Road Transport Taxation in Developing Countries

The Design of User Charges and Taxes for Tunisia

David M. Newbery, Gordon A. Hughes, William D. O. Paterson, and Esra Bennathan
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David M. Newbery, Gordon A. Hughes, William D. O. Paterson, and Esra Bennathan

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INTRODUCTORY NOTE

The Design of User Charges and Taxes for Tunisia is part of the report on a World Bank research project, launched in 1982 under the original title of Pricing and Transport Fuels in Developing Countries, and completed in 1986. The total product of the research includes, in addition, methodological work on the appropriate concept of road use cost; on the derivation of road use cost from road network and traffic data under different maintenance regimes; on the corresponding rules for charging cost to users; on pure taxation of transport; on the price-level and distributional impact of transport taxes, taken on their own or relative to other taxes. It includes also detailed empirical work, to estimate some of the relationships, and as required for a full-dress application of the methodologies to the case of Tunisia.

The part now published as a Discussion Paper reports on the Tunisian case study. It does this in essentially non-technical terms and without a full account of the derivation and estimation of the underlying relationships of road use costs: those are unavoidably technical and can be learned from the relevant technical papers (listed in the Annex and available from the World Bank's Infrastructure Department). It thus takes a great deal of the technical underpinning as given and focuses chiefly on how to fit ascertained use costs into a realistic system of taxation, in a real economy, and on the expected effects.

Chapter 5 of this report (Economic Impact of Transport Taxes and Energy Pricing Policies) is partly based on the application of a taxation impact model. To facilitate the implementation of this model by others, a special matrix programming language was developed in the course of this research. This is a highly portable package which can be installed on a variety of computers -- micro as well as mainframes. It allows those working with input-output models to convert a formal statement of their model in terms of linear algebra into a computer program, enabling the modeller to experiment with alternative specifications at low cost. The package can be obtained by contacting Professor Gordon Hughes, Department of Economics, University of Edinburgh, Edinburgh, United Kingdom.
ACKNOWLEDGMENT

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ABSTRACT

The taxation of road transport has two purposes: to charge road users for the costs they impose on the road and on other users, and to raise revenue for the government. In designing a tax system or in tax reform, these functions need to be considered separately because different principles apply. The problem to be solved in designing road user charges, corresponding to marginal costs, arise from the limitation of the tax instruments available for the purpose, from further limitations that arise from possible conflicts between policy objectives or from existing distortions beyond the reach of reform, and from the existence of side-effects, inside and outside the transport sector, associated with the use of different instruments. Alternative configurations of the complete road transport tax system need therefore also to be tested for their effects on income distribution, price level and government revenue.

The present study analyses these problems as they appear in the case of Tunisia, and suggests solutions. It starts with an estimate of road use costs of vehicle traffic and compares them with prevailing road use charges. It then discusses the best way of charging for road use costs, and of levying taxes over and above cost-based charges. The repercussions which such charges and taxes might have on the rest of the economy are analysed next, and followed by suggestions of what appear the best available options.

The dominant component of road use cost (RUC) in Tunisia is the cost of congestion. Road damage cost attributable to vehicles of all kinds amounts to only 12 percent of RUC (1982); even for trucks, it is only 44 percent of total truck-RUC. When congestion is thus taken into account, the variation of RUC among different vehicle classes is drastically reduced relative to the variation in vehicle-specific road damage cost: road damage cost varies across vehicles by a factor of 600 to 1, but total RUC varies only as 4 to 1, or as 10 to 1, depending on the severity of urban congestion. This narrower variation of inclusive RUC, across vehicles, is comparable to the variation in the consumption of fuels, tyres, parts and of capital by the different vehicle types. There is thus substantial proportionality between the road use costs caused by different classes of vehicles and the input requirements for operating these vehicles. Taxes on those inputs and on vehicle purchase appear therefore as an adequate base for charging for road use.

The adequacy of Tunisia's system of road taxes on diesel vehicles (essentially, therefore, on freight vehicles) cannot be assessed with certainty because it is not clear that the implicit subsidy on diesel that emerged in 1982 (c 7.5/liter) was settled tax policy. But when taxes on diesel, tyres, parts and vehicle purchase, and the annual license fees are examined on different assumptions about the level of intended rates, it appears that most diesel vehicles are charged about as much as the RUC attributable to them. This conclusion does not, however, hold for small freight vehicles (utilities).
While the level of taxes in 1982 appears about right this is less clear as regards structure. Improvements in tax structure depend, first, on what instruments are available, and, second, on the expected effect of different instruments on utilization and loading of different vehicles:

- **Tax on transport service.** RUC per ton-km is found to be fairly uniform across different categories of trucks. A tax per ton-km — on transport service — should therefore be an ideal way of charging for road use cost of freight transport. The most manageable base for such a tax would be the freight bill which emerges in professional haulage transactions. In Tunisia, however, something like one-half of freight transport is performed by own-account haulage. Transport service taxes cannot easily be extended to this mode of transport which would therefore have to be taxed by other instruments. Moreover, the cost of freight transport regulation in Tunisia appears to be high. If deregulation were to be pursued so as to free entry into professional haulage, the regulatory separation between professional and own account transport would get blurred or disappear, and transport service taxation might be found administratively unmanageable. What appears on other grounds as the best tax base may thus in practice conflict with the objective of deregulation.

- **Fuel taxes** appear as the next most attractive instrument inasmuch as fuel is a reasonably good measure of distance driven and a tax would also penalize overloading. Taxes on fuels — on diesel and its close substitutes — are moreover relatively free of undesirable effects on the price level and (horizontal) distribution, no worse or indeed better (in terms of the price-level effect) than other available instruments of road freight transport taxes. A serious qualification to the case for heavy reliance on fuel taxes arises, however, when substitution between fuels and other factors in production is allowed for. 60 percent of diesel is used outside transport. A tax on diesel and kerosene (being close substitutes, they must unfortunately be taxed together, however desirable a subsidy to kerosene would be on distributional grounds) should therefore, have substantial effects in non-transport activities. An estimate of the results of substitutability, between fuels, and between fuels and other inputs, across the economy, suggests that the deadweight loss associated with such a tax (i.e., what is lost in excess of what the government receives) may amount to over 50 percent of the tax revenue. Much smaller dead weight losses are estimated for taxes on road transport, vehicles, parts or tyres.

- **Tyre taxes,** like those on fuel, fall in some measure on distance travelled and also penalize overloading. Against these merits stands the risk to safety from overused tyres.

- **Taxes on parts,** except at modest rates, should have undesirable consequences similar to those of tyre taxes.

- **Purchase taxes,** while not varying with the activity that causes RUC (whether road damage or congestion) have the desirable characteristic of being able to discriminate between vehicles, and license fees, also, can be set so as to distinguish between vehicle configuration and number of axles.
By selecting among these instruments one can balance out various
distorting effects: fuel taxes and license fees can thus be employed to off-
set purchase taxes in their opposing influence on vehicle life-time.

The problems associated with taxing diesel and kerosene in Tunisia
are also relevant to the design of pure taxation of transport (i.e., imposi-
tions not related to road use cost). Indeed, since diesel is used largely
outside the transport sector, the road charging and taxing aspects of diesel
taxes cannot be separated. Pure taxation of transport can have several
objects: to make up the difference between short-run marginal cost of road
use (the underlying cost concept in this study) and the average cost; to
realize distributional policies; to support government revenue in the face of
a narrow tax base, or to correct distortions within or outside the transport
sector. Available information on costs and expenditures suggests that
Tunisia's road expenditure would be more than fully covered if road use is
charged at short-run marginal cost (congestion cost being included). This
remains the finding even after capital cost is accounted for: annual invest-
ment expenditures seem quite close to annualized marginal road expansion
costs which forms the appropriate criterion under an optimized road system.
These are tentative estimates, but even if wrong, the standard argument in
economics against charging above marginal cost applies. The argument from a
narrow tax base is most valid for taxing consumers (i.e., personal trans-
port), not intermediate goods used by producers. Intermediates may neverthe-
less have to be taxed if they enter into the production of consumer goods
that prove hard to tax. A survey of those goods in Tunisia (according to
distributional weights assigned to different goods on various assumptions
about Tunisia's attitude to income inequality) shows no persuasive case for
taxation of transport to correct this kind of distortion.

Personal transport is a final consumption good and thus a legiti-
mate object for pure taxation since such taxes will not interfere with
productive efficiency. Road use cost for this sector consist overwhelmingly
of congestion cost. Several rules emerge for road use charges. Public
transport should thus be subsidized in the rush hours if private transport
cannot be adequately charged during that period. The alternative would be to
impose higher taxes on private vehicles. Pure taxation of personal transport
by private cars in Tunisia is already relatively high: some 109 percent of
economic cost of private transport (including value of time), about 60 per-
cent above the tax falling on other locally produced goods. A calculation of
the distributional characteristics of various goods in Tunisia (that is, of a
measure of their relevance to an evening-out of the income distribution,
assuming certain attitudes towards inequality) ranks purchased personal
transport relatively high in the list, and private transport, relatively low:
on distributional grounds, gasoline, cars and spares are chief candidates for
taxation. The actual desirable level, however, is difficult to determine
without more information than exists on price elasticities (required to
determine the aggregate tax-revenue response to a tax rate raised on one
good). Employing the best approach available in these circumstances, it
appears that the existing taxes on vehicle purchase, and the annual license
fees are too high for efficiency, and inappropriately structured.
The analysis of road use costs in Tunisia and of the available tax instruments and their expected or knowable effects in Tunisia's circumstances stakes out the area within which the country's road taxation should be designed. It places limits on what is advisable if the social cost of charging for road use (and raising pure taxes) is to be kept low but it does not lead to any unitary prescription. A possible scheme, for road user charges on trucks, would collect one-quarter of the total from fuel. It sets modest rates on tyres and parts, and leaves the rest to purchase tax and annual license fees, balanced so as to neutralize the opposing effects of these two instruments on vehicle life. The proposed scheme would raise the same revenue from trucks as the 1982 system of charges, but alters the structure so as to raise the level on the lightest and certain heavier vehicle weights. The scheme presented for passenger transport distinguishes between gasoline cars (with an increased tax on the fuel and a pure tax of 40 percent of vehicle operating cost) and diesel passenger cars. The relation between the two, and the balance between the various available tax instruments, is adjusted so as to inhibit the switch from gasoline to diesel-engined vehicles. The suggested tax on urban buses is lighter than on rural buses, to encourage transfers from private to public transport. Each is designed to make distinctly smaller contributions to pure tax revenue than private cars.
Abbreviations and Glossary

I. Common abbreviations

c - U.S. cents
DT - Tunisian Dinars = 1,000 millimes (1982 average: DT 0.59 = US$1)
ESA - Equivalent Standard Axle: road damaging effect of vehicle
l - liter
PCE - Passenger Car Equivalent: congestive effect of vehicle
PCU - Passenger Car Equivalent
RUC - Road Use Cost
veh - Vehicle
VKT - Vehicle Kilometers Travelled
VOC - Vehicle Operating Cost

II. Vehicle classes referred to in this study.

1G - Car, gasoline
1D - Car, diesel oil
2 - Utility ("pickup")
3 - Light Truck (2 axles)
4 - Medium Truck (2 axles)
5a - Heavy Single Truck (2 axles)
5b - Heavy Tandem Truck (3 axles)
6 - Articulated Truck (average axles: 4.2)
7 - Bus (2 axles)
8 - Special Vehicles
Chapter 1: Road Use Costs in Tunisia

by David M. Newbery
and William D. O. Paterson

Taxes on transport serve two different purposes - they charge for the social costs caused by vehicle use, and they raise additional revenue for the government. The main social costs in developing countries are the damage to the pavement, the resulting increase in subsequent vehicle operating costs, and congestion costs. Pollution, which may also be serious in some urban centres (Mexico City is a good example), and accidents comprise the other main quantifiable externalities, but it seems reasonable to lump pollution together with congestion costs, and accident costs with pavement damage. There are no doubt a host of other subtle and unquantifiable consequences, but these will have to be ignored.

The social costs visited upon the rest of society will be termed the road use cost (Walters 1968, defines this as the economic user charge, or EUC). It is borne both by other road users (as reduced speed and higher operating costs), and by the Highway Authority (as higher maintenance costs and demands for further road investment). The road use cost will vary with the vehicle, the road (its strength, capacity, and condition) and the level of traffic. In an ideal world the vehicle user would be charged directly for the road use cost, and would thus be forced to take account of the total cost of using his vehicle on the road. As a result, he would be encouraged to choose the most appropriate type of vehicle, the correct loading, the best route, and the right time of day for the journey, if it were worthwhile, and would not make the journey if the benefit did not exceed the total cost.

However, we do not (yet) have the means to make direct charges on vehicles equal to their road use costs. The only alternative is to levy taxes or charges on various inputs which are used in the production of transport services. The main instruments available are:

Taxes on vehicle ownership:
purchase taxes (including customs duties)
annual license fees

Taxes on vehicle use:
purchase taxes (which affect depreciation)
fuel taxes
tyre taxes
taxes on spare parts
direct taxes on transport services
The problem of charging for road use is then the problem of choosing a set of rates for taxes and fees on these inputs.

There are two main difficulties in designing a set of road user charges. The first is the obvious difficulty of relating the charges to the road use costs so as best to reflect these costs in the charges on specific vehicles in specific circumstances. Vehicle taxes are well designed to discriminate between different types of vehicle, but not by distance travelled. Tyre and fuel taxes are able to charge for distance travelled, but are not necessarily well suited to match charge with cost for different types of vehicles. None of the instruments are well suited to discriminate between different types of road (paved vs unpaved, congested vs uncongested, etc.)

The second difficulty is that charges on fuels will affect their price to non-road users, and hence have possibly undesirable effects elsewhere. This means that the level of fuel taxes cannot be set without considering the rest of the economy. In practice the difficulty only arises for diesel, for the following reason. Gasoline is only used for transport, and then is only an efficient choice for cars, pickups, and light vehicles with low annual mileages. An increase in the price of gasoline with no corresponding increases in the price of diesel might induce road users to choose inappropriate diesel powered vehicles to avoid the gasoline tax. This can be partly prevented by imposing a higher annual license fee on diesel powered cars, equal to the difference in tax collected for the breakeven annual distance (defined as the distance at which on efficient grounds, it first becomes economic to use diesel instead of gasoline).1/ The main problem will be that potential car owners might switch to using pickups or other light commercial vehicles.

Diesel, on the other hand, is used for non-automotive uses (tractors, generators, stationary machines, heating etc.) and is a close substitute for gas-oil and kerosene. If diesel is heavily taxed, and kerosene is less heavily taxed, or subsidized, then there will be strong economic incentives to adulterate diesel with kerosene. There is little difficulty in using up to 30 percent kerosene mixed with diesel for road use, and considerable evidence that this degree of adulteration and more occurs when kerosene prices are kept significantly below the price of diesel.

Quite clearly, taxes on diesel will affect the use of diesel elsewhere in the economy, and may induce kerosene to be substituted for transport use so that the diesel tax will fail to adequately charge for transport fuel use. If kerosene is taxed at the same rate as diesel, then the taxes will succeed in charging for transport fuel use, but will have more widespread effects on the rest of the economy.

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1/ If the annualized extra economic cost of a diesel engine of comparable performance is k, and the cost saving (at efficient prices) is s per km, then the breakeven distance is k/s km, and the extra license fee for a diesel vehicle should be dk/s, where d is the excess in tax per km driven of gasoline use over diesel use.
These considerations suggest the following approach. As the taxation of private cars raises quite separate issues, that will be dealt with separately in Chapter 6, and the main emphasis in the first five chapters will be on road user charges for diesel powered commercial vehicles. The first step is to calculate the road use costs for different types of vehicles in Tunisia. The next step is to ask how best to levy these charges, ignoring the problem of kerosene mixing and consequent fuel substitution. It may be that diesel taxes are not necessary, in which case the problem of fuel substitution can be largely avoided. If, as we shall argue is in fact the case, it would be desirable to use fuel taxes for road charging, then it becomes important to see how far setting the diesel tax is constrained by other considerations. These issues are considered further in Chapters 2-5. In this chapter we confine attention to calculating the road use cost of vehicles in Tunisia in 1982.

1. The Level and Sources of Road Use Costs in Tunisia

The only costs to be included in road use costs are those caused by additional vehicles using a particular road. Overhead costs such as street lighting, verge maintenance, the provision and maintenance of traffic signals will not vary with the number of vehicles using a particular road, and hence are excluded. The costs which will be included fall into two categories - those arising from the damage done to the road by the vehicle (road damage costs) and those arising from the direct interaction between vehicles (congestion costs). Neither accident costs nor pollution costs have been calculated, but similar principles apply in deciding how these should be allocated.

While congestion is the classic source of external disbenefit in road traffic, it is not the only one. The road damage cost of traffic consists not only of pavement cost (the increased cost of repairing the road) but also, in principle, of the road damage externality: the increase in the vehicle operating cost of driving on the more damaged or the rougher road, suffered by subsequent vehicles. A main theoretical result reached in this study concerns this externality. It says that if vehicles cannot be charged for each road they traverse, but only in proportion to distance travelled (and type of vehicle), if the road network has a fairly uniform age distribution, and if maintenance policies are condition-responsive, then road damage externalities are identically zero in an important special case, and negligible in all reasonable cases. The special case has zero traffic growth and all road damage caused by vehicles. In that case the fundamental theorem of road damage costs states that the efficient charge is the road damage cost, which is exactly equal to the average cost of maintenance per Equivalent Axle-km.

The argument goes as follows. The state of the road is measured by its roughness, R, and vehicle operating costs increase with R. The damaging power of a vehicle is measured by its number of ESALs (equivalent standard axle loads). If W is the load on a dual-tyred single axle in tons, then its ESAL is approximately \((W/8.2)^4\), so damage is approximately proportional to the fourth power of the axle load. We consider first the simple case in which R is a function of cumulative ESALs since last overlay, and independent
of time-related environmental effects. Suppose also that the road will be
overlaid when roughness reaches a pre-determined level, $R$, after which its
roughness will fall to the initial value, $R_0$. The 'age' of the pavement for
this purpose can be measured in terms of cumulative ESALs. Imagine a road of
length say 100 km, comprising sections having uniformly distributed ages but
nominally homogenous in pavement strength. If its lifetime is $N$ ESALs before
overlay, then a fraction $m/N$ km will have an age of $m$ or less, as shown in
Figure 1. Initially suppose that the youngest section is at the start of the
road, and the oldest section, just requiring overlay, is at the end. Each
year, if annual traffic is $n$ ESALs, a fraction $n/N$ will be overlaid at a cost
of $C/km$, or a total annual cost of $Cn/N$, or $C/N$ per ESAL-km. As time passes,
the 'age' of sections at each distance will change as shown in Figure 1, but
the 'age' distribution (the portion of road of any age since overlay) will
remain unchanged. Variations in the annual flow will alter the rate at which
the 'age' of a particular piece of road changes, but not the distribution.

![Figure 1: Age Distribution of Roads](image)

The cost of traversing the road will depend on the average roughness, which
will depend on the age distribution of the road, but this will also be
unaffected by traffic. Thus there is no damage externality, and the social
cost of an extra vehicle is just $C/N$, the extra maintenance cost required.
The marginal social cost of an extra vehicle will be equal to the average
cost borne by the highway authority, allocated over the total number of
ESALs.

Another way to understand this surprising result is to examine the
time path of vehicle operating costs (VOC) (and roughness) shown in Figure
2. The effect of an extra ESAL now is to raise subsequent VOC by the verti-
cally shaded amount, to advance the date at which roughness reaches the
critical level $R$ and overlay occurs, and to lower subsequent vehicle operat-
ing costs as a result by the amount of the horizontally shaded area. Averag-
ing over roads of all ages, these two areas balance in present discounted
value.

Going beyond the special case, it is found that the externality
will not vanish but be negligible in all reasonable cases, included in the
general case that allows for the effects of weather, time and traffic growth
on the state of the road.
In practice, roads deteriorate with the passage of time under the influence of weathering and other environmental factors, in combination with the effects of traffic. In the context of roads under condition-responsive maintenance in which the total mount of damage is fixed, the effect of weathering is therefore to reduce the proportion of pavement damage that is attributable to traffic. In this case the proportion depends on the severity of the climate (through the durability of the surface and the sensitivity of the pavement to moisture and temperature variations), and on the stringency of the maintenance standards (in terms of the roughness range $R_0$, to $R$); in the general case it depends also on the level of traffic loading in relation to the pavement strength. In arid subtropical climates the proportion attributable to traffic ranges typically between 0.6 and 0.8, in humid sub-tropical or non-freezing temperate climates between 0.6 and 0.8, and in freezing temperate climates between 0.2 and 0.6; stringent maintenance standards or low traffic levels giving the lower values.

![Time path of Vehicle Operating Costs](image)

**FIGURE 2:** Time path of Vehicle Operating Costs

The effect of traffic growth on the relationship between road damage costs and total maintenance costs is two fold. First, the road will require strengthening to withstand higher traffic volumes, if similar intervals between maintenance are to be achieved, and so part of the maintenance is an expansion or investment cost, more correctly attributable to future traffic levels. Second, the rest of the current maintenance cost is the result of past, different (lower) traffic volumes. Hence there is a problem of matching the timing and fraction of expenditure attributable to current traffic. It is not difficult to calculate the appropriate level of road damage costs and to relate them to current maintenance levels, but there is no longer the simple formula of taking the current level of maintenance cost per km and dividing it by lifetime ESALs. Calculations for Tunisia suggested the combined effect of (high) traffic growth and weathering was that the ratio of efficient charges to road maintenance costs on lightly trafficked roads lasting 20 years would be about 55 per cent, and on more heavily trafficked
roads lasting 15 years the ratio would be 65-75 per cent. Allowing for the greater fraction of VKT on more heavily trafficked roads, an average ratio of two-thirds seems reasonable; though for more severe climates lower values such as one-half or less would apply.

1.1 Road Damage Costs on Paved Roads

Roads deteriorate both as a result of traffic and weathering, and the ways in which various types of road are damaged by various types of vehicles are explained in detail in Paterson (1985 Chapter 3). Vehicles cause paved roads to crack and/or ravell, and hence advance the date at which maintenance (resealing) is required. The calculation of these resealing costs is described in detail in Newbery (1985a). In Tunisia, it appears that on older surface treatment roads cracking was more important than ravelling as a cause of rescaling, whereas on newer roads (with lower quality bitumen) ravelling is likely to be a more important cause of rescaling than cracking. Ravelling is caused by the passage of vehicle axles, and all motorized axles are apparently equally damaging regardless of axle loading. Ravelling costs, which are in any case trivial are therefore allocated on the basis of axle km.

Cracking is caused by the passage of loaded axles, with heavier axle loadings causing more damage. The (crack) damaging power of an axle is proportional to the square of its load, and thus the costs are allocated on the basis of equivalent standard axles with damaging power $m^2$, or $\text{ES}A^2$ km. One $\text{ES}A^2$ is defined as equivalent to the damaging power of a dual tire single axle of 8.16 tonnes or 80 kilonewtons (Paterson 1985, p.26). The average damaging powers of different vehicles are given in Table 1.

Table 2 gives the costs of ravelling and cracking on the assumption that rescaling is caused by cracking on half the road surface treated, and by ravelling on the other half. Asphaltic concrete roads only ravel after rescaling and account for 15 per cent of vehicle km travelled (VKT).

The main road damage is that caused by deformation of the pavement, which is measured by increased roughness. Here the damage done is proportional to the fourth power of the axle load, and the damaging power of a vehicle is therefore measured in equivalent standard axles with a damaging power $m^4$, or $\text{ES}A^4$. Most Highway Authorities, including those in Tunisia, overlay the road to restore the surface to its original state of roughness when it has deteriorated to some predetermined level. For authorities following such a maintenance strategy, the costs of roughness are that subsequent vehicles experience higher vehicle operating costs, and that the date is advanced at which the surface has to be restored to its original state by a costly overlay. The method of calculating these overlay costs is set out in Newbery (1985a, 1986a) and the results of applying these methods to

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2/ Surface treatment roads (ST) comprise over 90 per cent of the paved interurban network, the remainder being surfaced with asphaltic concrete (AC) (7.5 per cent) or portland cement concrete (0.2 percent). See Paterson (1985, p39).
### TABLE 1: Average Damaging Factors for Vehicles in Tunisia

<table>
<thead>
<tr>
<th>Type of Vehicles</th>
<th>Number of Axles</th>
<th>Average PCE&lt;sup&gt;2&lt;/sup&gt;/ PCE</th>
<th>ESA&lt;sub&gt;2&lt;/sub&gt;</th>
<th>ESA&lt;sub&gt;4&lt;/sub&gt;</th>
<th>PCE&lt;sup&gt;2&lt;/sup&gt;/ Interurban</th>
<th>PCE Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>1G Car (gasoline)</td>
<td>2</td>
<td></td>
<td>0.01</td>
<td>0.0001</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1D Car (diesel)</td>
<td>2</td>
<td></td>
<td>0.13</td>
<td>0.001</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2 Utility</td>
<td>2</td>
<td></td>
<td>0.09</td>
<td>0.008</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3 Light Truck</td>
<td>2</td>
<td></td>
<td>0.3</td>
<td>0.092</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>4 Medium Truck</td>
<td>2</td>
<td></td>
<td>0.8</td>
<td>0.58</td>
<td>1.7</td>
<td>2.0</td>
</tr>
<tr>
<td>5a Heavy Single Truck</td>
<td>3</td>
<td></td>
<td>2.83</td>
<td>5.38</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>5b Heavy Tandem</td>
<td>2</td>
<td></td>
<td>1.63</td>
<td>2.60</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>6 Articulated Truck</td>
<td>2</td>
<td></td>
<td>3.65</td>
<td>6.80</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>7 Bus</td>
<td>2</td>
<td></td>
<td>0.92</td>
<td>0.49</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>8 Special Vehicles&lt;sup&gt;1/&lt;/sup&gt;</td>
<td>2</td>
<td></td>
<td>(0.92)</td>
<td>(0.49)</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

<sup>1/</sup> In the absence of data, special vehicles are assumed similar to buses.

<sup>2/</sup> PCE: Passenger Car Equivalents (congestive effect).

**Source:** Paterson (1985, p.32)

### TABLE 2: Road Use Costs on Interurban Roads

<table>
<thead>
<tr>
<th>Road damage costs on paved roads</th>
<th>c/axle km</th>
<th>c/veh km</th>
<th>c/ESA&lt;sub&gt;2&lt;/sub&gt;km</th>
<th>c/ESA&lt;sub&gt;4&lt;/sub&gt;</th>
<th>c/PCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>. Resealing cost:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ravelling</td>
<td>0.003</td>
<td></td>
<td>0.052</td>
<td></td>
<td>0.80</td>
</tr>
<tr>
<td>Cracking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Overlays:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road damage costs on unpaved roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per km unpaved roads:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.08</td>
</tr>
<tr>
<td>Congestion costs averaged over interurban paved roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. On narrow roads</td>
<td></td>
<td></td>
<td>0.03</td>
<td></td>
<td>0.20</td>
</tr>
<tr>
<td>. Time loss costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sources:** Newbery (1985a, 1986a, b, c, d)
Tunisia are presented in Newbery (1986b). The costs per vehicle-km vary by a factor of 15 from the most lightly trafficked roads (where they are highest) to the most heavily trafficked roads, and the figure given in Table 2 is weighted by VKT.

1.2 Road damage costs on unpaved roads

Unpaved roads are maintained by periodic blading, and if, as seems to be the case in Tunisia, the blading is done once a year, after the wet season and just before the harvest is evacuated, then the road use costs consist entirely of the effect of increased roughness on subsequent vehicles, since vehicle use has no effect on the costs of maintenance. The theory and estimation of these costs for Tunisia is set out in Newbery (1984) and presented in Table 2. Although these costs may vary with traffic volume, the range of variation is much smaller than for overlay costs.

1.3 Congestion costs on interurban paved roads

There are two distinct types of congestion costs on interurban roads. On narrow roads (of 5m width or less) if two vehicles approach each other, then at least one vehicle and possibly both are forced onto the shoulder in order to pass. Even if there is no slackening in speed, and hence no effect on the travel time, the vehicle experiences higher operating costs when running on the unpaved shoulder than on the paved road, and the shoulder will require additional maintenance.

Using the data from the 1977 Traffic Census, the estimated cost amounts to 0.12c/veh km on roads of 5m or less in width, which, averaged over the whole paved network, amounts to 0.03c/veh km, which is larger than the resealing cost.

The other type of congestion is the conventional one in which more traffic means lower average travelling speeds, and hence additional vehicles impose time loss costs on the existing traffic stream. It has been argued by Walters (1968, p. 175) that congestion costs on interurban or rural roads are of trivial importance. On the other hand there is a standard argument from welfare economics that if there are constant returns to increasing capacity (road width) and if capacity is freely adjustable, then collecting a road charge equal to the congestion cost would cover the costs of optimally expanding capacity (widening roads). Carried to its logical conclusion, the argument says that road capacity should be adjusted so that congestion costs are at a level equal to the average total cost of the road (i.e. the interest costs on capital and width/capacity related maintenance per year per km, divided by the annual traffic, as a cost per vehicle km). Such costs might amount to between 1-3c/veh km and are thus substantial.

There are two obvious weaknesses with this argument, and a third less obvious weakness. First, there may be decreasing costs per unit of additional capacity. Here the evidence is mixed; it would be fair to say that, while there is a mild presumption in favour of decreasing costs, the case is not clear cut. If there are decreasing costs, then congestion charges might still be as high as 70-80% of average costs. Second and more
important, it may not be sensible to make gradual increments to capacity, but it may be preferable to make significant changes periodically (from single to double lane, from double to triple, etc.). If so, then roads will be periodically overcongested and underutilized. It is not clear what effect this might have on the average level of congestion charges if roads are optimally expanded, but some trial calculations suggest that they might be somewhat lower than marginal expansion costs. Of course, if a large fraction of the network were still uncongested then the present congestion charge might be well below its long run average level, but since traffic is fairly uniformly distributed over roads of varying widths, and as a large fraction of VKT occurs on narrow roads, this argument is less compelling.

The third, and less obvious objection is that congestion is caused not by motorized traffic but by animal drawn carts, pedestrians, cycles, etc. This was certainly a major part of Walter's argument, and is possibly true in South East Asian and Latin American countries. In Tunisia it is not convincing, as animal drawn traffic accounts for only 2% of the traffic flow.

Thus on the face of it one might expect road capacities to be such that congestion on interurban roads might be considerable, and that congestion costs might be substantial when compared to other road use costs. The difficulty in testing this argument is that the estimates of congestion costs are very sensitive to the speed-flow model used, and to its calibration (or, equivalently, to the measurement of the capacity of roads of varying widths and configurations). Nevertheless, an attempt has been made to quantify these costs for paved roads in Tunisia in Newbery (1986e). The unit of damage is the passenger car unit or equivalent (PCU or PCE). For generous measure, animal drawn vehicles count as 3 PCU, bicycles as 0.5 PCU. Other figures are given in Table 1. The best estimate, using 1977 census data on traffic volume by road width, and recent recalibration of speed-flow relationships, is that the congestion costs are 0.20c/PCU km, as shown in Table 2.

1.4 Congestion costs on urban roads

If estimating congestion costs on interurban roads is difficult, then it is substantially more so on congested urban roads, where intersections, parked cars, and traffic signals all make the concept of road capacity ill-defined. The methods available are discussed in Newbery (1986f), and the results are summarized in Table 3. Unfortunately, we have no information on the proportions of VKM travelled on the various types of road, let alone the proportions of different classes of vehicles, and so the allocation of congestion costs to vehicles will be more than usually conjectural. It will therefore be important to test the sensitivity of road use costs to urban congestion costs, by considering an alternative in which these costs are reduced to one third of their value in Table 3.
TABLE 3: Urban Congestion Costs in Tunisia

<table>
<thead>
<tr>
<th>Types of Roads</th>
<th>Marginal Externality Cost/PCU km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Veh. hr/PCU km</td>
</tr>
<tr>
<td>Very congested</td>
<td>0.1</td>
</tr>
<tr>
<td>Moderately congested</td>
<td>0.04</td>
</tr>
<tr>
<td>Slightly congested</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Source: Newbery (1986f)

2. Allocation of Road Use Costs to Vehicles

Paterson (1985 Table 1.9 p.21) gives the vehicle kilometres travelled (VKT) by class of vehicle, reproduced below as Table 4A.

TABLE 4A: Vehicle Utilization of Road Network, Tunisia 1982
(million km)

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Non urban</th>
<th>Urban congested</th>
<th>Total (million)</th>
<th>% of Total VKT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paved</td>
<td>Unpaved</td>
<td>Heavy Mod. Light</td>
<td></td>
</tr>
<tr>
<td>1G Car (gas)</td>
<td>1404</td>
<td>0</td>
<td>91 91</td>
<td>2284</td>
</tr>
<tr>
<td>1D Car (diesel)</td>
<td>464</td>
<td>0</td>
<td>30 30</td>
<td>755</td>
</tr>
<tr>
<td>2 Utility</td>
<td>1665</td>
<td>56</td>
<td>77 77</td>
<td>2572</td>
</tr>
<tr>
<td>Trucks:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 . light</td>
<td>427</td>
<td>14</td>
<td>13 13</td>
<td>659</td>
</tr>
<tr>
<td>4 . medium</td>
<td>161</td>
<td>0</td>
<td>0 0</td>
<td>177</td>
</tr>
<tr>
<td>5a . heavy single</td>
<td>204</td>
<td>0</td>
<td>0 0</td>
<td>224</td>
</tr>
<tr>
<td>5b . heavy tandem</td>
<td>12</td>
<td>0</td>
<td>0 0</td>
<td>13</td>
</tr>
<tr>
<td>6 Articulated</td>
<td>133</td>
<td>0</td>
<td>0 0</td>
<td>140</td>
</tr>
<tr>
<td>7 Buses</td>
<td>125</td>
<td>0</td>
<td>9 9</td>
<td>188</td>
</tr>
<tr>
<td>8 Special</td>
<td>150</td>
<td>70</td>
<td>6 6</td>
<td>298</td>
</tr>
<tr>
<td>Totals</td>
<td>4744</td>
<td>140</td>
<td>226 226</td>
<td>7310</td>
</tr>
</tbody>
</table>

Source: Paterson (1985, Table 1.9)

As much of the discussion below concerns using fuel taxes for charging for road use, and hence with VKT for diesel powered vehicles, this is given in Table 4B below. It is useful to have input consumption per km in order to compare road use costs with input costs, since these are the instruments available for road user charging according to distance.
TABLE 4B: Diesel Vehicle Utilization of Differing Roads, Tunisia, 1982

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Non urban</th>
<th>Urban congested</th>
<th>Totals % by Road</th>
<th>Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paved</td>
<td>Unpaved</td>
<td>Heavy Mod. Light</td>
<td></td>
</tr>
<tr>
<td>1D Cars</td>
<td>62</td>
<td>0</td>
<td>4 4 30</td>
<td>100</td>
</tr>
<tr>
<td>2 Utilities</td>
<td>65</td>
<td>2</td>
<td>3 3 27</td>
<td>100</td>
</tr>
<tr>
<td>Trucks:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 light</td>
<td>65</td>
<td>2</td>
<td>2 2 29</td>
<td>100</td>
</tr>
<tr>
<td>4 medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5a heavy single</td>
<td>91</td>
<td>0</td>
<td>0 0 9</td>
<td>100</td>
</tr>
<tr>
<td>5b heavy tandem</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Articulated</td>
<td>95</td>
<td>0</td>
<td>0 0 5</td>
<td>100</td>
</tr>
<tr>
<td>7 Buses</td>
<td>66</td>
<td>0</td>
<td>5 5 23</td>
<td>100</td>
</tr>
<tr>
<td>8 Special</td>
<td>50</td>
<td>23</td>
<td>2 2 22</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Paterson (1985, Table 1.9)

Table 5 gives these for diesel vehicles for fuel in litres/1000 km, tyre consumption in US (1983) cents/km, consumption of spare parts (excluding labour costs) in cents/km and interest and depreciation of the vehicle per km, the latter three at economic cost (i.e. excluding taxes). (Gasoline vehicles are considered in Chapter 6.) Tyre, fuel and parts consumption are proportional to distance, and both tyre and fuel consumption increase under congestion (tyre consumption in urban areas may be twice that on paved inter-urban roads).

Tyre consumption is also higher for unpaved roads, and fuel consumption increases with payload, as does overlay cost. Capital costs have been argued to be proportional to distance travelled, since it is claimed that vehicle life is measured in cumulative distance travelled, not calendar years. This, however, overlooks the large interest element which is time related. If the vehicle falls apart after a fixed number of km, and if the discount rate is 15%, then doubling the annual distance and thereby halving the life lowers the capital cost per km to 75 per cent of its previous value. This effect can be seen in Table 6 below. Nevertheless, the cost is better related to distance travelled than the annual license fee, particularly as older vehicles with lower capital costs per km, typically travel fewer km p.a.
TABLE 5: Running Costs Per Km for Diesel Vehicles

<table>
<thead>
<tr>
<th>Vehicle class</th>
<th>Litres/1000km (1)</th>
<th>Tyre costs c/km (2)</th>
<th>Capital cost c/km (3)</th>
<th>Parts cost c/km (4)</th>
<th>Vehicle Operating Operating cost (economic) c/km (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D</td>
<td>65</td>
<td>0.30</td>
<td>3.34</td>
<td>0.72</td>
<td>6.44</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>0.53</td>
<td>3.83</td>
<td>0.96</td>
<td>12.44</td>
</tr>
<tr>
<td>3</td>
<td>150</td>
<td>1.08</td>
<td>6.09</td>
<td>1.44</td>
<td>20.37</td>
</tr>
<tr>
<td>4</td>
<td>200</td>
<td>2.52</td>
<td>7.41</td>
<td>2.16</td>
<td>32.37</td>
</tr>
<tr>
<td>5a</td>
<td>390</td>
<td>3.75</td>
<td>9.68</td>
<td>3.00</td>
<td>39.13</td>
</tr>
<tr>
<td>5b</td>
<td>445</td>
<td>5.05</td>
<td>11.62</td>
<td>3.60</td>
<td>n.a.</td>
</tr>
<tr>
<td>6</td>
<td>487</td>
<td>8.11</td>
<td>23.2</td>
<td>4.80</td>
<td>75.78</td>
</tr>
<tr>
<td>7</td>
<td>357</td>
<td>2.87</td>
<td>19.9</td>
<td>6.00</td>
<td>62.38</td>
</tr>
<tr>
<td>Average</td>
<td>135</td>
<td>1.12</td>
<td>5.76</td>
<td>1.45</td>
<td>18.54</td>
</tr>
<tr>
<td>Average per truck</td>
<td></td>
<td>2.61</td>
<td>8.95</td>
<td>2.23</td>
<td>32.11</td>
</tr>
</tbody>
</table>

(2) Paterson 1985, Table 2.17 (average, rolling terrain)
(3) " " " " , Table 2.13, economic costs, RG=4
" " " " , Table 2.8, economic capital values, interest
and depreciation at interest rate of 15% p.a. distance as in
Table 2.7
(4) Paterson 1985, Table 2.13, economic costs, RG=4
(5) " " " " , " " " " , " " " " , " " " " (1D adjusted
for higher capital costs.)
n.a.: not available.

Table 7 collects together the costs per vehicle/km by type of vehicle and
type of damage, whilst Table 8 expresses the road use cost as equivalent
charges on the four inputs. Thus light trucks (class 3) incur a road use
cost of 2.27 c/km averaging over VKT by light trucks, and if this were to be
recovered solely by a fuel tax then a tax of 15.13 c/l or 100 millimes/l
would be required. Alternatively, a tyre tax of 210% would recover the
costs, assuming in each case no behavioral response to the taxes. The
weighted average figures show the tax levels needed to recover all road use
costs of diesel vehicles, and the tax levels needed to recover the road use
costs of freight transport. The figures in brackets are weighted coeffi-
cients of variation and give a rough measure of the extent to which a uniform
tax should recover the road use costs from each class of vehicle. It is
interesting to observe that purchase taxes do rather well by this criterion
(and can, in any case, be made vehicle specific). Fuel taxes are reasonably
good ways for taxing trucks. The required rates for taxes on tyres or parts
are obviously too high, and they would not be suitable individually as the
TABLE 6: Effect of Vehicle Lifetime on per km Capital Costs

<table>
<thead>
<tr>
<th>Vehicle class</th>
<th>Life time</th>
<th>Capital Cost and Purchase tax/km (index)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Years</td>
<td>at 10% (3)</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>137</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>113</td>
</tr>
</tbody>
</table>

Note: 1. Assumes constant distance driven over life of vehicle.
2. Capital costs per km for average lifetime shown as index of 100.
3. Effects of differing interest rates on capital costs shown in columns (3 and 4).

base for a set of road user charges, and the variability of required tyre taxes is the highest. Nevertheless, at rather low rates of tax they have attractive features for road user charging as will be discussed below.

It is noteworthy that road damage costs amount to only 12 percent of total road use costs, the balance coming from congestion costs. Urban congestion costs alone account for 80 per cent of the total. Even for trucks, road damage costs are only 44 per cent of the total, smaller than urban congestion costs. Of course, it is entirely possible that congestion costs have been greatly exaggerated, both because we have no hard data on urban traffic flows or congestion levels, and because the state of the art in measuring urban congestion is not very advanced. These hypotheses can be examined first by looking at the revenue collected by road use charges and by examining road expenditures in more detail. Road use charges may reveal the Government's view on the appropriate level of charges (and hence costs), whilst road expenditure should be related to congestion costs. Both aspects are examined in the next chapter.
### Table 7: Road Use Cost by Type of Vehicle, Averaged Over Whole Network

<table>
<thead>
<tr>
<th>Vehicle class</th>
<th>Vehicle Type</th>
<th>Road Damage</th>
<th>Congestion</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>USc/veh km</td>
<td>Interurban</td>
<td>Urban</td>
</tr>
<tr>
<td>1G</td>
<td>Car (gas)</td>
<td>.01</td>
<td>.14</td>
<td>1.77</td>
</tr>
<tr>
<td>2D</td>
<td>Car (diesel)</td>
<td>.01</td>
<td>.14</td>
<td>1.77</td>
</tr>
<tr>
<td>2</td>
<td>Utility</td>
<td>.03</td>
<td>.15</td>
<td>1.46</td>
</tr>
<tr>
<td>3</td>
<td>Lt. truck</td>
<td>.12</td>
<td>.21</td>
<td>1.94</td>
</tr>
<tr>
<td>4</td>
<td>Med. truck</td>
<td>.51</td>
<td>.33</td>
<td>0.44</td>
</tr>
<tr>
<td>5a</td>
<td>HS truck</td>
<td>2.18</td>
<td>.39</td>
<td>0.52</td>
</tr>
<tr>
<td>5b</td>
<td>HT truck</td>
<td>4.46</td>
<td>.39</td>
<td>0.52</td>
</tr>
<tr>
<td>6</td>
<td>Articulated</td>
<td>5.64</td>
<td>.41</td>
<td>0.44</td>
</tr>
<tr>
<td>7</td>
<td>Bus</td>
<td>0.45</td>
<td>.28</td>
<td>5.40</td>
</tr>
<tr>
<td>8</td>
<td>Special</td>
<td>0.69</td>
<td>.16</td>
<td>1.64</td>
</tr>
</tbody>
</table>

Weighted average:
- (all vehicles) USc/veh km: 0.26, 0.17, 1.67, 2.10
- (diesel veh.) USc/veh km: 0.37, 0.19, 1.62, 2.18
- (trucks only) USc/veh km: 1.24, 0.29, 1.27, 2.80

Source: Tables 1-4.
### TABLE 8: Road Use Cost Allocation to Inputs of Diesel Vehicles

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Road use cost c/km</th>
<th>Per litre diesel c/l</th>
<th>As % of tyre costs</th>
<th>As % of capital costs</th>
<th>As % of parts cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D</td>
<td>1.92</td>
<td>29.50</td>
<td>640</td>
<td>57</td>
<td>267</td>
</tr>
<tr>
<td>2</td>
<td>1.64</td>
<td>18.22</td>
<td>309</td>
<td>43</td>
<td>171</td>
</tr>
<tr>
<td>3</td>
<td>2.27</td>
<td>15.13</td>
<td>210</td>
<td>37</td>
<td>158</td>
</tr>
<tr>
<td>4</td>
<td>1.28</td>
<td>6.40</td>
<td>51</td>
<td>17</td>
<td>59</td>
</tr>
<tr>
<td>5a</td>
<td>3.09</td>
<td>7.92</td>
<td>82</td>
<td>32</td>
<td>103</td>
</tr>
<tr>
<td>5b</td>
<td>5.37</td>
<td>12.07</td>
<td>106</td>
<td>46</td>
<td>149</td>
</tr>
<tr>
<td>6</td>
<td>6.49</td>
<td>13.33</td>
<td>80</td>
<td>28</td>
<td>135</td>
</tr>
<tr>
<td>7</td>
<td>6.13</td>
<td>17.17</td>
<td>214</td>
<td>31</td>
<td>102</td>
</tr>
<tr>
<td><strong>All diesel vehicles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighted average (weighted CV)</td>
<td>2.16</td>
<td>16.0</td>
<td>193</td>
<td>38</td>
<td>149</td>
</tr>
<tr>
<td><strong>Trucks</strong></td>
<td></td>
<td>(35%)</td>
<td>(71%)</td>
<td>(21%)</td>
<td>(16%)</td>
</tr>
<tr>
<td>Weighted average (weighted CV)</td>
<td>2.80</td>
<td>11.6</td>
<td>107</td>
<td>31</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>(30%)</td>
<td>(54%)</td>
<td>(20%)</td>
<td>(13%)</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Tables 5, 7.

1/ Weighted by VKT excluding special vehicles.

Tax/l fuel = Weighted Avg. RUC/col.(1) of Table 5 etc.

CV - Coefficient of Variation.
The effect of reducing the estimated level of urban congestion cost to one third of the earlier figures is shown in Table 9 below.

**Table 9: Road Use Cost Allocation to Inputs of Diesel (Low Urban Congestion Costs)**

<table>
<thead>
<tr>
<th>Road Use Cost c/km</th>
<th>Of which % Concession Costs</th>
<th>Per Litre of Diesel c/l</th>
<th>As % of Tyre Costs</th>
<th>As % of Capital Costs</th>
<th>As % of Parts Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D Car (diesel)</td>
<td>0.74</td>
<td>99</td>
<td>11.37</td>
<td>264</td>
<td>22</td>
</tr>
<tr>
<td>2 Utility</td>
<td>0.67</td>
<td>97</td>
<td>7.41</td>
<td>126</td>
<td>17</td>
</tr>
<tr>
<td>3 Lt. Truck</td>
<td>0.98</td>
<td>88</td>
<td>6.51</td>
<td>90</td>
<td>16</td>
</tr>
<tr>
<td>4 Med. Truck</td>
<td>0.99</td>
<td>48</td>
<td>4.93</td>
<td>39</td>
<td>13</td>
</tr>
<tr>
<td>5A HS Truck</td>
<td>2.74</td>
<td>20</td>
<td>7.03</td>
<td>73</td>
<td>28</td>
</tr>
<tr>
<td>5B HT Truck</td>
<td>5.02</td>
<td>11</td>
<td>11.29</td>
<td>99</td>
<td>43</td>
</tr>
<tr>
<td>6 Articulated</td>
<td>6.20</td>
<td>9</td>
<td>12.73</td>
<td>76</td>
<td>27</td>
</tr>
<tr>
<td>7 Bus</td>
<td>2.53</td>
<td>82</td>
<td>7.09</td>
<td>88</td>
<td>13</td>
</tr>
<tr>
<td>Average diesel vehicle</td>
<td>1.08</td>
<td>66</td>
<td>8.0</td>
<td>96</td>
<td>19</td>
</tr>
<tr>
<td>(Weighted CV)</td>
<td></td>
<td>(27%)</td>
<td>(42%)</td>
<td>(29%)</td>
<td>(26%)</td>
</tr>
<tr>
<td>Average truck</td>
<td>1.95</td>
<td>36</td>
<td>8.06</td>
<td>75</td>
<td>22</td>
</tr>
<tr>
<td>(Weighted CV)</td>
<td></td>
<td>(34%)</td>
<td>(21%)</td>
<td>(21%)</td>
<td>(15%)</td>
</tr>
</tbody>
</table>

**Source:** Tables 5, 7

**Note:** Road Use Cost = road damage cost + interurban congestion cost + 1/3 urban congestion cost given in Table 7.
Percentage congestion costs are interurban + (low) urban congestion costs as percent of total road use cost.
CV - Coefficient of variation.

This shows that road damage costs now amount to 34 percent of total road use costs for diesel vehicles as a whole, and for trucks, to 64 percent. It is interesting that the same (more moderate) fuel tax would effectively charge trucks and other diesel vehicles equally, and that if anything the variability of these rates across classes of vehicle has fallen, simplifying the task of designing a set of user charges.
Conclusions

Although the damaging power of vehicle measured by ESA vary across vehicles by a factor of 10,000 to 1, with light vehicles having negligible (Table 1) damaging power, and total road damage costs vary by a factor of 600 to 1, (Table 7, Column 3) total road use costs vary by a factor of between 4 and 10 to 1 across vehicles, (Table 7, Column 6) depending on the severity of urban congestion costs (the more severe, the lower the rates). These variations of road use costs across vehicles are comparable to the variation in their consumption of fuel, tyres, parts, and capital (purchase cost), suggesting that taxes on these bases might be quite successful at charging for road use.
Chapter 2: The Present Structure of Transport
Taxes on Diesel Vehicles

by David M. Newbery

The next step is to determine the present structure of road taxes in Tunisia, to see how well they charge road users for road use costs, and whether the general level of road taxes is about right, or will need substantial changes. The examination may also throw light on whether the government considers that urban congestion costs are as high as suggested in Chapter 1. Again, we confine attention to taxes on diesel vehicles, since the taxation of private transport raises separate issues which are discussed later.

1. Fuel Taxes

The price of fuels is set by the government and the various components from the refinery to the pumps are promulgated periodically. Over the recent past the evolution of prices has been as shown in Table 10. The table shows that domestic (pump) prices are kept stable as far as possible, and before the first oil shock were well above cif prices, so that diesel was effectively taxed at a rate of 16 mill/litre or 8c/l at 1982 prices. The increase in world prices in 1973-4 eventually put upward pressure on the domestic price, which was raised in 1977, once more leading to a (small) positive tax on diesel. As Tunisia is an oil exporter, the Treasury benefited from the increase in oil prices, and was therefore under little pressure to maintain old sources of tax revenue. It is possible that they considered it desirable to redistribute some of the oil wealth, and chose kerosene subsidies as a well targeted method of doing so. Column (8) of Table 10 gives the ratio of domestic kerosene to diesel prices (at cif prices kerosene is invariably slightly more expensive than diesel). It shows that from near parity at the start of the decade kerosene has been progressively more heavily subsidized in absolute and proportional terms, and this subsidy may well have constrained the increase in diesel prices.

Nevertheless, history repeated itself with the second oil shock, though this time the government increased domestic prices more quickly and has gone some way to reducing the implicit subsidy, again constrained by the now larger kerosene subsidy.

How, then, is one to interpret the government’s intended tax on diesel? Does one take the explicitly identified taxes (excluding the tax à la production, which, as a value added tax, does not fall on transport but on final consumers)? If so, then one could argue that by 1982 the government considered the right tax to be about 6c/litre. Support for this interpretation can be found from the 1970 effective (implicit) tax rate, though that rate may have reflected the government’s greater need for revenue then compared with 1982. It is worth noting that with forecast declines in oil production and exports, not to mention the fall in oil prices in 1986, Tunisia’s revenue needs are now increasing rapidly.
### TABLE 10: Evolution of Diesel Price in Tunisia

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Domestic Price at Pump</th>
<th>Handling</th>
<th>'Wholesale' Price</th>
<th>Cif Price</th>
<th>Implicit Tax</th>
<th>Explicit Tax</th>
<th>Kerosene Price as % of Diesel Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incl. VAT (1)</td>
<td>Excl. VAT (2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td>1970</td>
<td>37</td>
<td>35</td>
<td>6</td>
<td>29</td>
<td>13.1</td>
<td>15.9</td>
<td>92</td>
</tr>
<tr>
<td>71</td>
<td>37</td>
<td>35</td>
<td>6</td>
<td>29</td>
<td>13.1</td>
<td>15.9</td>
<td>92</td>
</tr>
<tr>
<td>72</td>
<td>45</td>
<td>42</td>
<td>7</td>
<td>35</td>
<td>23.7</td>
<td>11.3</td>
<td>80</td>
</tr>
<tr>
<td>73</td>
<td>45</td>
<td>42</td>
<td>7</td>
<td>35</td>
<td>36.7</td>
<td>-1.7</td>
<td>80</td>
</tr>
<tr>
<td>74</td>
<td>45</td>
<td>42</td>
<td>7</td>
<td>35</td>
<td>35.5</td>
<td>-0.5</td>
<td>80</td>
</tr>
<tr>
<td>75</td>
<td>45</td>
<td>42</td>
<td>7</td>
<td>35</td>
<td>39.7</td>
<td>-4.7</td>
<td>80</td>
</tr>
<tr>
<td>76</td>
<td>60</td>
<td>57</td>
<td>9</td>
<td>48</td>
<td>44.7</td>
<td>3.7</td>
<td>67</td>
</tr>
<tr>
<td>77</td>
<td>60</td>
<td>57</td>
<td>9</td>
<td>48</td>
<td>48.5</td>
<td>-0.5</td>
<td>67</td>
</tr>
<tr>
<td>78</td>
<td>66</td>
<td>63</td>
<td>10</td>
<td>53</td>
<td>114.8</td>
<td>-61.8</td>
<td>68</td>
</tr>
<tr>
<td>79</td>
<td>75</td>
<td>72</td>
<td>11</td>
<td>61</td>
<td>107.5</td>
<td>-46.5</td>
<td>29</td>
</tr>
<tr>
<td>80</td>
<td>100</td>
<td>97</td>
<td>13</td>
<td>84</td>
<td>126.6</td>
<td>-42.6</td>
<td>43</td>
</tr>
<tr>
<td>81</td>
<td>125</td>
<td>122</td>
<td>16</td>
<td>106</td>
<td>149.3</td>
<td>-43.3</td>
<td>45</td>
</tr>
<tr>
<td>82</td>
<td>145</td>
<td>142</td>
<td>16</td>
<td>126</td>
<td>143.6</td>
<td>-17.6</td>
<td>45</td>
</tr>
<tr>
<td>83</td>
<td>160</td>
<td>157</td>
<td>17</td>
<td>140</td>
<td>106.1</td>
<td>-47.5</td>
<td>46</td>
</tr>
<tr>
<td>84</td>
<td>180</td>
<td>177</td>
<td>17</td>
<td>160</td>
<td>106.1</td>
<td>-47.5</td>
<td>47</td>
</tr>
<tr>
<td>85</td>
<td>230</td>
<td>227</td>
<td>18</td>
<td>209</td>
<td>23.4</td>
<td>63</td>
<td>47</td>
</tr>
</tbody>
</table>

**Source:** Price regulations, Government of Tunisia.

**Notes:**
1. mid year value
2. tax a la production, a value added tax
3. is pump price, less VAT and handling, comparable to cif price
4. cif price calculated from world price and freight rates, average for year
5. wholesale price less cif price
6. taxes defined in price regulations.
7. 1000 millimes = 1DT = US$1.5 (1983)

Alternatively, does one take the 1977 figure of an implicit tax rate of 4 millimes/litre (equivalent to about 0.7 1982c/litre) as the equilibrium intended tax rate? Or might even this reflect a failure to fully adjust after the 1974 oil shock, so that the intended tax rate should be higher? Or does one take the 1982 implicit tax of -44 millimes/litre or -7.5c/l? Since any of these positions could be defended, we shall examine the consequences of two extremes -- a tax of 6c/l and a subsidy of 6c/l.
(which is closer to the 1983 position than that of 1982). Moreover, with the fall in world oil prices in 1986, the Tunisian government has the opportunity of not lowering the domestic price and restoring the earlier, positive tax levels.

2. Tyre Taxes

The non-value-added tax component on tyres is the set of import duties (and their close relatives under the taxe de compensation), and currently amounts to 38 per cent, which, in view of safety problems, is arguably rather high. As will be discussed below, apart from safety problems, tyre taxes are rather well suited to recover road use costs as they vary with distance and the road damaging power of the vehicle (across broad classes of vehicles). Table 11 shows that on their own, tyre taxes recover between 18 and 75 per cent of road use costs for trucks, and the weighted average for all trucks (class 3-6) is 31%. If urban congestion costs are lower, as shown in Column 3, then tyre taxes do relatively better.

Do the tyre taxes successfully offset the fuel subsidies (taken as 6c/l)? Column 4 of Table 11 gives the tyre tax plus the (negative) fuel tax, and shows that except for articulated lorries the answer is, no. On the other hand, there is clearly a limit to the desirable extent of tyre taxation which may well have been reached at 38%, and one must therefore look to the other taxes which vary less with distance.

3. Vehicle Purchase Taxes

Taxes on the acquisition of vehicles consist of import duties, production taxes ('taxe à la production') and consumption taxes ('taxe à la consommation'). The last two types of tax are value added taxes and hence are part of the system of taxing final consumption. They cannot therefore be included among those taxes intended for road user charging, which leaves the customs duties as the only remaining purchase tax. The rates are given in Table 12, together with estimates of actual taxes paid from Paterson (1985). The average import duty on all goods imported in 1979 and 1980 was about 20 per cent, but since Tunisia imported significant quantities of grain which were subsequently sold at subsidized prices, the average duty on all taxable goods was presumably higher (though not necessarily on intermediate goods).

The case for so doing is strengthened by noting that vehicles constructed in Tunisia are only subject to the two value added taxes, and not to any purchase tax. It might therefore be argued that the import duties are intended to raise the import price level to the right level relative to domestic production costs, which are in turn above their accounting prices. It must be said that this argument is not completely satisfactory for tariffs are a second-best solution to the problem of distorted domestic prices, but one could reasonably argue that the effective purchase taxes are somewhat below those shown in Table 12, perhaps as much as 13 per cent lower, making the effective rates zero for heavy trucks. The figures adopted are shown in the final column, and are the lower of the observed rate and the nominal duty rates.
TABLE 11: Tyre Taxes on Diesel Vehicles

<table>
<thead>
<tr>
<th>Vehicle class</th>
<th>Tyre Tax as % of RUC Costs</th>
<th>Tyre Tax + Fuel Subsidy (6c/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tyre Tax</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c/km</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>1D</td>
<td>0.11</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>0.20</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>0.41</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>0.96</td>
<td>75</td>
</tr>
<tr>
<td>5a</td>
<td>1.43</td>
<td>46</td>
</tr>
<tr>
<td>5b</td>
<td>1.92</td>
<td>36</td>
</tr>
<tr>
<td>6</td>
<td>3.08</td>
<td>47</td>
</tr>
<tr>
<td>7</td>
<td>1.09</td>
<td>18</td>
</tr>
</tbody>
</table>

Notes:
(2) Tyre tax as percentage of road use cost, standard case.
(3) Tyre tax, low urban congestion case (Ch.1, Table 9).
(4) Tyre tax plus fuel subsidy of 6c/l, as tax per km.
Negative values indicate subsidies.

Should one therefore only consider the excess duty above the average on inputs as constituting the relevant charge?

TABLE 12: Import Duties on Vehicles

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Customs Duties Rate</th>
<th>Figures from Paterson</th>
<th>Adopted Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200 (average)</td>
<td>157</td>
<td>157</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>5a</td>
<td>20</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>5b</td>
<td>13</td>
<td>24</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>13</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>32</td>
<td>22</td>
<td>32</td>
</tr>
</tbody>
</table>

Source: Bulletin International des Douanes, Ch. 87.
Paterson (1985, Table 2.8, p. 71).
### TABLE 13: Annual fees for vehicles, 1984

<table>
<thead>
<tr>
<th>Vehicle class</th>
<th>Capacity</th>
<th>Fee DT p.a. per veh.</th>
<th>Treasury fee $p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D</td>
<td>Taxi plying in 3 main Gouvernorats elsewhere</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>60</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>0.75 t payload farmer OA</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>non farmer OA</td>
<td>61</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>2 t payload farmer OA</td>
<td>86</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>non farmer OA H</td>
<td>162</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>144</td>
<td>130</td>
</tr>
<tr>
<td>4</td>
<td>5 t payload OA H</td>
<td>540</td>
<td>486</td>
</tr>
<tr>
<td></td>
<td>360</td>
<td>324</td>
<td></td>
</tr>
<tr>
<td>5a</td>
<td>12 t payload OA H</td>
<td>1296</td>
<td>1166</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>864</td>
<td>778</td>
</tr>
<tr>
<td>5b</td>
<td>15 t payload OA H</td>
<td>1620</td>
<td>1458</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>1080</td>
<td>972</td>
</tr>
<tr>
<td>6</td>
<td>25 t payload H</td>
<td>1800</td>
<td>1620</td>
</tr>
<tr>
<td>7</td>
<td>48 seater bus urban</td>
<td>922</td>
<td>830</td>
</tr>
<tr>
<td></td>
<td>non urban</td>
<td>2304</td>
<td>2074</td>
</tr>
<tr>
<td></td>
<td>Average non urban bus</td>
<td>3338</td>
<td>3004</td>
</tr>
</tbody>
</table>

**Notes:**
- OA: Own Account
- H: For Hire

4. **Taxes on Parts**

The figures given in Paterson (1985) suggest a rate of tax on parts (which includes labour) of 20%, and in the absence of more details about their taxation this figure is used in Table 14 below. At this rate of tax only a fraction of road user costs will be recovered by the tax on parts.
**TABLE 14: "1982" Structure of Road User Charges on Diesel Vehicles in Tunisia**

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>c/km</th>
<th>Road User Charge as % of Total Road Use Cost with Fuel 1/ subsidy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Road Use Cost (2)</td>
</tr>
<tr>
<td>1D Car</td>
<td>1.92</td>
<td>-0.39</td>
</tr>
<tr>
<td>2 Utility</td>
<td>1.64</td>
<td>-0.54</td>
</tr>
<tr>
<td>3 L. truck</td>
<td>2.27</td>
<td>-0.90</td>
</tr>
<tr>
<td>4. M. &quot;n&quot;</td>
<td>1.28</td>
<td>-1.20</td>
</tr>
<tr>
<td>5a HS. &quot;n&quot;</td>
<td>3.09</td>
<td>-2.34</td>
</tr>
<tr>
<td>5b HT. &quot;n&quot;</td>
<td>5.37</td>
<td>-2.67</td>
</tr>
<tr>
<td>6 Articul.</td>
<td>6.49</td>
<td>-2.92</td>
</tr>
<tr>
<td>7 Bus</td>
<td>6.13</td>
<td>-2.14</td>
</tr>
</tbody>
</table>

**Source:** Ch.1, Tables 5,7; Ch.2, Tables 11,12,13

**Notes:**

1/ Fuel subsidy of 6c/l assumed

2/ Licence fees at 1984 rates (slightly higher than in 1982)

3/ Alternative fuel tax of 6c/l added.

5. **Annual taxes**

Only private cars pay an annual license fee ('vignette') at rates between DT 30 for cars of less than 4cv to DT1000 for those of more than 16 cv. Other vehicles pay a monthly fee ('compensation') 60 per cent of which goes to the Treasury, 40 per cent to the Caisse de Compensation et de Societes des Transports Routiers. Before 1984 the fees for own account vehicles were somewhat below those for hire, but this was reversed in January 1984. The annualized values of these 1984 fees are given in Table 13 together with the Treasury's fraction, which might be argued to correspond to the licence fee element. The fees are assessed per ton nominal payload or per seat, at standard rates within various categories.

Table 14 compares the road use costs with the road user charges in "1982" (which includes the license fees at the rates in force in 1984), first on the assumption that the fuel subsidy of 6c/l was indeed intended, and then in the final column, on the alternative assumption that a fuel tax of 6c/l was the intended rate.
The net effect of the actual 1982 taxes (including the fuel subsidy) was to slightly overcharge diesel vehicles as a whole, and to slightly undertax freight vehicles. Passenger transport (diesel cars, mostly taxis, and buses) are heavily taxed, as is quite logical, but utilities (many of which are probably purchased instead of cars for passengers transport) are undertaxed. It is not clear that the tax structure would have been improved by replacing the fuel subsidy of 6c by a tax of 6c without lowering other changes such as the license fees, as the effect of the extra fuel tax would be to considerably overcharge all vehicles except utilities.

6. Conclusions on the System of Road Charging in Tunisia

It appears that, apart from utilities, most diesel vehicles are charged at least as much as their road use costs, though the way in which this charge has been levied has varied quite significantly over the past decade. Initially, most of the charge was distance related (fuel and tyre taxes) rather than access related (annual fees). When world oil prices increased various considerations argued against increasing domestic diesel and kerosene prices in line with world prices, and so fuel taxes were replaced by fuel subsidies. To offset this, annual access fees were charged, and the cumulative effect of the fuel subsidy, the tyre tax, vehicle purchase taxes, and license fees has been once more to restore road charges more or less to the level of road use costs, as shown in column (9) of Table 14.

Whilst the level of taxes in "1982" appeared to have been about right, it is less clear that the structure was ideal. The next chapter discusses the general principle of designing a set of road user charges for diesel vehicles, bearing in mind the effects different taxes are likely to have.
It is instructive to approach the design of road user charges in three steps. First, how would the charges appear if their imposition caused no change in behaviour? This is the simplest calculation, but since the aim is in fact to alter behaviour, and to make road users respond to the costs they incur, it is obviously unsatisfactory to stop at this first stage. The second level of sophistication is to ask how to modify the original structure to allow for responses, and to induce optimal responses. The last step takes account of the substitutability between diesel as a transport fuel and other fuel uses in the economy.

It seems sensible to start with the design of road user charges for trucks, since passenger vehicles raise somewhat different issues. Table 15 shows the effect of uniform road user charges on different inputs (purchase taxes and licence fees can be varied across vehicles with little difficulty). It shows that light trucks (which are assumed to cause considerable urban congestion) would be under-charged relative to medium and heavy single trucks. However, these costs are based on observed average levels of loading, and it is instructive to examine the effect of overloading on the relation between road use costs and the uniform charges that would, on average, just cover road use cost attributable to trucks. This is done in Table 16. Finally, Table 18 gives the road use cost (RUC) per ton km for each class of truck, both normally loaded and overloaded, for the base case and for the case of lower urban congestion costs.

If the level of road use charges on trucks is first set at the correct level (as appeared to be the case for 1982), then Table 15 shows the extent to which different types of charge will tend to encourage the use of certain categories of trucks compared to others. Table 18 shows that there is little difference in RUC/tonne-km for normally laden trucks, except for light trucks (again, because of their assumed contribution to congestion). Even overloaded trucks have fairly uniform RUC/tonne-km, roughly twice as high as normally loaded trucks. On the face of it, then, there is little merit in attempting to switch freight between averagely laden trucks, and the tax system should ideally be designed to be neutral between classes of vehicles, and to provide as far as possible the right incentives to avoid overloading or inappropriate utilization. Tables 15 and 16 show that taxes on different inputs have a slightly different impact on different vehicles, so that combining them is likely to improve the match between charges and costs. All three input taxes do a reasonable job, which can be more finely adjusted by purchase taxes and annual license fees. It remains to explore the extent to which different taxes encourage overloading and/or inefficient normal utilization. The regulatory environment is almost certainly more important than the tax system for both these decisions, but one can still ask what potentially distortionary effects different methods of charging might have.
### TABLE 15: Amount by which Road Use Costs Exceed Uniform Road Use Charges for Trucks (+/km)

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>VKT mkm</th>
<th>VKT %</th>
<th>Road Use Cost (c/km) (1)</th>
<th>Excess of Road Use Cost over Uniform Tax on</th>
<th>Uniform Tax on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fuel (11.60/1) (5)</td>
<td>Tyres (107%) (6)</td>
</tr>
<tr>
<td>3 L. truck</td>
<td>659</td>
<td>54.3</td>
<td>2.27</td>
<td>0.56</td>
<td>1.13</td>
</tr>
<tr>
<td>4 M. &quot;</td>
<td>177</td>
<td>14.6</td>
<td>1.28</td>
<td>-1.0</td>
<td>-1.39</td>
</tr>
<tr>
<td>5a HS &quot;</td>
<td>224</td>
<td>18.5</td>
<td>3.09</td>
<td>-1.36</td>
<td>-0.89</td>
</tr>
<tr>
<td>5b HT &quot;</td>
<td>13</td>
<td>1.1</td>
<td>5.37</td>
<td>0.3</td>
<td>0.02</td>
</tr>
<tr>
<td>6 Articul.</td>
<td>140</td>
<td>11.5</td>
<td>6.49</td>
<td>0.94</td>
<td>-2.11</td>
</tr>
<tr>
<td>Total or Average</td>
<td>1213</td>
<td>100</td>
<td>2.80</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Sources: Col. 4, from Table 7  
Col. 5, from Table 5  
Note: Negative numbers indicate that vehicle is overtaxed.

### TABLE 16: Effect of Overloading on Relation Between Road Use Costs and Road User Charges

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Av.max ESA (1)</th>
<th>Excess Road Use Consumpt. (c/km) (2)</th>
<th>Fuel Tax (c/km) (5)</th>
<th>Tyre Tax (c/km) (6)</th>
<th>Parts Tax (c/km) (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 L. truck</td>
<td>0.25</td>
<td>0.2</td>
<td>.64</td>
<td>1.33</td>
<td>0.67</td>
</tr>
<tr>
<td>4 M. &quot;</td>
<td>2.7</td>
<td>2.2</td>
<td>.68</td>
<td>0.81</td>
<td>0.78</td>
</tr>
<tr>
<td>5a HS &quot;</td>
<td>7.4</td>
<td>5.9</td>
<td>5.0</td>
<td>5.01</td>
<td>5.24</td>
</tr>
<tr>
<td>5b HT &quot;</td>
<td>12.5</td>
<td>10.0</td>
<td>8.34</td>
<td>10.02</td>
<td>10.87</td>
</tr>
<tr>
<td>6 Articul.</td>
<td>28.1</td>
<td>22.5</td>
<td>22.2</td>
<td>20.39</td>
<td>23.00</td>
</tr>
</tbody>
</table>

Sources: Vehicle loading characteristics and fuel consumption for different loadings from Paterson (1985), Tables 1.12 and 2.17.  
Col. 3 = Col. 2 x cost per ESA = 0.8+ from Table 2.  
Col. 5: Col. 3 + RUC from Col. 4, Table 15 less (fuel tax 11.6+) x (Col. 4).  
Col. 6: Col. 6, Table 15 + Col. 3.  
Col. 7: Col. 7, Table 15 + Col. 3.  
Notes: Vehicles are assumed to be loaded to maximum observed load for one half of trip, empty for return. Tyre cost and parts consumption are assumed to be invariant to overloading. Tax rates as in Table 15.
### Table 17: Annual Distance and Tonne-km of Trucks in Tunisia 1982

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Average Payload /km(^1)/tonne</th>
<th>Tonne-km</th>
<th>% of t-km</th>
<th>Overloaded Vehicle Average Payload tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 L. truck</td>
<td>1.05</td>
<td>691</td>
<td>17.6</td>
<td>1.6</td>
</tr>
<tr>
<td>4 M. &quot;</td>
<td>2.47</td>
<td>437</td>
<td>11.1</td>
<td>5.25</td>
</tr>
<tr>
<td>5a HS &quot;</td>
<td>4.73</td>
<td>1060</td>
<td>27.0</td>
<td>7.0</td>
</tr>
<tr>
<td>5b HT &quot;</td>
<td>7.62</td>
<td>99</td>
<td>2.5</td>
<td>10.9</td>
</tr>
<tr>
<td>6 Articul.</td>
<td>11.67</td>
<td>1634</td>
<td>41.67</td>
<td>20.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.23</strong></td>
<td><strong>3921</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Paterson (1985), Tables 1.9, 1.12

**Note:** 1/ Average Payload assumes 52.6% loading.

### Table 18: Road Use Cost per Tonne-km

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Road Use Cost per ton-km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Congestion Cost</td>
</tr>
<tr>
<td></td>
<td>Payload</td>
</tr>
<tr>
<td>(1)</td>
<td>Normal (2)</td>
</tr>
<tr>
<td>3</td>
<td>2.16 (0.73)</td>
</tr>
<tr>
<td>3 (interurban)</td>
<td>0.52 (0.66)</td>
</tr>
<tr>
<td>5a</td>
<td>0.65 (0.70)</td>
</tr>
<tr>
<td>6</td>
<td>0.56 (1.69)</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>0.86</strong> (0.60)</td>
</tr>
</tbody>
</table>

**Source:** Tables 16, 17

1/ (3 interurban) gives RUC less the excess level of urban congestion cost, and is a measure of RUC attributable to the choice of vehicle for given freight haulage, ignoring its relation and advantages for urban use.
1. Fuel Taxes

Distance related charges like fuel taxes will tend to discourage utilization compared to license fees and purchase taxes. To the extent that fuel and tyre taxes undercharge per km they will provide incentives for greater than optimal annual utilization, though the effect may be slight. Fuel consumption increases with load, as does wear and tear. Fuel taxes and purchase taxes thus discourage overloading, though the discouragement is slight. Table 19 shows that fuel consumption per tonne-km decreases with gross vehicle mass for laden vehicles, and so fuel taxes tend to (slightly) encourage freight movement in larger vehicles. For average rates of loading, Table 18 shows that this form of substitution results in a (very) slight reduction in road use cost per tonne-km (from 0.65c/tonne-km on interurban roads for classes 3 and 4 together to 0.60c/tonne-km for classes 5 and 6 together: as appears when the weights in Table 17, Column 4 are applied to the figures in Table 18, Column 2). If payloads are distributed randomly about the mean, so that some are higher than average, some lower, then the average road use cost per tonne-km will tend to increase with vehicle capacity, and fuel taxes will induce a (slightly) adverse shift. The shift to larger vehicles will also (slightly) reduce the road charge collected per tonne-km or per unit of damage done. However, provided overloading is not a serious problem, these distortion effects are very small.

2. Tyre Taxes

Like fuel taxes, tyre taxes tend to discourage utilization relative to licence fees and vehicle purchase taxes. Tyre costs increase with vehicle size, and tend to fall with load (across vehicle classes) rather less than fuel costs (Table 19). Tyre taxes thus tend to encourage the use of heavier

**Table 19: Fuel and Tyre Consumption per Tonne km**

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Max Observed Degree of Overloading (%)</th>
<th>Fuel consumption Average (c/t-km)</th>
<th>Overladen (c/t-km)</th>
<th>Tyre cost (c/t-km) Average</th>
<th>Overladen</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 L. truck</td>
<td>60</td>
<td>0.14</td>
<td>0.10</td>
<td>1.0</td>
<td>0.60</td>
</tr>
<tr>
<td>4 M.</td>
<td>123</td>
<td>0.08</td>
<td>0.05</td>
<td>1.0</td>
<td>0.45</td>
</tr>
<tr>
<td>5a HS</td>
<td>56</td>
<td>0.08</td>
<td>0.05</td>
<td>0.8</td>
<td>0.51</td>
</tr>
<tr>
<td>5b HT</td>
<td>50</td>
<td>0.06</td>
<td>0.04</td>
<td>0.67</td>
<td>0.45</td>
</tr>
<tr>
<td>6 Articul.</td>
<td>82</td>
<td>0.04</td>
<td>0.03</td>
<td>0.7</td>
<td>0.38</td>
</tr>
</tbody>
</table>

*Note: 1/ assumes no increased tyre wear with overloading.*
vehicles less than fuel taxes. Presumably tyre consumption increases with load for a given vehicle, though probably not as fast as fuel taxes, so though not encouraging overloading as much as overhead charges (license fees, purchase taxes), tyre taxes are probably slightly inferior to fuel taxes on this score.

The main objection to tyre taxes is that they encourage excessive use and retreading with adverse safety consequences. The second main objection is that holding payload constant, increasing the number of tyres reduces the load per equivalent axle, and hence reduces road damage costs. Of course, if it were desirable to tax tyres for other reasons, then this effect could be offset by making the license fee a function of the number of axles and tyres. Provided one can tax fuel there are no very compelling reasons to tax tyres, and some rather strong arguments against doing so. It therefore seems simpler to accept that tyre taxes should be low (relative to alternatives, in this case other taxes on vehicle use and the cost of retreading).

If, as seems to be the case in Tunisia, tyre taxes are fairly high (the import duties are 38 per cent) then it would seem desirable to see if tyres are excessively worn and retreaded. If so, then there may be a case for reducing tyre taxes and increasing inspection and infringement penalties.

3. Taxes on parts

Taxes on spare parts of 125 per cent would equal average road use costs (as shown in Table 15). At this rate the tax would overcharge medium and heavy lorries and undercharge everything else, as column (7) of Table 15 shows. Since the consumption of parts is remarkably close to fuel consumption, this suggests that if fuel taxes are constrained by their effects elsewhere, then their effect may be achieved to some extent by parts taxation.

The limitation of taxes on parts is that they will encourage the inefficient substitution of maintenance labour for parts, repair for replacement, and the cannibalization of scrapped vehicles. Given the small tax base and the ease with which these undesirable consequences could occur, only a small fraction (perhaps 20 per cent) of road use costs might reasonably be recovered by taxes on parts.

4. Vehicle Distance Charges and Taxes on Vehicle Services

If tyre taxes are unsatisfactory for safety and other reasons, parts taxes have too small a base, and if fuel taxes may have undesirable consequences elsewhere, then why not tax distance directly, by, for example, making the annual license fee depend on last year's recorded distance travelled? New Zealand has an even more complex system of charging in which the charge is related not just to distance, but effectively to ESA₆ km (Starkie, 1984). The system requires vehicle owners to purchase licenses to carry not more than agreed loads for a specified number of km. Licenses are displayed and subject to check. Enforcement costs are 4 per cent of revenue, but evasion is perceived to be high and is a major problem. Obviously odometers can be tampered with in various ways, though this is almost unheard of in the UK where more sophisticated tachometers are used. Whether these meters would
be cost effective is not yet clear, and cannot be considered in isolation from a review of the whole system of truck regulation. Several states in the US now operate ton-mile taxes which are enforced by auditing the books of the haulage companies. Again, this presupposes a high degree of tax compliance and a predominance of organized trucking, neither of which may be realistic in developing countries.

Another attractive alternative is a tax on vehicle services, since the road use cost is roughly proportional to ton-km (Table 18), and haulage charges are also roughly proportional to ton-km. Indeed to the extent that haulage charges per ton-km decrease with length of haul, the effect of a uniform tax rate on the charge would be to capture some of the urban congestion costs caused by urban use. Tunisia already has a tax on public haulage services (the taxe à la production), but as a VAT it is rebateable, and hence is not a road user charge, but a tax on final consumption. If the tax were replaced by a non-rebateable tax, then the main problem could be that own-account haulage would be exempt. This could be addressed preferably by a distance charge on the tachometers reading or, less satisfactorily, as at present by a differential license fee on own account haulage. The main drawback with any tax which discriminates between own-account and professional haulage is that it complicated the process of deregulation.

5. Vehicle Purchase Taxes

Vehicle purchase taxes (import duties, excluding value-added taxes) on trucks vary from 13 to 28 per cent (Table 20). On their own, these rates undertax freight vehicles. Uniform tax rates would tend to encourage the use of heavier vehicles with neutral to slightly adverse effects on road use costs per tonne km, and therefore (slightly) adverse effects on the adequacy of road taxes collected.

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>RUC c/km</th>
<th>Current purchase tax c/km</th>
<th>Current purchase tax %</th>
<th>Road use cost as % of capital cost per km</th>
<th>Capital costs c/per ton-km</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.27</td>
<td>1.71</td>
<td>28</td>
<td>37</td>
<td>5.8</td>
</tr>
<tr>
<td>4</td>
<td>1.28</td>
<td>1.56</td>
<td>20</td>
<td>17</td>
<td>3.0</td>
</tr>
<tr>
<td>5a</td>
<td>3.09</td>
<td>2.02</td>
<td>20</td>
<td>32</td>
<td>2.0</td>
</tr>
<tr>
<td>5b</td>
<td>5.37</td>
<td>1.56</td>
<td>13</td>
<td>46</td>
<td>1.52</td>
</tr>
<tr>
<td>6</td>
<td>6.49</td>
<td>3.14</td>
<td>13</td>
<td>28</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note: Capital cost, excluding taxes, for diesel vehicles (Table 5).
The great advantage of vehicle purchase taxes is that, like license fees, they can be made vehicle specific, to encourage the right choice of vehicle for the prevailing conditions. There is also evidence that excessive overloading reduces vehicle lifetime, perhaps substantially, greatly increasing the case for purchase taxes to discourage overloading. Their main drawback is that they increase the difficulty of financing road transport, as they require the future road charges to be capitalized and paid in advance. If the social rate of return of investment by the truck buyer is higher than that in the public sector this forced loan will involve an additional loss. This problem could be offset by offering hire purchase facilities to truck buyers (or loans hypothecated on the vehicle).

The other drawback of purchase taxes is that they encourage excessive durability and maintenance, and reduce the flexibility of the vehicle stock to changes in fuel prices, and technical innovations. Since license fees have the opposite effect, penalizing older, less heavily weighted vehicles relatively more, they are a useful adjunct to purchase taxes.

To the extent that vehicles age as a function of distance travelled rather than lapsed time -- an especially reasonable assumption in a hot, dry climate -- the impact of purchase tax on transport cost will vary with (cumulative) distance travelled. Vehicles utilized less intensively last longer, and the purchase tax will be spread over more years. Whereas doubling annual utilization halves the license fee per km, it has much less effect on the capital cost or purchase tax per km (as Table 6 showed). High purchase taxes will therefore tend to increase the distance driven before the vehicle is scrapped, as can readily be seen by looking at the distance driven by older vehicles still in use in countries with high purchase taxes. Annual license fees will have the opposite effect, so that it is in principle possible to offset this adverse aspect of the purchase tax by increasing the license fees. In the absence of good empirical evidence on the effects of purchase taxes on vehicle lives, the best we can do is model the vehicle owners choice between increased maintenance to prolong vehicle life and replacements. This is done in Newbery (1985b) with the following rough estimate for a Class 4 medium truck:

For each 1 percent increase in the percentage rate of purchase tax the annual license fee must be increased by $250 to offset the increased maintenance costs.

Each lc/veh km distance charge (via fuel taxes or tyre taxes) reduces the economic vehicle lifetime distance by 3000 km or less than 1 percent, and can be offset by an increase in the purchase tax by 1.2 percent, or by an increase in the license fee of $300, or some suitable mix of the two.

These estimates should, however, be treated with caution. They rest on a very specific model of vehicle choice which has yet to be empirically validated. They suggest that it may be rather difficult to offset the effect of purchase taxes on longevity, except with fuel and tyre taxes.
One final set of problems should be noted. First, any variations in vehicle purchase tax rates will lead to unexpected capital gains or losses for the current vehicle owners. In principle, variation in purchase taxes should translate immediately into variations in the opportunity cost of using a vehicle of any age, for variations in the tax-inclusive new price will affect second hand values. On the one hand this is desirable if it is intended to adjust purchase taxes in order to reflect road use cost, but on the other hand frequent changes in the tax rates will increase risk and hence needlessly raise operating costs.

So far everything has been based on the assumption that vehicle owners take account of capital costs when making use decisions. To the extent that haulage tariffs will reflect average cost this seems reasonable. But for own account operation vehicle owners are more likely to treat depreciation as an overhead, in which case their short-run decisions may be insensitive to the tax rate, and they will tend to overuse vehicles. The great advantage of fuel taxes (and, to a lesser extent, tyre taxes) is that they are immediately perceived as additions to operating costs.

6. **License fees**

These have the great merit of being finely adjustable to vehicle characteristics, without the financial disadvantage of the purchase tax. They appear to have a small effect on vehicle maintenance and durability (see Newbery, 1985b) tending to reduce economic lifetime slightly. They discriminate more heavily than purchase taxes against owners with low annual utilization rates, and to that extent discourage own account operation, and encourage the use of smaller vehicles which can be more fully utilized. Although this does not reduce road use costs it tends to increase road use charges per tonne-km, and it is a useful offset to the contrary effects of distance charges. They can also be tailored to encourage the correct number of axles to reduce the damaging power of vehicles for a given payload.

7. **Conclusions**

The most striking feature of the structure of road use cost for freight vehicles, per ton-km, is that it is fairly uniform across different categories of truck. A tax per ton-km, or equivalently, a tax on transport services, would therefore seem to be an ideal method of charging for the road use costs of freight transport where that is feasible. It is, however, unlikely that a ton-km tax would be feasible, whilst a tax on transport services would be hard to collect except from professional hauliers. Own account hauliers might be taxed on a different base as suggested in the chapter, but if the intention is to encourage (or not discourage) the deregulation of freight transport, then differential taxes are undesirable or they may create interests in favour of maintaining or even tightening the structure of regulation.

Fuel taxes emerge as the next most attractive method of levying road user charges. They well reflect distance driven, and to some extent, the extra costs of overloading. Their main drawback is that they would also fall on the relatively large consumption of diesel (and kerosene) outside the transport sector.
Tyre taxes share the attractive features of fuel taxes and, unlike fuel taxes, fall only on the transport sector. But if they are set at too high a rate they will induce unsafe utilization. Taxes on parts are similar in terms of sectoral incidence and of potential adverse side-effects, but if set at a modest rate (with similar taxes on tyres) will provide a useful component of the structure of road user charges.

Vehicle purchase taxes can be tailored to the specific vehicle and are quite a good way of charging for utilization of the road system, so long as vehicle operators realize that the costs are largely distance related (and commercial operators presumably would reflect such costs in charges). Purchase taxes and fuel taxes have opposite effects on vehicle lifetime, as do purchase taxes and license fees, so that it should be possible to design a set of charges with a roughly neutral effect on vehicle lives.

Finally, the balance can be collected by license fees, which can also be used to encourage the best type and configuration of vehicle. Road damage decreases with the number of axles for a given payload. Vehicle operating costs, however, increase with the number of tyres. The license fee offers a potentially very useful offset to this effect on costs, and could encourage vehicles operators to choose configurations with the least social cost per ton-km.
Chapter 4: Freight Transport Taxation as Part of General Taxation

by David M. Newbery

1. Introduction

In chapter 1 the main objective was to measure the road use cost of various vehicles in Tunisia. In chapter 2 the road use costs were compared with the existing structure of road user charges. Chapter 3 was concerned with possible ways of charging for these costs. The ideal set of road user charges would confront each road user with the marginal social cost of road use, and would have no impact elsewhere on the economy. Some instruments available—license fees are a good example—fall only on specific vehicles and not elsewhere, but they fail to confront road users with the social costs of an additional trip. Other instruments, such as fuel taxes, are better suited to charging for road use, but fall on non-transport users as well. Since diesel is used elsewhere in the economy, and its price may affect the use of kerosene, it is no longer possible to neatly separate the road charging and tax aspect of diesel taxes.

This chapter has two related objectives. The first is to examine the case for additional taxation of freight transport over and above the level of road user charges. The second is to examine the wider repercussions of various road taxes (especially fuel taxes) on the rest of the economy. This analysis is continued in greater detail in the next chapter. We begin with the first question, which raises wide issues, and observe that there are two quite different arguments for such taxation.

The first argument claims that road use costs as defined in Chapter 1 are effectively short run marginal social costs (properly, the excess of these over private costs), and may fail to cover the average costs of the road network. If so, the argument goes, since road users benefit from the total costs of the road network, they should pay, not the marginal, but the average cost. This argument is examined briefly below.

The second argument is that the government must raise revenue by taxation, and freight transport is a legitimate base for general taxation. What guidance is given by the modern theory of public finance (as set out, for example in Newbery and Stern 1987, or Atkinson and Stiglitz 1980)? The answer depends sensitively on what tax tools are assumed to be available. At one extreme if the government can tax all transactions and is prepared to adjust all taxes to consistently pursue an objective of maximising social welfare, and if all pure profits are completely taxed away (or, equivalently, if there are no pure profits because competition and constant returns have eliminated them) then the optimal tax on intermediate goods is zero (Diamond and Mirrlees 1971). Since freight transport services are intermediate goods
they should not be subject to any pure taxation, and so the only taxes on freight transport should be road user charges set equal to road use costs.

Even under these stringent assumptions, it will in general be desirable to tax private car use and passenger transport. Only on the strong assumption that taxing car use does not add any additional redistributive leverage to the income tax system will the optimal pure tax on private car use be zero. Even those developed countries which have instituted a uniform value added tax on final consumer goods (essentially equivalent to an income tax) have for the most part imposed additional, often heavy, taxes on private car use\(^3\).

Although this ideal of zero taxation of intermediate goods is of real practical value in developed countries with an effective system of value-added taxation, it requires that all final goods be taxable. In developing countries it is infeasible to tax goods produced in the household or small farm sector, and it may be hard to tax many other goods, so the theorem is not immediately applicable, though it continues to provide a useful benchmark. We shall therefore need to explore the case for taxes on commercial transport. (The treatment of private transport is dealt with separately in Chapter 6.)

2. Covering Total Highway Cost

First, though, let us return to consider the argument that road use costs as defined are below average costs, because they exclude overheads (such as verge maintenance, traffic signalling, policing, lighting) and interest on the fixed capital of the road network. This argument is incomplete, because we have already pointed out in the context of interurban congestion charges that if highway expenditures are optimized, and if there are constant returns to such expenditures, then charging at short run marginal cost will cover not only average construction costs, but also a substantial fraction of width-related maintenance costs. Since a substantial fraction of maintenance costs will be recovered by charging for road damage costs, it would seem that the highway budget would make a profit. However, it may well be that lumpiness or indivisibilities, together with increasing returns to scale, cause road use costs to fall short of average highway costs. Certainly for overlay costs this is the case if traffic is growing, and weathering contributes to road damage, as shown in Newbery (1986a). But is this the case in Tunisia? Table 21 sets road use cost for the whole network against the 1982 budget expenditure on roads. Expenditure, current and capital, was only 46 per cent of the road use costs.

\(^3\) It is hard to calculate road use costs for typical private car use in European countries whose cities experience serious congestion costs, and it is possible that the high taxes are intended to reflect these congestion costs, since the other components of the road use costs are negligible for private cars. However, since most European countries tax private car use substantially above US levels, and since US road taxes are intended to act as road user charges, it seems likely that cars are subject to pure taxation in Europe.
### TABLE 21: Road Use Costs and the Road Budget, 1982

<table>
<thead>
<tr>
<th></th>
<th>Per veh-km</th>
<th>Total (7310 m veh-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Damage Costs</td>
<td>1.67 millimes (0.25c)</td>
<td>DT12.2m</td>
</tr>
<tr>
<td>Congestion Costs</td>
<td>12.27 millimes (1.84c)</td>
<td>DT89.7m</td>
</tr>
<tr>
<td>Total Road Use Costs</td>
<td>13.93 millimes (2.09c)</td>
<td>DT102m</td>
</tr>
<tr>
<td>Recurrent Expenditures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Average 1978-1981, 1982 prices)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Road Damage Costs/Rec. Exp. %</td>
<td></td>
<td>83%</td>
</tr>
<tr>
<td>- Capital Expenditure (same basis)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Congestion Costs/Cap. Exp. %</td>
<td></td>
<td>275%</td>
</tr>
<tr>
<td>Total Road Budget</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Congestion Costs/Total Exp. %</td>
<td></td>
<td>190%</td>
</tr>
<tr>
<td>As per cent of Road Use Costs</td>
<td></td>
<td>46%</td>
</tr>
</tbody>
</table>

**Source:** World Bank.

**Note:** VKT are for both diesel and gasoline vehicles, and the RUC is adjusted accordingly.

However, this comparison is misleading. Maintenance expenditure in this period was agreed to be too low, and capital costs of the past network have been ignored. Average investment costs will fall short of capital costs if the rate of expansion is below the rate of interest, and will fall further short if incremental investment costs fall short of average capital costs. It is, therefore, interesting to see whether the capital expenditure of DT33m is significantly out of line with the (annual interest on) marginal expansion costs of (roughly) doubling current capacity. The incremental capital cost of moving from 5m to 7m width in rural areas is very roughly DT35,000 per km. In 1977 71% of VKT were on roads of 6.5m width or less, so adding an extra lane might also double the capacity of the interurban network. In 1982 the paved network was some 9300 km in length, so at an interest rate of 10% real p.a., the (annual) marginal expansion cost would have been DT32 m p.a., very close to the investment expenditure.

Of course, the marginal expansion costs in urban areas would be higher than this, as they would be for the stronger more heavily-used roads, and adding an extra lane might expand capacity by less than 100 per cent, so the figure of DT32m is likely to be a considerable underestimate of the system wide average expansion cost. This supposition is strengthened by noting that 93% of the congestion costs are incurred in urban areas, which suggests
either that expansion costs in urban areas are more than ten times as high as in rural areas, or that capacity is poorly adjusted to traffic levels. It is perfectly possible that correctly evaluated capital and maintenance costs would exceed congestion costs. It is also quite possible that congestion costs have been seriously overestimated in urban areas and may be only half as high as the figures shown.

Does this mean that road user charges should be increased in order to collect the (estimated) total costs? Presumably if the costs are worth incurring, then the benefits exceed these costs, and the beneficiaries (i.e., the road users) would be willing to pay the costs (rather than forgo the benefits). Does this mean they should pay the costs? The short answer is no, for reasons set out in Walters (1968, Chapter IV) and in any textbook on public utility pricing. The only argument on efficiency grounds for forcing public enterprises to cover their costs is that this will force them to reduce inefficiency and waste. This argument is weak for a monopoly supplier, and in any case largely irrelevant here, since the highway budget excludes interest on capital, and does not directly receive the revenues for the highway charges.

Suppose that the Tunisian government is faced with a sharp fall in oil revenue, and thus either has to find alternative sources of revenue or to cut expenditure. Does this not mean that road users should pay more, (together with everyone else) in order to balance the total government budget? The argument that transport is a legitimate object of taxation has been briefly discussed and will be considered more fully below. Suppose it is held undesirable to tax transport because it is an intermediate good, (and this case needs to be made in the specific context of Tunisia) then any extra contribution to the budget must come from final consumers. Increased value-added taxes on transport, and increased taxation of private motorists may both be desirable ways of increasing revenue, but neither of them affects the present discussion of the taxation of freight transport. There is one other way in which a shortage of general government revenue will affect road user charging. If revenue is scarce, then fewer investments will be justified, and the criterion for selecting new projects will be made more demanding - a higher discount rate and a higher accounting price for public funds relative to private consumption.

Consequently fewer road investment and expansion projects will be accepted, and congestion will have to become more severe before relief is cost-effective. Congestion costs will increase, and so will road use costs, and if road user charges are set equal to road use costs, then revenue will (eventually) increase. The process may well be rather slow - though since congestion costs rise very rapidly indeed beyond some critical point the effect may not be too delayed provided that road charges are adjusted quickly.

3. The Desirability of Taxes on Intermediate Goods

If the government cannot tax all final goods, then there is a simple intuitive argument for having positive taxes on intermediate goods, for if these are used in the production of the untaxed final goods then they
can be used to tax final goods indirectly. The argument is correct under certain conditions, and is set out formally in Newbery (1986g). An alternative argument, which can be used more widely, is that developing countries frequently suffer from a narrow tax base — personal incomes may be hard to tax — as well as a wide range of goods produced outside the formal (large scale modern) sector. If the tax base is small, and the demand for government revenue high, then taxes will be pushed to the point where the marginal social cost of collecting additional tax revenue is high. Against this background, taxes on inputs and intermediate goods may be relatively less expensive ways of raising additional revenue than further taxes on a limited range of final goods.

A summary of the argument proceeds as follows. Define the distributional characteristic (Feldstein, 1972) $d_i$ of good $i$ as

$$d_i = \frac{\sum h \beta_i x_i}{\sum h x_i}$$

where $x_i^h$ is the consumption of good $i$ by household $h$ and $\beta^h$ is the social weight on consumption by this household.

The distributional characteristic $d_i$ is relatively large for goods whose budget share is large for households with high $\beta^h$, presumably those with low incomes. Thus goods with low income elasticities (i.e. necessities) will typically have high values for $d_i$. On the other hand the efficiency of collecting tax revenue will be low if the own price elasticity is large and/or the tax rate is high, if the tax rates on close substitutes are low or if the tax rates on close complements are high.

If it is not possible to tax all final goods (and it will be especially difficult to impose taxes on the consumption of any goods produced by farmers or households) then there is a very strong case for taxing goods which are inputs into untaxed goods, provided it would have been desirable to tax the untaxed goods, instead of subsidizing them.

Newbery (1986g) derives a very simple formula which allows one to judge the desirability of a production tax on good $m$ (i.e. a tax levied at the point of production or import, and payable on inputs to other industries as well as on sales to final consumers). If all taxes which fall on final sales of goods $i=1,...,m-1$, are set at optimal rates, so that the marginal social cost of raising extra revenue by any of these taxes is equal, and has
common value \( \lambda \), and there are no taxes on goods \( i=m, \ldots, n \) then it is desirable to impose a production tax on good \( m \) if

\[
\sum_{k=m}^{n} d_k b_{mk} X_k (\lambda - \lambda_k)/\lambda_k > 0,
\]

(2)

where \( b_{mk} \) is the total direct and indirect requirements of good \( m \) per unit of production of good \( k \), so \( b_{mk} X_k \) is total sales of good \( m \) to industry \( k \), and \( d_k \) weights this by the social desirability of such sales. If \( \lambda_k < \lambda \), then the social cost of taxing good \( k \) is less than that of current taxes, and it would be desirable to tax \( k \) if possible. Formula (2) says that if this can only be achieved via input taxes on good \( m \), then such taxes are desirable. Even if some goods should be subsidized (i.e. some \( \lambda_k > \lambda \)), provided their social weight \( d_k b_{mk} X_k \) is not too great, input taxes will still be desirable.

4. The desirability of taxing diesel

In order to judge whether diesel would be a suitable candidate for such input taxes one needs an estimate of the value of \( \sigma_k \) for sectors which are both desirable to tax and hard to tax, where

\[
\sigma_k = \frac{d_k b_{mk} X_k}{\sum_k d_k b_{mk} X_k}
\]

(3)

Table 22 gives the values for \( \sigma_k \) of the larger consuming sectors of diesel.

The next question to ask is whether any of these sectors come into the category of 'desirable to tax and hard to tax', and any into the category 'desirable to subsidize and hard to subsidize'. Cereals (which, directly or indirectly have a weight \( \sigma_k \) of 35 per cent) are subsidized, and the structure of subsidy (of fixing the price to farmers in each region) is well designed to offset any transport tax element, so it can be ignored. That essentially leaves various foodstuffs, all with very similar distributional characteristics, all (except fish) higher than the median.

The distributional characteristics have been scaled so that the average social weight \( \beta \), is unity, which implies that the social marginal cost of a uniform lump sum tax is also unity, and the social value of money redistributed as a uniform lump sum transfer is also unity. If such lump sum redistributions are feasible (and considered desirable) then it will in general be desirable to tax goods whose distributional characteristic is less than unity. In this case it would be desirable to tax non-cereal foodstuffs and, if it were hard to do so directly, then a diesel tax would indirectly contribute to such taxation.

If it is felt desirable to redistribute income to the poor, but for some reason the most attractive option of uniform lump sum transfers financed by increased commodity taxes is considered infeasible, then the case for
TABLE 22: Major diesel using sectors in Tunisia, 1977

<table>
<thead>
<tr>
<th>Sector Number</th>
<th>Sector Name</th>
<th>Share $\sigma_k$</th>
<th>Cumulative share $\Sigma \sigma_k$</th>
<th>$d_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cereals</td>
<td>14</td>
<td>14</td>
<td>0.87</td>
</tr>
<tr>
<td>21</td>
<td>Flour</td>
<td>13</td>
<td>27</td>
<td>0.76</td>
</tr>
<tr>
<td>19</td>
<td>Olive Oil</td>
<td>11</td>
<td>38</td>
<td>0.55</td>
</tr>
<tr>
<td>111</td>
<td>Road Transport</td>
<td>9</td>
<td>47</td>
<td>0.54</td>
</tr>
<tr>
<td>15</td>
<td>Slaughtering</td>
<td>8</td>
<td>55</td>
<td>0.50</td>
</tr>
<tr>
<td>22</td>
<td>Baking</td>
<td>8</td>
<td>63</td>
<td>0.58</td>
</tr>
<tr>
<td>6</td>
<td>Fresh Fruit</td>
<td>6</td>
<td>69</td>
<td>0.49</td>
</tr>
<tr>
<td>8</td>
<td>Live Animals</td>
<td>5</td>
<td>74</td>
<td>0.59</td>
</tr>
<tr>
<td>13</td>
<td>Fish</td>
<td>4</td>
<td>78</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Median distributional weight 0.461

Notes: $\sigma_k$ assumes that there is no final consumption of diesel (i.e. $X_k=0$) otherwise the figures must be proportionately reduced. The values of $d_k$ are calculated for an inequality aversion of $c=1$. This value of the coefficient of inequality aversion (Atkinson 1970) indicates that the marginal social value of income halves as expenditure per head doubles.

Taxing non-cereal foodstuffs is weakened, for these goods have higher distributional characteristics than the median, and might have to be used as (rather inefficient) methods of redistributing income. Even in this case, since flour and cereals have a substantially higher value of $d_k$, one could clearly concentrate the subsidies on these goods until the distortion costs (measured by the revenue effect $\partial R/\partial \sigma_k/X_k$) became too large. It might well be desirable to have (low) positive taxes on non-cereal foods provided the rate of subsidy on cereals were not too high (thereby lowering the social value of further subsidies, measured by $\lambda_{cereals}$).

5. The importance of kerosene

The other major factor to take into account when choosing the level of diesel taxation is the price of kerosene. If kerosene is priced at or below the price of diesel then substantial substitution of diesel by kerosene is likely to take place in the industrial sector. This is inefficient as the world price of kerosene is typically higher than that of diesel (though in normal times only by a few per cent). If the price of kerosene drops significantly below the price of diesel then it is likely to be added as an adulterant to diesel as a road fuel. There is apparently little difficulty in substituting up to 30 per cent of diesel by kerosene while retaining its automotive properties, and there is clear evidence from India and Indonesia that even higher levels of adulteration occur. The size of the problem depends upon the nature of the fuel distribution system, the efficiency of
enforcement, and the extent of the price differential, but in many developing countries it is unrealistic to expect that considerable kerosene substitution can be avoided if the price falls much below that of diesel. The cross price elasticity of diesel with respect to kerosene may be as high as 3 or more in this case.

This affects the argument for taxing diesel as an input in two ways. First, the test statistic given in equation (2) assumed that all other inputs were untaxed and unsubsidized, and was a test that some taxation of diesel would be desirable. The optimal tax rate would, in this case, satisfy

\[
\frac{\sum_{i=1}^{n} \frac{d_i b_i x_i}{\lambda_i} \left( \frac{1}{\lambda_i} - \frac{1}{\lambda} \right)}{-\partial Z_m/\partial t_m} = (4)
\]

(as shown in Newbery, 1986g) where the sum is over the untaxable goods, and \(\partial Z_m/\partial t_m\) measures the response of gross diesel use, \(Z_m\), to the tax rate. If kerosene is a close substitute, then, even if it is untaxed, the denominator of (4) will be high and will greatly reduce the desirable tax rate on diesel.

The second problem is more serious. Kerosene has a high distributional characteristic in most developing countries (Hughes, 1987) and Tunisia is no exception. Of the 73 items distinguished in Hughes' analysis, kerosene has the highest value for \(d_k\), (of 0.871), slightly higher than cereals (0.867). In Tunisia (though not in Thailand) its value is still below unity and so it might still be desirable to tax kerosene in order to finance lump sum transfers, but if this is infeasible, and it is considered desirable on distributional grounds to subsidize cereals, then there would seem to be a slightly stronger case for subsidizing kerosene, apart from its high substitutability with diesel. At this point it is important to remember that any road user charges must be treated as taxes when examining the impact of kerosene subsidies on revenue, for if subsidized kerosene replaces diesel, then the government loses the road user charge.

6. The spatial argument for transport subsidies

The Government of Tunisia is concerned that the benefits of development are spread widely throughout the country, and not all concentrated in urban areas. Roughly speaking, incomes levels decrease with distance from the main urban centres, with the south of the country being the poorest. There would appear to be three ways of attempting to redress this geographical inequality. The first is to treat it as an aspect of general inequality, and to choose taxes and subsidies optimally, taking due account of distributional considerations. To the extent that locationally specific transfers correlate well with poverty, these might well be part of a general attack on poverty. Social services, which are in any case often locationally specific, provide one such mechanism.
The second way is to try and increase incomes directly in disadvantaged agricultural regions, by investment, or by paying higher prices for their agricultural produce. This is already effectively done for cereals, when procurement prices are uniform over the purchasing centres, despite considerable differences in transport costs. The drawback with this technique is that it only applies to government purchased crops, and it will adversely affect net purchasers of food, who may be even poorer.

The final way would be to subsidize transport since this will have the effect of raising farmgate prices of crops, and raising them in proportion to their distance from the main urban consuming areas. The cost of the subsidy could be met by lowering the government purchase price at the urban destination from \( p \) to \( p' \) leaving the general level of prices unchanged, but altering their geographical distribution, as shown in Fig. 1 below:

![Figure 1: Effect of Transport Subsidy on Farmgate Price](image)

The advantage of such a transport subsidy would be that it would apply to a wider range of goods, and not distort their relative values at different places as much as a subsidy confined to cereals. Against this, it would overencourage the dispersion of agricultural activity, possibly lead to a comparatively disadvantageous choice of cropping pattern and intensity, and again, adversely affect distant net purchasers of these goods (though they would gain from lower purchase prices of goods shipped out from the urban areas).

Taking all these factors into account, it is difficult to believe that transport (i.e., diesel) subsidies would be distributionally more effective than direct regional support (direct investment, improved infrastructure, improved social services), and the existing system of uniform cereal pricing.
7. **Implication for the Design of Road User Charges for Freight Transport**

We have seen that there may be a case for subsidizing kerosene on distributional grounds as it has a high distributional weight. Whether this argument will continue to hold as the real price of oil falls is another matter, for such a fall would raise the need for government revenue and reduce the urgency of offsetting disadvantageous price movements affecting the poor. We have also seen that it is hard to argue for using diesel taxes as a means of taxing hard-to-tax sectors. The next consideration is potentially the most important and is discussed in the next chapter. As only 40% of diesel is used in the transport sector, any taxes on diesel designed to charge for road use will have potentially undesirable effects outside the transport sector. The correct level of fuel taxes will involve balancing these other costs against the costs of having to use other instruments than fuel taxes in levying the road user charges. The key question is, therefore, how costly is it to levy fuel taxes on non-transport users, which will depend on the extent of substitution possibilities available, and the structure of the whole tax system. This question is addressed in the next chapter.
Chapter 5: The Economic Impact of Transport Taxes and Energy Pricing Policies

by Gordon A. Hughes

1. Introduction

This chapter examines the wider economic impact of transport taxes imposed on either fuels or other inputs into road transport. It draws upon the results of studies of the impact of changes in energy prices, fuel taxes and other taxes on the general price level and on the distribution of income in Tunisia, Thailand and Indonesia (Hughes 1986a, 1986b, 1987). Primary emphasis will be given to the results relating to Tunisia, but the value of the other country studies is that they enable one to establish the extent to which the results are special to the circumstances of a particular country or are quite general.

In discussing fuel prices the studies focus exclusively upon policies which affect the prices facing energy users, so that we do not consider the impact of prices on energy supply. In effect, commercial energy production is treated as if it were an offshore activity and it is assumed that all changes in revenue resulting from changes in fuel prices accrue to the government either directly or as changes in the profits of state-controlled energy producers and distributors. On this basis it is appropriate to refer interchangeably to changes in fuel taxes and changes in the consumer prices of energy products.

Decisions about energy prices or transport taxes involve weighting the efficiency and equity effects of price changes. Putting aside equity considerations temporarily, there is a general presumption on efficiency grounds that, in the absence of market distortions, energy prices for intermediate consumption should be set equal to border prices plus a uniform ad valorem tax at a rate similar to that imposed on other industrial products. The basis for this presumption is, of course, that discriminatory taxes or subsidies will either lead to substitution that are inefficient (in terms of producer or shadow prices), between energy and other inputs or between different fuels. However, in practice there are many market distortions in developing countries so that the issue then becomes whether such distortions justify the imposition of discriminatory taxes on all energy or on specific fuels. This can only be answered by studying the specific circumstances of individual countries, but there are a number of powerful general points which need to be borne in mind:

(a) The imposition of a general tax/subsidy on all energy may be an appropriate response to perceived distortions in the energy sector, but it will contribute relatively little to correcting the impact of other distortions since energy represents a rather small proportion of industrial and household expenses and in the long term there is substantial scope for substituting between fuels and other items.
(b) The considerations which influence the taxation of fuels used as inputs into production and those entering into final consumption are quite different. This might imply substantial discrimination between the taxes imposed on fuels used almost exclusively by producers - e.g. fuel oil, coal, lignite - and those used predominantly by households - e.g. gasoline, LPG. Such discrimination can be reinforced by the imposition of differential taxes on different categories of users of fuels such as electricity and gas whose use is easily monitored. However, such price discrimination is very difficult to enforce for fuels such as diesel oil and kerosene which can be used in many different ways.

(c) The role of diesel and kerosene as substitutes for each other and for other fuels imposes critical constraints on the extent of discriminatory pricing of different fuels. Kerosene can quite easily be substituted for diesel oil in most industrial uses - this is readily illustrated by a comparison of the relative use of kerosene and diesel in Indonesian and Thai industries - and may be mixed with diesel for use in vehicles. In simple terms, the shadow (border) prices of gasoline, kerosene and diesel oil may be treated as being equal. The ease of substitution of kerosene for diesel means then that it is inadvisable to tax kerosene less heavily than diesel oil. Kerosene in turn is a substitute for both LPG and electricity in domestic consumption - especially for cooking, light and heating for urban households. Diesel engines may substitute for gasoline engines in cars and pickups if gasoline is too heavily taxed, unless vehicle licensing fees or regulations are invoked to discourage this switch. A major shift away from gasoline towards diesel as a motor vehicle fuel has already occurred in Tunisia and is in progress in both Indonesia and Thailand. Diesel oil can also be used in place of heavier fuel oils or coal in steam-generation and heating in industrial processes or even in electricity generation. This again limits the scope for discrimination in the taxation of these fuels.

(d) Within the transport sector it is necessary to distinguish between freight transport and passenger transport. The former is almost exclusively used as an intermediate input into the production of other goods and services, the latter primarily as a final consumption item. For road transport it is possible to distinguish between the two activities by the type of vehicle used - subject to the dual use of pick-ups and light utility vehicles which are an important component of the vehicle fleet in Tunisia and many other developing countries. But for these important exceptions, differential taxation according to vehicle type is possible if one confines oneself to purchase taxes and license fees. Other taxes -- e.g. taxes on the output of road transport enterprises, on tyres and spare parts, and on fuels -- are less easy to impose in a discriminatory manner. Even when taxes differentiate between different types of transport, there may be substantial substitution at the margins and the costs of enforcing regulations designed to preserve the integrity of the taxes may be high.

The scope for achieving a system of discriminatory taxes and prices which approximates to the ideal arrangement from the point of view of production efficiency is thus very limited. Hence, it is important to examine the effects of imposing non-discriminatory taxes on various fuels and transport activities.
Another problem which faces those concerned with the design of taxation is the appropriate balance between the short and long term effects of their decisions. This is relevant to the construction of models designed to analyse the impact of tax and pricing policies. For the short run impact of such policies it is reasonable to assume that there is no substitution between inputs into production or in patterns of consumption in response to the taxes and induced price changes. However, this assumption is at best an approximation for the short run. For longer term analysis it is wholly inappropriate as substitution may have a significant impact on the structure of production as well as on the composition of demand. For both Tunisia and Thailand two related models have been constructed:

(a) The main analysis of the impact of taxes and price changes rests upon linear or non-substitution models which assume that aggregate demands and the composition of inputs into production are not affected by the changes examined. This approach provides predictions of the immediate consequences of the policies. Because of the structure of the models, they may be constructed using highly disaggregated data in order to gain detailed insights into the effects of a wide range of highly specific taxes and their impact on quite narrowly-defined sectors of the economy.

(b) The longer term analysis rests upon more aggregated models which incorporate a full range of substitution possibilities in both production and consumption. These require a substantial amount of additional data on the magnitude of the substitution elasticities. Unfortunately, there has been very little useful empirical work in developing countries from which estimates of the relevant parameters can be obtained. As a result the models rely upon figures (or guesses) derived from a wide variety of sources whose reliability and transferability is at best uncertain (see Appendix to this chapter). The full substitution models should be regarded as experimental constructions whose purpose is to identify the possible sources of divergence between the results of short and long run analysis.

Most previous studies of the impact of tax or price changes on the economy have relied upon a cost-plus approach. This assumes that all changes in input costs can be passed on by producers in the prices they charge for their output. As a result price or tax changes should, in the short run, cause no significant changes in money income, so that it is sufficient to examine the impact of the policies upon the prices paid by consumers and those responsible for other components of final demand. In practice, however, the producers in many sectors are unable to pass on cost increases in this manner but are obliged to absorb them either by accepting a reduction in profits or by lowering the payments made to other factors of production. For example, farmers producing exported agricultural goods or manufacturers competing with imported goods do not have the freedom to price their outputs on a cost-plus basis.

The models take account of divergences from cost-plus pricing in calculating the impact of tax or price changes on the general level of producer or consumer prices. At the same time non-cost-plus pricing implies that those working in certain sectors may experience significant income
changes as a result of a change in transport taxes or energy prices. Considerable technical and data problems arise when one attempts to estimate the magnitude and distribution of these income effects. An attempt has nevertheless been made to do this for Thailand, which has a particularly rich set of household budget survey data.

Once the impact of a particular tax or pricing change on producer and consumer prices has been computed, it is relatively straightforward to assess the consequential effects of the change on the household distribution of real income. The analysis of the distributional impact of a policy focuses not only upon whether it improves or worsens the degree of inequality of the distribution of household income - vertical equity - but also on the extent of differences in the impact of the policy on households with similar initial income levels and demographic characteristics - horizontal equity.

The next two sections of this chapter focus upon the impact of general taxes and of specific transport or fuel taxes, using the short run linear model. Differences between the conclusions of the short and long run analyses as a result of substitution are discussed in section 4 while section 5 discusses the evidence on the magnitude of the own-price elasticities of demand for transport fuels which turn out to be key parameters in the substitution analysis. In order to compare the effects of different tax changes it is necessary to normalise them in some way. For the present study the most appropriate basis of comparison is that the taxes should generate equal amounts of revenue after deducting any additional costs on the expenditure side of the government. In the case of the general taxes discussed in the next section, the rates were set to generate net revenue equal to 1 percent of total final demand. The specific taxes upon fuels and transport were normalized to generate various amounts of net revenue differing according to the context, but all comparisons relate to taxes with equal revenue yields.

2. General Taxes

When world energy prices rose sharply following the two oil price shocks of 1973-74 and 1979-80, the governments of many developing countries were reluctant to allow domestic fuel prices to follow world prices upwards because of fears about the possible adverse effects of a general rise in energy costs. The effects of general energy taxes may thus be explained by addressing a number of these fears specifically:

(a) Will higher fuel prices exacerbate inflation?

Inevitably, higher fuel prices mean higher costs of production which must in part be reflected in higher consumer prices. However, even for Thailand in 1982 - i.e. after the second oil price shock - the taxes on all fuels and on petroleum products lead to increases in the general consumer price index of approximately 1.0 percent by comparison with a figure of 1.9 percent if the same revenue had been collected by a general sales tax on consumption. A tax restricted to gasoline and jet fuel alone has a somewhat greater impact on consumer prices. For an oil-importing country an increase in world energy prices inevitably implies a reduction in real national income which may be reflected in a deterioration in the balance of trade. Some
countries reacted to these changes by increasing import barriers. Comparison of the price effects of an import sales tax and general fuel taxes in all three countries shows that the former leads to a larger rise in the general consumer price index for the predetermined macroeconomic adjustment than for any of the general fuel taxes. This is particularly important at the present time when world energy prices have fallen sharply. As a result oil-importing countries have become better-off and will experience an improvement in their balances of trade. The question then is how this real income gain should be fed through into the domestic economy. One method would be to allow domestic fuel prices to fall in line with world energy prices. On the other hand the implication of the comparison between an import sales tax and a general tax on all fuels is that it would better from the point of view of the impact on inflation to lower import duties and maintain the previous level of fuel prices by raising _ad valorem_ fuel taxes. Allowing for the effects of inter-factor and inter-fuel substitution merely strengthens the advantage of fuel taxes over import taxes, since substitution reduces the price impact of all the general fuel taxes by at least a quarter whereas substitution has little effect on the price impact of the import sales tax.

(b) Do fuel taxes worsen the distribution of income?

On balance the taxes on all fuels and all petroleum products taken together tend to reduce inequality in all countries, though the effect is relatively small. The tax on gasoline and jet fuel has a significant progressive impact, while the tax on other petroleum products is regressive in Indonesia - which has a very high average share of kerosene in total expenditure - but is neutral or very marginally progressive in the other cases. The impact of the general tax on all fuels on overall inequality is very similar to that of the import sales tax, so that the switch from import duties to fuel taxes envisaged in the previous paragraph would have no net effect on the degree of inequality of the distribution of income.

While the fuel taxes are progressive in their overall impact, they also generate substantial horizontal inequity in the sense that there is considerable dispersion in the impact of the taxes on households with similar original real incomes. The most progressive tax - that on gasoline and jet fuel - is also the source of the most horizontal inequity. On the other hand, the taxes on all fuels and all petroleum products are no worse by this criterion, than the import sales tax though the industrial sales tax is best of all the general taxes considered. The implication is that fuel taxes would be a poor and probably contentious method of attempting to reduce income inequality, but they need not be rejected on the grounds that they will worsen the distribution of income. The one clearly progressive tax - that on gasoline and jet fuel - may provoke strong objections on the grounds of its uneven impact.

The effects of the taxes on the distribution of income reported so far were computed from the changes in the cost of living experienced by households. Entrepreneurial and self-employment income also changes, as a result of backward shifting of the taxes. When estimates of these changes were allowed for in the Thailand studies, the progressive impact of the tax on all petroleum products as well as of the other general taxes increased
quite significantly. The reason for this appears to be that the income transfers - most of them involving reductions in profits and self-employment income - are concentrated in the upper part of the income distribution. However, it should also be noted that in experiments which assumed that a tax on all petroleum products or on industrial sales is accompanied by a fall of 1 percent in real wage rates, the effects on inequality were no different from those obtained when no reduction in real wages was assumed.

(c) Which industries will be most severely affected by fuel taxes?

The general taxes on all fuels and all petroleum products will raise production costs in almost all sectors but the impact is modest for all but a small number of energy-intensive sectors. Cement, transport and electricity generation would be the most severely affected sectors, whereas the import and industrial sales taxes would have a more substantial impact on manufacturing sector costs. The effects of the taxes on sectoral profitability depend on their joint effects on costs and producer prices. With one or two exceptions all of the general taxes tend to reduce profit rates in agriculture, though the percentage changes are small. Charcoal and firewood production benefit greatly in Thailand and Indonesia from an increase in the price of competing fuels, while fishing and mining suffer because of the rise in their fuel costs. Import-competing manufacturing would, of course, benefit substantially from an increase in import duties but these sectors are penalized by fuel and other taxes which raise their costs of production. Substitution between factors and fuels reduces the magnitude of the losses suffered by the worst-hit sectors and increases the gains made by those which benefit, but it does not change the broad picture.

(d) Will particular sub-groups of the population be severely affected by the taxes?

Reliance upon disaggregated household data for the analysis of the impact of the taxes allows us to identify the consequences of tax changes for specific sections of the community. This is useful information because it enables policy-makers to identify potential sources of political objections to particular proposals and to consider whether specific remedies to mitigate the impact of energy price change on particular sub-groups might be justified. The studies have concentrated on the impact of the tax changes on the deciles of the real income distribution for all households and for urban and rural households separately. For the taxes on all fuels and all petroleum products, the average transfers by decile for all households conform to the pattern of a mildly progressive impact. Comparing the average transfers by income decile for urban and rural households one finds that the major redistributive effects of the fuel taxes stem from the heavier impact of the taxes on urban households, even when deciles with similar average real income levels are compared. Within the urban sector the taxes are progressive only at the top and bottom ends of the distribution, whereas among rural households the average transfers increase fairly consistently from the lowest to the highest deciles.

Overall, the analysis of the effects of the general fuel taxes is that the two broad-based taxes - those on all fuels and on all petroleum
products—do not have any major disadvantages as potential sources of government revenue. There seems, therefore, to be no reason to hold down the general level of domestic fuel prices when world energy prices rise. Equally, the gains from lower world energy prices will primarily flow from the consequent macroeconomic stimulus to the economy. Since the import sales tax seems to perform worse (or no better) than the two broad fuel taxes according to the criteria adopted, there is a strong case for allowing the benefits of lower world energy prices to be transmitted via a general reduction in import duties rather than by reducing domestic fuel prices. From the point of view of more general macroeconomic adjustment the industrial sales tax and, one assumes, widely-based taxes on incomes or payrolls are preferable sources of revenue to fuel taxes. Nonetheless, general fuel taxes are clearly better than trade taxes and a number of other taxes adopted by government seeking to reduce effective demand.

3. Specific Fuel and Transport Taxes

With the exception of taxes on gasoline and related products it is unlikely that taxes on either specific fuels or on transport would be regarded as potentially significant sources of government revenue. A contrary instance is provided by the implicit subsidy on kerosene in Indonesia in the late 1970's—i.e. the difference between the border price and the much lower domestic price—which was estimated to cost an amount equivalent to 10 percent of central government tax revenue at the time. But such cases are unusual and in general specific transport and fuel taxes or subsidies are viewed as methods either of reducing or of correcting market distortions elsewhere in the economy.

Focusing initially on the redistributive impact of specific fuel taxes we have already seen that a gasoline tax is the most progressive of the general taxes. This result must be kept in perspective: an equivalent redistributive effect could be achieved by a uniform lump sum transfer to households in the bottom quartile of the income distribution and would involve expenditure of less than one-sixth of the revenue of the gasoline tax. Such a reform of redistribution would also avoid the possible problems concerning horizontal equity associated with the gasoline tax. The gasoline tax does confer positive distributional benefits but these would not be sufficient grounds for imposing such a tax unless alternative, more effective redistributive taxes were not available. This might seem a surprising conclusion in view of the fact that gasoline consistently has one of the lowest distributional characteristics of all of the consumption items examined (see Chapter 4, Section 3.). In part this reflects the limited efficacy of commodity taxes and subsidies as a method of redistributing income—which is further reduced when we take account of substitution in consumption. The second reason for the limited redistributive impact of gasoline taxes is that private consumption represents a surprisingly small fraction of total gasoline demand; for Thailand in 1982 the share was only 22 percent, so that the main impact of a gasoline tax is mediated through its impact on the prices of other goods.

Two other fuels—electricity and LPG—also have relatively low distributional characteristics and taxes on them would have a similar redis-
tributive impact as the gasoline tax. Both taxes would also generate a significant degree of horizontal inequity - especially the tax on LPG among urban households - though neither tax is as bad in this respect as the gasoline tax.

The classic candidate among fuels for price discrimination on distributional grounds is, of course, kerosene. The basis for such intervention is readily seen in the results of the studies. In all cases, kerosene has among the highest distributional characteristics and a kerosene excise has a regressive distributional impact. However, the problems of using kerosene subsidies to achieve distributional objectives are clearly shown by a comparison of the three country studies.

(a) Kerosene has been heavily subsidised in Indonesia for many years, so that total kerosene demand for both private consumption and industrial use is much higher relative to other fuel consumption than in the other countries. As a result kerosene subsidies have become a major drain on government resources, but raising kerosene prices would have a substantially regressive impact on household incomes, especially for those living in rural areas. Thus, the government has tended to oscillate uneasily between a policy of increasing kerosene prices when there are severe budgetary pressures and holding them down at other times on distributional and environmental grounds.

(b) In Thailand the subsidy on kerosene was substantially increased between 1976 and 1982, which had the effect of encouraging substitution in favour of kerosene in both consumption and industrial use. As a result the distributional benefits of kerosene subsidies were significantly reduced over this period, which suggests that kerosene subsidies may be self-defeating in the sense that they induce substitution which undermines their original justification. Further, by 1982 private consumption constituted only 48 percent of total demand for kerosene, so that a substantial fraction of any revenue devoted to kerosene subsidies would accrue to those using kerosene as an intermediate input in production.

(c) In Tunisia kerosene consumption is largely restricted to rural households, so that kerosene subsidies would be as effective per dinar spent as a lump sum transfer in improving the distribution of income, provided that any consequential substitution does not alter the composition of demand significantly.

In both Thailand and Tunisia aggregate kerosene consumption is small relative to the total demand for petroleum products, so the cost of kerosene subsidies would be low - as evidenced by the very high tax rates required to yield even quite small amounts of tax revenue. However, the major constraint in both countries on the use of kerosene subsidies as a method of redistributing income is the consequent need to hold down diesel and even fuel oil prices in order to discourage inefficient inter-fuel substitution. Since total consumption of diesel oil is over 9 times that of kerosene in each country, the net contribution of a joint subsidy on both kerosene and diesel to reducing inequality may be estimated by weighting the effect of the individual taxes appropriately. On this basis it would be very
expensive to achieve a significant reduction in inequality via fuel subsidies. In other words the view that kerosene subsidies can be an effective method of redistributing income turns out to be a chimera if the difficulty and cost of discriminating between kerosene and diesel in setting fuel prices are taken into account.

The taxes on road transport services and on vehicles, spare parts and tyres both lead to rather higher increases in the consumer price index than do either of the taxes on gasoline or diesel oil and kerosene which raise the same revenue, though the difference between the tax on diesel and kerosene and that on vehicles, etc. is slight. Still, after adjusting for differences in net revenue, even the tax on road transport services, which has the largest price impact of the road use taxes, leads to an increase in the consumer price index which is only slightly worse than that for an import sales tax. The distributional impacts of the taxes on diesel and kerosene together and on road transport services are both adverse, though the magnitude of the welfare loss is much lower than for an equal net revenue tax on kerosene alone. The tax on vehicles, etc. tends to improve the distribution of income by approximately the same amount as the tax on gasoline. Finally, the taxes on diesel and kerosene and, even more, on road transport services generate substantial horizontal inequity. This suggests that they may arouse vociferous opposition, but since diesel and road freight are primarily intermediate inputs the nature of the distributional impact of these taxes may not readily be perceived by most households.

4. Substitution and the Long Run Impact of Taxes

Models which allow for substitution between fuels and between aggregate energy inputs and other factors or aggregate inputs in production have been constructed for both Tunisia and Thailand. Because of the complexity of the models, it was necessary to use a much less detailed sectoral disaggregation than was possible in the linear models; the substitution models were based on approximately 30 sectors including 8-9 fuel sectors whereas the linear models distinguished up to 120 sectors. To test the effects of levels of aggregation, we compared the impact of taxes as generated by the linear models, with different degrees of disaggregation, and found the results to be quite similar. Thus, a high degree of disaggregation may be useful for studying the impact of policy upon specific sectors or sub-groups in the economy - especially on the income side - but it is not required to produce reasonably reliable estimates of the overall impact of policies in the short run.

All comparisons between the full substitution models and the linear non-substitution models are based on models with identical sets of sectors and assumptions about the relevant price rules, etc. This means, in effect, that the linear model is simply a restricted version of the full substitution model in which all substitution responses are set to zero.

The predictions of the linear and full substitution models are quite similar as regards the impact of the various taxes on consumer prices and on the distribution of income. Substitution does reduce the price rises associated with specific fuel taxes in individual sectors, but this effect is
much more important in sectors subject to cost-plus pricing than in others and cost-plus pricing sectors account for a relatively modest proportion of aggregate private consumption in small or open economies such as Tunisia and Thailand. Overall, allowing for substitution results in small reductions in the changes in the consumer price index following the tax and fuel price changes, but these do not alter any of the conclusions derived from the short run model in which substitution is not allowed for. The same is true for the distributional assessment of the impact of the taxes. Differences between the two models in the various indicators of the vertical and horizontal equity effects of the reforms are very slight and follow no simple pattern.

Thus far, it might appear that there is no reason to be concerned about differences between the short and long run impacts of the taxes investigated. However, there is one further potential source of difference which turns out to be extremely important for any evaluation of the relative merits of alternative tax proposals. In the linear model, the tax change is calculated by assuming that aggregate patterns of final and intermediate demand do not change. The revenue generated by a gasoline tax, for example, is calculated by multiplying the existing value of sales by the tax rate and deducting the additional cost of government expenditure. This is very schematically illustrated in Figure 3. If the tax is increased by \( \Delta t \), then the predicted extra revenue assuming no substitution is the area ACDF. Allowing for substitution, the derived demand schedule is EC, and predicted revenue is ABEF. The dead weight loss is roughly the triangle EBC, or one half the difference between the two revenue predictions.

![Figure 3: Effect on Tax Revenue of Allowing for Substitution](image-url)

When substitution is allowed for, two effects will determine the impact of a tax change on revenue and dead weight loss:
(i) The rise in the price of the taxed item will lead to a reduction in demand for it which will lower the revenue from any pre-existing taxes as well as from the new tax. This loss of revenue may be easily estimated given information on the aggregate own-price elasticity of demand for the item and the original rate of taxation imposed upon it.

(ii) The fall in the demand for the taxed item will be accompanied by changes in the composition of production inputs and final demand, leading to changes in the amount of revenue collected from items not directly affected by the tax. The amount of such additional revenue will depend upon the overall structure of taxes and subsidies upon transactions altered as a result of the substitution responses. The particular circumstances of the country investigated will be very important in determining both the sign and the magnitude of this component of the revenue adjustment, so that its estimation may involve a quite detailed study of the country's system of taxes and subsidies.

These two components of the revenue adjustment as a consequence of substitution will be referred to as the 'own-price revenue adjustment' and the 'cross-price revenue adjustment'. In view of the possible difficulty of collecting the data required to estimate the cross-price revenue adjustment reliably it would be reassuring if this was found to be small relative to the own-price revenue adjustment, or at least consistent across alternative tax reforms. Unfortunately, in the case of Tunisia - the only country for which these calculations have been carried out - the cross-price revenue adjustments are large for some tax changes and differ greatly in both absolute magnitude and sign across tax changes. There are, for example, important differences between the taxes on gasoline and on diesel oil and kerosene. The former induces substitution in favor of items which are quite heavily taxed. This generates a substantial positive cross-price revenue adjustment which partially offsets the large negative own-price revenue adjustment. Taxing diesel and kerosene induces substitution towards items which are either lightly taxed or subsidized, making the cross-price revenue adjustment small though positive.

The excess burden of a tax may be estimated as one-half of the difference between the net revenue in the non-substitution model and in the model with substitution. This measure may in turn be used to calculate the social cost of collecting revenue by using various tax bases. On this criterion, the Tunisian study suggests that the social cost of taxing diesel and kerosene is high because the revenue shortfall as a result of substitution amounts to more than one-half of the expected tax revenue in the short run linear model. The fuel taxes have social costs of revenue which are much higher than those of taxes on road transport services and on vehicles, parts, and tyres. These differences in the social costs of revenue constitute a very powerful argument against reliance upon a diesel and kerosene tax as a basis for recovering the road use costs of heavy vehicles.

Comparing the results obtained with the linear and the full-substitution models, the only important differences appear to relate to the net tax revenue generated by different taxes. The implications of long run
substitution must be taken into account when making fundamental long run decisions such as designing the structure of a tax system or a mechanism for recovering road use costs. On the other hand, decisions about the adjustment of tax rates or energy prices in response to changes in domestic or external circumstances can reasonably be based upon analysis with the linear model, provided, of course, that the decisions do not involve changes in the basic structure of tax system.

5. **Conclusions**

The implications of the findings reported in previous sections for the design of energy pricing and transport tax policy may be expressed as three interrelated points.

1. The welfare costs of taxing or subsidizing fuels are high because substitution in response to taxes or subsidies leads to relatively large changes in the aggregate demand for fuels. Hence, there is a very strong presumption that the domestic prices of petroleum products should be set close to their border prices. Further, the welfare costs of taxing or subsidizing fuels are higher, the greater are the differentials between the initial taxes or subsidies on the products. This implies that fuel tax or subsidies should not discriminate between different petroleum products.

2. Policies to adjust the domestic prices of petroleum products in accordance with the precepts laid down in the previous point may be resisted on the grounds that they will worsen inflation or the distribution of income. The impact analyses demonstrate that these fears are not justified and, indeed, that there would be positive benefits to a policy of lowering import duties while raising energy taxes. This would be a particularly appropriate policy to adopt in a period when world oil prices are falling.

3. The welfare cost of revenue raised by the use of road use taxes, such as taxes on road transport services or on vehicles, spare parts and tyres is much lower than of revenue derived from fuel taxes. Hence there is a strong presumption that it will be preferable to recover road use costs via transport taxes rather than via fuel taxes.
Appendix: Demand Elasticities

This chapter established that the magnitude and character of substitution responses to tax and price changes are important in determining the revenue effects of alternative policies and thus, the social cost of using various tax bases for revenue collection. At the same time, evidence concerning the scale of these substitution responses is very sparse, so that the reliability of estimates of the social cost of revenue from various taxes is quite uncertain. As a part of this study, investigations were initiated to reduce the extent of such uncertainty. The results were hardly reassuring. Our studies examined (a) the demand for gasoline and other transport fuels and (b) own-price and cross-price elasticities of household demand for consumption items.

The Demand for Transport Fuels

Much work was carried out in the late 1970's on the demand for gasoline and the conventional wisdom based on these studies is that the short run price elasticity is low—approximately -0.15—while the longer run elasticity is much higher at -0.8. The difficulty with most of this work is that it was based on time series analysis of data for individual countries drawn from a period when there was a very strong trend growth in the demand for transport fuels combined with rather limited variation in their prices. Thus, little reliance can be placed upon the long run demand elasticities generated by this econometric work. Other studies have instead utilized cross-country data to estimate the long run elasticity of gasoline demand. These equations should, however, be seen as the reduced form outcome of a very long term simultaneous model in which fundamental national differences in geography, urban structure, and the provision of public transport interact to influence the setting of gasoline prices as well as the demand for transport fuels. Such elasticities may not be very helpful for the analysis of policy in a particular country.

Our approach was to combine time series and cross-section data in order to estimate both short and long term elasticities on a consistent basis. This was carried out using data for a large sample of developed and developing countries. Not surprisingly, the work confirmed the standard estimates of the short run elasticity of gasoline demand. The long run elasticity of gasoline obtained from this work was dominated by the cross-section variation in gasoline prices. More important, the estimation procedure produced results which suggested that the equations might be seriously mis-specified. One interpretation of the results is that the long-run demand elasticity simply cannot be disentangled from a simple random walk in determining the behavior of gasoline demand over time. This does not mean, that a long run demand elasticity for gasoline cannot be identified, but it suggests that more, perhaps even different, data will be required.

Household Demand Elasticities

The parameters of the household expenditure function are important in the analysis of the impact of taxes for two separate reasons. First, they
determine the price elasticities of private consumption which may be an important component of total demand. Second, the effect of the general price changes resulting from a change in taxes or energy prices on household welfare will depend on the sensitivity of the expenditure function to various prices. Since no plausible set of household demand elasticities or expenditure function parameters was available for either Tunisia and Thailand, attempts were made to estimate them for both countries.

The problem which immediately confronts anyone embarking on this exercise is to select a specification which makes best use of the data available. For both countries, this consisted of the results of large scale household budget surveys which contained plenty of income variation across households but no identifiable price variation. In practice, prices do vary between districts or regions in most developing countries, but it is very difficult to identify such price variation and to disentangle it from quality variation which may also be substantial. The linear expenditure system (LES) is the only general specification which can be estimated using such data but which is capable of yielding prices as well as income elasticities. Price responses can be obtained from the LES because they are linked to the income responses by the rather restrictive assumptions of the model. Against this disadvantage, must be set the ease of estimating the LES for the set of sectors in the substitution models supplying goods and services consumed by households.

A basic feature of the LES is that there is assumed to be minimum or subsistence level of expenditure on each item, though some of these may be negative and the levels can be allowed to depend upon each household's demographic characteristics. To satisfy the concavity requirement for a valid expenditure function it is necessary that total household expenditure should exceed the sum of the subsistence consumption levels. Unfortunately, this condition was not satisfied for almost one-half of the households included in the datasets for each country, even when subsistence consumption levels were estimated as functions of the demographic characteristics of the household. This result implies that the LES is not an appropriate specification for estimating household expenditure functions for these two countries and little credence can be attached to the demand elasticities derived from the LES parameters. Hence, these parameters and elasticities were not used in the full substitution model or in the analysis of the impact of price changes on household welfare. The root cause of the problems was the lack of price data and hence the necessity of using the LES as the only suitable specification. To circumvent this lack of price data in household budget surveys requires either a pooled dataset drawn from a number of separate surveys carried out at different times on data in which regional price differences are identified.
Chapter 6: The Taxation of Personal Transport and Private Cars

by David M. Newbery

Passenger transport is a final consumption good and hence a legitimate object for indirect taxation, over and above the collection of road use costs. Indeed, it is probably desirable to think of taxes on passenger transport as consisting of a road use charge (equal to the road use cost) and a pure tax component (defined as the excess of the tax over the road use cost). It is convenient to consider these two components separately.

Table 23 reproduces the road use costs for passenger vehicles derived in Chapter 1, first for the base case, and second, for the case in which urban congestion costs are reduced to one third of their original estimates, as it is possible that these estimates were on the high side. Except for large buses, the overwhelming fraction of the road use cost consists of urban congestion costs, and it is hard to finely adjust charges to these highly variable costs. There are promising technical developments in electronic pricing, though at the moment plans to introduce them in Hong Kong have been delayed because of consumer resistance to the perceived invasion of privacy. There is considerable evidence that various forms of traffic management, traffic constraints, and area licensing schemes can alleviate the congestion problem. (World Bank, 1986, and Transportation Research, Special Issue, March 1986). Even if charges can only be set at a weighted average of congestion costs, it appears that adjusting urban highway capacity may reduce the inefficiencies caused by congestion substantially (Mohring 1986), though this remains controversial. If the main mechanism of adjustment to congestion levels is via location, and the size and configuration of cities, then urban highway expansion may be largely self-defeating.

The design of road user charges for passenger transport has two obvious dimensions—encouraging as far as possible the right level of road use (by time of day) and the right choice of mode (car, bus, train, taxi, bicycle, foot). Bertrand (1977) offers two potentially attractive rules for setting the structure of congestion charges between different classes of passenger transport vehicle. The first is that if congestion charges do not affect the total number of passenger-km travelled during a particular period of the day, then the "second best" (i.e., best feasible) set of charges should equalise the difference between the "tax" and the externality across modes, i.e., should equalise distortions per passenger across modes. ("Tax" includes all taxes and subsidies levied on the road user as a function of his choice of transport mode. If public transport is allowed to run at a loss, then this is equivalent to a subsidy.) For example, if private cars and taxis are taxed at roughly uniform rates per km for different levels of congestion, they will be undercharged on congested roads and overcharged on uncongested roads. If feasible, this rule would then argue for subsidizing public transport on congested roads by the same amount per passenger, and taxing them on uncongested (e.g., interurban) roads.
Table 23: Road Use cost of Passenger Transportation in Tunisia in 1982

US cents/veh km

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Vehicle Type</th>
<th>Road Damage Cost</th>
<th>Road Use Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Base case</td>
</tr>
<tr>
<td>1G</td>
<td>Car (gas)</td>
<td>0.01</td>
<td>1.92</td>
</tr>
<tr>
<td>1D</td>
<td>Car (diesel)</td>
<td>0.01</td>
<td>1.92</td>
</tr>
<tr>
<td>(2)</td>
<td>utility</td>
<td>(0.03)</td>
<td>(1.64)</td>
</tr>
<tr>
<td>7</td>
<td>Bus</td>
<td>0.45</td>
<td>6.13</td>
</tr>
</tbody>
</table>

Source: Tables 7, 9.

The second rule is that if raising charges on any mode reduces total passenger km during that period, then any charge that can be raised during that period, should be raised above the level that equates distortions across mode. The second rule substantially modifies the first, for if it is not feasible to vary charges on private transport by time of day, then only public transport fares can be raised. Since an increase in these fares will certainly reduce total passenger km during that period, there is a case for reducing the subsidy for rush hour users of public transport.

In practice, these rules are mainly useful as rough tests to rule out obvious inefficiencies. The exact level of charge and subsidy will depend not only on the level of congestion costs (which are hard to measure) but also on own and cross-price elasticities of demand for trips by various modes (which are almost impossible to measure). Several conclusions can, however, be drawn. There appears to be a case for subsidizing rush hour public transport if it is hard to adequately charge rush hour private transport. If bus subsidies lead to inadequate financial control and prevent otherwise desirable reforms such as privatizing bus services, or result in inferior and underfinanced public transport service, then the case for raising charges on private vehicles greatly increases.

6.1 Road user charges for private vehicles

In the technical papers, Newbery has calculated the optimal distance charge per km and access charge (or license fee) for private cars on the assumption that the charge cannot be varied across roads or by time of day. On the assumption that the time cost per vehicle hour is 1.11 DT/hr. in the rush hour and 0.97 DT/hr in the off-peak period (Newbery 1986f, Table 5b), Table 24 below (reproduced from Newbery, 1986f, Table 6) gives the short and long run marginal congestion cost for private cars in Tunisia. Table 25 uses the formulas in the technical paper to estimate the distance and access charges. The access charges arise because they discourage the marginal (poorest) car owner from his purchase, and if, as assumed, marginal car owners drive a higher fraction of total VKT in congested urban areas, the effect will be to somewhat reduce congestion. However, the estimated annual
Table 24: Distance-Related Congestion Costs in Tunisia for Private Cars

<table>
<thead>
<tr>
<th>Type of Road</th>
<th>Fraction of VKT</th>
<th>Time Cost DT/1000 km</th>
<th>Total Cost DT/1000 km</th>
<th>Short Run Congestion Cost</th>
<th>Short Run MCC DT/1000 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very congested</td>
<td>.04</td>
<td>30.3</td>
<td>44.4</td>
<td>74.6</td>
<td>0.10</td>
</tr>
<tr>
<td>Moderately</td>
<td>.04</td>
<td>28.4</td>
<td>22.2</td>
<td>50.6</td>
<td>0.04</td>
</tr>
<tr>
<td>Slightly</td>
<td>.30</td>
<td>26.7</td>
<td>14.8</td>
<td>41.5</td>
<td>0.02</td>
</tr>
<tr>
<td>Interurban roads</td>
<td>.62</td>
<td>28.3</td>
<td>8.3</td>
<td>36.6</td>
<td>0.034</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: MCC - Marginal Congestion Cost; LRMCC - Long Run MCC

Col (2) Paterson 1985, Table 2.13 excl. utilization (overhead) costs and making adjustments for fuel consumption.

Col (4) = (4) + Col (2)

Col (6) Interurban costs from Newbery (1986e, Table 10).

Others: Plausible figures discussed in Newbery (1986f).

.access charge for congestion is only DT 19, compared to the annual distance related congestion charges of DT 147 for the marginal car owner, or DT 193 for the average car owner. Somewhat surprisingly, in this very simple model, access charging for vehicle use appears relatively less important than distance related charges, though the model has ignored potentially important interactions between car ownership, car use, and the demand for and quality of public transport. The optimum distance charge is DT 9.63/1000 km or DT 0.12/litre, exactly the 1981 tax rate on gasoline. Note that the charges (Table 25) are not equal to the costs (Table 24) because we are seeking to move to an optimum, lying between Long Run and Short Run Marginal Cost.

6.2 Road Taxes on Private Cars

Table 26 gives the evolution of the implicit tax on gasoline and shows it has almost always been above this figure (in real terms), though the tax rate has tended to decrease both in absolute terms (by 27 per cent between 1971 and 1982) and in ad valorem terms (from 86 per cent of the retail price to 45 per cent.) There is little evidence from the figures that the government has felt inhibited in raising domestic gasoline prices in response to world price movements, as seems to have been the case for diesel.

Private cars are also subject to heavy import duties, various value-added purchase taxes, and very progressive annual license fees.
Table 25: Access and Distance Charges for Congestion in Tunisia

<table>
<thead>
<tr>
<th>Type of Road</th>
<th>'000 km Annual VKT</th>
<th>'000 km Average Marginal</th>
<th>$k_i$</th>
<th>$\alpha_i$</th>
<th>$\sigma_i m_i$</th>
<th>$(m_i-t) k_i x_i - \sigma_i x_i^*$</th>
<th>$\pi_i^*$</th>
<th>$\pi_i$</th>
<th>$\pi_i^{**}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very congested</td>
<td>0.800</td>
<td>0.650</td>
<td>0.57</td>
<td>0.019</td>
<td>2.11</td>
<td>101.4</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congested</td>
<td>0.800</td>
<td>0.630</td>
<td>0.72</td>
<td>0.028</td>
<td>1.09</td>
<td>29.4</td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slightly congested</td>
<td>6.000</td>
<td>4.680</td>
<td>0.81</td>
<td>0.258</td>
<td>4.90</td>
<td>9.4</td>
<td>0.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interurban</td>
<td>12.400</td>
<td>9.300</td>
<td>0.97</td>
<td>0.694</td>
<td>1.53</td>
<td>-7.4</td>
<td>-0.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals or Tax Rates</td>
<td>20.000</td>
<td>15.260</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.63</td>
<td>19.0</td>
</tr>
</tbody>
</table>

Notes: $k_i = 1/(1 + cm_i/p_i)$, when $t$ is elasticity of trip demand, $m_i$ is SRMCC from col (7) of Table 24, and $p_i$ is the weighted average total cost, $p_i$ from col (5) of Table 24. $\alpha_i = x_i/(p_i + cm_i)$, $t$ is the optimum distance charge, $x_i^*$ the marginal car owner's VKT, and $x_i^{**} = \sum k_i x_i^* = 13.64$. $T = \sum (m_i-t)(k_i x_i^* - \sigma_i x_i^{**})$, and is the sum of the product of the two final columns. It is the estimated annual access charge for congestion. Formulas are derived in Newbery (1986f).

('vignettes') ranging from DT 30 p.a. for 4cv cars up to DT 1000 for these above 16 cv, with vehicles which entered service more than 10 years ago paying one half. Tyres and parts are also taxed heavily, if the value-added taxes are (correctly) counted. Paterson (1985, Table 2.13) estimates the road user charges for gasoline vehicles as DT 79.7/1000 km, representing a tax of 125 per cent on the cost net of taxes. Deducting the cost-based road use charge of DT 10.6/1000 km, (DT 9.63 distance charge + DT19 annual access charge for an average VKT of 20 000 km) the pure tax on private cars is DT 69.1/1000 km, or 109 per cent of the cost. This compares with the standard value-added tax rate of 16.6 per cent (on pre-tax prices) for the production tax, and the additional consumption tax rates of between 9.3 and 26 per cent of the pre-tax price, making a total tax of up to 46 per cent for some goods.
Table 26: Evolution of price structure of regular gasoline in Tunisia

<table>
<thead>
<tr>
<th></th>
<th>cif Price (1)</th>
<th>Handling (2)</th>
<th>Wholesale (3)</th>
<th>Implicit Tax (at 1982 prices) (4)</th>
<th>Retail Price (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>9.8</td>
<td>4.4</td>
<td>14.2</td>
<td>85.8</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>11.1</td>
<td>4.4</td>
<td>15.5</td>
<td>84.5</td>
<td>(183.6)</td>
</tr>
<tr>
<td>2</td>
<td>12.0</td>
<td>5.0</td>
<td>17.0</td>
<td>98.0</td>
<td>115</td>
</tr>
<tr>
<td>3</td>
<td>24.3</td>
<td>5.5</td>
<td>29.8</td>
<td>85.2</td>
<td>115</td>
</tr>
<tr>
<td>4</td>
<td>37.3</td>
<td>7.0</td>
<td>44.3</td>
<td>95.7</td>
<td>(187.3)</td>
</tr>
<tr>
<td>75</td>
<td>37.9</td>
<td>7.0</td>
<td>44.9</td>
<td>120.1</td>
<td>165</td>
</tr>
<tr>
<td>6</td>
<td>45.9</td>
<td>7.3</td>
<td>53.2</td>
<td>111.8</td>
<td>165</td>
</tr>
<tr>
<td>7</td>
<td>44.0</td>
<td>7.8</td>
<td>51.8</td>
<td>128.2</td>
<td>(203.8)</td>
</tr>
<tr>
<td>8</td>
<td>53.6</td>
<td>8.6</td>
<td>62.2</td>
<td>124.8</td>
<td>187</td>
</tr>
<tr>
<td>9</td>
<td>109.0</td>
<td>11.4</td>
<td>120.4</td>
<td>84.6</td>
<td>205</td>
</tr>
<tr>
<td>1980</td>
<td>111.1</td>
<td>12.4</td>
<td>123.5</td>
<td>96.5</td>
<td>(126.9)</td>
</tr>
<tr>
<td>1</td>
<td>131.8</td>
<td>13.8</td>
<td>145.6</td>
<td>119.4</td>
<td>265</td>
</tr>
<tr>
<td>2</td>
<td>145.2</td>
<td>15.8</td>
<td>161.0</td>
<td>134.0</td>
<td>(134.0)</td>
</tr>
<tr>
<td>3</td>
<td>143.0</td>
<td>16.2</td>
<td>159.2</td>
<td>160.8</td>
<td>320</td>
</tr>
<tr>
<td>4</td>
<td>360</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>395</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 (Jan)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>430</td>
</tr>
</tbody>
</table>

Notes:
(1) Estimates from posted price + shipping cost.
(2) = col (1) x 0.04 + 0.5 reported (or estimated) handling costs in 1981-2 from price regulations - an attempt to estimate the handling cost in earlier years.
(3) = (1) + (2).
(4) = (6) - (3).
(5) Figures in brackets at 1982 prices.
(6) Maximum regulated price, average for year.

Thus private transport is taxed about 60 per cent more heavily than locally produced goods, though imported goods pay additional import duties at significant rates.

We have already argued that it is quite reasonable to tax private transport, so the two main questions to resolve are whether the level of the pure tax on private transport is right, and whether its structure is right. If the government is concerned with equity (as appears to be the case) then it is logical to impose heavier taxes on goods consumed by the wealthier, provided this does not have an adverse effect on revenue by inducing them to switch their expenditure into less heavily taxed alternatives. The formal
expression of this intuitive idea is given (following Stern 1984) by the
social cost of raising revenue by a tax on good $i$, which in turn can be
written as:

$$
\lambda_i = \frac{\sum_{h} \phi_h X_i^h}{\sum_{h} \phi_h x_i^h} = \frac{d_i x_i}{\phi_i x_i^t} = \frac{d_i}{\phi_i}
$$

(1)

Where $R = \sum_{j} t_j x_j$

and

$$
\frac{\partial R}{\partial t_i} = \chi + \sum_{j} \phi_j \frac{\partial x_j}{\partial t_i}
$$

(2)

Here $\phi_h$ is the social weight placed on household (higher for the more
deserving), $x_h^i$ is the household's consumption of good $i$, $X_i$ is aggregate
consumption of good $i$, $q_i$ is its price to the consumer, $t$ is tax and $R$ is
government revenue and $d_i$ is the distributional characteristic of good $i$
(see Chapter 4, s. 3). The numerator thus measures the social cost to the
households of raising the price of good $i$ by one unit. The denominator
measures the extra government revenue raised by a unit increase in the price
of good $i$, and the whole is therefore the social cost per unit of revenue
raised.

Hughes (1987) has calculated the distributional characteristics for
various goods in Tunisia and their values are given in Table 27 for two
values of $c$, the coefficient of inequality aversion. A value of $c = 1$ re-
flects a moderate attitude to inequality, in which the marginal social value

<table>
<thead>
<tr>
<th>Good</th>
<th>$d_i$ $(c = 1)$</th>
<th>Rank</th>
<th>$d_i$ $(c = 2)$</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerosene</td>
<td>0.871</td>
<td>1</td>
<td>0.465</td>
<td>2</td>
</tr>
<tr>
<td>Cereal products</td>
<td>0.765</td>
<td>5</td>
<td>0.315</td>
<td>9</td>
</tr>
<tr>
<td>Bread</td>
<td>0.577</td>
<td>19</td>
<td>0.202</td>
<td>16</td>
</tr>
<tr>
<td>Gasoline</td>
<td>0.253</td>
<td>68</td>
<td>0.031</td>
<td>70</td>
</tr>
<tr>
<td>Cars and spare parts</td>
<td>0.252</td>
<td>69</td>
<td>0.039</td>
<td>66</td>
</tr>
<tr>
<td>Electrical goods</td>
<td>0.396</td>
<td>53</td>
<td>0.070</td>
<td>54</td>
</tr>
<tr>
<td>General services</td>
<td>0.352</td>
<td>57</td>
<td>0.065</td>
<td>57</td>
</tr>
<tr>
<td>Hotels and services</td>
<td>0.418</td>
<td>48</td>
<td>0.083</td>
<td>50</td>
</tr>
<tr>
<td>Road Transport</td>
<td>0.536</td>
<td>27</td>
<td>0.153</td>
<td>27</td>
</tr>
</tbody>
</table>

Note: 1. $d_i$ is derived from $\phi_h$, the social weights on a household's
consumption, scaled so that mean $\phi_h = 1$.
2. Number of goods $= 73$. 
of income halves with a doubling of expenditure (per head). With $c = 2$, it falls to a half squared, or a quarter, and reflects a much greater aversion to inequality.

The table confirms one's basic expectations. The top three items are important for the poor, and at $c = 1$ kerosene is the highest ranked good (relatively the most important for low income families). The middle set of five goods have low values of $d_i$, and their ranks lie in the bottom third. Cars and gasoline are almost alike (as expected) and almost the lowest ranked goods. They are therefore prime candidates for heavy taxation. Purchased road transport (which includes taxis, buses, as well as commercial freight) lies in the top third, and is clearly quite important for the less wealthy.

If the value of $d_i$ is low for private transport, it does not automatically follow that the tax rate should be high, for the desirable level of taxation also depends on the unit revenue response, $\phi_i$. On this we can say little, as we have no data on consumption at different prices, only cross section data at a single date when oil prices are the same. Of course, with these data one can estimate the Linear Expenditure System, and Hughes (1986) has done this, but it confirms what Deaton (1987) and others have already argued - that the implied price elasticities are artefacts of the estimation procedure, and are all closely related to the expenditure elasticities. Goods with high expenditure elasticities (and low $d_i$'s) have high own-price elasticities. It would seem that on equity grounds they are good candidates for heavy taxation but on efficiency grounds they are bad candidates. Since the price elasticities are almost completely meaningless, one should not pay too much attention to this deduction.

Faced with this difficulty, Deaton (1987, p.99) suggests the following strategy. Suppose that taxes on good $i$ have a negligible effect on the total revenue collected from taxes on other goods. Then (2) can be simplified to

$$\phi_i = 1 - \tau_i \epsilon_i$$

(3)

where $\tau_i = \frac{t_i}{q_i}$, the ratio of tax to tax-inclusive price, and $\epsilon_i$ is the own-price elasticity of demand expressed as a positive number. Suppose that the average tax rate on other goods is $\tau$, that the representative or average value of $\epsilon_i$ is $\epsilon$, and the representative distributional characteristic of other goods is $d$, then the marginal social cost of raising revenue by other taxes is, on average

$$\lambda = \frac{d}{1 - \epsilon \tau}$$

(4)
Suppose also that one has some feeling for the value of the own-price elasticity of demand for good \( i \) (e.g., gasoline). Then the appropriate tax rate on good \( i \), \( \tau_i \), would equate the marginal social cost of raising the tax, \( \lambda_i \), with that elsewhere, \( \lambda \). This, in turn, yields a rough expression for \( \tau_i \):

\[
\tau_i = \frac{1 - d_i (1 - \varepsilon \tau)}{\varepsilon} \tag{5}
\]

For example, if the median good has a distributional characteristic of 0.461 (for an inequality aversion \( \varepsilon = 1 \)), and if \( \tau = 0.2 \), and \( \varepsilon = 0.8 \), and if the (long run) demand elasticity of gasoline is 0.8, then the tax rate on gasoline should be:

\[
\tau_g = \frac{1 - 0.253 \times 0.84/0.461}{0.8} = 0.67 \tag{6}
\]

The tax as a ratio of the before-tax price would then be about 200 percent, though it is clear that the estimated tax is very sensitive to the rather imprecisely estimated parameters.

Similar calculations can be done for other goods and are shown in Table 28. They tend to suggest high tax rates on vehicles, and subsidies on kerosene (at perhaps quite a high rate).

<table>
<thead>
<tr>
<th>Table 28: Implied tax rates for selected good</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Car and spare parts} )</td>
</tr>
<tr>
<td>Car and spare parts</td>
</tr>
<tr>
<td>Kerosene</td>
</tr>
<tr>
<td>Purchased Transport services</td>
</tr>
</tbody>
</table>

Note: \( \tau_i = (q_i - p_i)/q_i \), the tax rate on the (tax inclusive) consumer price.
The tax element in the variable operating costs of an average car is DT 15.5/1000 km or 47 per cent of the variable cost before taxes plus road use cost, quite close to the value added tax on some of the more heavily taxed goods. The ownership taxes on cars are equivalent to DT 56/1000 km or 142 per cent of the pre-tax cost. These amount to DT 1100 p.a. or a significant fraction of median salaries, and account for the quite low level of vehicle ownership in Tunisia for a country of its income level. From Table 28, if the own price elasticity for car ownership were about -1.5 (and given its cost one would expect quite a high figure) then the optimal tax might be 56 per cent of the pre-tax price. Thus one might conclude that although taxes on variable costs (fuel and tyres and parts) are not obviously too high, those on vehicles purchase do look excessive.

The same criticism can be leveled at the structure of vignette charges, which heavily discriminate against more powerful cars. Since these are likely to incur if anything a larger excess of fuel tax payments over road cost use than do small cars, there is no argument on efficiency grounds for penalizing them so heavily, and it is clear that car owners are willing to choose smaller cars to avoid the fee. It is hard to escape the conclusion that license fee revenue (and tax revenue in general) would be higher if the higher fees were reduced.
Chapter 7: The Effects of Regulation

by Esra Bennathan

Transport regulations are relevant to the design and reform of transport taxation on three counts. First, if regulations are effective in constraining the behaviour of suppliers and users of transport, they will also constrain their adjustment to changing prices and taxes. Second, they cause distortions that translate into costs falling on transport users and that ought to be recognized as such whenever tax changes are contemplated that will alter the price of transport services. Lastly, specific tax proposals may not be administratively compatible with particular forms of regulation or with deregulation. To deal with some of these points we proceed to outline Tunisia's transport regulations; examine features of her transport that those regulations are likely to affect so as to get a sense of the costs of the system; discuss ways in which regulations would determine the response to different tax changes, and finally, investigate the compatibility of a major tax proposal in this study with Tunisia's regulatory policy.

1. The Regulations

Tunisia's system of freight transport regulations seeks to protect the railways against the road, and professional haulage against own-account haulage. It seeks to limit competition between the professional haulage operators and controls their prices. The system, broadly stated, is thus of a type quite common to developing countries and the fact that Tunisia's professional haulage is essentially reserved to public sector enterprise makes it only a little less common.

The relevant regulations cover the activities of all goods vehicles of a gross weight over 3.5 tons (a payload of approximately 1.5-2 tons); except that farmers' vehicles are exempted up to a payload of 5 tons, when used for carrying agricultural products. The regulated sector consists thus of professional haulage and of own-account transport if performed by vehicles above the exempt limit.

Professional haulage is the preserve of 16 public sector enterprises, notably one 'national' company (STM) which is by far the largest single road haulage enterprise, and 12 provincial companies (SRTGs). The overt regulations of professional haulage consist, first, of a system of zonal restrictions. The national company enjoys preferential treatment in the granting of licenses for zonally unrestricted haulage: a policy known to be under some pressure from the regional companies and their political backing in the various gouvernorats. Restrictions also limit road carriage along certain routes served by railways. The transport of phosphates and iron ore is reserved to rail. The other major element of overt regulation is the official obligatory tariff. In addition, public haulage enterprises, all in the public sector, are understood to be subject to some measure of quantity
restriction or at least some control over their investments: investment seems to rely heavily on finance from external sources. Since public sector enterprise is an instrument of the government's employment policy (and transport is by far the largest employer in the public sector), this public sector status is bound to affect the operating costs and financial results of the professional haulage companies (cf. World Bank, March 1985 and July 1985). Their operational efficiency is more difficult to assess. It has come under criticism in a series of studies and the question is important because the effects of regulations are not easily disentangled from those of the degree of efficiency of regulated professional haulage.

Own-account transport is debarred from carrying for third parties (whether for hire or not). The rule is occasionally broken, especially in rural areas, but appears on the whole to be enforced. The other important element of own-account regulation is quantity restriction, operating through a system of non-transferable licenses specifying vehicle capacity and allowed use in terms of commodities. The authorization requirement was relaxed in the 1970s for the smaller trucks, leading in 1984 to the exemption of trucks below 5 ton capacity from licensing restrictions. Further relaxation has been promised but not so far carried out. While exemption limits varied, licensing policy has always been to ration the more stringently the larger is the truck size applied for.

2. The official tariff

The rates in the official tariff are mandatory and appear to be generally enforced, at least for hauls above 30 km.

Fixed tariffs, however they are set, unavoidably create incentives for own-account transport (as shown already by Burstein and Egan, 1965). The peculiarities of Tunisia's freight tariff appear from the comparisons in Table 29. They are based on official tariff rates and on costs modelled from Tunisian vehicle operating cost estimates. The estimates allow for different probabilities of backloads and for the lower level of vehicle utilization in own-account operations that is consistent with both the prohibition of entry into carriage for hire and the normal difference in the objectives of own-account operators and professional hauliers. It appears then that the tariff offers little or no incentive to professional haulage on the longer hauls, its special province in countries where the transport market is free. It further contains a clear disincentive to the hire of small trucks or the largest trucks. In the latter respect it seems to shelter behind the regulatory quantity restrictions on own-account operators. Column 2 of the table compares tariff rates with what would be charged (at average cost plus normal profit) by a professional haulier under competitive pressure but otherwise working with the same operational efficiency, rates of vehicle utilization and probability of backload, as the regulated carrier. The average excess of tariff-based charges over the competitive charge (with weights approximating the truck size and length-of-haul distribution of Tunisia's public haulage)

1/ The evidence and analysis summarized in this and the following section are set out in Bennathan (1985).
Table 29: Road transport charges and Costs: the official tariff\(^1\), competitive charges and own-account costs, Tunisia, 1984.

<table>
<thead>
<tr>
<th>Truck Size (capacity)</th>
<th>Distance of job (km)(^2)</th>
<th>Public haulage</th>
<th>Own account</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>REVENUE/COST, at tariff rates q = .25(^3)/</td>
<td>TARIFF/COMPETITIVE CHARGE (^4)/ q = .25(^3)/</td>
<td>TARIFF/OWN COST (^5)/ q = 0(^2)/ u = .75(^5)/</td>
</tr>
<tr>
<td>Light (3.5 tons)</td>
<td>50</td>
<td>1.36</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>1.73</td>
<td>1.67</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>1.87</td>
<td>1.77</td>
</tr>
<tr>
<td>Medium (6 tons)</td>
<td>50</td>
<td>1.25</td>
<td>1.26</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>1.24</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>1.23</td>
<td>1.16</td>
</tr>
<tr>
<td>Heavy (12 tons)</td>
<td>50</td>
<td>1.01</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>1.10</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>1.14</td>
<td>1.09</td>
</tr>
<tr>
<td>Articulated (25 tons)</td>
<td>50</td>
<td>1.27</td>
<td>1.31</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>1.36</td>
<td>1.33</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>1.40</td>
<td>1.34</td>
</tr>
</tbody>
</table>

Source: Bennathan (1985), Tables 8, 9 and App. 1.

Notes:

1/ rates for general merchandise.

2/ from (single) point of loading to (single) point of discharge, one load: 1/2 of round trip, base to base.

3/ q - probability of backload.

4/ charging job at average cost less expected revenue from backload, charged also at average cost.

5/ U - annual utilization (mileage) of vehicle relative to utilization in professional haulage.

amounts to 22 percent: one (very partial) measure of the cost-raising effect of the regulations.

3. The road transport of freight under regulation.

Having thus examined the working of Tunisia's regulations one is led to investigate those aspects of road haulage in which regulatory effects should show up. There is first the composition of the vehicle fleets.
Vehicle stock statistics are still inadequate but all the evidence points to a massive growth in the stock of utilities and small trucks (payload of 3.5 tons or less) during the 1970s, the growth rate exceeding 12 percent p.a. between 1977 and 1982. Recent estimates (amended by Harrison, 1985) place the number of light units (3.5 t payload or below) at ca. 42,000 and that of the heavier classes at ca. 5,000. Traffic census data suggest that the fastest growth in this light vehicle class during recent years occurred in the light trucks rather than in the smaller utilities categories. Rapid growth in the volume of light trucks is consistent with economic progress in Tunisia, but also with the exempt status of those classes under the regulations.

Turning next to the division between professional and own-account ownership (for which the statistics are even weaker) the 1982 estimate suggests plausibly that some 79 percent of the light vehicles were in own-account fleets. The professional haulage companies have been moving progressively into the heavier truck classes, above, say 8-10 ton capacity. The same tendency is documented for own-account operators except that those were held back by rationing. Rationing policy in the 1980s resulted in excess demand for vehicle sizes above 5 tons and perhaps greatest in the classes of 10 to 20 tons payload; demands apparently not stilled by the increasing offer of large sizes from the professional hauliers. The inducement to own-account operation lies partly in the structure of the official tariff. The preference for transport integrated into one's own enterprise operates universally, reflecting differences in the nature or quality of service that hired and own transport can render, but the degree to which the preference is acted on depends on the relation of hire-rate to own-cost, and on the efficiency of the public haulier service. We cannot disentangle these in Tunisia but note that own-account operators (actual or potential) were queuing up for authority to acquire middle-sized trucks even though their cost of operating them seems to have exceeded the cost of hiring at the official tariff by some 20 percent.

Such estimates take on more meaning when one turns to the characteristics of transport operations. The average annual utilization of the professional haulage fleets was estimated in the 1970s to be some one-third below the norm accepted in developed countries and our study showed remarkably low utilization of the heaviest trucks. Empty running accounts for some 45 percent of vehicle kms on the longer hauls, greater by one-third to one-half than in regulated transport activities of developed countries.

Turning finally to what these vehicles are doing, the picture appears abnormal in two respects. First, the share of light trucks (say, 1.5-3.5 tons capacity) in the total kms performed in medium and long haul transport seems to be about 12 percent. If so, it would be more than twice the typical share of what are defined as light trucks — hence of a size substantially larger than that adopted in Tunisia — in France or Britain. Second, it appears that own-account vehicles in the larger size classes are likely to be substantially engaged in long-haul transport. The significance of these characteristics of relatively long-haul transport is, first, that the economics of trucking assigns the larger vehicle to the longer haul; second, that the long haul is normally performed dominantly by specialist transport enterprise. Neither is the case in Tunisia. Zonal restrictions on
professional haulage operations and the impediment to inter-lining that is inherent in the tariff rules may explain part of these abnormalities: lighter vehicles than one expects on long haul, low utilization and empty running. The rest -- probably much the larger part -- seems to be associated with the division of labor between professional haulage and own-account operations that characterizes Tunisia. Our calculations broadly agree with the estimates of various consultant studies in the late 1970s: that professional haulage accounts for not much more than 45 percent of ton-kms in Tunisia's road transport of freight, the remainder being carried on own account.

Low average vehicle utilization and a high percentage of empty vehicle-kms are indeed consistent with a high share of own-account operations, whether one considers the effect of regulations barring carriage for hire or the operational characteristics of transport integrated into non-transport activities.

Judged by these tests, the cost of freight transport in Tunisia is high. Causes are more difficult to assign: the general level of efficiency, the regulations, or relatively low efficiency in professional haulage? The latter two are presumably linked; what other studies have taken for the cause: a high share of own-account operations insufficiently controlled by the regulators, is more likely to be the symptom. Experience in other countries points to deregulation as the more promising road to improvement.

4. Response to tax changes under regulation

The structure and level of road user charges prevailing in Tunisia in (notionally) 1982 were examined in Chapter 2. The comparisons of the actual charges with computed road cost (chap. 2, Table 14) suggest directions for the reform of, at least, the structure of taxation. Reform on those lines should then elicit responses from suppliers and users of road transport. The direction and magnitude of those responses will determine the fiscal outturn of the tax scheme (for given tax rates) and thus also the price of road transport of goods in Tunisia: an important point since these are intermediate services that enter into production and location decisions. The prevailing transport regulations, however, and the more persistent consequences of earlier regulation policy, enter into the determination of those responses.

Two features of Tunisia's regulated transport sector link the findings in Chapter 2 with the present discussion. First, Tunisia's freight appears to rely abnormally on transport in relatively light vehicles: in the class of Light Trucks and the lower ranges of Medium Trucks, the former undercharged by the present structure of road user charges and the latter significantly overcharged. The heavier classes of truck (except for the articulated trucks) appear more or less significantly undercharged relative to road use cost. Second, the classes of Light Trucks and Medium Trucks (and especially the lower sizes in the range represented by that type) are dominated by own-account transport, much of it engaged on work that a less constrained (and generally more efficient) transport sector would assign to professional haulage. (Utilities may be ignored in this connection. They are not likely to be used as substitutes for trucks in the Light and higher
Further, rationing appears to have resulted in excess own-account demand for heavier vehicles, in the (overcharged) Medium Size Truck range and the (undercharged) heavier classes.

If the reform of road user charges along the lines indicated in Chapter 2 results in heavier impositions on light freight vehicles there should result an incentive to the use of heavier vehicles. Such an evolution would seem to be in the right direction in terms of resource use in that it would tend to correct cost-raising characteristics of Tunisia's freight transport. It is, however, impeded, insofar as own-account vehicle acquisitions and operations are concerned, by the prevailing regulations, and the structure of the obligatory tariff for professional haulage. The preferences of transport users for own-account operations seem sufficiently strong to inhibit the extent of substitution on a scale that one would expect from the mere change in relative prices. If rationing is abolished altogether, as has been promised, the substitution of heavier for lighter trucks will go further, even in face of significant increases in the charges for the (currently undercharged) heaviest non-articulated truck classes. More thorough going substitution of heavier for lighter trucks in freight transport, however, can only be expected from deregulation going further, to the freeing of entry into professional haulage and the removal of the mandatory character of the official freight tariff.

A view held of the structure of road user charges in many other developing countries is that they undercharge the heavier truck classes. The Tunisian situation is less simple (as Chapter 2 showed) but the case can still be put in terms of the effective constraints operating in Tunisia (though not relevant to the real Tunisia). If the tax structure is then adjusted and tilted against the heavier truck classes, to conform to relative road use costs, it would entail (under circumstances found in Tunisia) relatively little substitution of lighter for heavier trucks. Substitution would be damped by existing excess demand for heavier vehicles in own-account service, and substitution would be largely at the expense of professional haulage: lighter own-account vehicles taking over from heavier ones in public service. Deregulation however, if associated with reform in the taxes, would then almost certainly swamp the price effects of such a reform and result in a substantial transfer of cargo to heavier vehicles.

5. Implications for the Choice Among Tax Instruments

Tunisia's transport taxes lend some support to her regulatory policy, most overtly in the differential rates of the stabilization tax ('compensation'): for vehicles in the size classes to which the regulators apply effective rationing -- above 5 tons capacity -- the tax for own-account operators is 50% higher than for professional haulage. Regulation policy is however, under review with the intention towards liberalization. The intention is reflected in the recent exemption of trucks of 5 tons capacity or less from the rationing procedure, and in the promise to lift the requirement altogether. The mere size of the market share of own-account haulage argues for liberal treatment even if the role of own-account operations as a safety valve in a regulated system is not generally acknowledged. The questions that then arise in connection with tax reform are, first, how to avoid
unintentional bias against own-account operations carried on within the range permitted by the regulations? and, second, how to avoid the creation of durable obstacles to regulatory reform through the tax design?

The first question can be focussed on access taxes, notably the annual license fee which has a significant place in the prevailing system as well as in the proposals of this study (Chapter 3). Transport integrated into non-transport firms is intended for different purposes than those served by professional transport enterprise, except to the extent that it is used as a substitute on grounds of relative cost. On average, therefore, own-account vehicles have lower utilization rates than similar vehicles in professional haulage service: in the regulated road transport sector of France, for instance, something like 7.5 tons of carrying capacity of larger own-account vehicles are used per 100,000 ton-km of service against 3.5 tons used by professional haulage, and in the strictly regulated German system the relation is as 9.4 to 3.8 (Bennathan, 1986). If licence fees are assessed on the average expected utilization of vehicles in a given size class, irrespective of mode of service, a bias is created against own-account operators.

The second question focusses on the scope for employing a service tax as a major instrument of transport taxation. The directness of this tax makes it attractive, the more so because of the inefficiencies of diesel as a base for transport taxation which this study has revealed. Ideally, the tax should be based on physical activity, vehicle-kms or ton-kms (the input or the output of the service). In practice, to minimize evasion, the base will have to be the freight bill. In own-account operations no freight bills emerge. The tax regime, if it is to contain a service tax, will therefore have to be varied according to the mode of working. It can be varied in what is a technically easy way, by imposing a service tax on the professional haulage sector while relying on access taxes (annual licenses) for dealing with own-account operators. While present regulations persist and professional haulage is working at its present level of efficiency, heavy reliance on access-related taxes for what is the major component of Tunisia's freight operations is less than desirable. It is however, feasible and the resulting distortion can be weighed against the consequences of applying other tax instruments. In Tunisia, application of a service tax to the professional haulage enterprises is facilitated by their reporting requirements (fueilles de route). Beyond this, the regulations themselves segregate the own-account sector by denying it entry into carriage for hire. This segregation disappears when transport is deregulated to the point where entry into haulage for hire is essentially free (as in Britain, Nigeria or Sweden) and it becomes progressively more difficult to enforce if own-account operators are freely admitted into all vehicle size classes even though debarred from carriage for hire. Under free entry, any operator can carry for hire or for himself, some operations giving rise to freight payments while others do not. The natural base for a service tax then dissolves and the instrument can only survive by more complex arrangements. The conceivable alternatives would nevertheless always require some form of enforced segregation. One might consider optional systems. Operators might be offered the option of working their vehicle as pure professional transport in which case they would be debarred from own-account carriage, or as a mixed carrier. License fees for the mixed carrier might then be assessed on an estimate for own-account
traffic while additional carriage for hire would be subject to a service tax. Alternatively, the mixed license fee might be assessed on total expected mileage, with tax receipts rebatable against it when they arise. The description of such alternatives points to their administrative complexity and the need for maintaining a substantial inspecting and policing apparatus; not least, contention will mount as the conflict between professional and own-account operators -- many of whom are also public sector enterprise -- is transferred from the stage of authorization procedures to that of license tax assessment. Tax administrations may therefore not regard these complex arrangements as manageable. In consequence, a tax system that relies heavily on service tax (combined with heavier reliance on annual license fees for own-account operators) may be found inconsistent with deregulation and may become an argument against moves towards freer competition in transport.
1. Road Use Charges for Freight Transport

The main thrust of Chapters 1 - 7 can be summarized as follows. Diesel taxes cannot be raised much above efficient (world market price) levels because of the adverse effects outside the transport sector. Raising diesel taxes reduces the substitution of diesel for gasoline, which is desirable, and will tend to increase revenue, but it increases substitution away from diesel elsewhere, which is undesirable. Raising diesel taxes will require compensatory increases in kerosene taxes (or reductions in subsidies) which is distributionally adverse.

If road transport services could be taxed without creating problems for the reform of regulation, then such a tax would be an excellent method of charging for freight vehicles, but we do not believe this to be the case, and, therefore, we reject such a system for Tunisia. This leaves fuel taxes as an important part of the system of road user charges, and we suggest collecting one quarter of the total charge by a fuel tax of 3c/litre (about 20 millimes/liter in 1982 prices) (see Table 8). We would argue that the retail price of kerosene should not fall much below 80 per cent of the retail tax-inclusive price of diesel to keep the degree of adulteration and substitution within manageable limits; revenue considerations may also point to higher kerosene prices.

Tyre taxes and tax on parts are set at 20 per cent to reduce adverse substitution and excessive or unsafe utilization. Purchase taxes and fuel taxes have opposite effects on vehicle lifetime, as do purchase taxes and license fees, so that it should be possible to design a set of charges with a roughly neutral effect on vehicle lives. A reasonable fraction of the balance of the road use cost can then be recovered by a vehicle purchase tax, with the remainder to be covered by the license fee. Table 30 shows one possible scheme. It should be stressed that there are many possible combinations of charges on different instruments, each with slightly different advantages and limitations.

Table 30 is based on the high figures for urban congestion, and so would raise the same level of revenue from trucks as the 1982 system of charges. Given the growth in traffic and the increasing pressure to which the budget is subject, it is likely that even if congestion costs were overestimated for 1982, they may have since risen to a figure close to the assumed level. If, on the other hand, the congestion costs are too high, then the distance-related taxes could all be reduced somewhat.
### Table 30: Possible System of Road User Charging for Trucks

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Road Use Cost c/km</th>
<th>Fuel Cons. @3c/l 1 (20%)</th>
<th>Fuel Tax (20%)</th>
<th>Tyre Tax (20%)</th>
<th>Parts Tax c/km</th>
<th>Balance c/km</th>
<th>Parts Tax %</th>
<th>Purchase Tax p.a.</th>
<th>License Fee p.a.</th>
<th>Excess p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 L</td>
<td>2.27</td>
<td>0.15</td>
<td>0.45</td>
<td>0.22</td>
<td>0.14</td>
<td>1.46</td>
<td>2.0</td>
<td>150</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>4 M</td>
<td>1.28</td>
<td>0.20</td>
<td>0.60</td>
<td>0.50</td>
<td>0.21</td>
<td>-0.03</td>
<td>5*</td>
<td>150</td>
<td>402</td>
<td></td>
</tr>
<tr>
<td>5a HS</td>
<td>3.09</td>
<td>0.39</td>
<td>1.17</td>
<td>0.75</td>
<td>0.30</td>
<td>0.87</td>
<td>10</td>
<td>150</td>
<td>242</td>
<td></td>
</tr>
<tr>
<td>5b HT</td>
<td>5.37</td>
<td>0.445</td>
<td>1.34</td>
<td>1.01</td>
<td>0.36</td>
<td>2.66</td>
<td>19</td>
<td>250</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>6 Artic</td>
<td>6.49</td>
<td>0.485</td>
<td>1.46</td>
<td>1.62</td>
<td>0.48</td>
<td>2.93</td>
<td>10</td>
<td>300</td>
<td>43</td>
<td></td>
</tr>
</tbody>
</table>

**Construction of Table:**

- (2) from Table 5
- (3) = 3c x (2)
- (4) and (5) - from Table 5
- (6) = (1) - (3) - (4) - (5)

**Example: vehicle 3L:**

- (4) = 0.2 x 1.08 (from Table 5, column 2) - 0.216
- (5) = 0.2 x 1.44 (from Table 5, column 4) x 0.5 (footnote 1)
  = 0.144
- (7) (8) (9) - recommended purchase tax rate transformed into tax/veh-km using Table 20, columns 3, 4. Deducting result from (6), and multiplying by assumed annual veh-km (Paterson 1985, Table 2.3) gives (8) + (9).

* Nominal amount; could be set to zero.
1/ If labour contributes 50% to repair costs, 20% tax on parts gives 10% average tax on parts + labor.

### 8.1 Current Taxes on Passenger Transport

Gasoline in 1982 was taxed 134 millimes/liter or about 20c/liter. Gasoline cars have lower annual utilization rates than diesel cars, but are cheaper to buy. Table 31 collects the relevant information together and distinguishes between urban buses (which are assumed to spend all their time in urban areas) and rural buses (which spend all their time on interurban roads), as these are differently taxed under the present (1984) system of license fees. It is noticeable that rural buses are very heavily taxed under the current system of license fees.

### 8.2 Taxation of Passenger Transport

There appears to be no strong case for taxing bus passengers heavily, as they are of modest means and there is a case for inducing a
Table 31: Road Use Costs and Road Taxes on Passenger Transport

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Cons 1/1000 km</th>
<th>Annual Utilization '000km</th>
<th>Capital Costs c/km</th>
<th>Road Use Cost c/km</th>
<th>Current Tax c/km</th>
<th>Operating Costs (Economic) c/km</th>
</tr>
</thead>
<tbody>
<tr>
<td>1G Car (gas)</td>
<td>80</td>
<td>20</td>
<td>5.41</td>
<td>1.92</td>
<td>10.59</td>
<td>8.79</td>
</tr>
<tr>
<td>1D Car (diesel)</td>
<td>65</td>
<td>46</td>
<td>3.34</td>
<td>1.92</td>
<td>5.26</td>
<td>6.44</td>
</tr>
<tr>
<td>2 Utility</td>
<td>90</td>
<td>35</td>
<td>3.83</td>
<td>1.64</td>
<td>0.59</td>
<td>12.44</td>
</tr>
<tr>
<td>7U Bus (urban)</td>
<td>357</td>
<td>63</td>
<td>19.90</td>
<td>5.51</td>
<td>8.03</td>
<td>62.38</td>
</tr>
<tr>
<td>7R Bus (rural)</td>
<td>357</td>
<td>63</td>
<td>19.90</td>
<td>0.93</td>
<td>11.52</td>
<td>62.38</td>
</tr>
</tbody>
</table>

Sources: (2) - Table 5
(3) - Paterson (1985)
(4) - Paterson (1985), Table 2.8 and Table 5
(5) - Table 7
(6) - Table 14, column 8
(7) - Paterson (1985), s. 2.4

Note: 1. Congestion costs element of road use cost recomputed for buses.
2. License fees now differentiated for buses.

A switch from private cars to buses to reduce urban congestion. (The same argument has less force on the less congested interurban roads.) Cars were argued in Chapter 6 to merit a high tax on gasoline, which will require a comparatively high license fee on diesel powered vehicles to prevent inefficient substitution. If the breakeven distance for choosing a diesel rather than a gasoline engined car is 25,000 km p.a., then the additional license fee is readily calculated (see P. 4 above).

The efficient distance related tax for private cars was argued to be DT9.63/1000 km or 1.44c/km, rather below the estimated road use cost of 1.92c/km even after allowing for the access charge of 0.14c/km. In addition, a pure tax of 50 percent on the pretax price of gasoline and the purchase of the vehicle could be defended. The 1982 actual tax on gasoline was 134 millimes/liter or 20c/liter, about two thirds European levels. One could therefore, argue for a 50 percent increase in the tax rate, and this is the rate adopted for the proposed system of road taxes. (It should again be stressed that there is considerable flexibility in the components and even in the overall level of some, depending on the extent to which it is felt desirable to levy additional taxes on private road users). Table 32, which gives one possible system, is constructed on the following principles. The gasoline tax recovers the road use cost, and contains a (modest) pure tax
Table 32: Possible System of Taxation for Passenger Vehicles

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Fuel Tax Rate</th>
<th>Tyre Parts Purchase Tax Rate</th>
<th>License Fee</th>
<th>Total Proposed Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>IG</td>
<td>2.40</td>
<td>0.06</td>
<td>0.07</td>
<td>50</td>
</tr>
<tr>
<td>1D</td>
<td>0.20</td>
<td>0.06</td>
<td>0.07</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>0.27</td>
<td>0.11</td>
<td>0.10</td>
<td>40</td>
</tr>
<tr>
<td>7U</td>
<td>1.07</td>
<td>0.57</td>
<td>0.60</td>
<td>20</td>
</tr>
<tr>
<td>7R</td>
<td>1.07</td>
<td>0.57</td>
<td>0.60</td>
<td>20</td>
</tr>
</tbody>
</table>

Sources and notes: (2) - gasoline tax at 30c/liter, diesel tax at 3c/liter (3) - tax at 20% of Table 5, column 2 (4) - 20% of 0.5 of Table 5, column 4

Table 33: Comparison of Current and Proposed Road Taxes

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Total Proposed Tax</th>
<th>Total Current Tax</th>
<th>Excess of Proposed Tax Over Road Use Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>IG</td>
<td>5.39</td>
<td>10.59</td>
<td>3.47</td>
</tr>
<tr>
<td>1D</td>
<td>3.35</td>
<td>5.26</td>
<td>1.43</td>
</tr>
<tr>
<td>2</td>
<td>2.15</td>
<td>0.59</td>
<td>0.51</td>
</tr>
<tr>
<td>7U</td>
<td>7.49</td>
<td>8.03</td>
<td>1.98</td>
</tr>
<tr>
<td>7R</td>
<td>10.98</td>
<td>11.52</td>
<td>10.05</td>
</tr>
</tbody>
</table>

Sources: (2) - from Table 32, column 9 (3) - from Table 14, column 8 (4) = (3) - (2) (5) - vehicle operating cost from Paterson (1985), s. 2.4

element, limited by the need not to encourage excessive switching to diesel vehicles (including pickups). Table 33 compares the proposed system with the current tax rates, and calculates the implied pure tax rate of the proposal as a percentage of total before tax vehicle operating costs.

For gasoline cars, the pure tax is 40 percent and higher purchase taxes or license fees might be justified on redistributional grounds (though, as argued in Chapter 6, not as high as at present).
If this is accepted, then the taxes on diesel cars are such that the extra license fee plus purchase tax would equate the tax paid per km for diesel and gasoline engined cars at a utilization rate of 25000 km p.a. (As diesel cars in fact are utilized more intensively, their actual tax per km is lower than for gasoline cars). Rural buses are taxed at the current license fee rate to yield a pure tax on passenger services of 16 percent, somewhat lower than for diesel cars (taxis). Urban buses are also assumed to pay the same license fee as in 1984, and must obviously pay the same rates of tax on other inputs. As a result, they are relatively less heavily taxed (3 percent) to encourage a switch away from private car use (though cars are still taxed more heavily per passenger km of urban driving). Utility tax rates are an uneasy compromise designed to rectify the current undercharging, to discourage the choice of utilities rather than cars, and not to tax utilities genuinely purchased for productive purposes.

8.3 Conclusion

This chapter is a brief attempt to apply the principles set out earlier to the design of a set of road use charges and road taxes. It is brief because a full treatment would require more detailed information about the overall budgetary position of the Tunisian government, the structure of the rest of the tax system, and the problems of transition from the current to the proposed system, any of which could lead to adjustments to what is a fairly flexible set of possible instruments. If any one instrument is constrained in the rates of tax which are considered feasible or desirable, then adjustments can be made to other rates. Thus, the proposals are only one of many possible systems of road user charging.
Chapter 9: Some General Lessons

Mainly on Road Use Cost and Charges

The various conclusions of the individual studies which contributed to this report have been summarized in the preceding chapters, so we will not repeat them. Here we concentrate on a small number of points concerning the general applicability of these results and on the design of studies of road user charges and fuel taxes.

The first issue is philosophical. Is there much point in devoting extensive resources to the design of a system of road user charges in an economy in which almost all prices are distorted? The answer is, No. It is hard to believe that large improvements in transport efficiency will result from changes in road charges on their own. It is more likely that the major transport improvements will come from ensuring the availability of vehicles, parts, and fuel at realistic exchange rates and import duties, and from improving the maintenance of the road network. Even on strict efficiency grounds, it may be unclear whether commercial transport should be taxed (over and above the level of road use costs) or subsidized, if other producer prices are heavily distorted. If the main demand for transport is for the export of heavily taxed goods (export crops), then transport subsidies can be defended to partially offset these taxes; if transport is primarily a substitute for domestic production (in delivering imports, for example), transport taxes may improve the allocation.

In such cases the following rather pragmatic approach may appeal. Transport taxes (over and above charging for road use costs) are likely to be a relatively indirect way of correcting distortions elsewhere in the economy, and it seems more logical to attempt to correct these other distortions directly. Where the other distortions are an inevitable by-product of the tax system (e.g., taxes on the main agricultural export crop), then complementary transport subsidies (which would be part of an efficient system of taxing these export crops) are probably best organized by influencing the spatial price patterns paid for the crop at different buying points. This has the advantage that transport is only subsidized for the relevant commodity and not for all other transport uses.

The advantage of implementing a system of road user charges for commercial transport equal to road use costs is that the system will not need to be changed once the other major distortions have been corrected. Even if one is pessimistic about the chances that other distortions will be corrected, it is quite likely that they will vary, perhaps dramatically, from year to year as the government responds to their more adverse consequences by introducing new interventions. Continuously adjusting road user charges in response to these other policy shifts is unlikely to have many beneficial effects since short-run demand elasticities for transport (and for the use of
different types of vehicles) are likely to be low. The major responses of transport to the structure of road user charges are likely to occur more slowly and, hence, require a stable pattern of charges for their effect.

The second point to make is that the design of a set of road user charges should not be a very expensive undertaking, and much can be achieved at very low cost using some of the shortcuts suggested below. Most of the data required are typically collected in the course of studying maintenance policy which, as suggested, is likely to have a far higher priority than reforming the structure of road user charges.

The obvious exception to this claim arises where maintenance is severely underfunded and where additional revenue for road maintenance can be obtained only by raising road user charges. If this really is the constraint, then it becomes important to ensure adequate financing, and urgent to increase road taxes. The following arguments suggest that this will not be in conflict with the aim of ensuring a sensible set of road user charges.

Theoretical and empirical work on road deterioration and maintenance has shown that it is possible to specify robust rules for calculating road damage costs which do not require much data. Typically these data are already collected for highway design studies; but if all the requisite information is not readily available, the cost of compiling data to fill the gaps is likely to be relatively small. It may be possible to borrow many relevant figures (on axle loading by type of vehicle, for example) from similar countries, validating them by visits to local trucking companies.

The main question to ask is whether road maintenance is condition responsive or not. If it is, the road authority's criteria for overlay in terms of roughness, typical repair intervals, and cost need to be ascertained. If not, then more complex calculations will be required and it is less likely that road damage costs will be stable over time. In such cases, designing a finely tuned set of road user charges is less important than reforming the management and finance of the highway system. In conditions of road crisis, higher levels or road user charge are likely to be justified than for well-managed systems: there is then no conflict between the need for revenue and the choice of an efficient set of road user charges. Later, when repairs have been completed and appropriate maintenance schedules are operational, road user charges can be adjusted downward.

The original design of the research project excluded congestion costs. However, during the course of the research, it became clear that congestion costs could not be omitted from our work because they are likely to be at least as important as road damage costs overall, and important for heavy vehicles as well as for cars. As a rough estimate, congestion costs are likely to be significant fraction of the interest on the capital stock of the road network plus the non-damage-related overheads of operating the road system.
As a rule of thumb, congestion costs are relatively less important than road damage costs on unpaved roads, are comparable to road damage costs on interurban paved roads, and are relatively more important on urban paved roads. The importance of congestion costs thus depends to some extent on the type of transport system, but it is hard to escape the conclusion that any serious study of road use costs should include congestion costs as well as road damage costs.

Road damage costs vary greatly across types of vehicles -- the ratio of costs for vehicles with the highest and lowest damaging effect is about 10,000:1. However, the sum of road damage and congestion costs varies much less across types of vehicles -- the ratio of highest to lowest is more likely to be about 10:1. Thus, any set of road user charges based upon recovering road damage costs alone would be quite inappropriate in its distribution of the charging burden and would almost certainly be unsustainable. On the other hand, sets of road user charges designed to reflect total road use costs, including congestion costs, can easily be designed and varied to reflect changing circumstances.

Rural congestion costs are likely to be less important than urban congestion costs. The theory relevant to computing such costs has been reasonably well worked out and the requisite data -- road widths and traffic flows -- are either available or can be collected at an acceptable cost.

Urban congestion is likely to be the larger part of total congestion costs. The complexity of the network effects (traffic spreads out over alternative roads in its attempt to avoid delays) and the greater variability of traffic flow over time on urban roads than on interurban roads make it difficult to measure congestion costs accurately. Some measure of area-wide relations between speed and flow is required, though it may be possible to adopt relations estimated for other cities and calibrated by observations on mean journey speeds. The measurement of urban congestion costs requires further research to improve the basis for estimating overall road use costs.

Although it is difficult to measure urban congestion costs with much accuracy, the effect of measurement errors may not be so serious, because the instruments available to charge for congestion are so blunt. Again, however, it would be helpful to have this hypothesis tested by more careful research on the problem.

In the absence of any satisfactory data, an extremely rough system of cost allocation can be defended as a first approximation. One such system would be to allocate two-thirds of the costs of road damage repair in proportion to ESA km; and then allocate two-thirds of the balance, including interest on capital, in proportion to PCU km (this allows for some weathering and some returns to scale in highway construction). The total revenue is likely to exceed total expenditure unless the road network is growing at a rate comparable to the rate of interest (which is unlikely over sustained periods of time).
Some data are essential if road use costs are to be estimated and allocated to individual vehicle classes. The warranted range of data, however, and thus the warranted efforts in collecting them, depend largely on the precision and efficiency with which costs can be translated into charges, and especially on the power of available instruments to discriminate between classes of users and segments of the network (e.g., urban and non-urban; different road classes). When the instruments available for charging are very blunt, as in the case just discussed, the range of necessary data can be kept to modest proportions; more would be wasteful. In section A of the following chart we summarize the data and computational steps required for a quick but roughly adequate determination of road use costs. When a significant share of annual road expenditures is devoted to surface maintenance rather than strengthening activities (as, for example, with a network in stable and good condition) there is a case for refining the quick method by distributing damage costs with slightly lower sensitivity to axle-loading. The steps are indicated in section B. But when the existing supply of data (through pavement management systems, investment studies and traffic surveys) is ample, or the efficiency of available instruments for charging for road use is sufficiently developed, then a detailed study, on the pattern described in Chapter 1 and the supporting technical papers, presents the most profitable solution.
A. QUICK METHOD

1. Sum all pavement- and bridge-related annual expenditures, including rehabilitation, resurfacing and
pavement maintenance items, but excluding construction items related to expansion or extension of the
network, and non-pavement and non-bridge-deck routine maintenance.

2. Evaluate the trend of road network condition under current and planned expenditures. If the condition of the
network is deteriorating in the medium term and the maintenance backlog is growing, then adjust the sum
calculated in A.1. upward by an amount that would be adequate to eliminate the backlog over a reasonable
period.

3. Estimate the ESA4 km travelled (EKT) by each vehicle class:
   (a) Determine ESA4 for a fully laden vehicle (the near-maximum, e.g., 95th percentile, observed loading,
       not the nominal value), derived from the fourth power of individual axle loads relative to a reference
       load of 80 kN.
   (b) Estimate average payload factor on a distance-travelled basis (default = 0.6), and average ESA4 =
       Load factor x ESA4 for full load (this assumes that empty vehicles have relatively negligible ESA4).
   (c) EKT = average ESA4 x annual VKT of vehicle class on paved roads.

4. Estimate fraction of damage attributable to traffic loadings as function of environment (default = 0.70), i.e.:

<table>
<thead>
<tr>
<th>Environment</th>
<th>ESA4 Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry nonfreeze</td>
<td>0.90</td>
</tr>
<tr>
<td>Wet nonfreeze</td>
<td>0.70</td>
</tr>
<tr>
<td>Dry freeze</td>
<td>0.55</td>
</tr>
<tr>
<td>Wet freeze</td>
<td>0.35</td>
</tr>
</tbody>
</table>

5. Unit road damage cost = adjusted sum of annual pavement expenditures [A.2] x traffic damage fraction

6. Determine passenger-car equivalent (PCE) km travelled (PKT) for each vehicle class.

7. The approximation to congestion costs is estimated from two amounts determined as follows: a) the sum of
all current road and bridge expenditures (excluding only investment-related items for expansion and
extension of the network, and upgrading and betterment of road standards), adjusted as in A.2 above. b) interest on the capital value of the network, e.g., the real international opportunity cost of borrowing on the
replacement cost of the network.
8. Congestion unit cost = \(2/3 \times \text{sum of adjusted annual expenditures and annual interest on capital of network}\) \([A.7]/\text{PKT [A.6]}.\) (Money/PCE km).

9. Road use cost = Road damage unit cost \([A.5] \times \text{ESA4 [A.3(b)]}\) + congestion unit cost \([A.8] \times \text{PCE [A.6]}\) (in money/km for each vehicle class).

B. REFINEMENT OF QUICK METHOD

(When the rehabilitation or strengthening program is small relative to the resurfacing and maintenance programs):

1. Divide the annual pavement and bridge-related expenditures of A.1 into:
   (a) strengthening-related items (e.g., rehabilitation, parts of betterment and reconstruction items) and
   (b) other resurfacing and maintenance items.

2. Adjust both expenditure sums \([B.1]\) appropriately to compensate for the medium-term trend of condition of the network (as for A.2).

3. (a) Determine the EKT in ESA4 km, as in A.3.

   (b) Similarly determine the EKT(2) in ESA2 km where ESA2 is derived from the second power of the axle loads relative to an 80 kN load reference.

4. Follow A.4 and modify step A.5 as follows:

   - Unit road damage cost (a) = Strengthening expenditures \([B.2(a)]\) x traffic-damage fraction \([A.4]/\text{EKT [B.3(a)]}\)
   - Unit road damage cost (b) = Other pavement expenditures \([B.2(b)]\) x traffic-damage fraction \([A.4]/\text{EKT (2) [B.3(b)]}\).

5. Follow steps A.6, A.7 and A.8 unchanged.

6. Road use cost = \{(damage unit cost (a) x average ESA4) + damage unit cost (b) x average ESA2 \([B.3, B.4]\)} + \{congestion unit cost \([A.8] \times \text{PCE [A.6]}\}\) (in money/km, for each vehicle class).

C. DETAILED METHOD

1. Using data on pavement condition, pavement strength, traffic volume, axle loadings (ESA4, ESA2), environment, and maintenance practices and costs, compute marginal road damage costs using a set of deterioration models in derivative form, following for example the methodology described in Part II of Newbery, Hughes, Paterson and Bennathan (1987).

2. Using data on existing road widths, speed, traffic flows and traffic capacities, compute congestion costs for inter-urban and urban conditions by an appropriate methodology (see Chapter 1, sections 1.3 and 1.4, for example).
Mainly on Taxes and Tax Bases

Before recommending an overall level for taxes on transport fuels, vehicles and other inputs into transport, it is necessary to consider, in addition to road use costs, how far transport offers an appropriate basis for general taxation. Here, the distinction between commercial freight and private passenger transport is crucial. The former is primarily an intermediate input into production, so that standard arguments imply that, provided suitable taxes on final goods are available, freight transport should not be subject to general taxation. However, the assumption that it is possible to impose appropriate taxes on items entering into final consumption is probably not satisfied in most countries. One might, therefore, wish to tax (or subsidize) freight transport as the best substitute for taxes or subsidies on commodities which cannot be taxed directly and for which transport costs have a significant impact on final price. The same argument can be extended to the taxation of diesel fuel, considering this both as an input into freight transport and as a general intermediate input into other activities. Any leverage of this kind would operate primarily through the effect of diesel and transport taxes on the prices of commodities such as cereals, cereal products and other foodstuffs. In Tunisia, as in many other countries, the government already intervenes to influence the prices of cereals and cereal products, while the case for taxing or subsidizing other foodstuffs on distributional grounds was found in Tunisia to be weak. It seems, therefore, that there are no grounds for imposing a pure tax (or subsidy) on freight transport. We would expect the same conclusion to hold in most developing countries. A further case against pure taxation of freight transport is also likely to arise from road transport regulation. As practiced in many developing countries, regulation already acts like a tax. It tends to raise the cost of transport, first to users of regulated public haulage enterprise (in Tunisia, by at least 15-20 percent above competitive levels), and then to own-account operators when quantity restrictions plus restrictions on use prevent them from operating the most economical vehicles in the most economical manner.

A much stronger case can be made for pure taxes on private transport as a source of general revenue and for redistributive purposes. Both car ownership and gasoline consumption are concentrated among the richer households in the population. Evidence on the social cost of revenue collected by taxes on gasoline and vehicles suggests that it would be appropriate to tax them at moderately high rates. Comparison between these rates and the current structure of taxes on private transport in Tunisia implies that taxes on gasoline could indeed be raised, while those on vehicle purchase and ownership seem to be excessive, particularly the fees imposed on more powerful cars. There is no efficiency argument for penalizing them relative to less powerful cars and their effect seems largely to have been a substitution of smaller for larger cars.

The case for switching the burden of taxation on private transport from vehicle ownership to the variable costs of car operation -- i.e., fuel, tyres and parts -- is strengthened by the analysis of the composition of road use costs associated with private vehicles. Since private cars are mainly
used in heavily congested urban areas, it might seem appropriate to recover their road use costs via access charges, i.e., license fees for operating vehicles in congested areas, but it turns out that the distance related component of congestion costs is much larger than the access related component. No method of recovering road use costs satisfies the ideal requirements of closely matching tax payments with marginal road use costs. Nonetheless, a tax on gasoline emerges clearly as the best method of recovering the road use costs of private vehicles as well as providing an appropriate method of levying a pure tax on private transport.

The major disadvantage of a tax on gasoline is that it collects too much revenue from private vehicles which are predominantly used on uncongested interurban and rural roads. Finer tuning would be possible if vehicle license fees were differentiated by area of registration, but this is almost certainly administratively infeasible and unenforceable. One major adjustment to vehicle license fees that certainly is required is to impose much heavier license fees or purchase taxes on cars and pickups with diesel engines than on similar vehicles with gasoline engines. Experience in Tunisia and elsewhere indicates that differential taxation of diesel and gasoline, if not accompanied by differential license fees, leads to a substantial shift from gasoline to diesel engines, undermining any attempt to recover road use costs and to tax private transport via a gasoline tax. A switch from gasoline to diesel engines in cars is also economically inefficient (at border prices) unless the cars are being used for at least 20,000 km per year.

Substitution between fuels also imposes important constraints on the taxation of diesel. A strong case can be made in many countries for subsidizing kerosene on distributional grounds. However, kerosene is a relatively close substitute for motor diesel oil and experience shows that it is almost impossible to prevent adulteration of diesel with kerosene if the prices of the two products diverge by more than 10-20 percent. Total kerosene consumption is typically small relative to total diesel consumption, but in a few countries such as Indonesia kerosene subsidies have encouraged substantial substitution away from other fuels in favor of kerosene. Prices and taxes for these fuels cannot be set independently and, in general, the scope for taxing or subsidizing either fuel is constrained by the consequent effects on the pricing and consumption of the other.

Freight transport typically accounts for less than one-half of total diesel oil consumption, so that any proposal to tax diesel in order to recover road user costs must take account of the response of non-transport users. Outside the transport sector diesel oil is primarily used by industrial enterprises which are able to switch to heavier fuel oils or to other fuels. The analysis of the impact of fuel taxes in models that allow for substitution between fuels and also between energy and other inputs suggests that the social cost of revenue collected through a tax on diesel and kerosene is high relative to revenue collected by taxes on gasoline, on vehicles, tyres and parts, and on road transport services. Equivalently, the social cost of subsidizing kerosene and diesel is also high. This implies
that domestic prices of diesel oil and kerosene should, as far as possible, be kept reasonably close to border prices, which limits the extent to which diesel oil can be used to recover road use costs from the freight transport sector.

The analysis of the social cost of alternative methods of recovering road use costs suggests that, in principle, the ideal method of taxing freight transport would be to impose a non-rebateable tax on road transport services. Unfortunately, this runs directly counter to the objective of encouraging deregulation of the road transport sector. It is difficult to devise methods of imposing a service tax on the activities of own-account transport operators, so that it would be necessary to rely upon higher license fees on vehicles used for own-account transport operations. Administratively, it would be necessary to insist upon a clear division between own-account and common carrier operators which would reinforce the regulatory wedge between the two types of operation. On the other hand, the point of deregulation would be to encourage competition between own-account and common carrier operations, so that any operator would be able to mix own-account and for-hire haulage in order to achieve efficient levels of vehicle operation and back haulage. Thus, if regulation is costly, so that deregulation should be an important object of road transport policy, it may be necessary to eschew use of a transport service tax in favour of taxes on inputs into road transport.

The assessment of the various instruments for recovering road use costs from freight transport has emphasized the complexity of the task of devising an appropriate scheme of road use taxation for a country. In particular, it is clear that any scheme should rely upon several components rather than a single tax - largely because diesel fuel offers the best single tax base but this has a high social cost outside the transport sector. There may also be considerable variations between countries in the suitability of different instruments of road use taxation, reflecting different circumstances such as the ratio of diesel oil consumption in transport to total consumption, the nature of the regulatory system and whether it would be possible to integrate a transport service tax with a general system of value-added or sales taxation.

Despite the lack of simple, prescriptive conclusions concerning the detailed structure of road use taxes it should be emphasized that the study has adequately demonstrated that fears about the wider impact of road use taxes may largely be discounted. In particular, taxes on fuels, transport inputs and transport services have a smaller effect on the general level of prices, and a (relatively) favorable distributional impact, by comparison with a number of important alternative tax instruments. The introduction of road use taxes in a revenue-neutral manner need therefore not conflict with the object to reduce cost-push inflation or to improve the distribution of income, provided that the revenue adjustment is achieved by lowering import duties or similar taxes.
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Note: The mention "Report Part II" in the following list refers to the Technical Papers produced for the World Bank's research on Pricing and Taxing Transport Fuels in Developing Countries. The full list of these is presented in the Annex to this paper. Copies of individual reports or papers (unless published in journals or books) are available from the World Bank, Infrastructure and Urban Development Department.


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Annex

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