offered to all road haulage companies irrespective of nationality;

-- Extensions to urban and suburban areas, thus providing them with the fast traffic routes they lacked and linking up better with the motorways for long-distance journeys.

The Ile-de-France and Lyons regions have priority in this connection.

*

Based on over thirty years' experience with the toll system, these projects will speed up a number of changes already underway in the network and highlight new requirements so that better service can be offered. The essential maintenance of tolls up to the end of the concession periods, which are to be extended to the year 2015 to cope with the new programme, means that such changes are both indispensable and urgent.

The denser mesh of motorways in open country will help to relieve the increasingly overloaded older roads and no doubt avoid the need for increased capacity at the existing toll booth barriers and terminals. In order to make the most of this situation, efforts should be made which go beyond existing national frontiers to establish means of information and guidance to enable users to organise their journey and select the routes best suited to their requirements. At the same time, information of use for monitoring traffic flows should be made available to the authorities concerned.

In or near urban areas the aim should be to try to separate as far as possible the commuters from long-haul travellers on long journeys, since this would improve the continuity and homogeneity of the mesh system of link motorways and the consistency of the toll collection procedures on the network. The example of Toulouse (the eastern toll road ensuring continuity of the Narbonne-Bordeaux route and the Western toll-free road for distributing traffic) is particularly interesting in this connection.

Toll collection on link motorways, where a new generation of equipment is being installed to improve reliability and traffic flow, should not be radically changed in the coming years. However, the use of electronic funds transfer will develop considerably.

The introduction of automated exit lanes in closed systems is being studied and should allow an increased traffic flow without an increase in the number of "payment points".

The concession-holding companies will have to make considerable efforts in the field of information technology in order to find joint solutions to the problems which will no longer be specific to each of them, and may involve:

-- The connection of closed systems belonging to two or more companies without placing barriers side-by-side, a problem that has already been settled at Poitiers, between ASF and COFIROUTE, and will be settled in 1990 at Bourges between SAPRR and COFIROUTE and at Le Mans between COFIROUTE and ASF. Other cases will arise as the motorway network is extended;

-- Season tickets granted to professional road hauliers which will have to be centrally managed at some time.

The introduction of tele-tolling on link motorways gives rise to the problem of identifying which vehicles in traffic as a whole are equipped, a more difficult problem than that of developing the electronic system for the operation. The problem will be more readily resolved in the case of specifically urban traffic which essentially consists of season ticket holders. It is precisely in this case that the fullest advantage can be taken of tele-tolling in view of the flexibility offered by the road surface installation and changes in the toll rate according to peak periods. There is every reason to think that this new system will be fully operational by 1992 and that European standardization will facilitate its development.

8. CONCLUSION

On the basis of the toll system, France has rapidly constructed a network of link motorways which, given the additional roads to be built between now and the year 2000, will open up the whole of the country to European traffic in satisfactory conditions in terms of speed, safety and comfort. It has also helped to provide up-to-date facilities on most of the major traffic arteries of European importance linking the northern and southern parts of the Community.

The toll system is applied without any discrimination as regards nationality. All the progress accomplished in toll collection is based on means such as bank cards which, at the same time, are coming into wider use for other purposes within the Community.

The aim should be for the same to apply in the case of "tele-tolling" which is now in course of development. Here France is working with neighbouring countries using the toll system (Italy and Spain) in the DRIVE project, a project that is an integral part of much broader research to develop a standardized ground/vehicle communications system at European level so that all the various operations can be carried out in the different countries (tolling, road pricing) and provide users with other services such as information or, eventually, guidance.

The presentation of the project in the context of the DRIVE programme is one of the first steps towards this European standardization of ground/vehicle communications.

TABLES AND FIGURES

* * *

Table 1

FRENCH MOTORWAY NETWORK

Concession-holding company	In service as at 31st December 1987	Under construction (kms)	At planning stage (kms)
Société des autoroutes de la Côte Basque (ACOBA)	66	-	-
Société des autoroutes Rhône-Alpes (AREA)	270	4	29
Société des autoroutes du Sud de la France (ASF)	1 341	128	48
Compagnie financière et industrielle des autoroutes (COFIROUTE)	682	27	33
Société de l'Autoroute Estérel-Côte d'Azur (ESCOTA)	328	30	58
Société des autoroutes du Nord et de l'Est de la France (SANEF)	864	69	-
Société de l'Autoroute Paris-Normandie (SAPN)	187	-	-
Société des Autoroutes Paris-Rhin-Rhône (SAPRR)	1 020	129	158
Société du Tunnel Routier sous le Mont-Blanc (STMB)	105	-	2
Total	4 863	387	328

Definitions:

Motorways under construction:
Work underway, contracts concluded, and probable date of entry into service is known.

Motorways at planning stage:
Layout has been decided and the project has been declared of public utility; to be started in 1988.

Source: Direction des routes (Highways Department).

NB: This table does not cover any additional facilities that it was decided to include in the programme in 1988.

Table 2

TOLL REVENUES AND AVERAGE RATES PER KILOMETRE AT 31ST DECEMBER 1986

Country	National currency / European monetary unit (Ecu)		Toll revenues (millions)	Average rate per kilometre: All categories of vehicle combined	Average rate per kilometre: Private cars: type R1t 14	Average rate per kilometre: Lorries + Trailers 4 axles
AUSTRIA	Schilling	14.605	1 772.9	2.20	1.73	5.59
-- Concessionary motorway system in service 255.5 km	Ecu	1	121.39	0.15	0.12	0.39
SPAIN	Peseta	140.94	51 973.9	8.82	8.20	17.31
-- Concessionary motorway system in service 1 832.7 km	Ecu	1	368.77	0.06	0.058	0.12
FRANCE	Franc	6.872	9 593.0	0.33	0.30	0.63
-- Concessionary motorway system in service 4 712.1 km	Ecu	1	1 395.95	0.048	0.043	0.092
GREECE	Drachme	148.60	2 240.0	0.68	0.55	1.21
-- Concessionary motorway system in service 802.0 km	Ecu	1	15.074	0.005	0.004	0.008
ITALY	Lire	1 446	2 649.266	84.18	76.02	151.19
-- Concessionary motorway system in service 5 162.6 km	Ecu	1	1 332.14	0.059	0.053	0.105
PORTUGAL	Escudo	156.15	2 959	4.06	4.01	10.26
-- Concessionary motorway system in service 157.9 km	Ecu	1	18.95	0.026	0.025	0.066
YUGOSLAVIA	Dinar	437.38	13 251.6	3.59	7.79	11.49
-- Concessionary motorway system in service 663.0 km	Ecu	1	37.45	0.013	0.016	0.024

Table 3.

5 CATEGORIES OF VEHICLE

The criteria used to define the categories are physical and can be measured: 

- Height H at right angles to the front axle of the vehicle or combination
- The number of axles of vehicle or combination

N.B.: Neither the weight nor the fiscal horsepower of a vehicle or combination are used as criteria for the category.

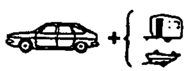
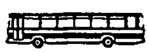
CATEGORY 1 Vehicles with 2 axles and H equal to 1. 30 m or less, with or without luggage trailer		Examples: Toyota Land-Cruiser: Renault Espace Range Rover and Land-Rover Lada Niva Family minibus with no more than 9 seats
CATEGORY 2 Vehicles or combinations with 2 or more axles and H equal to 1. 30 m or less		Cat. 1 towing another vehicle (regulation towing system). Cat. 1 towing a trailer (other than luggage trailer). Citroen CX or DS (Tissier type) 3 axles.
CATEGORY 3 Vehicles with 2 axles and H over 1.30 m	 	* Renault Estafette, Trafic and Master Citroen C25, C35 and Tub. Peugeot J5, J7 and J9. Fiat 850T, 900T, 238. VW Kombi, Transporter, LT, Ford Transit (all models with two axles), Bedford CF 2 axles. Toyota Hiace and Lite ace. Leyland Sherpa *except in minibus version Iveco – Unic Daily – Solo road tractor. PL3 live axles, one lifting axle.
CATEGORY 4 Vehicles with more than 2 axles and H over 1. 30 m. Coupled combinations with more than 2 axles and H over 1. 3 m.	  	Cat. 3 towing a Cat. 1 or Cat. 3 (regulation towing system). Cat.3 towing a trailer. Peugeot J7 with flat back and 3 axles
CATEGORY 5 Motorcycles		Motorcycles with side-cars Motorcycles with trailers.

Figure 1. **GENERAL ORGANISATION OF THE SYSTEM OF FRENCH MOTORWAY CONCESSIONS**

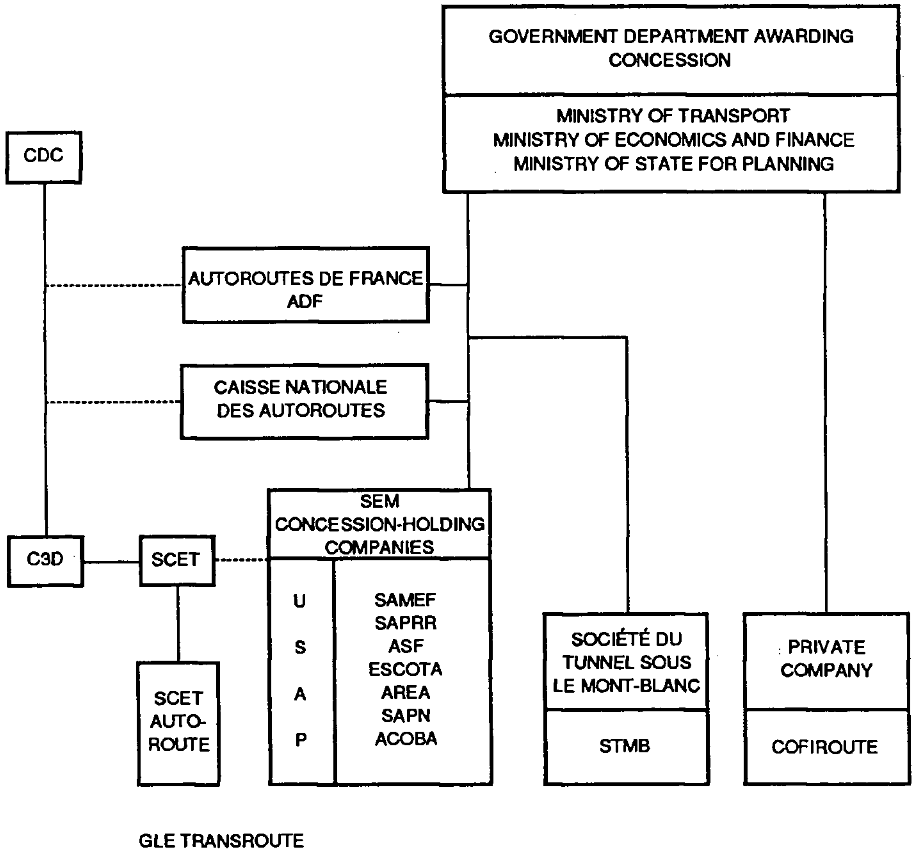


Figure 2

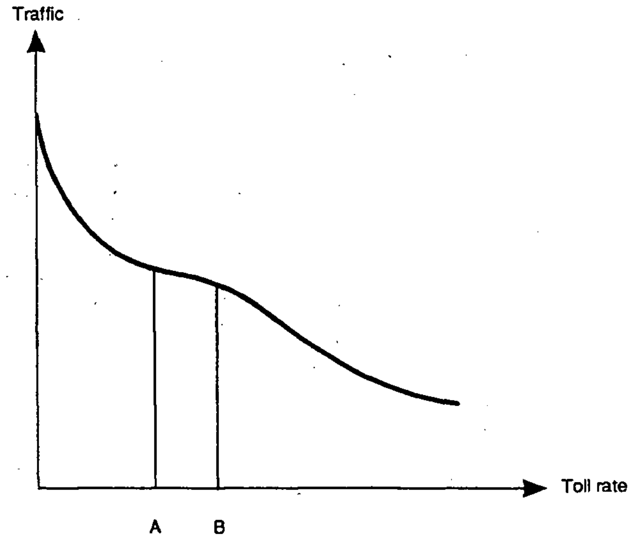


Figure 3

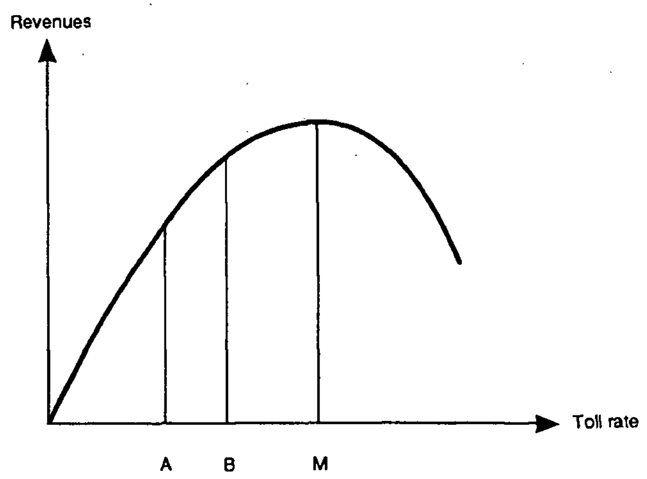


Figure 4

OPEN SYSTEM

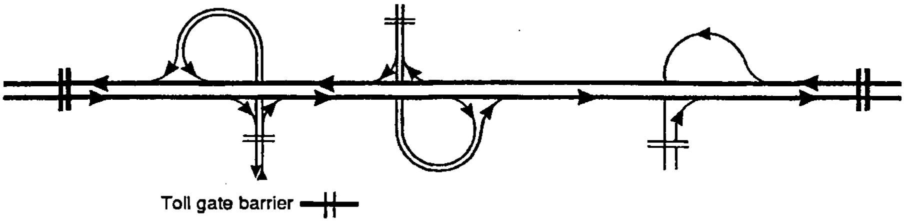


Figure 6

OPEN SYSTEM

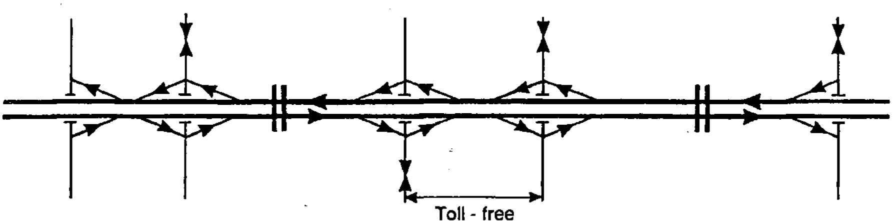
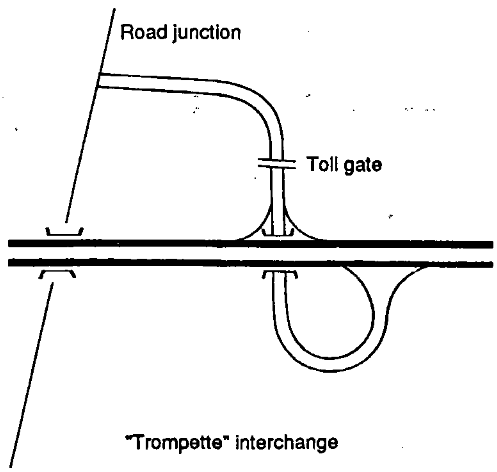
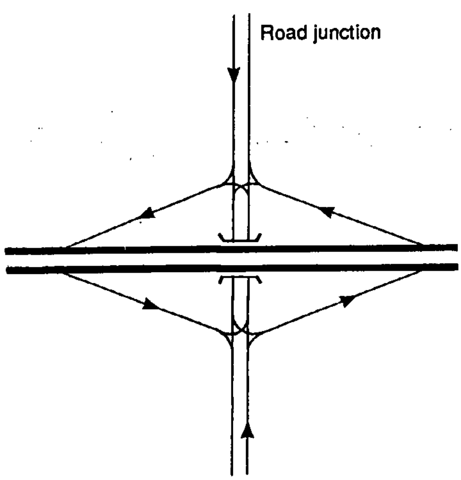


Figure 5

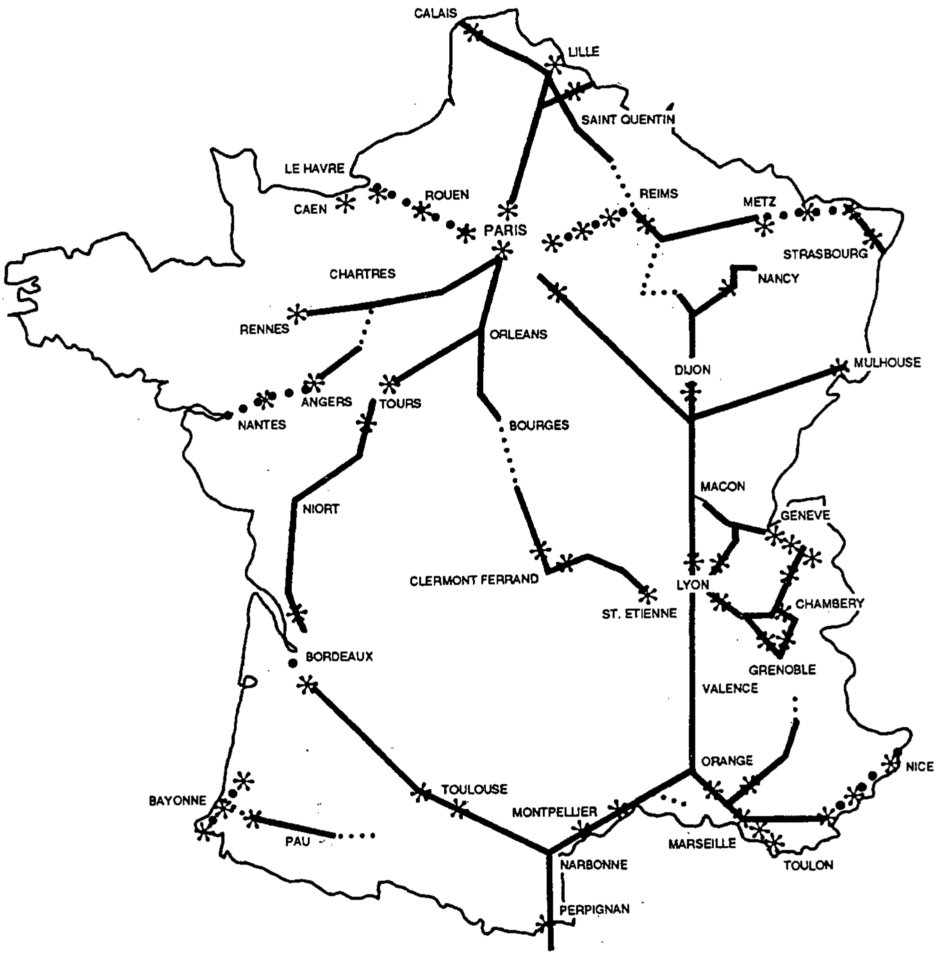


"Trompette" interchange



"Losange" interchange

Figure 7. **TOLL MOTORWAY SYSTEM IN FRANCE AS AT 1st JANUARY 1988**



Closed systems — Full-width toll barriers *

Open systems • • • • Sections under construction ....

Figure 8. **EXEMPLE OF OPEN SYSTEM**
MOTORWAY A13: MANTES - CANNES

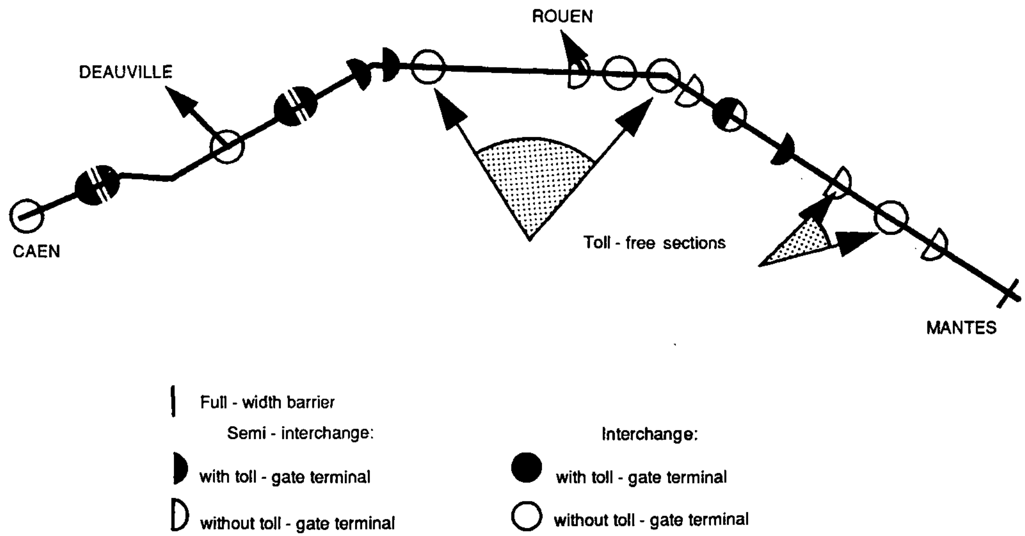


Figure 9. **DISTRIBUTION OF SEASON TICKETS FOR ROAD HAULIERS AS AT 31 st DECEMBERT 1987**

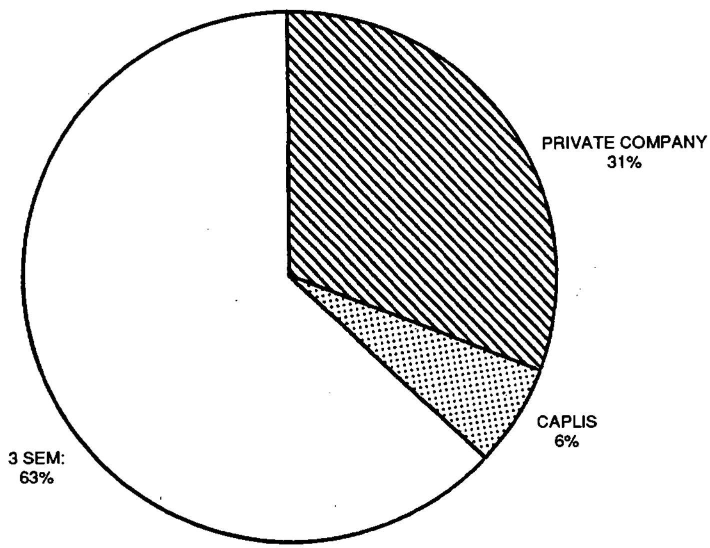
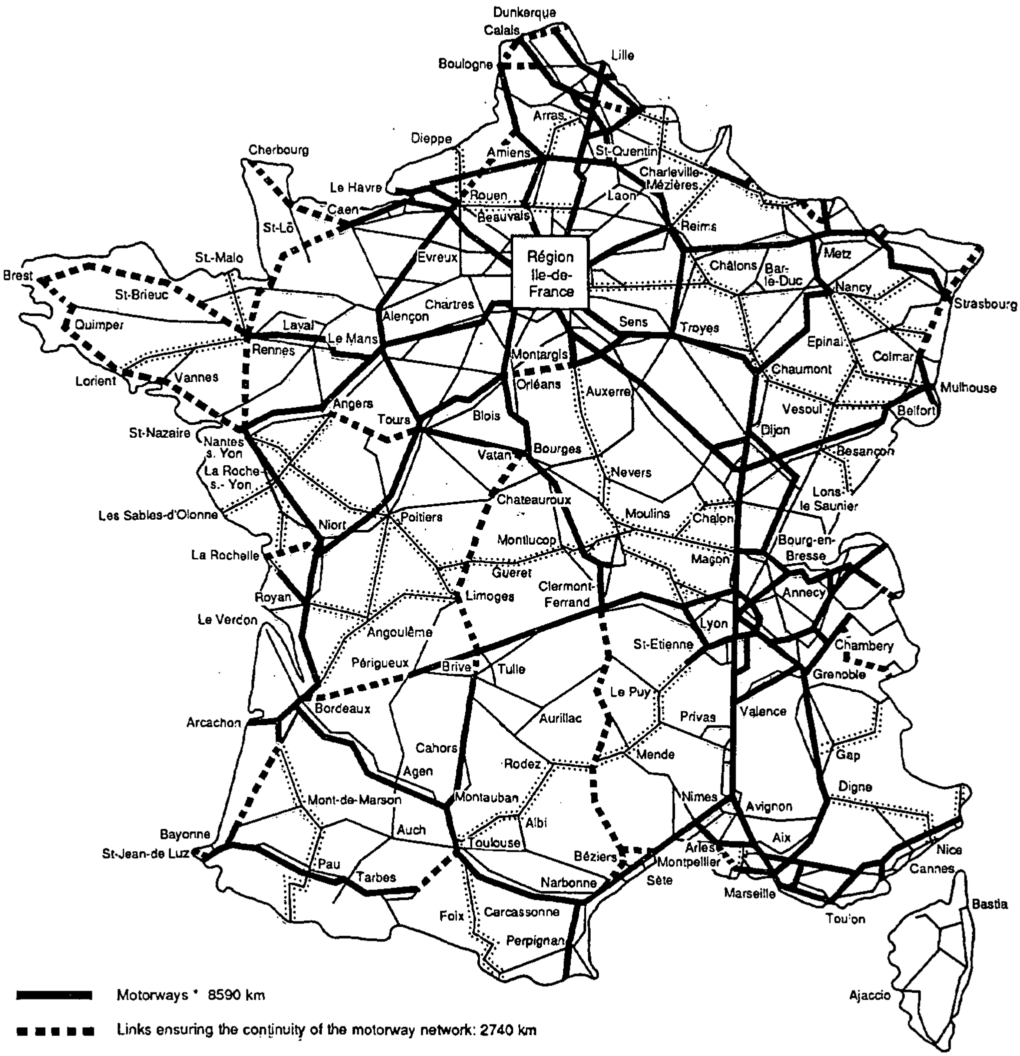


Figure 10. **MASTER PLAN FOR NATIONAL ROADS**



Motorways * 8590 km

Links ensuring the continuity of the motorway network: 2740 km

Other major links for regional development: 4850 km

Other national highways covered by the master plan: 20600 km

* As no final decision has been taken concerning the layout of the new motorways covered by the plan, the corresponding routes are indicated provisionally by straight lines.

SWITZERLAND

*

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THE SWISS ROAD ACCOUNT

SUMMARY

Lausanne, September 1988

1. INTRODUCTION

In 1959 the Swiss Federal Council issued a "message" concerning the use of some of the revenues from import duties on motor fuels for the purpose of road construction and said that it would arrange for a road account to be drawn up which would show the income accruing to the public authorities from motor vehicle traffic together with the road costs generated by this traffic.

The initial statement, which took account of the years prior to 1959, was published in 1968. As from 1976, the figures were finally established with a breakdown by motor vehicle category.

2. THE ROAD ACCOUNT: OBJECTIVES AND LIMITATIONS

The main purpose of the road account is to determine the extent to which road costs are offset by particular taxes and duties on motor vehicle traffic.

In line with the principle whereby each branch of the transport sector should cover its own costs, it is also useful to calculate the degree of financial self-sufficiency of motorised road traffic for purposes of comparison with other modes of transport.

The law specifies that the road account provides a statement showing the monetary flows between the private economy and public purse arising from motorised road traffic. In other words, the account exclusively concerns the corporate sector insofar as the flows taken into consideration relate, on the one hand, to the benefits offered by roads for motor-vehicle traffic and, on the other hand, to the contributions made by such traffic towards covering public expenditure on roads.

Accordingly, the Swiss road account (Figure 1) is confined to direct road costs and income and excludes external effects (pollution, accidents, congestion, impact on regional economy, safety, etc.) and, as it stands at present, cannot therefore meet requirements in connection with the allocation of resources and can in no way whatsoever be seen as an instrument for the choice of investment in the transport sector.

This fairly narrow concept of the road account at present precludes any question of establishing the bases for a fiscal policy in the road transport sector, since the data taken into account to calculate the financial self-sufficiency of user categories are inadequate for any value judgment on the economic performance of these users.

This situation is currently prompting those responsible for drawing up the road account to broaden its scope to include social factors. However, the results of this endeavour are uncertain in view of the difficulties involved, owing to the large volume of economic data to be taken into account and the number of simplifying assumptions that have to be accepted by all the parties concerned in order to place a value on the social costs and benefits, and then allocate them among the various user categories.

Three different methods of calculation are taken into consideration in drawing up the road account:

1. A capital account, in which roads are regarded as an asset made available to users and for which provision is made for depreciation and also interest on the residual value; the cost of maintenance, administration and traffic policing are also taken into account; the statement shows the degree of financial equilibrium.

2. An expenditure account, in which all costs for the financial year are written down in the current year; annual income and expenditure are set against one another and only deficits (or actual surpluses entered) are subject to interest charges; this account determines the rate of coverage.

3. A financial policy account, in which the import duties on motor fuels are entered in accordance with legal provisions since the other data are consistent with the capital and expenditure accounts; the results obtained therefore depend on financial policy decisions.

3. ORGANISATION OF THE COLLECTION AND PROCESSING OF DATA

The three institutional levels (Confederation, cantons and communes) are involved in drawing up the road account from the standpoint of the collection, synthesis and processing of the data (Figure 2).

The Swiss network consists of three categories of roads, one for each institutional level, namely communal, cantonal and national.

While the Confederation is responsible for building national roads, the cantons maintain and operate both cantonal and national roads. The communes manage the whole of their network themselves.

The Federal Department of Statistics sends out a questionnaire each year to collect the data from the communes and cantons, data which are found in the management accounts of the public authorities and have to be adjusted to bring them into line with the requirements laid down for drawing up the road account. After various cross-checking procedures, the Federal Department prepares a synthesis of the data compiled.

3.1. Costs

After deducting the costs that are not directly related to road infrastructure (ancillary costs), public road expenditures are grouped by category of road and by seven separate types: new construction, improvements and modifications, maintenance, administration and social security, signs and signals, regulations and interest on expenditure in excess of income.

In order to take account of the fact that road infrastructure also serves many public purposes (pedestrian areas, markets and meeting places) and is likewise used by other vehicles (bicycles, agricultural tractors, etc.), quotas are applied on the amounts for each category of road (communal: 70 per cent, cantonal: 90 per cent, national: 100 per cent).

The year 1919 was selected as the point of departure for calculating depreciation since it is around the year in which motor vehicles were introduced. An initial value was estimated for the road network and the cost of new construction, improvements and modifications is added to this amount each year and is written down on a linear basis over forty years (rate of 2.5 per cent). The land is not written down since there is no financial depreciation. More recently, the cost of maintenance has also been capitalised and written down (rate of 8 per cent) in view of the close relationship between the initial investment and expenditure on maintenance.

3.2. Income

The income from motor vehicle traffic included in the road account consists of the ordinary import duties on motor fuels, supplementary customs duties on motor fuels, the turnover tax on imported products (including spare parts) and cantonal duties and taxes on motor vehicles. As regards the customs revenues, account is taken only of the proportion of the taxes in excess of the average of the import duties on all taxable goods. Since 1985, the revenues from both the road tax ("vignette") and the charge on lorries have also been included.

Once account has been taken of the interest charges, the overall rate of coverage or the overall degree of financial equilibrium (Figure 3) can be calculated by setting the expenditure against income (expenditure account) and the cost against revenues (capital account).

In order to draw up the road account by user category, motor vehicles are divided up into twenty-three groups.

4. ASSUMPTIONS GOVERNING THE ALLOCATION OF EXPENDITURE AMONG USER CATEGORIES

The principle of equity requires that each user of the road network should pay according to the costs that he generates, a criterion that calls for the identification of the costs specific to each category of user of the road infrastructure. Experts have calculated that 5.5 per cent of investment in new construction, improvements and modifications has related to the need to ensure that road structures are made stronger and larger owing to the weight and size of lorries. Similarly, 10 per cent of the cost of improvements and modifications in repair work is also attributable to lorries. The system of allocating the latter expenditure among the sub-groups of lorries is based on the establishment of an equivalence factor (load per axle raised to the power of 2.5) and the kilometrage per year. The specific costs of investment in new construction, improvements and modifications are allocated in proportion to the kilometrage multiplied by the load per axle.

Since the expenditure entered in the road account consists essentially of common and global costs, it is allocated among user categories on the basis of the criterion of degree of use. Accordingly, the annual kilometrage is the basis for allocating all expenditure with the exception of investment in the road surface for which account is taken of the characteristics (length) of vehicles. Lastly, interest charges are broken down in the same proportion as the other items of expenditure.

A few specific costs are allocated directly to categories of lorries. For example, the proportion of new construction, improvements and modifications assigned to the categories of lorries is broken down on the basis of an axle load equivalence factor and annual kilometrage; the amount for repairs depends on the weight and is allocated on the basis of gross tonnage multiplied by kilometrage.

The assumptions used for the allocation of expenditure are summarised in Figure 4.

5. THE ROAD ACCOUNT STATEMENT

The specification of the items to be taken into consideration in the road account, and the way in which the amounts are to be calculated and allocated among user categories, have been the subject of many studies and much negotiation among those concerned.

The road account for 1985, the latest to be published to date, is the outcome of a thorough review undertaken in 1981, and it shows road traffic is having a greater degree of financial self-sufficiency than in the past since, as compared with the previous financial year calculated according to the former method, the overall degree of equilibrium (capital account) improved by 10 points, rising from 80.6 to 90.6, essentially owing to adjustments to the costs as a whole and the fact that account was taken of new income such as the charges on lorry traffic (SF 109 million), the road tax "vignette" (SF 141 million) and a proportion of the turnover tax (SF 76 million).

The capital account for 1985, giving the most significant result, showed totals of SF 4.4 billion in costs against SF 4 billion in income, i.e. a shortfall in income of some SF 400 million.

Whereas Switzerland's motor vehicle population roughly doubled over the past 15 years (1970 to 1984), the road account costs calculated according to the former method increased 2.7 times. In fact, annual expenditure on investment in new construction, improvements and modifications changed very little during that period (+13 per cent). The main reason for the increase is the cost of depreciation relevant to the economic life of the infrastructure, which reflects the substantial increase in investment expenditure during the 1960s. Owing to the expansion of the road network, maintenance charges are also tending to account for an increasingly large proportion of costs in the road account (+102 per cent between 1970 and 1984).

Income doubled during the period 1970 to 1984, thus keeping pace with the growth of the motor vehicle population. The divergent trends in expenditure and income have meant that the overall degree of equilibrium changed from a positive value in 1970 (115.5 per cent) to 80.6 per cent in 1984 (Figure 5).

The results by major groups of vehicles (light vehicles, heavy vehicles) followed the same pattern as the overall degree of equilibrium, with the former showing a steep fall (-35 per cent) from 129.6 in 1970 to 83.8 in 1984, while the figure for heavy vehicles fell from 72.4 to 64.2 (-11 per cent) over the same period.

The relative stability of the rate of coverage is largely attributable to the levelling-off of investment in new construction while income from road traffic has been steadily increasing.

6. CREDIBILITY OF THE RESULTS

The substantial proportion of common and global costs in road expenditure as a whole means that the allocation of these amounts among user categories calls for systems of allocation that are necessarily somewhat subjective, so the results calculated are sometimes questioned and are given as grounds for opposing any tax decisions based on the degree of financial self-sufficiency of categories of vehicles.

The choice of cost-allocation systems can clearly appreciably alter the structure of the financial results, especially for categories of vehicles which account for only a small proportion of the total vehicle population.

When the road account was recently revised, a few systems of allocating capacity costs were tested in order to calculate the rate of coverage (expenditure account) by user category.

These systems (Figure 6) are either based solely on annual kilometrage or combine the latter with particular vehicle characteristics (road surface occupied, length, speed), thus showing how difficult it is to make a value judgement about the real financial situation of one category of vehicles as compared with the others, the most evident case being that of lorries with a total weight of 4 to 6.5 tonnes for which the rate of coverage ranges from 90 to 140 per cent according to the cost-allocation system adopted.

It was also thought useful to show the effects of the relative reliability of the parameters used in the allocation systems. For example, the uncertainty concerning the estimate of annual kilometrage travelled by vehicles has been taken into account in the system of allocating capacity costs as used at present. This exercise has shown the scale of uncertainty about the value calculated, especially where lorry categories are concerned, and confirms the need to qualify one's assessment when the degree of financial self-sufficiency of a user category is calculated on the basis of such determinants (Figure 7).

7. RECOMMENDATIONS WITH A VIEW TO IMPROVING THE BASES FOR CALCULATING THE SWISS ROAD ACCOUNT

The currently used method of breaking down costs by the direct or indirect allocation of types of cost is fairly rudimentary. Its main advantage is the simplicity of the calculations, while the inevitable shortcoming is that it is both imprecise and arbitrary; since how can one establish one or more systems of breaking down costs which can properly be applied to all the components of the formidable amounts of money grouped by types of expenditure or totals as diverse as the headings "New construction" or "Improvements and modifications"?

This approach underwent a radical reappraisal which gave rise to a number of major changes both in the amounts taken into account and in the systems of allocating or breaking down certain groups of costs. The Federal Department of Statistics, which is responsible for drawing up the road account, is also continuing its work with a view to improving the quality of the basic data supplied by the public authorities and, more particularly, with a view to finding a method that takes better account of the reliability of data.

The incremental type of approach, as recently proposed by the United States Department of Transportation, may provide an attractive point of reference at first sight, since it seeks to show cause and effect relations between the origin of a mechanism and the occurrence of expenditure or a cost, thus bringing to light a large number of specific costs that can be directly attributed to user categories. The main drawback of this method lies in the fragility of all empirical relations and in the cost of implementing it since it calls for a very detailed breakdown in the collection of data which are organised not only by types of cost but by regions, types of road and road structures, surfacing materials, gradients, width of carriageway, and so on.

Accordingly, the Swiss road account is expected to move towards a progressive system of allocating costs and income which consists in organising the accounting data in homogeneous sub-sets and then distributing them in the light of the margin for error in the allocation at each stage of the breakdown (Figure 8).

In order to adopt the approach recommended, it is advisable to define a number of intermediate stages characteristic of the route followed by the financial flows between their origin or source and a destination or analysis unit (Figure 9). These intermediate stages constitute what are known as the main sections in cost accounting, and four types of main section can be defined as follows:

1. Transport supply, i.e. the technical infrastructure made available (main section: ROADS);

2. Demand, i.e. the user categories expressing particular requirements and providing specific services (main section: USERS);

3. The market on which supply is set against demand; the market is characterised by the traffic or operational

services as against the services characterising supply (main section: TRAFFIC);

4. Any other expenditure that does not clearly come under one of the above three headings (main section: RESIDUE).

The arrangement of the data into main sections enables us to establish sets of costs for which the degree of relationship with user categories and final destinations is more evident. For example, any expenditure relating to user categories is assigned directly to the groups concerned whereas that relating to the "TRAFFIC" section is assigned by means of an allocation system for movements. The main section: "ROADS" makes use of utility criteria (capacity) and the system of allocation has to be established accordingly.

Complete cost allocation is therefore achieved by stages by first breaking down the specific costs, then the common costs and, lastly, the global costs, and by setting out the findings by descending order of reliability.

This approach, similar to the technique of direct cost accounting (calculation of successive contributions), seeks however to show the full costs. It also has the advantage of the simplicity of incremental allocation methods, so it enables us to identify the provenance of wrong interpretation and, accordingly, gradually gather additional facts to reduce any uncertainties. For example, the results of the rate of coverage for the "heavy cars" user category are given in Figure 10, the average rate being 116.14 and the standard deviation 8.76. There is, therefore, about a 95 per cent chance that the real rate will be between the values 98 and 134, allowance being made for all the simplifying assumptions concerning the data available.

At first sight it would seem more difficult to interpret the results in the form of a probability distribution or a risk curve, but in fact the contrary is true. Interpretation of these curves provides a great deal of information and helps towards an understanding of the mechanisms governing the management of such a complex infrastructure as a national road network.

The situation changes somewhat when we try, for example, to explain the assumptions that lead to a lower rate of coverage for the category of lorries under 6 500 kg payload than for the under 4 000 kg category, whereas the mean values of the rates of coverage indicate precisely the opposite. Many examples of this type can be given and they are particularly pertinent where very different user categories are under consideration (motorcycles as compared with private cars, private cars as compared with delivery vans).

To conclude, it would seem that the results of calculating full costs entail a number of assumptions which lead to considerable uncertainty as to the value of performance indicators. It is therefore necessary to establish a method of allocating costs by successive stages whereby the expenditure can be broken down by type for destinations or user categories, while indicating at each stage the uncertainty about the accuracy and significance of the results.

In accordance with current practice, the proposed model enables us to publish results in full costs by user category, but it primarily provides a basis for cost analysis which, in accordance with a logic hinging on a set of relational data (Figure 11), offers the possibility of:

-- Analysing costs and their development by type, destination, and institutional level;

-- Disaggregating the costs according to a standard classification or ad hoc classification;

-- Regrouping the disaggregated costs by types of road structure, road, geographical area, period, and administrative unit;

-- Simulating the application of different systems of allocating aggregated or disaggregated costs and revenues so as to identify the performance indicators needed for a particular study;

-- Gradually incorporating in the same model a set of recommendations established by specialists' reports on weight-related costs, capacity-related costs, depreciation and other expenses.

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FIGURES

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Figure 1. **COVERAGE OF THE SWISS ROAD ACCOUNT**

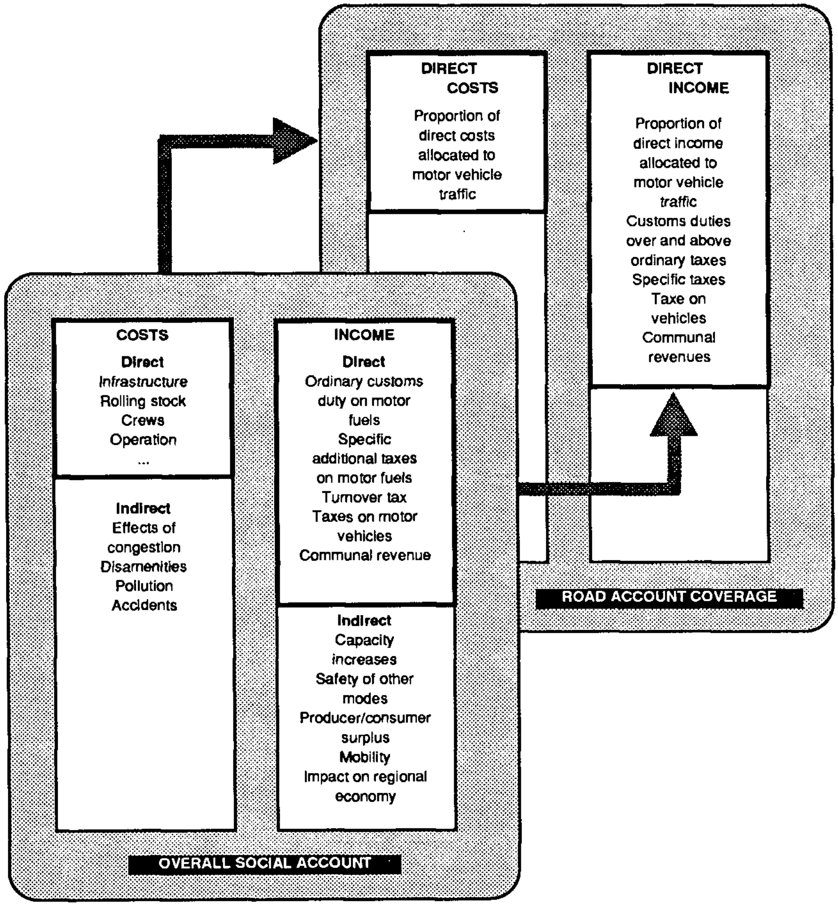


Figure 2. **PROCEDURE FOR COLLECTION AND PROCESSING OF DATA**

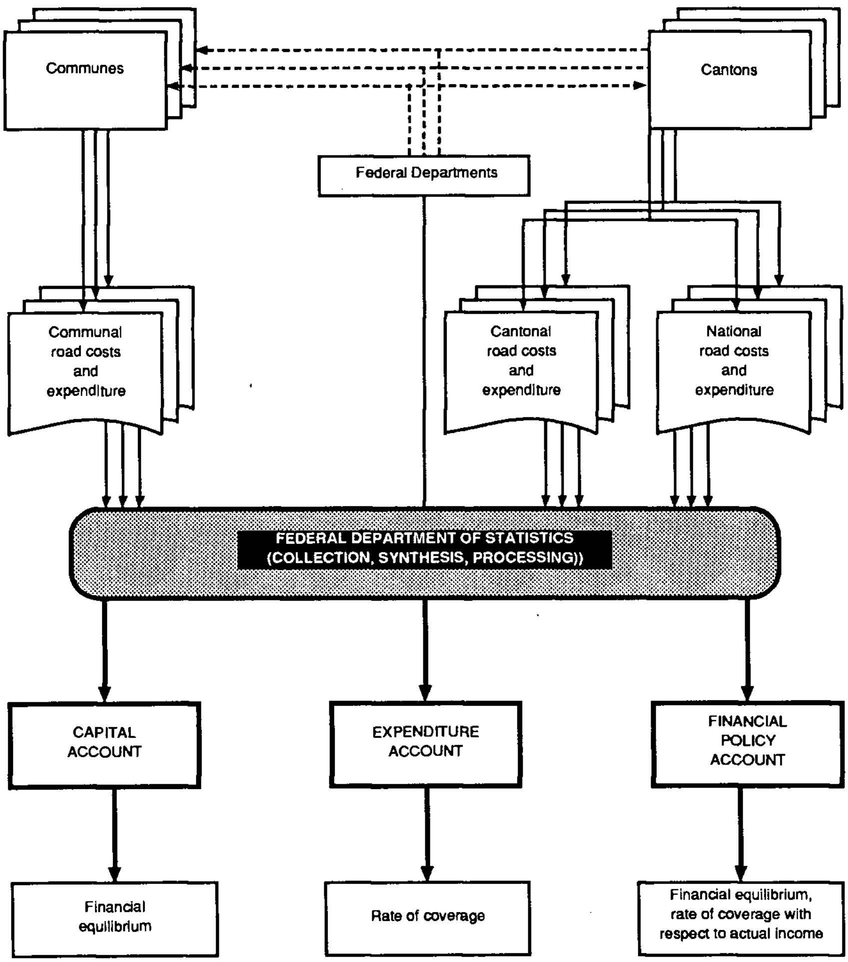


Figure 3. **GENERAL APPROACH TO COMPUTATION OF THE EXPENDITURE ACCOUNT**

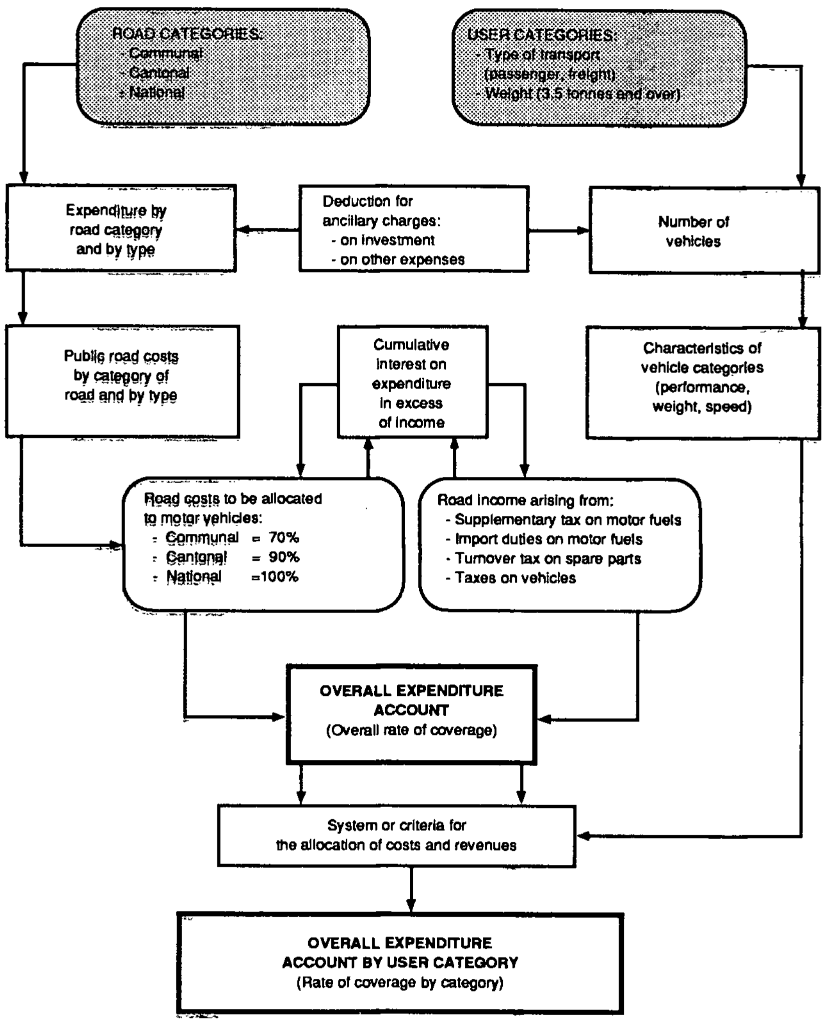
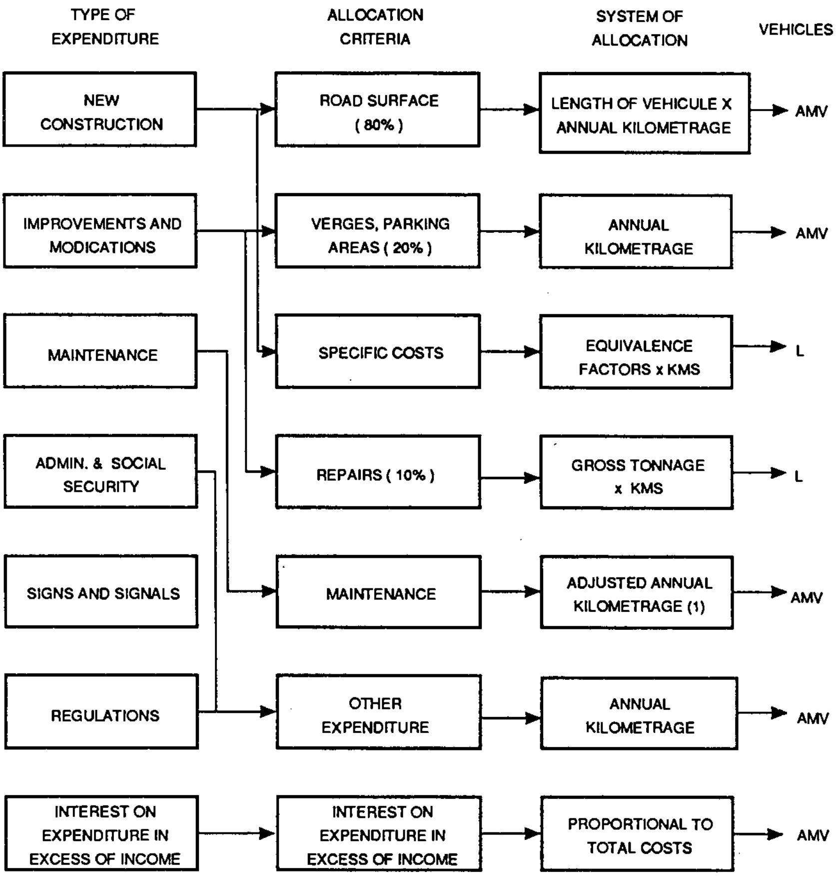


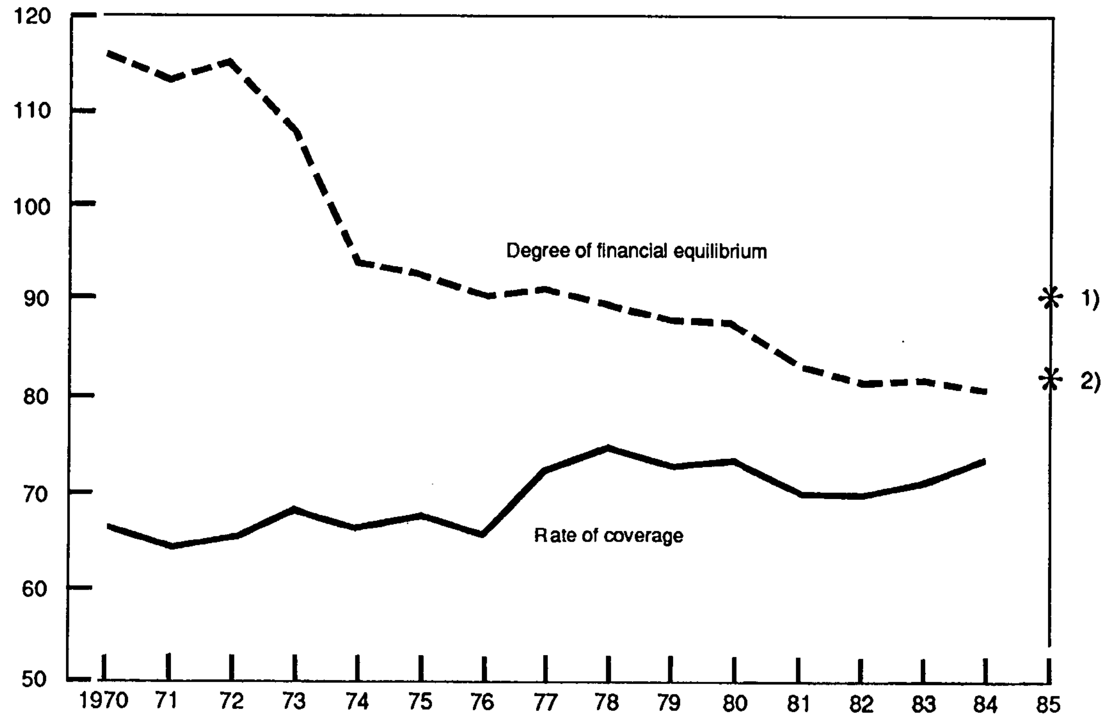
Figure 4. **SYSTEM OF BREAKING DOWN EXPENDITURE AMONG VEHICULE CATEGORIES**



Key : AMV = All motor vehicles
L = Lorries

1. Annual kilometrage reduced for mopeds and motor cycles.

Figure 5. **TREND IN THE DEGREE OF FINANCIAL EQUILIBRIUM AND RATE OF COVERAGE (1970 - 1985)**



1. Degree of financial equlibrium in 1985 (new method)
2. Rate of coverage in 1985 (new method)

Figure 6. **RESULTS OBTAINED WHEN APPLYING THE VARIOUS COST - ALLOCATION SYSTEMS**

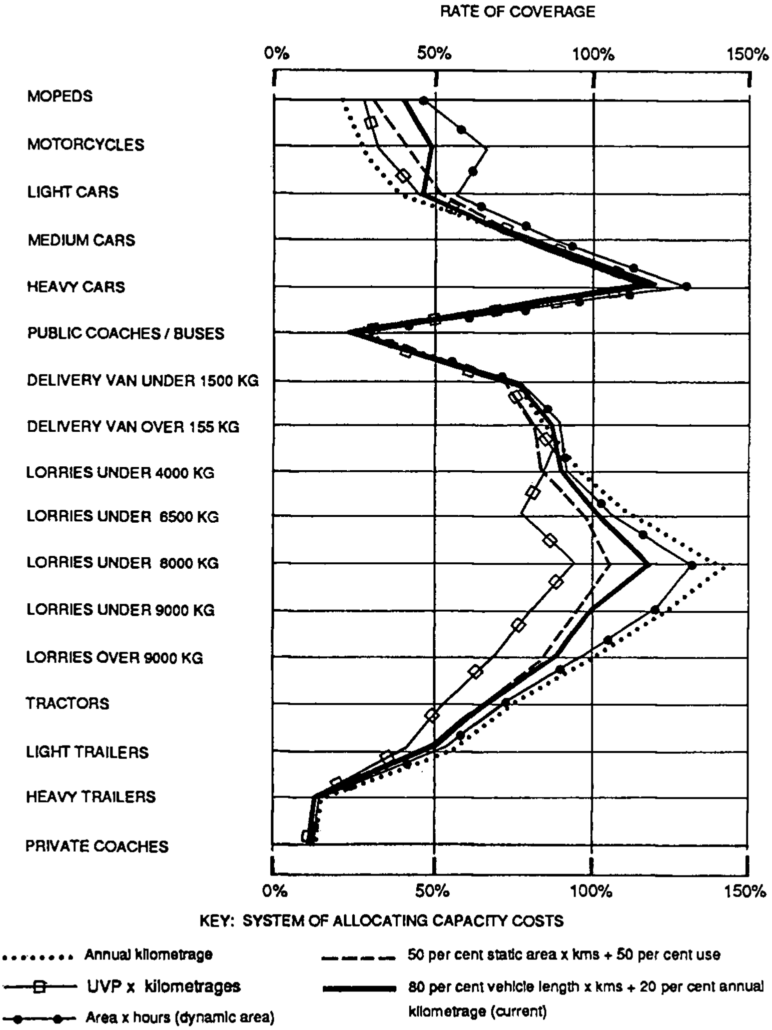


Figure 7. **MARGINS OF ERROR WITH THE EXISTING SYSTEM ACCORDING TO THE UNCERTAINTY OF THE BASIC PARAMETERS**

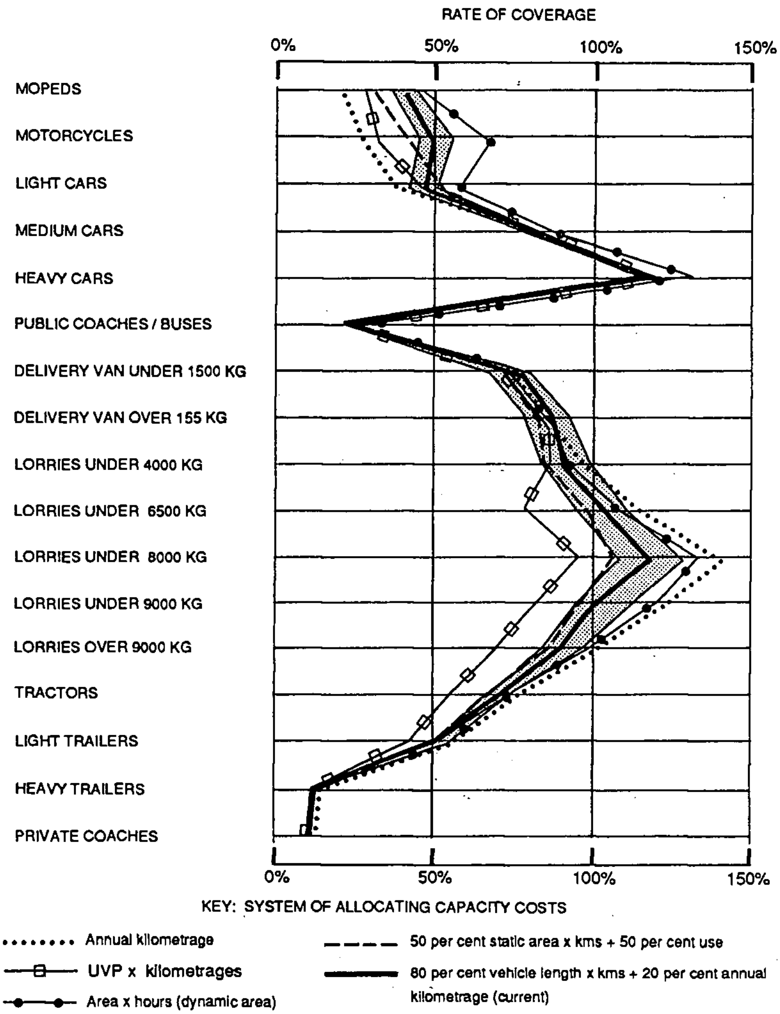


Figure 8. **GENERAL PRINCIPLES OF THE BREAKDOWN OF EXPENDITURE**

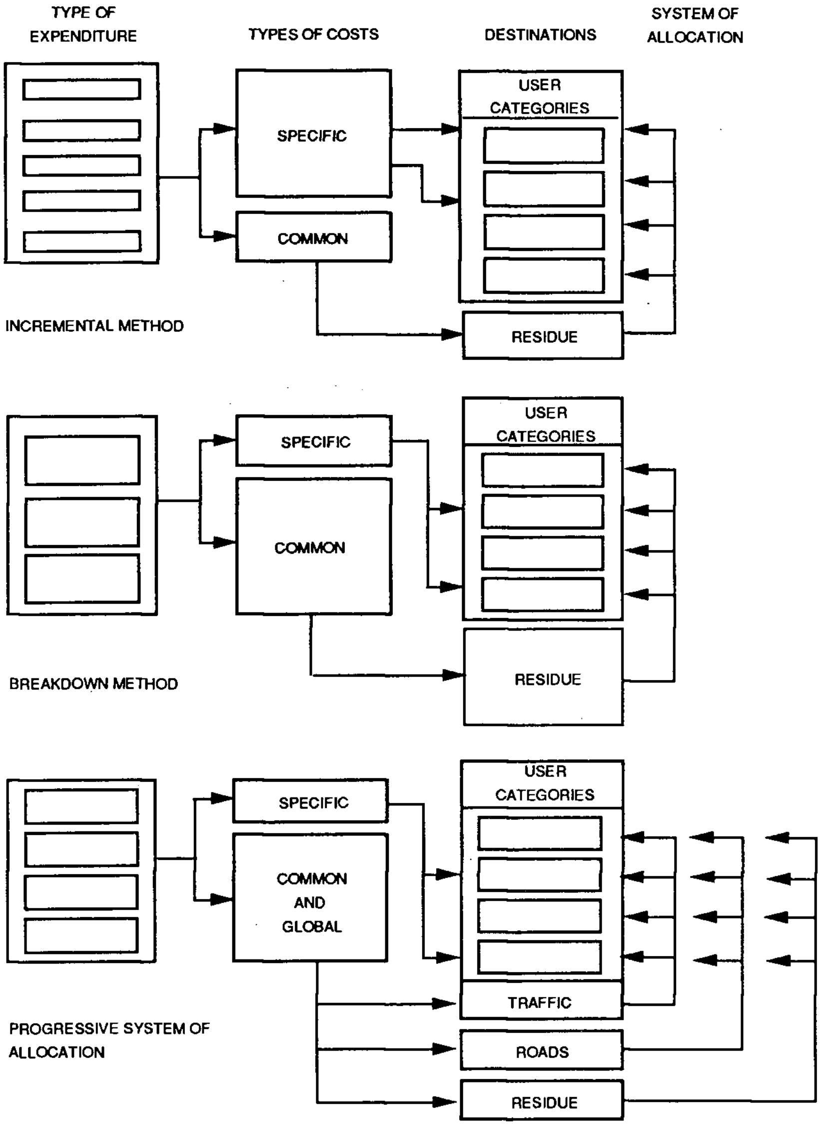


Figure 9. **PRIMARY AND SECONDARY BREAKDOWN OF GROUPS OF EXPENDITURE**

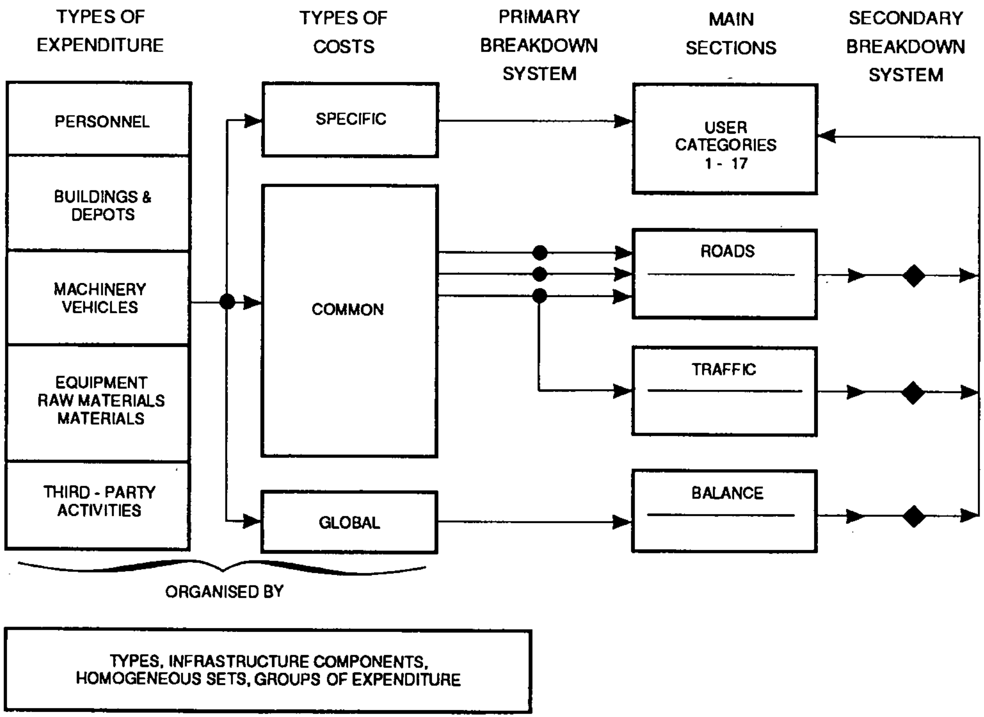


Figure 10. **PROBABILITY DISTRIBUTION OF THE RATE OF COVERAGE FOR THE HEAVY CARS CATEGORY**

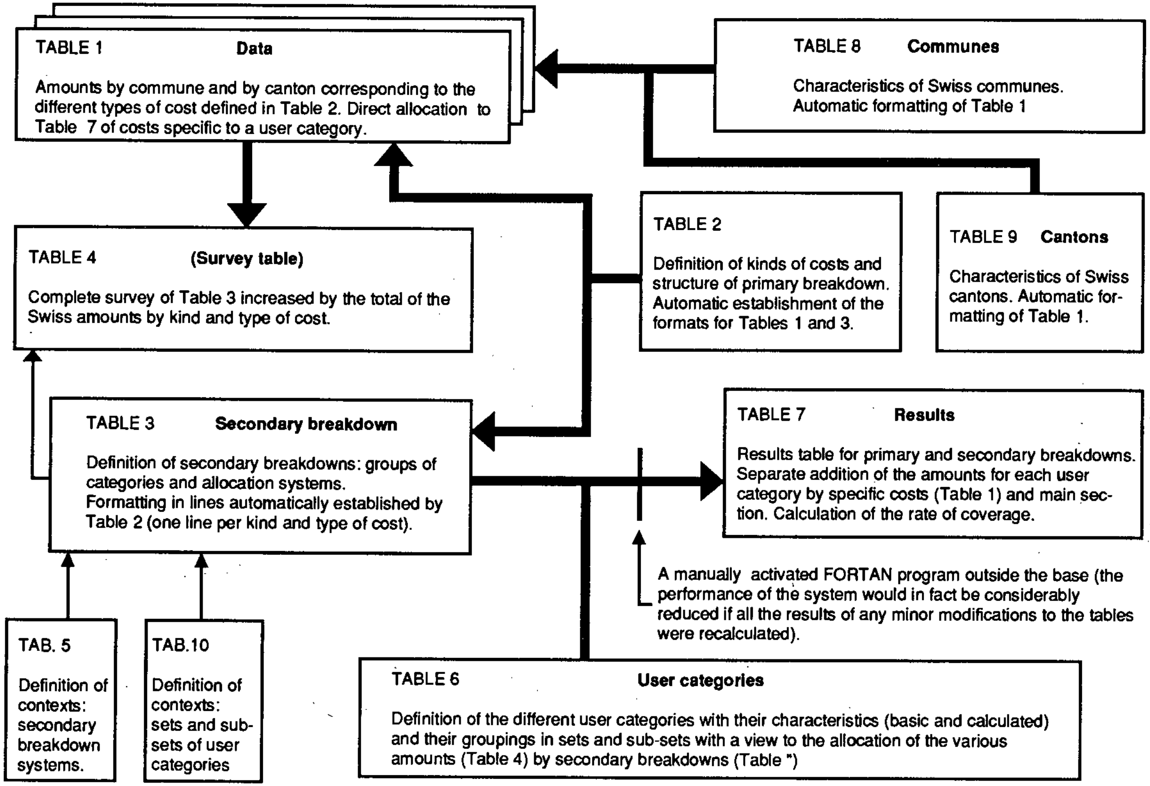
SIMULATIONS (N = 1000)

Mathematical expectation	116.14
Arithmetical mean	116.14
Standard deviation	8.76

Length of Probability Intervals 0.5

From	To	Prob. (%)	Histogramme
97.00	97.50	.20	00
98.00	98.50	.30	000
99.00	99.50	.30	000
100.00	100.50	.40	0000
101.00	101.50	.30	000
102.00	102.50	.90	000000000
103.00	103.50	1.20	000000000000
104.00	104.50	.90	000000000
105.00	105.50	1.20	000000000000
106.00	106.50	1.40	00000000000000
107.00	107.50	1.40	00000000000000
108.00	108.50	1.60	0000000000000000
109.00	109.50	2.70	000000000000000000000000000
110.00	110.50	1.70	00000000000000000
111.00	111.50	1.90	0000000000000000000
112.00	112.50	1.90	0000000000000000000
113.00	113.50	2.80	0000000000000000000000000000
114.00	114.50	2.00	00000000000000000000
115.00	115.50	2.30	00000000000000000000000
116.00	116.50	1.90	0000000000000000000
117.00	117.50	2.20	0000000000000000000000
118.00	118.50	1.70	00000000000000000
119.00	119.50	1.70	00000000000000000
120.00	120.50	2.30	00000000000000000000000
121.00	121.50	1.80	000000000000000000
122.00	122.50	1.50	000000000000000
123.00	123.50	2.00	00000000000000000000
124.00	124.50	1.50	000000000000000
125.00	125.50	1.00	0000000000
126.00	126.50	.70	0000000
127.00	127.50	1.50	000000000000000
128.00	128.50	.70	0000000
129.00	129.50	.40	0000
130.00	130.50	.40	0000
131.00	131.50	.30	000
132.00	132.50	.30	000
133.00	133.50	.10	0
134.00	134.50	.60	000000
135.00	135.50	.20	00
136.00	136.50	.20	00

Figure 11. **SCHEME USED TO ORGANISE INFORMATION FOR THE ROAD ACCOUNT**



SUMMARY OF DISCUSSIONS

SUMMARY

1. ROAD PRICING

What is the case for road pricing?

Is there too much traffic or do people make too many unnecessary journeys? Road traffic is increasing continually but infrastructure seems unable to handle the flows satisfactorily. The inadequacy of infrastructure has become particularly evident in densely-populated areas, especially in recent years as a result of the very steep increase in road traffic.

ECMT statistics show the following trend of road traffic in Western Europe:

Billion passenger-kilometres	1980	1985	1987
-- Cars	2 248	2 449	2 685
-- Buses and coaches	336	338	353
Total	2 584	2 787	3 038
Billion tonne-kilometres	687	753	825

It can be seen that demand accelerated from 1985. Such a new and fairly sudden problem obviously calls for new solutions. Furthermore, road congestion seriously jeopardises the working of the economy. Some people argue that road pricing, by differentiating between the various types of traffic, would solve the problem.

Transport needs to be set within a broader context in which social and financial objectives have to be distinguished. On the principle that transport should be financed by users, the interest of the community at large could require that public transport be financed out of individual transport. But all too often, the issue tends to be approached in purely commercial terms, whereas collective economic considerations also need to be taken into account.

Users are often hostile to road pricing since they consider that they have already paid once and should not have to pay twice over. The validity of this point of view needs to be examined. It is also necessary to consider whether existing charging systems are still suited to the needs of present-day transport, which is in total flux. In short, is the means still suited to the end?

Road pricing has many aspects, some of which will be analysed in more detail below. They are:

-- The various applications;
-- Private and public financing of infrastructure;
-- Traffic management;
-- The role of road pricing as a congestion tax;
-- The internalisation of external costs;
-- Harmonization of charges where there is competition;
-- The guiding of demand where necessary.

Road pricing is an instrument of transport policy, whose objectives form part of a broader set of aims such as environmental protection, improving the quality of life and access to town centres, and various other aims.

A basic distinction needs to be drawn between interurban and urban traffic, the problem posed by the former being primarily one of financing, while the latter involves mainly problems of traffic management. However, recent developments have blurred this distinction; motorway access roads are sometimes congested and traffic jams on motorways are sometimes several kilometres long.

The pricing principle should not be restricted to road traffic but should be applied to all modes. Unlike other modes, the owners of rail infrastructure are also the operators. It is often recommended that the ownership and operation should be separated, but the few examples of separation of the two functions that do exist show that in practice the railways cover only a small proportion of their infrastructure cost, the remainder being borne by the State. Furthermore, the fact that the State bears the cost of infrastructure means that the railways have to rely on the funds, if not the goodwill, of the supervisory authorities. Lastly, the railways cannot let trains operate freely like cars on a road. Infrastructure and operation are closely linked; this is reflected in the fact that trains run according to timetables, so if several undertakings were operating on the same line, the timetable would always give priority to one of them.

Likewise, it is not feasible for several motorways or railways to compete on the same route. This would be a step backwards to the unsatisfactory situation that existed over a hundred years ago. Furthermore, it is difficult to see how such competition could be reconciled with present-day environmental requirements. The closing decade of the century will be marked by a conflict between environmental or community interests, and those of individuals and groups, a conflict that will be resolved by policy trade-offs; road pricing could be one of the solutions.

How will charging systems be affected by the single European transport market? First, the revenue from user charges need not necessarily be reallocated to traffic needs. Consumption taxes, for example, are used to finance essential needs that are not self-financing, such as administration, education, the armed forces, justice, police, etc., and a proportion of the revenue from road charges could be allocated likewise. Most governments are unwilling to specify what that proportion would be, since it would create budgetary rigidities that could prove constraining when needs changed. Part of the solution to this problem is to allow private companies to build and operate infrastructure.

In principle, there is no reason why road charges should be allocated to the road network; at the same time, it remains to be shown that they cover all costs, including external costs. Some of the background papers for this Round Table contain interesting information on the matter. Insurance covers only a very small proportion of the cost of road safety. The cost of environmental damage can be calculated only roughly. Lastly, time wasted in traffic jams also has to be taken into account. The claim that cars are taxed too heavily cannot therefore be accepted so readily; and this is particularly true of heavy lorries and caravans which do not pay for the road wear and congestion that they cause.

Furthermore, not all infrastructure user charges can be considered to be prices in the economic sense. A price relates to a particular time and place of consumption, which is not the case for pre-paid fixed charges. Such charges cannot regulate transport demand like a price mechanism because they do not affect two types of decision: the decision to make the actual journey and the choice of the mode of transport. Far from optimising the distance covered, such charges maximise it since the user has an incentive to recoup the money he has paid out by using the infrastructure as much as he can.

Markets cannot exist without prices. Prices operate only partially in the transport market (fuel taxes, parking charges, tolls), alongside flat-rate charges. Furthermore, items such as safety, environmental damage and congestion are not charged for at their full cost.

Another distortion is arising with the growth of international traffic. As some charges are paid in a vehicle's country of origin, a vehicle may pay only a very small part of the actual cost of using infrastructure in other countries. Studies, particularly those carried out for Round Table 71, showed that the distortions were much larger than people had been willing to admit.

The principle of charging on a national basis has thus been replaced by the fairer principle of charging on a territorial basis. The term "territorial" is, however, unfortunate since it conjures up barriers and impediments to a free market. The term "causal" is much better because it describes exactly what is involved.

A toll functions as a price only if it is collected at the moment of use because then the user makes the connection between the use and the charge. This is not true of a pre-paid permit because the connection between payment and actual use is very tenuous; such permits do not therefore have a regulating function. This is an important point that needs to be borne in mind, given that other regulating mechanisms are scheduled to be abolished, with infrastructure use being regulated entirely through the price mechanism. This is why an effective price mechanism is needed, otherwise the new market could be rapidly distorted.

Lastly, two likely developments will make an effective price mechanism even more necessary. Competition will increase initially, forcing down tariffs and driving a large number of transport operators into bankruptcy. This competition should not be at the expense of the community, as often happens where transport is concerned; it can be avoided by ensuring that prices reflect actual costs.

In the longer term, transport will inevitably become more expensive because it consumes resources that are becoming scarcer or that are non-renewable: land, the environment, energy. Prices rather than direct or indirect subsidies will also play a major role in regulating the market in these resources.

2. ECONOMIC ASPECTS

Although the principle of road pricing seems to be generally accepted, views differ as to the way it should be implemented. The various aims of road pricing therefore need to be examined.

First, one has to decide whether road pricing should be used to finance the construction and maintenance of infrastructure, or whether it should be used rather to reduce congestion.

It is initially necessary to lay down policy aims for transport or town planning, for example, and then decide how road pricing can help to achieve them.

Although from the individual's point of view it is certainly desirable to promote travel, in some areas it may not be in the public interest to do so. However, the reasons why people travel do not change much in the short run. The pattern of housing and activities can therefore be influenced only in the fairly long term. Also, logistical services now play a crucial part in the economy; suppliers need to be able to get to customers, and cannot do so if there is traffic congestion.

A policy of laisser-faire would push up marginal costs and reduce the revenue from user charges. A balance therefore needs to be struck between that which is optimal for individuals and that which is optimal for the community.

However, some people consider that the principle of road pricing is inconsistent. It is assumed that the prerequisites for optimising traffic exist, but is this really so? Road pricing should be seen rather as one of a set of measures. This was underlined several times during the Round Table. Furthermore, the report by Mr. Goodwin showed that the objectives of road pricing could become incompatible with one another. The solution is to differentiate pricing by geographical or functional areas.

In some extreme cases, for example in Swedish town centres, charging systems are reported to cover costs four or five times over, i.e. the primary aim is no longer to cover costs. Opinions also tend to differ as to whether charging systems reduce traffic congestion. However, it is difficult to draw any hard and fast conclusions on this issue since not enough systematic and conclusive experiments have been carried out over a sufficiently long period of time.

In any case, a congestion charge would not suffice by itself to encourage people to use public transport more. Public transport needs to be improved and adapted to new needs. For example, if access roads to a town centre are congested, the public should be able to take public transport from outside the town, thereby avoiding the traffic jams; usually, however, they can no longer do so. This would be a new role for suburban and even interurban public transport systems.

The participants in the Round Table were in general agreement that a charging system should generate revenue, but they agreed less about the way in which such revenue should be allocated. If there is traffic congestion, a charging system should not only cover user costs, but should also include a charge on traffic congestion. It must both reduce congestion and help to prevent the erosion of the urban fabric.

Given that infrastructure costs and social costs are related, the relationship is not the same for urban transport as for interurban transport. In conurbations the low degree of price elasticity of demand has little economic impact, since very high prices are ruled out for political reasons, at least in the short term. But in the long run it may have negative effects, for example, on employment. At a broader level, a charging system can also be used to improve public transport services, particularly on those routes that optimise traffic flows. Although theoretically the charges should vary according to the density of traffic, the variation should not be such as to reduce public revenue.

The Round Table considered that the degree of price elasticity was low in conurbations, as users often did not have a real or at least acceptable choice between transport modes. The degree of elasticity varies according to the type of traffic: it is low for commercial traffic but higher for private traffic.

The Round Table reviewed some of the experience acquired with charging systems. A reduction in public transport fares does not suffice by itself to make car drivers switch to public transport. Some speakers considered that such a measure was inconsistent with the basic objective of covering costs, and did not see why public transport should be exempt from this requirement.

Public transport fare policies must be accompanied by other measures with more tangible long-term effects: creation of pedestrian precincts, reduction in the number of parking areas. The scope for introducing road pricing is determined to a large degree by the prevailing political climate. Measures that penalise car drivers too heavily meet with opposition, whereas parking charges are more readily accepted. It is thus necessary to convince the public that an appropriate system of road charges is both useful and necessary.

Practices change over time and from one country to another. Motorway tolls are one example of how the public gradually got used to the principle of road charges. Initially, there was widespread hostility to these tolls, but gradually they came to be seen as a necessary source of finance for the motorways. The authorities succeeded in convincing users that without tolls there would be fewer motorways. Despite the existence of tolls, motorway traffic has been increasing steeply in recent years, showing that the users are willing to pay for the time saved on journeys. In this sense, motorway tolls are like the extra charge that one pays for an enhanced service, such as the supplements for express or first-class trains. On the other hand, car drivers in countries that do not have toll motorways consider that they are regressive and discriminatory, and that they should be done away with. Perhaps they equate freedom a bit too quickly with the fact of not having to pay. This equation is far more common than one might at first think, and must be overcome if transport prices are to reflect costs accurately.

The Round Table was fairly sceptical about the possibilities of altering the modal split by means of fare policy. In London, for example, a steep increase in fares had little effect on the split. Likewise, on the intercity routes in France, rail use and road use are fairly inelastic with respect to one another. Perhaps it is necessary to look at the pattern of transport over a longer period. Since 1970 the SNCF's traffic expressed in passenger-kilometres has risen by 50 per cent. This is a larger increase than anywhere else in Western Europe. It can be explained by a combination of three factors: the fairly long distances involved, high average speeds and the existence of tolled motorways. However, it is difficult to gauge exactly the impact of the motorway tolls.

Sometimes it is difficult to calculate costs accurately because accounts are unreliable. Expenditures are broken down into a large number of budgetary headings. It is not always clear how much is actually allocated to transport. Expenditures vary from one area to the next and from one year to the next (for example, expenditure jumps up before elections). Lastly, the different types of transport are not always clearly distinguished (cars, heavy vehicles, public transport, etc.).

Marginal cost pricing is appropriate to optimal situations but less suited to discontinuous changes in situation, particularly when they are rapid. This is especially true of routine maintenance costs, which rise very rapidly. Furthermore, marginal costs can sometimes be calculated only very approximately, for example, when calculating congestion levels.

3. POLICY AND TECHNICAL ASPECTS

The decisions concerning infrastructure charging systems are policy ones: the decision to charge in the first place, decisions on the method of collection and the level of charges. The implications and consequences of each decision need to be studied by specialists so that decision-makers can make their decisions with full knowledge of the facts, particularly as there are still some deeply entrenched prejudices about pricing systems.

A few examples of charging systems will show that each country tackles the problem after its own fashion. This does not necessarily result in an internationally harmonized system. For example, in Switzerland urban public transport is partly financed out of fuel tax revenue. In the Netherlands several systems are under consideration, including electronic charging systems; parking charges and fuel taxes are also being considered. In practice, most users do not have any choice as to the mode of transport between their home and place of work. They, therefore, consider that the employer should refund any charges. Others argue that there are other ways of dealing with the problem: new high-speed coach services, car pooling, etc.

The most radical experience of traffic management in Europe is offered by the new municipal government of West Berlin. It intends to promote the use of public transport by lowering the speed limit, reducing traffic and parking areas, levying a daily charge of one mark on each inhabitant that will be used to subsidise public transport, and by introducing road signals giving right-of-way to buses, etc. The ultimate aim is that 50 per cent of all urban travel will be by public transport. Berlin has two rail networks: a metro that has expanded considerably since the Berlin wall went up, and an urban railway, the use of which has fallen off considerably since then; however, it has been decided to modernise it.

Recourse to private financing does not mean that policy-makers will have no say over decisions, since they will still decide the construction programmes, the level of charges and, where appropriate, the amount of cross-subsidisation. If a privately-funded transport system removes a considerable burden from the public budget, it may be said to perform the same function as a public system.

Private funding may have several advantages. Private investors prefer to put their money into the most profitable routes, i.e. those on which demand is greatest and on which the motorways thus offer the best service. In other words, private funding ensures excess capacity is not built and limits the scope for policy trade-offs. Furthermore, it generates considerable resources for the maintenance of existing motorways as well as for the construction of new ones. Private motorways are usually maintained to very high standards. Private funding ensures that enough resources are available for maintenance, as is not always the case for publicly-funded highways.

In recent years toll systems have become highly modernised. Electronic payment systems have been introduced that can now be used on motorways that were not initially designed for them. Very often, the alleged drawbacks of toll systems no longer exist, and can be avoided by the use of modern technology.

Certain types of payment systems in which the driver pays after use are not acceptable because they interfere with privacy; however, not all countries regard this as a drawback. The drawback of pre-paid electronic season tickets is that the driver no longer makes the connection between the use of the road and the charge, which thus loses its price function. For this reason it is better to use toll collection systems that can be operated simply and quickly every time a driver passes through. This is one area in which European standards would be desirable in order not to create further impediments to a rapidly-expanding international traffic.

Lastly, the optimal level of the toll can be determined only by experience; if it is too high, traffic will switch to alternative routes, even if they are much slower.

4. CONCLUSIONS

In low-income countries or in countries that have chronic financial difficulties, toll revenue can make a considerable contribution to public finance.

As collection systems improve, there are fewer and fewer drawbacks to tolls.

Differentiated road charges should be gradually introduced so that they function like a proper price mechanism.

Systems need to be harmonized internationally so that they do not create new barriers at national borders.

Transport affects a wide range of people. The way the charging system works must therefore be transparent and be accompanied by a straightforward system of information processing.

An overall accounting system, or at least a set of interdependent accounting systems, needs to be adopted for all the transport modes.

Exchanges of experiences are very important; by proceeding step by step, rigid or costly systems can be avoided.

The effects of road pricing will be felt more particularly in the long term; this needs to be borne in mind when taking decisions.

The structure of charges must reflect actual costs and promote optimal use of the various transport modes.

Externalities and social factors also need to be taken into account.

The user can be made price-conscious only if he knows the price in advance; this would, however, make it difficult to operate a charging system that would vary according to the level of traffic congestion.

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