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TAXATION OF ROAD GOODS VEHICLES - An Economic Assessment

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Taxation of Road Goods Vehicles - An Economic Assessment.

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Abstract

This paper reviews the current position, recent research and potential future areas of research relating to road track costs, with particular reference to Heavy Goods Vehicles. It opens with a theoretical discussion, which concludes that the appropriate basis for changing is long run marginal social cost, but casts some doubt on whether the existing cost allocation procedure achieves this. The main reason for this is the likelihood that the marginal capital cost per unit of traffic of coping with an increase in traffic volumes greatly exceeds the average capital cost per unit of traffic at the present time.

The DTp method of allocating track costs is then outlined, and the sensitivity of the results to variations in a number of the key assumptions is tested.

The results show that the DTp method may only be allocating HGV's as little as half of their costs. Hence instead of covering their allocated costs by some 30% to allow for environmental effects, as the DTp. claim, it may be that these lorries are only meeting 65% of their allocated cost.

The sensitivity tests that yield the above results reflect the following concerns:

(1) FUEL CONSUMPTION

DTp measures lorry mileage and deduces fuel used and hence fuel tax paid. However, their fuel consumption figures look implausibly high. We have used FTA figures instead.

(2) TRAFFIC FLOW

DTp currently allocate many costs to vehicle kilometres (e.g. drainage, winter maintenance, traffic signs etc.), but accepts that the demand for a new road arises in proportion to PCUs (passenger car units), i.e. giving more weight to lorries. Our view is that once a road is opened any general costs involved in its continued use should also be allocated by PCUs.

(3) LORRY WEIGHTS

DTp use lorry weights as reported on a self completion questionnaire, which naturally omit any overloading. We have used observed values from a large study in Cheshire.

(4) CAPITAL EXPENDITURE

DTp charge only what is currently being spent. Following

cutbacks in all government expenditure, this amount is now some 50% lower than in the early 1970s. Since capital expenditure was roughly 60% of total road expenditure, this implies that cost allocations have fallen by 30% on this account. Our view is that even this understates the true long run marginal cost of road traffic.

Although the precise figures are subject to much doubt, in every case there seems good reason to suppose that the proposition is broadly correct. Taken cumulatively, they would be sufficient to convert the existing overpayment by HGVs (which presumably is intended to reflect unquantified environmental costs) into a substantial underpayment. If the increase in road haulage taxation which these figures would imply is politically unacceptable, then there is a good case for corresponding action to relieve the rail and water modes of part of their infrastructure costs.

1. Introduction

1.1.1 The purpose of this study is to review the current position, recent research and potential future areas of research relating to Road Track Costs, with particular reference to Heavy Goods Vehicles (HGV's).

1.1.2 From the DTp's "The allocation of road track costs" (Dept. of Transport, Annual) it is clear that DTp's position is that lorries more than cover their allocated costs, Annual and that the 'margin' to cover non-allocated costs (such as environmental costs) is sufficient to fulfill the recommendations of the Armitage Committee.

1.1.3 In this report we first consider the reasons why the level of road haulage taxation might be a matter of concern. In section 3 we discuss the principles on which an efficient road haulage taxation regime would be based, whilst section 4 discusses some of the practical problems in measuring the relevant concepts. Section 5 goes through existing D.Tp. practice. In Section 6, we present some evidence on the question of whether existing levels of road spending are appropriate as a basis for computing long run marginal cost. Section 7 presents the results of a number of sensitivity tests of changes in allocation procedures whilst sections 8, 9 and 10 look in turn at vehicle delay, accidents and environmental costs. Finally, we present our conclusions in section 11.

2. The Importance of Road Haulage Taxation

2.1.1 There are two issues involved in deciding the appropriate charges to make for use of the road system. These are the equity issue, and the issue of efficiency. Regarding equity, in a competitive industry such as road haulage, there seems little doubt that in the long run any change in road haulage taxation is passed on to customers, and ultimately to consumers of the products carried by the industry at large. It is generally believed that the price elasticity of demand for road haulage as a whole is low, so that the effects on the industry itself of a tax increase will be slight. According to the F.T.A. cost tables, taxation forms some 20% of the cost of operating a maximum weight HGV. (We believe that the reason some other tables give a lower proportion is that they overstate certain elements of overhead costs.) We believe that the finding of Edwards (1970) that freight transport typically constitutes some 10% of the final price of goods, is still valid. Thus, for instance, a 20% increase in road haulage taxation would lead to a 0.4% rise in the price level in general. Even this would be offset by the fact that the extra revenue accruing to the government would permit an offsetting tax reduction elsewhere. Thus we believe that it is appropriate to concentrate on efficiency issues when examining road haulage taxation, although we acknowledge that in political terms equity arguments may be influential.

2.1.2 Now it may be thought that, if the demand for road haulage is very price-inelastic, then the level of taxation is nôt very important in efficiency terms either. Whatever the level of taxation, the level of activity of the road haulage industry will be very similar. However, this viewpoint ignores a number of important factors.

2.1.3 Probably the most important is that the structure of road haulage taxation influences the type of vehicle used for certain kinds of work, and that different vehicle types have different implications, both for road maintenance costs and for social costs such as congestion and environmental intrusion. At the margin, the level of road haulage taxation might also influence decisions such as the number and location of depots, and thus the miles run by different types of vehicle on the road system. However, it is the issue of mode choice which has commanded the greatest debate.

2.1.4 It is generally accepted that a substantial proportion of road haulage consists of work that could not in any likely circumstances be undertaken by another mode. Rail - and, where they are available, water or pipeline transport - is only potentially competitive for traffic with certain characteristics, such as large flows of bulk materials and/or long lengths of haul.

2.1.5 How much of the current road haulage market satisfies these considerations is not known with any precision, although this is an issue we intend to investigate in the course of a major SERC funded project on freight mode split (Fowkes et al, 1987). It is worth noting however that of the 99 billion tonne-kilometres of freight transport undertaken by heavy goods vehicles in 1985, 75% was undertaken by articulated vehicles or rigids of over 25 tonnes gross vehicle weight, 67% was on lengths of haul in excess of 100km. and some 42% was of commodities in which rail has a significant market share (Dept of Transport 1986). There is undoubtedly some potential rail traffic amongst this large volume of road freight, and at the margin the level of road taxation will play a role in influencing the choice of mode.

2.1.6 It is far clearer that a large part of the existing rail freight market is subject to the threat of road competition which constrains the rail rate that can be secured. A given percentage change in the cost of road haulage for this traffic should translate fairly directly to an equivalent change in the rail revenue that can be secured from the traffic, and thus ultimately influence the size and scope of the rail freight business that can survive in the long run. It is in this respect that the level of road haulage taxation is of most importance to the future of British Rail.

3. The Analytical Issues Involved

3.1.1 In respect of all the efficiency issues discussed in the previous section, the conventional economic argument would be that the appropriate level of taxation for a particular vehicle should be equal to the marginal cost imposed on the rest of society by its use. These costs would include the costs imposed on the authority providing the roads, in terms of construction and maintenance costs, on other road users, in terms of delay and accidents, and on society at large, in terms of the environmental effects of road use. Only then will the vehicle operator or his customer correctly assess the costs involved in choice of mode, vehicle type or the amount of freight to transport.

3.1.2 Having stated this principle, there are a number of complications to be considered. Firstly, we have to define the time period with respect to which marginal cost is to be defined. If we measured marginal cost in the short run - that is to say with a fixed stock of roads - then it would obviously exclude all capital costs but would include the extra congestion created by additional traffic on the existing road system. If we measured marginal cost in the long run, we would include the appropriate amount of additional capital expenditure justified by the additional traffic, but only such extra congestion and environmental costs as would still remain when the road system had been fully adjusted to the new traffic level. Arguments exist in favour of both methods of charging. The short run approach is geared to obtaining optimal levels of traffic at a particular point in time for whatever road network happens to exist. The long run approach has as its aim the achievement of an appropriate level of traffic for the new situation which will exist when the road system is fully adjusted to any increase in volumes. The choice between the two depends on the degree to which the sacrifice of an optimal level of utilisation of the existing road system will lead to benefits in terms of more appropriate levels of traffic in the long run. Short run marginal cost pricing is the most appropriate approach when adjustment of demand to price is instantaneous whilst capacity adjustment is delayed. Long run marginal cost is the appropriate basis for pricing when demand is slow to adjust.

3.1.3 In general, if capacity is being adjusted appropriately to demand on a continuous basis then the two approaches should give equivalent results. In the British public sector in general, and in previous discussions of road taxation in particular, long run marginal cost pricing has generally been the favoured choice. This seems to be particularly appropriate in the case of freight transport, where many investment decisions cause customers to become locked in to particular distribution patterns for substantial periods of time.

3.1.4 An interesting attempt to estimate short run marginal cost for the use of roads is contained in Newbery (1987). However, we take issue with him on a number of points. The most serious is his treatment of a large proportion of maintenance costs as being due to the effect of the weather rather than traffic (see p. 16). We regard his derivation of congestion costs from speed-flow relationships as understating the delay caused by heavy lorries, which delay other vehicles even on uncongested roads. Also, the unquantified environmental costs of an increase in traffic are likely to be much greater in the short run, with a fixed stock of roads, than in the long run when capacity has adjusted to demand. For all these reasons, we expect his figures to substantially understate the short run marginal social cost of goods vehicles. We follow the more conventional approach of seeking to estimate long run marginal cost. But it is worth noting that, if capacity is optimally adjusted to demand and there are no indivisibilities (which is of course an unrealistic assumption in the case of each individual road, although looking at the network as a whole it may not be too far from the truth) then short run marginal cost and long run marginal cost will be equal (Rees, 1976, Ch. 4).

3.1.5 Whether we seek to measure short run or long run marginal cost, we have to recognise that these costs will vary enormously according to whereabouts on the system and at what time of day the traffic is moving. At some places and times there will be spare capacity, no congestion and little environmental intrusion; at other places and times the problems caused by traffic growth will be severe. The best that can be hoped of a single national tax structure is to charge the mean of all these individual marginal costs (strictly, on theoretical grounds, the best single tariff would be the mean weighted by the derivative of traffic volume with respect to price if this is known to vary by time or location, Turvey, 1974, Ch. 4). Thus - in the absence of a system such as electronic road pricing which can discriminate by time and place - road vehicle taxation is a very blunt instrument which cannot achieve an appropriate allocation of traffic at the level of the individual flow. This means that there is good reason in principle to supplement even the appropriate average level of road taxation with other measures to influence mode choice in particular circumstances, such as planning constraints or the Freight Facilities grant.

3.1.6 A third issue to consider at this stage is the problem of the second best. It is well known that demonstrations of the optimality of marginal cost pricing depend on its simultaneous achievement throughout the economy. Divergences between price and marginal cost in some sectors of the economy which cannot be put right in general justify divergences elsewhere. This has sometimes been taken to mean that, for instance, because environmental costs are not charged for throughout other sectors of the economy, they should not be charged for in the case of freight transport. This is a gross abuse of the theory. It would only hold true if all products inflicted equi-proportionate environmental costs. In general, second best problems are most severe where products have high cross-elasticities of demand. This suggests a pragmatic approach is to take account of them directly where the products in question are known to be related (i.e. either substitute or complements) and to assume that other effects are too small to be significant (Turvey, 1971, Ch. 3).

3.1.7 That would seem to place particular emphasis on the relative pricing considerations for different forms of transport. In the case of road and rail transport, the pricing regimes appear at first sight to be very different. Road transport is produced by a large number of firms operating at roughly constant returns to scale, and therefore - if the level of taxation is appropriate - one would expect its rates to aproximate reasonably to long run marginal cost. Railfreight, on the other hand, operates on a policy of charging what the market will bear subject to a constraint that the set of traffic attracted in this way must earn sufficient revenue collectively to cover the avoidable costs of the rail freight sector as a whole (including a 5% return on assets).

3.1.8 In fact, this combination of pricing regimes should work to achieve a reasonably efficient allocation of traffic. Rail has an incentive to try to attract any traffic that can cover its marginal cost, since this will improve its financial performance, and - in a regime of individually negotiated contracts - will not generally reduce its revenue from existing traffic. To the extent that it can and does charge a higher rate for specific flows without affecting its traffic volumes, this is of no allocative significance. If its pricing ceiling is in fact set by road haulage rates and these correctly reflect the marginal social cost of road haulage, then unless rail can cover all its avoidable costs with revenue then the total social costs of transport would be reduced by transfering all rail freight to road.

3.1.9 Of course, this argument strictly requires that rail management achieves absolutely perfect price discrimination, and charges exactly the maximum all freight is willing to bear. It also ignores the problem raised above that road haulage taxes at best reflect average marginal costs rather than those pertaining to any specific flow of traffic. Nevertheless, the argument does imply that the existing competitive regime might be a reasonably appropriate one provided that road haulage taxes accurately reflect the marginal social cost of road use. Two further provisos are worth adding. We are assuming that rail does not have the incentive and the market power to cross-subsidise unprofitable traffics and still achieve its financial targets. Thus, whilst traffics will vary in their contributions to overheads, every traffic and group of traffics will at least cover its avoidable cost. More questionably we are assuming that rail itself does not impose any external costs. To the extent that this assumption is untrue, these costs should also be recovered in the form of taxation.

3.1.10 From the foregoing it will be appreciated that road user charges should reflect long run marginal social costs. We must consider the optimal increase in road capital expenditure resulting from an extra 'unit' of road use. Given this capital expenditure, how will the additional unit of road use increase maintenance costs, environmental costs and costs to other road users? The following section looks at some of the principles on which we may base our methods of estimating these costs. Section 5 then looks critically at the existing DTp procedure.

4. Problems in Measuring Long Run Marginal Capital and Maintenance Costs

4.1 Simple Model

4.1.1 In the previous sections we established what it is that we are trying to measure. We concluded that we need to know, for a given increase in traffic, what on average is the extra capital expenditure on the road system that is optimal, and given this expenditure what is the additional maintenance and external cost still remaining.

4.1.2 Regarding capital expenditure, there is an immediate problem. Capital expenditure is incurred in order to produce a stream of output over time, rather than simply to accomodate the traffic flow of a particular year. Thus it is hard to find any justification for a process of attributing this expenditure entirely to the traffic of a particular year on a 'pay-as-you-go' basis. On the other hand, previous attempts to estimate appropriate levels of depreciation and interest to charge on the inherited stock of roads have required successions of very arbitrary assumptions. In any event, we have no interest in the historic cost of the existing stock of roads nor even in its replacement value. Provided that we properly assess the costs of maintenance and periodic reconstruction, then the existing stock of roads will have such a long life that we may, for all practical purposes, take that life as being infinite. What we are concerned with is the cost of constructing new roads or improving existing ones in order to cope with traffic growth. If we do indeed regard these roads as having infinite lives, then the capital cost per year of this process is simply the interest on the additional capital tied up.

4.1.3 Now, were it true that the existing stock of roads were perfectly adjusted to the current volume of traffic and that the current level of new investment were perfectly adjusted to the rate of traffic growth, then the calculation would be easy. We could simply relate the extra annual cost (r times I, where r is the rate of interest and I the current level of investment) to the growth in traffic (dQ, where Q is the volume of traffic). The appropriate charge would then be r.I/dQ per unit of traffic. The total revenue raised by this element of the charge would be r.I.Q/dQ. With a level of r of .07, and a rate of traffic growth of some 3% per annum, it is worth noting that this formula would charge users at least 2.33 times the current level of capital expenditure as the capital cost of using the road system.

4.2 Numerical Example

4.2.1 Table 4.1 shows that between 1975 and 1985, total vehicle kilometres by all types of vehicles has risen from 209.84 to 282.81 billion km. This is equivalent to 3.03% growth p.a.

4.2.2 For the ten financial years 1975/6 to 1984/5 the total road capital expenditure is shown in Table 4.2 to be £18071m in 1986 prices i.e. an average of £1807.1m p.a.. Hence, 1% growth in traffic is associated with roughly £600m capital expenditure.

4.2.3 If there were no growth in traffic we may assume no capital expenditure charge for the provision of extra road space. Each 1% growth in traffic requires/occasions £600m capital expenditure, which with a 7% interest rate is £42m capital charge. Looked at in reverse, the removal of any 1% of total traffic would avoid the £42m capital charge. Hence each 1% of traffic should be charged £42m, making the total charge £4200m. This is simply 1800 x 7/3. This confirms the theoretical analysis.

4.3 Complications

4.3.1 Of course, the assumptions of this simple model do not hold good. Road spending is not perfectly related to traffic growth. Nevertheless such evidence as exists suggests that - far from catching up with backlogs of spending - the current level of spending is inadequate to keep up with current levels of traffic growth. Evidence for this is given in section 6.

Table 4.1

Road Traffic. (Thousand million vehicle kilometers).

	Year			
	1975	1978	1981	1985
Rigid				
2 axle	11.28	12.19	11.72	12.82
3 axle	1.54	1.53	1.18	1.13
4 axle	0.81	0.93	0.94	0.97
Artic				
3 axle	1.49	1.05	0.78	0.67
4 axle	3.54	4.47	4.80	4.10
5+ axle	0.28	0.23	0.11	1.78
Total goods vehicles	18.84	20.39	19.53	21.48
Total all vehicles	209.84	234.30	251.86	282.81

Source:- Transport Statistics GB 1975-85, Table 2.1.

Table 4.2

Expenditure on Roads 1968/69 to 1985/86 (at 1986 prices) and Road Traffic 1968 to 1985

Year	Costs (£m) Capital	Current	Total	Traffic (Thous. mill. veh km) All motor vehicles	All HGV's
1968/69	2187	1086	3273	168.60	17.50
1969/70	2416	1125	3541	172.60	17.70
1970/71	2839	1198	4037	182.10	18.00
1971/72	2618	1245	3863	194.00	18.40
1972/73	2625	1384	4009	204.00	18.80
1973/74	2804	1416	4220	212.30	19.60
1974/75	2563	1315	3878	208.09	19.02
1975/76	2463	1357	3820	209.84	18.84
1976/77	2141	1330	3471	220.35	19.85
1977/78	1563	1291	2854	225.18	19.56
1978/79	1563	1423	2986	234.30	20.39
1979/80	1695	1384	3079	233.70	20.65
1980/81	1714	1388	3102	247.58	20.30
1981/82	1629	1524	3153	251.86	19.53
1982/83	1823	1388	3211	259.33	19.41
1983/84	1761	1466	3227	264.20	20.23
1984/85	1722	1454	3176	275.90	20.88
1985/86	1699	1462	3161	282.81	21.48

Source:- Derived from TSGB 1964-74 Table 20 and TSGB 1975-85 Tables 1.15, 2.1 and 7.4.

Note:- These cost classifications are not the same as used by DTp. for the track cost calculations, where reconstruction, haunching, resurfacing, surface dressing, skid treatments, bridges and remedial earthworks are all counted as current, and not as capital as in the above table.

4.3.2 It may also be said that additional road spending is not solely undertaken with the aim of creating more road capacity. Improved journey times and reduced environmental impact are other major factors leading to road investment. Yet we must ask why, if the road system was previously held to be appropriate to the traffic level, views have changed. An element of the reason might be that, with rising prosperity, the value put on a unit of improvement has increased. But in the majority of cases it seems likely that the factor that has led to a road improvement being justified where previously it was not is the growth in the volume of traffic using the existing system. Of course it is also the case that were the extra road spending sufficient to produce better conditions in terms of faster journeys and improved environment than existed before the traffic growth that justified it, then rather than having further external costs to add on, we should have to deduct those benefits from the spending which brought them about. Undoubtedly this is true for many individual schemes when opened. However, for every road that is improved (or duplicated), in a given year, there are many more which are not, and which consequently with growing traffic levels become more congested and environmentally poorer. It is a matter of debate whether current levels of road spending are leading to an overall improvement in travel times and environmental conditions. Whilst conditions may improve where a new road is opened, elsewhere traffic growth is leading to a deterioration which may well outweigh that improvement. We return to this issue in the next section.

4.3.3 Thus, in the absence of any evidence that the conditions on our roads are significantly improving, we believe that an attribution method which related the interest burden of new road spending to the rate of growth of traffic would not overstate the capital cost of catering for this traffic growth. There would be no equivalent adjustment for rail in most cases because there is no need for BR to create new infrastructure capacity to meet traffic growth. In the past decade virtually all (if not completely all) of BR's infrastructure expenditures would be classified as 'maintenance' if they were classified in the way road costs are. Only actual 'construction' costs are charged as capital for roads. BR 'capital' schemes have been renewals, albeit often seeking to improve travel standards but more often seeking to reduce operating costs. Hence, rail expenditures should continue to be charged on a 'pay as you go' basis. The implication for intermodal competition is that this difference in charges will properly reflect the costs/benefits to the nation of moving traffic from road (where investment costs will be saved by there being a reduction in the increasing level of traffic) to rail (where adequate capacity already exists), and vice versa. An exception to the above argument exists in the London area, where growth in commuting and the opening of the Channel Tunnel mean that many lines in Kent will be overfull. Usage of these lines should in that event attract a premium charge in the same way as we discussed for roads.

4.3.4 When we turn to maintenance expenditure, there is an equivalent procedure. Maintenance expenditure generally relates to either the volume of road space provided or the volume of traffic passing over it. For maintenance expenditure of the latter type, the appropriate measure of wear should be used to allocate costs. Where the expenditure is related to the extent and capacity of the road system, then it is also related to traffic volumes, but because it is the volume of traffic on the road system that has caused the capacity to be there. In this case, use of the same measure of the contribution of a particular class of vehicle to the traffic flow should be used as in the case of capital expenditure.

4.3.5 Again, we must add some provisos. It may well be that a portion of some items of maintenance expenditure is in the nature of an overhead, in that it is the price of having a reasonably comprehensive road system of at least minimal standard. This would be true particularly of spending on minor roads.

4.4 Measures of Traffic Flow

4.4.1 Before leaving this section it is worth commenting on what measure of traffic flow is appropriate to use in this context. Current procedures for the allocation of capital expenditure use PCU (passenger car equivalent) values for capital costs and vehicle km. for the relevant items of maintenance costs. The former values purport to relate the road capacity requirements of each capacity vehicle type to that of a car. We would favour the use of whatever measure best reflects the contribution of a particular class of vehicle to the case for new roads. Given that traffic flow is generally measured in PCUs, it may seem that this is the appropriate weight to use when allocating capacity costs between vehicle types. Certainly there is no case for using vehicle kilometres. But even PCUs may understate the contribution of goods vehicles to the case for new roads, for instance on environmental grounds. It has been found that in terms of environmental nuisance, an HGV is the equivalent of 7 cars (Mackie and Davies, 1981, P. 19). The National Audit Office argued that the role played by heavy Lorries in justifying new road building required a higher capital cost allocation to them than is currently made (National Audit Office, 1987, p 27).

5. The Existing Approach

5.1 The 1968 Road Track Costs Report

5.1.1 Present U.K. DTp. practice is a cost allocation exercise, whereby all public costs occasioned by road traffic are allocated to individual types of vehicle. The methodological underpinning dates back to the 1968 Road Track Costs report (Ministry of Transport, 1968). The methods were endorsed in Paper 6 of the 1976 Transport Consultation Document (Department of the Environment, 1976). This section will consider the reasons for the choice of this method, try to explain simply and briefly how the method is put into practice, and highlight some of the areas where the method has either been revised over the years or has been the subject of review.

5.1.2 The 1968 Road Track Costs Report (p4) presents the following categorisation of road costs:

> "Costs can be conveniently grouped into three categories: User, Public and Community. User costs are costs, such as

petrol, oil and tyres, and the time involved in travelling, which directly fall on road users. Public costs consist mainly of road construction and maintenance expenditures, and fall upon central and local government. Community costs are those occasioned by road users which do not fall on the road user himself nor on the government, but on other members of the community...

"Some costs, accident costs for example, fall into each category. A motorist causes, and suffers an accident. Whatever his insurance, it is likely that he will be put at least to some expense as a result. The state will often have to meet costs imposed on the National Health Service or pay social security benefits. Finally there may be others affected by the accident, pedestrians or relatives of the motorist, who also experience costs arising from it. By the definition used here, the first group are user costs, the second public costs, and the third community costs."

5.1.3 The report went on to consider 'charging principles' and opted for Long Run Marginal Cost Pricing (LRMC). However, 'user costs' were not to be charged for as they were internal to road users, ie. they were already borne by road users. Community costs were excluded on grounds of difficulty in estimation, and because of a belief that direct regulations might be the best way of controlling these costs.

5.1.4 Having decided to charge just the public costs of road usage, on the LRMC principle, the report considered next two approaches to the allocation. It rejected a Cost-Benefit approach, citing the joint cost problem and the difficulty of assessing benefits as the main reasons. The report chose the Cost Responsibility approach as the best approximation available, whilst recognising that (p29) "it suffers from important deficiences". The report gave (p29) the following description of the approach:

"The basic method is to consider each cost item in turn and attempt to isolate any component which can be said to be incurred for a particular vehicle class. Such costs are then allocated to that class. When this is done, the remaining costs can be shared between vehicles by some measure related to their use of roads, eg. vehicle miles."

5.1.5 The report discussed the deficiences of the approach as follows:

"Because of the impossibility of charging for particular types of road or particular journeys, it is likely that the charge on some will be too high and on others too low. Thus only limited economic significance can be drawn from the fact that heavy commercial vehicles cover their costs as allocated here, or that any other vehicle class does. These costs are not the public costs that would be saved were these vehicles to cease to use the roads if, for example, the traffic were transferred from road to rail. This is partly because the changes that result from allocating the total roads cost over all vehicles must necessarily be averages of cost conditions over all roads, and not only those on which competitive traffic moves, but also because of the nature of road costs. In most circumstances a given percentage change in traffic will not lead to an equivalent proportionate change in cost, i.e. marginal costs are unlikely to be the same as average costs. In some circumstances they may be more, in others less - wherever there are joint costs, this is likely to occur."

5.1.6 A particular problem area is the decision as to what capital charge to include. For Long Run Marginal Costs we require that a sufficient capital charge be levied to cover the cost of continually providing sufficient road space for the current traffic demand. All costs incurred in the past are ignored. The method of capital charging favoured by the report is known as the Pay-As-You-Go (PAYG) method. In this method the annual capital charge is set equal to the current year's investment expenditure. In the Long Run, the sum of capital charges will equal the sum of capital expenditures. The report felt that its recommendations were the best practical approximation to LRMC. The rationale of the approach was restated in Paper 6 of the 1976 DoE Consultative Document on Transport Policy, and accepted in the 1977 Transport Policy White Paper.

5.1.7 Objections to the above methodology have been numerous. Beesley and Gwilliam (1977,p222) critised the arbitrariness of the capital total allocated. Capital expenditure on roads might fluctuate from year to year for reasons unconnected with the demand for road space. The Department have allowed for this to some extent by using averages for 3 years. While this will reduce the effect of particularly abnormal years, it remains the case that if public expenditure is cut back for wider macroeconomic reasons, then capital expenditure on roads may be held below the level required to properly cater for the growing level of road use.

5.1.8 Currently, estimates of Road Track Costs are prepared annually by DTp. and forwarded to the Treasury for consideration by the Chancellor of the Exchequer at the time of the preparation of his annual Budget. The figures are reported in annual editions of 'The allocation of road track costs'. In general, figures used are averages of three years: the year preceding the year in which the calculation is being done; the current year; and the following year (this being the year for which the estimates are to apply, and for which they are dated). Financial years are used. It is immediately apparent that 'outturn' figures are only available for the first of the three years, so that the end results are heaily influenced by estimates made at this stage. An exception to this is that 'Police' expenditure is estimated by the Home Office as the average of the 3 most recent years for which outturn data is available.

5.2 The 1984 Revisions to the Method

5.2.1 A major revision in the methods used was made in 1984 following a short consultation exercise in 1983. The major change introduced was to carry out the cost allocation exercise separately for 4 different classes of road: Motorway(M), Trunk(T), Principal(P), and Other(O). For maintenance costs, this is clearly an improvement on previous procedures. For capital costs, however, it appears to assume that motorways are only built in response to traffic growth on motorways, and similarly for other road types. The first two of these road types are the responsibility of the Department of Transport, while Local Authorities are responsible for the other two. A major effect on the calculations was made by the simultaneous realisation that what had previously been regarded as an 'administration cost' to be spread pro-rata over all heads of expenditure were, in reality, only relevent to Local Authority maintenance expenditures. It is now argued that all other expenditure heads have already had their administation overhead added at an earlier stage. A charge for Department of Transport administrative and research costs is still pro-rated across all expenditure heads.

5.3 The Cost Allocation Process

5.3.1 The cost allocation process starts, then, with 8 figures representing capital and current costs each broken down by the 4 classes of road. Two more input figures are required : that for 'police' costs, and that for 'road safety'. We have mentioned police costs earlier. These comprise estimated costs of traffic police, traffic wardens, and court costs (although this last item has not been explicitly mentioned for some years). Road safety costs, which had not previously been explicitly mentioned, account for £27.4 million in the 1986/87 calculations. Like police costs, they are allocated by road types in proportion to vehicle kilometrage. Figures for vehicle kilometrage by road type are also absent from the report, but for 1986/87 they were:

Motorway	12.7%
Trunk	18.0%
Principal	36.2%
Other	33.2%

5.4 Capital Costs

5.4.1 We shall first consider the allocation of capital costs. For each of the 4 road classes the DTp. allocate 15% of the capital cost figure to vehicles over 1.525 tonnes unladen weight according to their maximum gross vehicle weights times the kilometres run (Max. GVW km.) and the remaining 85% is allocated to all vehicles (including those over 1.525 tonnes unladen) according to their Passenger Car Unit (PCU) values times kilometres run (PCU km.).In this calculation the 15% is taken to represent those capital costs only required to permit the use of large and heavy vehicles. Structures need to be taller, wider and stronger to cater for certain vehicles and various studies of road schemes have indicated that approximately 15% of the capital cost is incurred in this way. The latest official report to support the 15% figure has never been published. We are aware of EEC sponsored research into car-only motorways, which suggests that these may be constructed for around two-thirds of the capital cost of an equivalent all-purpose motorway (Echenique, 1987). The main reason for this diference appears to be that Echenique has allowed for narrower lane widths in the absence of heavy vehicles whereas DTp has not. As a very modest sensitivity test, therefore, we have reworked the DTp method with a 20:80 split instead of 15:85.

5.4.2 The Department allocate the 85% remaining capital costs by PCU km. on the grounds that this is a charge for the provision of additional roadspace and so should be paid for in proportion to the current usage of roadspace. Past studies indicated that, for the lorries then extant, an average lorry required twice as much roadspace as a car. It was evident that larger lorries took up more roadspace than smaller lorries and so the Department assigned gradually increasing PCU values ranging from 1.1 for lorries between 3.5 and 5 tonnes, up to 2.9 for lorries over 31 tonnes. The average for lorries started off at 2, but over time as lorries became larger, the average rose to 2.2. This was the position in 1983 at the time of a major revision to the Department's methods. It was then claimed that a new piece of TRRL research had found that the average value for lorries should be only 2. However, the work relates to delays at junctions and thus is only relevant for certain road types - it is not the appropriate measure for motorways.

5.4.3 On this evidence, the Department revised its PCU values to give an average of 2.0 for lorries. Rather than scale down all the lorry PCU values by 10%, the Department chose to reduce the PCU values for the largest lorries the most. Accordingly, the PCU value for lorries over 31 tonnes fell from 2.9 to 2.5, with this new value applying equally to the newly introduced 38 tonne lorries on the grounds that they were no bigger than 32 tonne artics.

5.5 Maintenance Costs

5.5.1 If we take the figures for road safety away from the current cost figures we get what the Department calls Maintenance costs. Table 3 of the 1986/87 report shows the percentages of each of the 4 maintenance totals that fall under each of 14 cost headings. The table also shows how costs under each of the 14 headings are to be allocated; the 4 possibilities (parameters) the Department use being: Vehicle km.; Average Gross Vehicle Weight(GVW) km.; Standard Axle km.; and Pedestrians. The allocation for each of the 14 cost headings are the same for all 4 road classes, except that Pedestrians are relieved of any share of Motorway costs - with their 'share' being reallocated.

5.5.2 The manner of the allocation of costs by each of the 14 headings to each of the first three parameters is governed by technical advice after consultation. We are not at the present time questioning any of these allocations, although the evidence for them appears scant. We note, however, that many changes have been made in the past - nearly all resulting in lower cost allocations to heavy lorries.

5.5.3 In the current DTp. allocation, Pedestrians are currently allocated 50% of Sweeping and cleaning; Footways, cycle tracks and kerbs; and Street lighting; - except on motorways where they are allocated no costs. Given the arbitrariness of this procedure, we undertook sensitivity tests on this item, but it made little difference to the results and is not discussed further.

5.5.4 Reconstruction and resurfacing costs, and 80% of patching and minor repair costs are allocated by Standard axle km. The definition of a Standard axle takes account of the 'fourth power law' relating road damage done by axleweights applied. The exact DTp. definition is complicated by the switch from imperial to metric measurements, so we shall quote the DTp. definition verbatim (p3, 1986/87 report):

> "A Standard axle is a computational device for comparing the damaging effects of different vehicles, taking account of the 'fourth power law' of road pavement damage. The 'Standard Axle' value of a particular vehicle can be calculated by summing the fourth powers of the weights (in tons) on each axle, and dividing by 10 to the power 4 (ie 10,000). Thus for a fully laden 16 tons, 2 axle rigid vehicle with estimated axle weights of 6 tons and 10 tons, the 'Standard axles' would be:-
>
> $$\frac{6x6x6x6 + 10x10x10x10}{10x10x10x10} = \frac{1296 + 10000}{10000}$$
>
> $$= 1.1296 \text{ in imperial tons}$$
>
> ie. the vehicle does 1.1296 times as much damage to the road pavement as a 10 tons axle. In this paper, axle weights quoted in metric tonnes have been used to calculate 'Standard axles' and the divisor has been 10.16 to the power 4, ie. 10 imperial tons,22400lb."

5.5.5 The DTp. use data from the Continuing Survey of Road Goods Traffic (CSRGT) to estimate the proportion of kilometres that a lorry of a particular type will run whilst empty, 5%, 15%, 25%, 35%, 45%, 55%, 65%, 75%, 85%, and 95% laden. Using these proportions gives what the DTp. term 'average standard axles'. For instance, for the 16 ton, 2 axle rigid discussed above, the 'average standard axle' value is 0.2659, compared to the fully laden value of 1.1296. The 1986/87 report comments as follows:

> "The weights on axles are assumed weights calculated for each degree of lading by comparing the axle weights of the unladen vehicle with those of a fully laden vehicle and assuming that intermediate loads give axle weights proportionately intermediate between the unladen and fully laden axle weights. The fact that some of the heavier vehicles have axles weighing above their legal limits is ignored, so the effect is to understate the damage caused by vehicles with assumed axle weights between 9 and 10 tons and, for articulated vehicles over 32.5 tonnes gvw, up to 10.5 tonnes."

5.5.6 It is therefore clear that the responsibility for road damage due to overloading is ignored in the DTp. calculations, the costs so caused being allocated over all vehicle types in accordance with their legal axle weights. However, it is clear that the arithmetic of the fourth power relationship will mean that it is only the overloading of the already heaviest axles that will cause significant extra costs. Hence lorries with such axles should themselves shoulder the burden of paying these costs. Exactly which types of lorry these are, and in what proportions, can be determined from the Transport and Road Research Laboratory (TRRL) surveys of overloading. The CSRGT is no help in this regard since it is an unchecked self-completion questionnaire, so it is unsurprising that instances of overloading are not reported. Later in this paper we will test the sensitivity of the DTp. methods to this point. It may be argued that opperators of overloaded vehicles can be fined if caught, thereby more fairly representing the cost causation. However, given the current prevalance of overloading, as revealed in TRRL surveys and elsewhere we doubt whether this penalty adequately reflects the social costs involved. In any event, failure to take explicit account of overloading will lead to a misallocation of costs between vehicle types.

5.5.7 The use of the 'fourth power law' has been subject to much debate. The 1968 Road Track Costs report used a third power rule. This was changed to the fourth power in the 1976 Consultation Document. Since then, a reworking of earlier results on which the fourth power law was based has been carried out by TRRL (Addis and Whitmarsh (1981)). For strong and very strong pavements, with structural numbers 5.18 and 5.97 respectively, the results are very close to a fourth power curve, although a slight kink at the upper end of the curve for very strong pavements with heavy axles has been interpreted in some quarters as indicating a power as low as three.

5.5.8 For medium strength roads (structural number 3.54) the appropriate power appears to be slightly below 4, but there is a pronounced kink in the curve, after which for very heavy axle weights the curve is best represented by a power of about 6. For weak pavement roads (structural number 2.38) the kink occurs much earlier, so that for typical UK axleweights the power is about 6. The foregoing observations are based on Figures 3 to 6 of the report, but is in agreement with the conclusions of that paper, where the conclusion is that compared to the fourth power law their work:

> "indicates reasonable agreement except for the medium and heavy spectra of wheel loads applied to the weakest pavements when the ... analysis indicates a greater damaging effect".

5.5.9 This is not a misleadingly selective reporting of their conclusions. Nowhere do they suggest using a lower power, for any purpose. It is therefore incorrect for DTp to say in their consultation document that "TRRL results indicate a sixth power relationship for some roads and a third power relationship for others".

5.5.10 In any event the DTp. did not feel the evidence was sufficiently commanding as to warrant its inclusion in the 1984 revised methods which did otherwise differentiate by road type.

5.5.11 The Armitage committee favoured the continued use of the fourth power law (Armitage, 1980, p113):

> "The fourth power law has been derived from large-scale experiments carried out by the American Association of State

Highway officials (AASHO) between 1958 and 1960. In these experiments, a series of roads were constructed, each road having sections of widely differing strengths. Different types of lorry, with single axles varying between 0.9 tonnes and 13.6 tonnes and tandem axles varying between 1.9 tonnes and 21.8 tonnes, were driven over the roads in a continuous stream, each road carrying lorries of one type only. The deterioration of all sections of the roads was measured. The results showed how many applications of a given axle load led to a given amount of physical damage, from which the relative damaging powers of different axle loads have been calculated. The AASHO tests suggest a statistical relationship between the fourth power of the static axle load and the damage done to the road....

"The tests were well designed and on a scale which should give statistically significant results. There does not appear to be any work that has fundamentally challenged the fourth power relationship... On the other hand, it would be wrong to draw over-precise conclusions from them.... There is still much uncertainty as to how axles damage roads, and hence also why the fourth power law should have emerged. A number of much more limited experiments on various aspects of the damage mechanism have suggested that anything between a third power and a sixth power relationship might obtain for different elements of damage. Nevertheless, all the authorities responsible for the design of roads or for regulations on the weight of lorries appear to use the fourth power law as giving the best overall indication of the relationship between the damage done to roads and the vehicles responsible for that damage. It remains the best single approximation we have."

5.5.12 The remaining road maintenance costs are split between 'Average GVW km.' and 'Vehicle km.', again based on "expert advice from highway engineers and research scientists". We are not going to question the detail here, although there have been many objections in the past and DTp. practice has varied over the years. What we will test, however, is the replacement of the Vehicle km. parameter by a Passenger Car Unit (PCU) km parameter. The argument here is that the Department accept the use of a PCU measure when allocating capital costs. PCU values are taken to represent the demand for road space, so the DTp. are saying that expenditures on new road space should be paid for in proportion to the present (growing) usage of road space. We are taking the argument one logical step further by suggesting that consequential maintenance costs of having road space (such as drainage, hedge cutting etc.) should also be allocated according to the demand for road space, ie. by PCUs. There is therefore no case for allocating any costs by Vehicle km. Where the department have identified costs as relating to other vehicle parameters (currently Average GVW km. and Standard axle km.) we have accepted this in this paper.

5.5.13 We should at this stage mention an argument which is sometimes heard, and which may have been given credence by a recent paper on the subject (Newbery, 1987). This is that a proportion of maintenance costs (taken by Newbery to be 60% in the British climate) is caused by weathering, regardless of traffic levels. In his calculations, this is therefore treated as a capacity cost, to be allocated by PCUs rather than as above. The justification for the formula he uses to derive this figure is unclear. He quotes an earlier paper of his, which gives a source, but the formula there is (at least) twice modified without justification before it reaches the form given in Newbery (1987). The calibration data apparently only relates to Brazil, and we have doubts about the ability of the calibration method to distinguish between the average level of standard axles passing per unit of time and the passage of time itself, as well as the transferability of the results.

5.5.14 In the case of major British roads, both construction and maintenance are planned on the basis of a life measured in terms of the numbers of standard axles passing, with no reference to elapsed time. We can therefore take the present DTp system of allocating 100% of road costs as being quite reasonable, except to the extent that some (minor) roads are maintained for purposes of accessibility even when their capacity is not really needed.

5.6 Determining the Tax/Cost Ratios for Individual Vehicle Types

5.6.1 Applying the percentages in Table 3 to the maintenance figures by road class, and applying the 15%-85% split to capital expenditure figures by road class, gives us the figures in Table 2 'Road costs for 1986/87 classified by road class and parameter'. The overall total expenditure is shown as £3863M, which breaks down M=599, T=644, P=1053, O=1567 by road class, and as follows by parameter:

Maximum GVW km.	240		
PCU km.	1359		
	----	Total capital	£1599
Standard axle km.	610		
Average GVW km.	408		
Vehicle km.	957	(includes Police and Road Safety)	
Pedestrians	290		
	----	Total current and police	£2264

5.6.2 Tables 6 and 7 give data on individual vehicle types, including sufficient information to be able to deduce vehicle parameter values (ie. PCUs, Standard axles etc.). We now multiply these parameter per vehicle figures by vehicle numbers, by kms. per vehicle and by percentages of kms. on each road class (shown in Table 4). We do this for each vehicle type seperately and then sum over vehicle types. This gives the totals of parameter units by vehicle types and by road classes. We next divide these figures into the appropriate cost totals in Table 2 (discussed above). This gives unit costs by parameter for each road class and these are shown in Table 5. We now multiply these unit costs by the units used, ie. the parameter kms. by a vehicle of each type on each class of road. By again using the road type usage distributions from Table 4 we form weighted averages to get total costs for a vehicle of that type. For lorries this is shown in Table 8, while for other vehicle types the DTp. report gives figures for totals of each vehicle type (in Table 6).

5.6.3 Having thus completed the cost side,we form tax estimates as Vehicle Excise Duty (VED - the tax disk, or Road Fund Licence) plus Fuel Tax per km. times the total number of kms. per vehicle. Dividing these tax estimates by cost give tax cost ratios, shown for lorries in Table 8 and for other vehicle types in Table 9. These calculations ignore the stage-carriage fuel tax rebate for buses, and car tax. Our view is that general fuel duty (2.7%) should also be deducted, since this is a general tax, but we have not made this deduction in this paper.

5.6.4 All the Department's calculations are carried out for an 'average' vehicle in each vehicle type (eg 29-31 tonne rigids). In particular, average values for kilometres run are used. This has the consequence that, since costs are taken to vary proportionately with kms while taxes vary less than proportionately (due to the VED 'intercept' or 'fixed cost' element) with kms, the ratio of taxes to costs will fall as kms rise. For example, if the tax:cost ratio was fixed for a particular type at exactly the desired level for the type as a whole, then vehicles travelling lower than average distances in a year will have higher than desired tax:cost ratios, and vice versa. As an indication of how large this effect is for the various lorry types, we have computed an additional column to add on to the end of the DTp's table. This column gives the 'breakeven distance' at which taxes just equal costs, for those vehicles for which the fuel tax per km is not itself greater than the allocated cost per km. Readers should bear in mind, however, the recomendation of the Armitage committee that desired tax:cost ratios for heavy lorries should be greater than one, in order to allow for unmeasured external costs caused by these vehicles. We shall consider some of the items of cost not presently charged for in sections 8, 9, and 10.

6. The Adequacy of the Current Level of Spending

6.1 Expenditure on Roads

6.1.1 Road track costs allocated to individual vehicles are dependent on the total expenditure on roads, both in terms of the level of maintenance and in investment in new roads, whether they be motorways or bypasses. There is increasing evidence that the level of spending in Great Britain is not keeping pace with the growth in the demand for road space as a result of low investment, and that the maintenance budget is insufficient to keep the roads up to the standard of previous years. If these propositions are true, then basing allocations on the present level of spending will understate long run costs.

6.1.2 Since 1980 the National Road Maintenance Condition Survey has shown a steady deterioration in the condition of our road system. The deterioration varies according to the class of road. In the case of trunk roads and principal urban roads, their overall condition is now much worse than it was in 1977 (Standing Committee on Highway Maintenance, 1986). The current level of reconstruction is not keeping pace with demand.

6.1.3 Though maintenance expenditure has remained fairly static in real terms, this is unlikely to be sufficient to keep roads in the same state when they are being used more intensively. Over the last decade, not only has the distance covered by vehicles in total risen (by 35%), but the distance covered by 4 and 5 axle artics has increased even more (by 58%) despite the heavier loads carried by the larger lorries now permitted. See Tables 4.1 and 4.2. There has also been an increase in maximum permitted axle weights (currently 10.5 tonnes for a drive axle).

6.1.4 Thus there has been a large increase in the number of standard axles imposed on parts of our road system over the last decade, particularly on motorways. The trend towards using the heaviest vehicles has continued following the introduction of 38t five axle artics in 1983.

6.1.5 The design of a motorway is based mainly on an estimate of the number of vehicles passing over it during a twenty year period in the case of flexible pavements, and forty years in the case of concrete. The volume of traffic is converted into an estimate of the number of standard axles in the period, and this determines the strength of the structure required. Thus the road is built to withstand a fixed number of standard axles passing over it, rather than being designed to last for a given number years. This means that a concentration of heavier vehicles, primarily using motorways, may lead to a considerable increase in the number of standard axles above those estimated, and reconstruction costs may be incurred in a shorter period of time than originally planned. This could lead to fluctuations in the maintenance budget allocated to such roads.

6.1.6 Evidence shows that while the demand for road space has risen steadily over the decade, capital expenditure has fallen in real terms by some 50% (Table 4.2). We argued above that there should be a proportional relationship between capital spending and the growth of road traffic. Though maintenance expenditure has remained nearly static in real terms, this is clearly not sufficient to cope with the higher level of use of the road system. The supposition is therefore, that the present level of spending understates the true long run cost of providing for the current level of, and growth in traffic.

7. Sensitivity Testing

7.1.1 Using a proprietary spreadsheet for a micro-computer, the figures published in 'The allocation of road track costs 1986/87'(DTp. 1986) have been subjected to various sensitivity tests. This was undertaken to determine whether changes in the allocation of costs would have a significant effect on the operating costs of goods vehicles. Several tests were undertaken to demonstrate the effect of altering the allocation of costs within the current level of expenditure, then the level of capital expenditure was increased, firstly to that obtaining in the early 1970s, and secondly by 133% (as suggested in section 4.1) so that each vehicle km. is charged its marginal capital cost. The results of the various sensitivity tests are given in Table 7.1. The effect of the sensitivity calculations has also been added cumulatively, the results of these being given in Table 7.3.

Table 7.1

<u>Summary of Sensitivity Tests.</u>

Column	1		2		3		4		5		6		7	
	i	ii	i	ii	i	ii	i	ii	i	ii	i	ii	i	ii
Vehicle class														
Cars + vans	3.22	-	3.22	-	3.26	-	3.22	-	2.58	-	1.94	-	3.32	-
Buses	0.84	-	0.84	-	0.82	-	0.93	-	0.75	-	0.63	-	0.81	-
HGV rigids														
2 axle 7.5t	1.80	-	1.80	-	1.73	-	1.74	-	1.37	-	0.98	19	1.70	-
2 axle 17t	1.11	49	1.05	42	1.07	45	1.06	44	0.96	34	0.79	22	1.06	44
3 axle 25t	1.09	48	1.08	46	1.06	44	1.20	63	0.96	34	0.79	23	1.05	43
4 axle 31t	1.07	64	1.05	61	1.04	59	0.91	43	0.93	45	0.76	30	1.02	57
HGV artics														
2+1 axle 25t	1.20	112	1.06	58	1.16	89	1.01	49	1.01	49	0.81	25	1.14	81
2+2 axle 28t	1.38	-	1.23	165	1.33	-	1.45	-	1.11	89	0.83	29	1.30	900
2+2 axle 32.5t	1.31	234	1.19	118	1.27	185	1.39	427	1.09	90	0.85	44	1.24	164
2+3 axle 38t	1.25	243	1.13	126	1.22	199	1.19	177	1.05	100	0.83	51	1.19	171
3+2 axle 38t	1.27	353	1.12	129	1.23	259	1.21	224	1.06	105	0.83	49	1.20	207
3+3 axle 38t	1.31	-	1.14	298	1.26	-	1.23	-	1.05	126	0.79	31	1.22	-

Column
1 Result using DTp data.
2 Figures using fuel consumption taken from FTA Cost Tables.
3 Figures for Vehicle km converted to PCU km.
4 Average GVW km and Standard Axle km as per Cheshire survey.
5 Total capital expenditure increased 50%.
6 Total capital expenditure increased 133%.
7 Twenty percent capital expenditure applied to Max. gvw km, 80% to PCUkm.

Sub-column
(i) Tax/cost ratio.
(ii) Breakeven distance (thousand kilometres per annum).

7.2 Fuel Consumption

7.2.1 DTp. estimates the revenue taken from each class of vehicle by multiplying the average mileage run by vehicles of that class in the Continuing Survey of Roads Goods Transport (DTp. 1986c) by an estimate of the rate of fuel consumption. This is taken from the theoretical results produced by Renouf (1981). DTp. (1986b) comments (P. 2) that "Estimates have been updated taking account of recent data".

7.2.2 The resulting figures for fuel consumption by the heavier classes of HGV are substantially higher than those used in the FTA cost tables (which we regard as the most reliable source of information on the costs of operating goods vehicles). Column 2 of Table 7.1 shows the effect of reworking the revenue/cost ratios with the reduced levels of fuel tax payment implied by the FTA. tables. The biggest effect is on 38 tonne vehicles, which on these assumptions are paying only 12-14% in excess of allocated cost, rather than the 25-31% implied by the DTp figures.

7.3 The Use of PCU km

7.3.1 In column 3 of Table 7.1, costs currently allocated to vehicle kilometers were related instead to PCU km. This again increased the proportion of the costs borne by HGV's In the case of 32.5t 4-axle artics the Tax/Cost ratio fell from 1.31 to 1.27. This is because such a lorry is assessed to be the equivalent of 2.5 PCU's, whereas in terms of Vehicle km they are considered to be equal to that of a car. Similar falls were recorded for other goods vehicles.

7.4 Mean Axle Weights

7.4.1 As discussed in paragraph 5.5.6 the allocation of costs by the DTp does not take account of the possibility of overloading, on the grounds that they should assume people are law abiding and leave the legal system to deal with miscreants. However, the damage caused by overloaded vehicles <u>is</u> charged for, since it is part of the maintenance cost allocated. As the Average GVW and Standard axle figures used by DTp. are those reported in a self completion survey (CSRGT, DTp. 1986c), these figures for a given lorry class will be underestimates. Hence the allocated cost per parameter unit will be inflated.

7.4.2 An alternative source of data on vehicle and axle weights is from surveys conducted on lorries stopped randomly. Results of five such surveys have been reported by TRRL, two of which were undertaken at Motorway sites (Prudhoe, 1982 and Shane, 1982), and the other three on Trunk roads (Glover, 1980; Glover and Shane, 1981). We attempted to use this data to revise Average GVW and Standard Axle figures in the track costs calculation. However, there were problems with this, largely because of the absence of data relating to Principal and Other roads, and because the representativeness of the 5 sites even for Motorways and Trunk roads was questioned. In particular, it was pointed out that one of the five sites was near docks, so that the widespread overloading found there might be a rather specialised occurance. The implication was, therefore, that our calculations were overestimating the extent of overloading.

7.4.3 Recently we have obtained the results from a random sample of 4216 HGVs collected during 22 axle-load surveys conducted at 18 survey sites with locations dispersed throughout the county of Cheshire. The report (Urqhhart and Rhodes, 1987) states that the survey sites were chosen carefully to represent eight classes of road and four ranges of heavy commercial vehicle flow. The survey therefore provides the sort of data we need. We are not claiming here that the weighting of road types in the total sample gives a correct representation of Cheshire, let alone Great Britain. (Further work with the raw data from the surveys, doing the necessary reweighting, would be highly desirable.) Cheshire was chosen as a fairly "average" county and our view is that the measured Average GVW and Standard Axles are probably closer to the true national values than those used by DTp, which clearly underestimate these values by excluding all overloading.

7.4.4 Table 7.2 shows the differences between the Cheshire and DTp figures. The Cheshire figures are, as expected, always higher than the DTp figures, although for 3 axle rigids the difference is very small. The biggest proportionate difference in Standard Axles is for light rigid 2 axle vehicles, which were particularly prone to overloading in the Cheshire survey. By contrast, the biggest proportionate difference in Average GVW was for 3 axle artics, where no overloading was found in Cheshire, but properly loaded vehicles were much heavier than would be expected from the DTp figures. Since the average plated weights were the same for both, we concluded that the difference was not arising because of a difference in size of 3 axle artics in Cheshire compared to elsewhere.

Table 7.2

Comparison of Lorry Weights-DTp versus Cheshire Survey

HGV Axle Group	Average GVW		Standard Axles	
	DTp Figures	Cheshire Study	DTp Figures	Cheshire Study
Rigid				
2-axle<7.5t	3.90	4.22	0.005	0.010
2-axle>7.5t	8.42	9.03	0.177	0.226
3-axle	14.85	14.88	0.468	0.479
4-axle	19.90	22.43	0.661	1.030
Atric				
3-axle	11.20	13.37	0.143	0.232
4-axle	20.82	20.92	0.676	0.724
5-axle	26.22	27.05	0.824	1.092
6-axle	26.60	27.10	0.493	0.679

Source:- Derived from The Allocation of Road Track Costs 1986/87 and TORG Research Report 64.

7.4.5 The results of using the Cheshire lorry weights in place of the DTp figures is given in Column 4 of Table 7.1. Comparing these with the DTp figures in column 1 shows tax/cost ratios increasing for buses (where we have no "overloading" data) for 3 axle 25 t rigids, and for 4 axle artics. We think this latter reflects a change in working practices, whereby the heavier loads previously carried by 4 axle artics are now tending to be carried by the new 5 axle 38 t artics, thereby reducing the average load carried by the 4 axle artics. Tax/cost ratios fall for 2 and 4 axle rigids, with the maximum weight 4 axle rigids (31 t) falling below unity (to 0.91). For 4 axle rigids the Cheshire survey found 53% of laden vehicles to be overloaded (by an average of 4.3% of plated weight). Tax/cost ratios also fall for 3 and 5 axle artics, for the reasons previously discussed. The Cheshire survey is the first published evidence on the extent of overloading of 38 t artics, about 25% of them exceeding the maximum weight restriction.

7.5 Increase in Total Capital Expenditure

7.5.1 We have argued earlier that the existing level of capital spending may be too low to prevent a deterioration in road conditions. We have tested the effect of returning to the spending levels of the early 1970s. From Table 4.2 this can be seen to require roughly a 50% increase, and this is the figure we have used. The result is shown in column 5; the tax/cost ratio of a 32.5 t artic being reduced to 1.09, with similar effects for other vehicles.

7.5.2 If the capital charge were increased by 133% which may be the sort of magnitude required to implement a true long run marginal cost pricing regime (see section 4.1), then few HGV classes would cover their track costs. This is shown in column 6, where all the popular types of HGV can be seen to have tax/cost ratios below unity some HGVs plated for less than the maximum for that axle configuration are, however, above unity. The ratio of a 32.5 t artic becomes 0.85, 38 t vehicles being slightly lower.

7.6 Capital Costs Specifically Allocated to HGV's

7.6.1 Because lorries are larger and heavier than other vehicles, they require different specifications for the design of roads to that of cars, such as higher and stronger bridges, when road construction is undertaken. Thus 15% of capital expenditure on roads is allocated specifically to lorries and other large vehicles according to their Maximum GVW km. As cars and motorcycles are assigned a Maximum GVW of 0, the effect is to allocate all of capital charges assessed under this parameter to goods vehicles and buses. The remaining 85% of Capital costs are allocated to all vehicles in proportion to their PCU values. As discussed above, evidence suggests that the 15% allocation may be an underestimate.

7.6.2 The allocation of costs between these measures was altered, to 20:80 to test the degree of sensitivity (column 7). The result was to reduce the tax/cost ratio for a 32.5t artic from 1.31 to 1.24, with similar effects for 38 tonners.

Table 7.3

<u>Cumulative Results of Sensitivity Tests.</u>

Column	1		2		3		4		5		6	
	i	ii	i	ii	i	ii	i	ii	i	ii	i	ii
Vehicle class												
Cars + vans	3.22	-	3.22	-	3.26	-	3.27	-	2.61	-	1.96	-
Buses	0.84	-	0.84	-	0.82	-	0.90	-	0.79	-	0.66	-
HGV rigids												
2 axle 7.5t	1.80	-	1.80	-	1.73	-	1.67	-	1.29	-	0.94	16
2 axle 17t	1.11	49	1.05	42	1.02	39	0.97	35	0.85	26	0.71	18
3 axle 25t	1.09	48	1.08	46	1.04	42	1.14	53	0.99	37	0.81	25
4 axle 31t	1.07	64	1.05	61	1.02	56	0.86	39	0.77	31	0.64	23
HGV artics												
2+1 axle 25t	1.20	112	1.06	58	1.02	51	0.86	32	0.75	23	0.61	16
2+2 axle 28t	1.38	-	1.23	165	1.18	121	1.23	173	0.99	51	0.75	24
2+2 axle 32.5t	1.31	234	1.19	118	1.15	104	1.21	131	1.01	69	0.78	39
2+3 axle 38t	1.25	243	1.13	126	1.10	113	1.04	97	0.88	62	0.71	39
3+2 axle 38t	1.27	353	1.12	129	1.09	114	1.04	96	0.87	59	0.69	36
3+3 axle 38t	1.31	-	1.14	298	1.10	178	1.04	107	0.84	42	0.65	21

Column

1 Result using DTp data.
2 Figures using fuel consumption taken from FTA Cost Tables.
3 As column 2 plus figures for Vehicle km converted to PCU km.
4 As column 3 plus Average GVW km and Standard Axle km as per Cheshire survey.
5 As column 4 plus total capital expenditure increased 50%.
6 As column 4 plus total capital expenditure increased 133%.

Sub-column

(i) Tax/cost ratio.
(ii) Breakeven distance (thousand kilometres per annum).

7.7 Cumulative Effect of Sensitivity Tests

7.7.1 Although the tests individually have generally produced only modest changes in the costs allocated to goods vehicles (with the notable exception of capital costs), a number of the tests taken cumulatively have a much more substantial effect. The results are shown in Table 7.3.

7.7.2 In Table 7.3, the cumulative effect of changing both the fue consumption of HGV's, and the Vehicle km to PCU km, is demonstrated in Column 3. Column 4 includes the additional effect of adjusting the Average GVW km and the Standard Axle km to take account of the weights of vehicles observed in the Cheshire survey.

7.7.3 When the capital investment in roads is increased to the level of the early 1970's (in real terms), as has been done in Column 5, then few classes of HGV cover their track costs. However, it should be noted that among those which do, just, are four axle articulated vehicles. In total, the cumulative effect of these measures has had a greater effect on the large rigid vehicles than on other vehicle types, though the 2+3 axle 38t articulated vehicle would only cover 88% of its' allocated track costs.

7.7.4 Column 6 replaces the 50% increase in capital costs assumed in Colum 5 with the 133% argued for in section 4.1. This brings the tax/cost ratios for all lorries below 1.

7.8 Cross Subsidisation by Mileage

7.8.1 Because the total taxation of vehicles includes a fixed element in the form of VED, vehicles which cover higher than average mileages per year tend to be subsidised by those which do below average. In the case of the heaviest lorries there is likely to be a double effect, because those covering large distances will also be those most likely to be loaded for all or part of the return journey. This increases their average GVW km and standard axle km considerably, and should increase their allocated costs when compared to the average vehicle in their class. Operators of long distance goods vehicles may therefore pay considerably less in road tax revenues per tonne of payload than the average.

7.8.2 Such a vehicle may nevertheless cover its allocated track costs (but with reduced margin to cover environmental effects) although this will be decreasingly so the more costs we deem chargeable to that vehicle class. So that this matter can be investigated, we have included in Tables 7.1 and 7.3 columns headed (ii) which give the breakeven distance. This is the distance (in kilometres) that a lorry of that class must travel to have its tax and costs equal. A dash indicates that the per kilometre tax (from fuel) is greater than the per kilometre allocated cost so that tax and cost are never equal. When tax cost ratios (column i) are less than one the breakeven distance is less than the average distance travelled by that class of lorry, and vice versa. In all cases the interpretation is that any lorries travelling further than the breakeven distances shown for their class are failing to cover their costs by the taxes they pay.

7.8.3 An offsetting effect is likely to be that the vehicles with the highest mileages within their class travel a higher proportion of their mileage on motorways, where the maintenance cost per standard axle is lower, and at night, when they are likely to cause less nuisance to other traffic. The mileage related taxes levied on goods vehicles in Scandinavia incorporate a rebate for very high mileage vehicles for just this reason.

8. Vehicle Delay

8.1.1 There are a number of costs, mainly of an environmental nature, which are not considered as part of the system of allocating road track costs. Some of these can be identified, and costs allocated on the basis of judgement and indicative data. Others, such as noise, are largely subjective and more difficult to estimate. Where we are able to establish reasonable cost estimates, the figures have been used to adjust the normal allocation costs. The results are enumerated in Table 8.1.

8.1.2 Lorries cause delays to other road users in two ways. First, they cause delay directly when they use the roads - because they are 'more traffic', because they are big and therefore more hazardous to overtake than are cars, and because they have lower power:weight ratios than other road users and so tend to get caught up with. Secondly, because of the generally accepted 'fourth power law', it is largely due to lorries that reconstruction road works take place, and these of course delay road traffic. The Department's own estimate is said to be that the delay time disbenefits from such roadworks are up to 40% of the material cost of the roadworks. However, the Department make no attempt to charge these delay costs to lorries, on the grounds that these costs are internal to road users.

8.1.3 In order to test the effect of inclusion of a cost for delay, we have adjusted the value of the parameter of vehicle, average gvw, and standard axle kilometers by 40% when applied to the following items of expenditure:

i) Reconstruction and resurfacing.
ii) Haunching.
iii) Surface dressing & skid treatments.
iv) Patching and minor repairs.
v) Drainage.
vi) Bridges and remedial earthworks.

8.1.4 The effect is significant, and is shown in Table 8.1. The tax/cost ratio for a 32t artic is reduced from 1.31 to 1.07, while that for a 38t with 2+3 axle configuration is reduced from 1.25 to 1.02.

Table 8.1

Results of Sensitivity Tests : Delay and Accident Costs.

	DTp allocation		Delay costs		Accident costs		Accident costs	
							per mill.	per
	i	ii	i	ii	i	ii	vehicle km.	vehicle
Vehicle class								
Cars + vans	3.22	-	3.07	-	2.55	-	2370	31
Buses	0.84	-	0.67	-	0.78	-	5119	234
HGV rigids								
2 axle 7.5t	1.80	-	1.69	-	1.63	-	1855	33
2 axle 17t	1.11	49	0.89	28	1.08	46	1855	69
3 axle 25t	1.09	47	0.87	28	1.05	42	4080	155
4 axle 31t	1.07	64	0.85	37	1.01	56	5868	317
HGV artics								
2+1 axle 25t	1.20	112	0.98	44	1.13	79	4197	197
2+2 axle 28t	1.38	-	1.17	133	1.31	-	3224	171
2+2 axle 32.5t	1.31	234	1.08	86	1.26	179	3224	219
2+3 axle 38t	1.25	-	1.02	91	1.21	189	3689	314
3+2 axle 38t	1.27	353	1.04	99	1.22	239	3689	314
3+3 axle 38t	1.31	-	1.11	242	1.25	-	3689	314

Sub-column

(i) Vehicle Tax/cost ratio.
(ii) Breakeven distance (thousand kilometres per annum).

8.1.5 What should be included in the long run marginal cost of road use is the net increase in journey times to other vehicles from an extra lorry kilometre, after allowing for the optimal level of capital spending. We believe that this will be positive, both because lorries delay other vehicles even on uncongested roads, and because of the effect of accelerated reconstruction referred to above.

9. Accident Costs

9.1.1 The 1968 Road Track Costs report (MOT, 1968) included in the road costs to be allocated a figure of one sixteenth of total road accident costs, as attributable to the net public costs of road accidents. The 1976 Consultation Document (DoE, 1976) estimated that one quarter of all accident costs were borne by the state and the community (as opposed to road users themselves), but did not include any of this in the tax:cost calculations. The Armitage committee (Armitage, 1980), however, in its reccomendation 4, said that the public costs of accidents should be included in the calculation of road track costs. The DTp's response came in their 1983 proposals (DTp. 1983). It was there proposed to accept the Armitage recommendation, and allocate £150 million to vehicles, of which lorries were to pick up £8 million. These figures were said to represent the public expenditure on ambulance and medical services, and social security benefits arising from road accidents. These costs were allocated to vehicle types according to the frequency and severity of the accidents in which they are involved. As it was not thought possible to establish vehicles' differing degrees of responsibility, a straightforward sharing was used. The proposals received little support.

9.1.2 Those who did want accident costs to be included argued for a much heavier weighting against lorries because they cause more damage in an accident than a car would. The Department rejected this, confusing the responsibility of the vehicle with that of the driver. Clearly, there must be many accidents where the lorry driver is blameless, but the lorry is responsible for the accident being much worse than it otherwise would have been. The Secretary of State took the view that it would be discriminatory to charge accident costs to road users "since other industries and high risk sports do not pay in this way for the costs they cause to public funds". As to community costs, these were to be dealt with as part of the 'margin' for social and environmental costs, as we shall see below.

9.1.3 We have attempted to estimate the costs of road accidents attributable to various vehicle axle categories by using the figures published annually in Basic Road Statistics (British Road Federation 1986), and the involvement rates for lorries (Armitage Report, Tables 34 and 35; and Road Accidents Great Britain 1985, Table 38). The total community cost of road accidents in 1984 was estimated to be £2660mill (£2974mill at 1986 prices). Following the 1976 Consultation Document, we have taken one quarter (£743mill) as being chargeable. This was split over vehicle types in accordance with their accident involvement rates weighted by severity (see British Road Federation 1986). The result is to reduce the tax/cost radio of a 32t artic from 1.31

to 1.26. See Table 8.1. It should be borne in mind that many accidents go unreported,so that official accident statistics, as used here, may be considerable underestimates. Also, the official values of accident costs have been raised by 50% since these figures were prepared, a further large increase in the value of fatalities has just been anounced. Thus these figures may represent a substantial underestimate. Moreover, if the accident rate rises more than proportionately with traffic volumes, or if the severity of the accident depends on traffic flow composition there is an additional externality to take into account (Newbery, 1987, p. 23) .

10. Environmental Costs

10.1.1 The Armitage Committee (Armitage, 1980) recommended that, because of the difficulty of measuring the environmental damage caused by lorries, the Chancellor of the Exchequer should cease the then current practice of overcharging light lorries, and should instead raise the amount of money involved from the heaviest lorries. This would create a 'margin' of taxes over allocated costs for these vehicles, in recognition that they create more environmental problems. The Department's 1983 proposals argued that 'to some extent road track costs already reflect social and environmental costs since roads expenditure, on which the costs are based, includes measures taken to deal with these problems'. Furthermore, they argued that 'stricter Government regulations on lorry noise and safety features direct some of the costs of dealing with social and environmental problems to their source: the lorry itself'. Nonetheless, the Department accepted Armitage's recommendation that there should be some margin between allocated costs and tax rates, particularly for the heaviest vehicles. They gave, and have subsequently given, no indication of how large they felt such a margin should be.

10.1.2 We believe that techniques of environmental evaluation are insufficiently developed to give much guidence on this issue, and that ultimately the margin must be a matter of political judgement. In recent years, the margin has been held to roughly 30%.

10.1.3 Lorries may be considered to damage the environment in two ways. Firstly, by contributing to the case for more road space they cause some of the environmental costs of an expanded road infrastructure. These costs comprise the effects of land-take, visual intrusion and severance, and should be added to the financial costs of road construction. Secondly, they create environmental costs by their movement along the road. These costs consist of noise, vibration, air pollution and visual intrusion.

10.1.4 A number of reports have attempted to place a value on traffic noise, mainly by reference to house prices (Roskill 1970, Llewellyn-Davies 1973). Lorries are generally noisier than other vehicles, and cause most nuisance at night when they form a larger proportion of a relatively small volume of traffic.

10.1.5 To reduce this nuisance, regulations have been introduced to progressively reduce the maximum noise emmissions from HGV's.

Thus the heaviest new lorries will be restricted to 84dB(A) from 1989, and this limit is likely to be further reduced during the next decade.

10.1.6 Generally large diesel engined lorries, in good working order, cause relatively little of the air pollution due to traffic. However, the black smoke produced by poorly maintained vehicles is unsightly and unpleasant.

10.1.7 A particular category of cost which Armitage recommended should be included in the track costs calculations, and which is sometimes categorised as 'environmental', is damage to underground services. The Department's 1983 consultation paper, however, took a different view of the evidence that Armitage presented. The result was that no estimation or allocation of these costs was made. There is a widespread feeling that the statutory undertakers have a good deal at present since they are not charged for delays caused to traffic when they need to access the underground services. Furthermore, it is no doubt the case that much of the damage to underground services would be avoided if the carefully designed road pavement were not weakened by access works. Nevertheless, as we are considering the 'marginal' cost of road use, it is clear that some damage would be avoided by the removal of all traffic or selected types of vehicle. Some value should therefore be included in the track costs calculations. Further research is needed to determine what an appropriate value might be.

10.1.8 A wider issue of a similar nature is damage caused by vibration. Athough this can be viewed as a seperate sort of 'noise', there is the difference that physical damage may result. Again there is very little hard evidence, particularly as damage may only manifest itself slowly over a long period and there may be a number of contributary 'causes'. It is understood that TRRL are undertaking further work on both information and damage to underground services.

11. Conclusions

11.1.1 The official position regarding taxes paid by lorries has changed from clearly not covering their track costs in 1975, to one of at least covering their direct track costs in 1986. This is partly the result of real changes but also due to major revisions in methodology which have taken place in the interim, nearly all favouring heavy lorries (see Table 11.1).

Table 11.1

Changes in Tax/Cost Ratios

Vehicle class	Total tax (£) 1975/76	1975/76 at 1986 prices	1986/87	Tax/cost ratio 1975/76	1986/87
Rigid					
16t	858	1873	2663	0.68	1.12
24t	1403	3063	3853	0.65	1.10
30t	2137	4665	6121	0.60	1.06
Artic					
24t	1390	3034	4025	0.63	1.21
32t	2065	4508	7344	0.55	1.29

Source:- i) The allocation of road track costs 1975/76, DTp.
ii) The allocation of road track costs 1986/87, DTp.

11.1.2 We have argued that there are a number of deficiencies in the current calculations. Firstly, it appears that the tax paid by heavy goods vehicles is overstated. Secondly, for a number of reasons, the costs allocated to HGV's may be an underestimate. Thirdly, it may be that the current level of spending is inadequate to maintain the standards of the road network in the long term. In any case, a true long run marginal cost pricing regime would relate capital expenditure to incremental traffic as described in Section 2. Fourthly, the current margin between allocated revenue and costs may be inadequate to allow fully for the external costs created by lorries, particularly those covering high mileages. As demonstated in the sensitivity tests, readjustment of the capital expenditure to 1975 levels would erode any excess of tax revenue over costs which exists at present. Restoring the present tax/cost margin would require a 30% rise in taxes on heavy goods vehicles. Moving to a genuine long run marginal cost pricing regime, as described in Section 2, might require a further 25% tax increase on top of that.

11.1.3 Despite this evidence of underpayment, there is currently strong pressure on the government to reduce the level of taxation on heavy goods vehicles, particularly in the interests of harmonisation of taxation within the European Community in preparation for the completion of the internal market in 1992 (Cooper, Browne and Gretton, 1987).

11.1.4 This may be one reason why the Chancellor has held taxation of HGV's constant in money terms in recent budgets, thus leading to a real reduction. If harmonisation to a lower level of taxation is seen as inevitable, then it would be appropriate to relieve rail and water modes of a part of their infrastructure costs as a compensatory measure. Such an action is permitted under EC regulations, and indeed has already been implemented in France. It should not be seen as a subsidy to those modes as such, but rather as a correction to a distortion in another sector of the economy.

11.1.5 Throughout this paper we have emphasised the lack of precise information behind many of the cost calculations. We understand that further work on dynamic axle-loading is being undertaken by Dr Rhodes of Newcastle University. Other particular areas for further work are:

(1) Further evidence and/or engineering advice might be sought on the extent to which pavement life is a function solely of standard axles, or is a mixture of standard axles and elapsed time.

(2) Further research on appropriate pcu values for heavy lorries in a variety of circumstances (eg. on motorways) rather than solely at junctions appears needed.

(3) The conflict between alternative sources on the cost savings to be achieved by building car-only roads needs to be resolved.

(4) Up to date work on vehicle delay caused by heavy goods vehicles is needed.

(5) Given advances in survey techniques, it may be worth a fresh attempt to place money values on the amenity costs of heavy goods vehicles.

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