A THEORETICAL MODEL FOR LOCAL ROADS GRANTS

A Evans
Professorial Fellow
Flinders University
Bedford Park
South Australia

ABSTRACT: *This paper presents an area-wide, policy-level, economic model of road taxation and investment to provide an intellectual framework for considering the distribution of local roads grants. Within this model the concepts of efficiency, equity, and fiscal equalisation all have a clear meaning. There is no escape from value judgements in grant distribution, but the type of model developed in this paper may demonstrate the nature and consequences of the choices involved. We have shown what sort of results the model gives by calculating the grant distribution on three principles for two imaginary countries with geographical characteristics similar to Australia and England. A conclusion is that the tension between equity and efficiency is more acute in countries like Australia with large low-density areas than for more densely populated countries.*

A THEORETICAL MODEL FOR LOCAL ROADS GRANTS

1 INTRODUCTION

Suppose national governments tax road users and then allocate a given quantity of the proceeds to finance local roads. How should this sum be distributed between local government areas? This question is faced by many governments, including those in Australia and Britain, but their practical answers lack a satisfactory intellectual basis. The most recent Australian review of the topic, that of the Independent Inquiry into the Distribution of Federal Road Grants (the Cameron Committee) (1986) concluded that the principles of cost-benefit analysis, fiscal equalisation, and the distinction between efficiency and equity could not be applied in distributing road grants; the Committee instead recommended that grants be distributed on the basis of an ad hoc and somewhat arbitrary combination of relevant indicators. While this recommendation may have been correct in the circumstances, it represents a challenge to provide a better intellectual framework.

This paper presents a simple economic model to investigate criteria for the distribution of expenditure and grants for local roads, and in particular to demonstrate the role that could in principle be played by cost-benefit analysis, fiscal equalisation, efficiency and equity. The model has two roots: first, area-wide, policy-level, road pricing and investment models of the kind pioneered by Keeler and Small (1977), and, secondly, the author's model investigating criteria for the distribution of grants for public transport subsidy (Evans, 1985). The roads model and the public transport model are similar in economic structure, and this enables ideas from both to be used.

The model abstracts drastically from the reality both of government and of roads. At the governmental level, we suppose that we have just two tiers of government, national and local, that each has responsibility for a separate and well-defined class of roads, and that there is only one form of road taxation. On roads, we assume that there are two classes of road, arterial and local, which are the responsibility of national and local government respectively; we focus on local roads. We also suppose that there is only one class of vehicle, which is in effect a composite of cars and commercial vehicles. The aim of this abstraction is to provide some insights into the principles of grant distribution without being lost in detail. At this stage we have made no attempt to test or estimate the model from empirical data, although we illustrate results from the model using guessed representative values of the parameters. We illustrate results for two imaginary countries, which are similar except for their populations, areas and road lengths: country A has a population of about 15 million in a large area, and somewhat resembles Australia (without its unincorporated parts); country E has a population of about 46 million in a small area, and somewhat resembles England (without Wales and Scotland). Monetary figures are in Australian dollars.

The paper continues as follows. Section 2 describes our assumptions about the structure of government and government finance in relation to roads. Section 3 presents the economic model of local roads. Section 4 considers criteria for the distribution of grants. Section 5 presents results for our two imaginary countries. Section 6 draws conclusions.

2. THE STRUCTURE OF GOVERNMENT

We suppose that a country has two levels of government. The upper tier is the national government; the lower tier comprises a number states or local governments, each of which covers a separate geographical area and all of which together cover the whole country. It does not matter for the purpose of this paper whether the country is a federation or a unitary state. We have in mind lower-tier governments that each have responsibility for about 5,000 kilometres of local roads. This is about the size of an English county; it is much smaller than an Australian state, but much larger than an Australian local government area. We shall refer to the lower tier governments as "local governments".

We assume that there are two classes of roads: arterial and local. Local roads account for about 85 per cent of the total road length, but only about one quarter of the vehicle-kilometres. In order to keep matters simple, we assume that the benefits from the use of arterial roads are diffused evenly over the whole country, but that the benefits of local roads accrue exclusively to the inhabitants of the local government area in which they are situated.

We assume that the arterial roads are the direct responsibility of the national government, and that local roads are the responsibility of local governments. However, only the national government raises a tax on road users. We assume this tax to be an amount per vehicle-kilometre, which might be a petrol tax. The national government uses the revenue from this tax for three purposes. First, it uses some to finance the arterial roads for which it has direct responsibility. Secondly, it transfers some to local governments in the form of grants to finance local roads. Thirdly, it may use some for non-road-related purposes.

We suppose initially that the local roads grants must be spent on roads (that is, are "tied" grants), and that the local governments have no other source of funds for local roads expenditure. This means that the grants and expenditures are equal. However, we later assume that the roads grants are untied, that local authorities may in fact raise local taxes, the burden of which falls locally, and that they have other functions besides roads. These later assumptions open up the possibility that the local roads expenditure of a local authority could be different from its local roads grant; it could be more if the local authority supplemented its grant from its local tax revenue; it could be less if the local authority used part of its road grant for some other purpose. It should be noted that such differences between grant and expenditure have no effect outside the local government area in question, because both the costs and the benefits of such differences fall locally.

On the assumptions above, arterial roads are funded by national taxes, and provide benefits which are nationally diffused. It follows that expenditure decisions on arterial roads have no local distributional consequences. We therefore ignore arterial roads for the remainder of this paper, and just consider the local road systems. If the assumption that the benefits of arterial roads are fully diffused seems too extreme, it would be possible to modify it, but that would complicate the presentation without adding new issues of principle.

We assume that the local road system is in a steady state, which is neither deteriorating nor improving in the long term. This avoids the distinction, which is important in practice, between the annualised total life-cycle costs of roads and the expenditure in any one year. These are different if there is a net change in average road condition over the year (see for example Luck and Martin, 1988, for a discussion). A steady state does not require that all road damage is repaired in the year in which it is incurred; it just requires that the total amount of maintenance and restorative work in a local government area balances the value of the total local road deterioration from all causes. We exclude from discussion any expenditure to improve or expand the local road system. Again, the distinction between major restorative expenditure and improvement expenditure may be more difficult to make in practice than it is in principle.

3. THE ECONOMIC MODEL

We present the economic model for a representative local government area. The model has four types of quantity: (1) policy variables; (2) output variables; (3) characteristics of the local government area; and (4) parameters. The policy variables are the tax per vehicle-kilometre, p, and the annualised fixed expenditure per local road-kilometre, k, which determines the average standard of local roads in the area. These variables are chosen by governments to meet whatever feasible criteria they specify. The output variables represent the response by road users to the choice of policy variables, and variables derived from this response. They are vehicle-kilometres, q, road expenditure, c, consumer surplus, s, net government revenue, r, and net economic benefit, b. The characteristics of the local government area are the population, n, and the local road length, l. We treat these as being outside the control of policy. The differences between different kinds of local government areas, from metropolitan to deep rural, are represented in the model by differences in the ratio of n to l. Finally, the model has four parameters, A, V, H and M, which are assumed to be the same for all local government areas. They are defined below.

Demand Function

The model has three equations. The first is the demand function:

$$q = q(g) = A.n.\exp(-g/V) \qquad (1)$$

where q is total vehicle-kilometres per year on the local road system; g is the generalised user cost per vehicle-kilometre, including time costs; n is the population of the local government area; A and V are parameters.

This model assumes that the number of local vehicle-kilometres in an area is proportional to population for given user costs per kilometre, g, and falls with increasing g ($V>0$) according to the exponential demand function. We have chosen the exponential demand function for convenience and because we used it successfully in the corresponding public transport model (Evans, 1985). We have no empirical evidence to support its use for road demand, although it is not implausible. The exponential function implies a skew distribution of gross valuations of travel by users: a minority of vehicle-kilometres are valued very highly, but a majority are valued at less than the average valuation.

As mentioned previously, we do not distinguish vehicle types in the model, presuming instead that the mix is the same in each local government area, though the mix on local roads may be different from that on arterial roads. A representative set of vehicle-kilometres is composed of a standard mixture of vehicle types, and generates the appropriate mixture of costs and benefits. Working with a notional standard mixture enables us to keep the model simple, and in particular to avoid the question of the relative cost-recovery rates of different classes of vehicles, which is the major focus of road cost-recovery studies (University of Tasmania, 1981; Travers Morgan, 1985; Luck and Martin, 1988). This question is not central to this paper. Nevertheless, the most obvious step for this model in the direction of realism would be to incorporate separate demand and cost models for different vehicle types.

The parameter V has the dimensions of price per vehicle-kilometre: in numerical work we give it the value of $0.50 per vehicle-kilometre. It can be shown from (1) that V is the negative of the ratio of any component of generalised cost to the elasticity of demand with respect to that component, and that this ratio is independent of the demand level. The figure of $0.50 is derived from Luck and Martin (1988, Table 7.1), which suggests a mid-range elasticity of demand of about -0.16 with respect to a price of about $0.08 per vehicle-kilometre. This in turn is derived from other studies, including that of the University of Tasmania (1981). The is great uncertainty about elasticity values, which translates in our model into uncertainty about the parameter V. Another way of thinking about V is furnished by the fact that with the exponential model V also turns out to be the average consumer surplus per vehicle-kilometre. In this light the value of 50 cents as an average over all vehicles and all journeys does not seem unreasonable. The value of the parameter A can be guessed more simply. We choose A so that, given the values of the other quantities, the demand model gives roughly the correct average number of vehicle-kilometres per person per year on local roads. We assume this average to be about 2,000, that is about one quarter of all vehicle-kilometres per person per year. The remainder are on arterial roads. The value of A found to give about this average and used in the illustrative calculations is 2,300.

The consumer surplus, s, to users of the local road system is the aggregate difference between the gross value that users place on their journeys and the total costs incurred, including time costs. This is the major benefit of the road system. With any demand function consumer surplus is the area under the demand curve above the current price. With the exponential demand curve, simple integration shows that consumer surplus takes a very simple form, namely

$$s = V.q \qquad (2)$$

This result that consumer surplus is proportional to vehicle-kilometres (or patronage in the case of public transport) is one of the attractions of the exponential demand function. As mentioned above, the constant of proportionality is V.

It is worth noting that if V is $0.50 and q is about 2,000 vehicle-kilometres per person per year, as mentioned above, the consumer surplus from the local road system per person per year is about $1,000. The consumer surplus for a country of 15 million inhabitants is therefore about $15,000 million, which is an order of magnitude greater than the public expenditure on local roads. This illustrates a general property of the economics of roads, that private benefits (and costs) are an order of magnitude greater than public expenditures. This means that small percentage changes in private costs or benefits can translate into sums that are not negligible when set alongside public expenditures.

Generalised Cost

We now come to the second equation in our economic model, that for generalised cost. This is

$$g = p + u(k) = p + H/k \qquad (3)$$

where g is the generalised user cost per vehicle-kilometre, p is the tax per vehicle-kilometre imposed by the national government, and u(k) is the user cost per vehicle-kilometre as a function of the annualised fixed cost per kilometre of road, k, which is a policy variable. The significance of the word "fixed" in the definition of k is that this cost is not traffic-related, and is incurred whether or not any traffic actually uses the road. We assume that u falls as k rises, most obviously because increasing k enables a better road surface to be provided, and also because increasing k permits the standard of the road to be raised more generally. The function u(k) therefore embodies the main engineering relationship in the model, that higher k permits a higher road standard, which reduces u. There is a optimal trade-off between the public costs, k, and the private costs, u.

In our numerical work, we have taken u(k) to be

$$u(k) = H/k \tag{4}$$

where H is a parameter. We have adopted this form for exploratory purposes because it has the right general shape, with increases in k giving large reductions in user costs when k is small, but much smaller reductions in user costs when k is large. We set H at 10 (in rather complicated units) by trial and error. The effect of this value can be illustrated by noting that with it the effect of raising k from $100 per kilometre per year (a very low standard of road, probably completely unsurfaced) to $1,000 per kilometre per year is to reduce u(k) by 9 cents per vehicle-kilometre, from 10 cents to 1 cent. This seems broadly consistent with the operating costs mentioned in Abelson (1986, pp43-45). We should mention at this point that a full specification of user costs per vehicle-kilometre also have a large constant added to the term H/k on the right-hand side of (4), representing the large component of user costs that do not depend on the policy variables p or k, including petrol costs, much of vehicle maintenance costs, and much of time costs. However, in this model such a constant is both unnecessary and indeterminate. This is because, when g is substituted back into the demand function (1), any constant becomes a constant in the exponent, which just becomes another multiplying constant alongside A, and indeterminate from A. We therefore absorb the invariant user costs into the constant A. This means that if the user costs change for an external reason, such as a change in the real petrol costs, then A would change.

The form of u(k) in (4) is different from the corresponding form in many of the previous policy-level roads models, such as those of Keeler and Small (1977), Starrs and Starkie (1986), and Newbery (1988). In these models the term involving k takes a form such as u(q/lk) in our notation, where l is road length, and k is a measure of road capacity, such as width or number of lanes. In these models u′ is positive, whereas in ours it is negative. The ratio q/lk is a measure of the traffic load factor on the network, and the u-term reflects the effect of congestion on user costs: the greater the load factor, the greater is u and hence g. In these models the motive for increasing k with increasing demand is to relieve congestion. This is completely different from the motive in our model, where increasing k reduces user costs generally, irrespective of the traffic load. In our model the reason why in equilibrium k increases with q is that on higher demand roads there are more vehicles to benefit from the user cost reductions promoted by k, and therefore it is worthwhile to increase k. This is the usual calculation made in cost-benefit analyses of rural roads. It is possible to have both types of term in a specification of generalised cost, but we have judged that a congestion term is unnecessary in our model, because congestion is not a major reason for investing in local roads, even in urban areas.

It is worth noting the parallel between the discussion above of the terms in the generalised cost equation, and the corresponding equation in public transport models, such as those of Glaister (1984) and Evans (1985). In public transport models, the role of k is taken by a policy variable representing the public transport service level, either bus-kilometres or frequency. The u-term in (4) corresponds to the term in public transport models reflecting the reduced waiting time from higher frequencies, sometimes called the "frequency benefit" or "Mohring effect". The frequency benefit per passenger is the same whatever the load factor, but it is more worthwhile providing high frequencies on high-demand routes than on low-demand ones because there are more passengers to benefit from them. It is possible also to have a congestion term in public transport models, as in Glaister (1984), but this term is a second-order effect. In public transport models the frequency benefit generates a case in principle for subsidy to public transport; so also does the u-term in (4) above. However, with our figures the magnitude of the net benefit from a roads subsidy is very small indeed.

Public Road Costs

The third and last equation of the economic model gives public local road costs per year, c.

$$c = l.k + M.q \qquad (5)$$

where M is the marginal or avoidable cost per (composite) vehicle-kilometre, and the other symbols have been defined above. M primarily represents avoidable road damage. We assume that M is the same for all road types, although it would be simple to make it depend on k. In the numerical work we assume that M is $0.015 or 1.5 cents per vehicle-kilometre. This is the average of a large proportion of light vehicles which do little damage, and a small proportion of heavier vehicles which do more. In equation (5) M.q is total avoidable cost, and l.k is the joint cost which does not vary with traffic.

Revenue, Consumer Surplus, and Net Economic Benefit

The policy variables p and k are chosen by governments. For any choice of these the net revenue, r, accruing to the national and local governments combined is total revenue less total cost. That is,

$$r = p.q - l.k - M.q \qquad (6)$$

If the tax on road users is a national tax, and local roads are financed entirely by grants from the national government, then both the revenue and the cost fall nationally, and the net revenue, r, accrues entirely to the national government. The benefits (or costs) are therefore diffused among the national taxpayers without discrimination in favour or against the inhabitants of any particular local government area.

The consumer surplus accruing from local roads was given in equation (2) as V.q. On the assumption of section 2, this accrues entirely to the local inhabitants.

Net economic benefit, b, is the sum of consumer surplus and net governmental revenue. It is given by

$$b = V.q + p.q - l.k - M.q \qquad (7)$$

This accrues partly to the local inhabitants and partly to national taxpayers. The total net economic benefit from all local road systems is the sum of expressions (7) over all the local government areas in a country. Inhabitants receive this benefit partly as national taxpayers and partly as users of their local road systems. However, on the assumption that local roads are financed from grants, the net economic benefit per head will not necessarily be the same in different local government areas. It will be the same only if consumer surplus per head is the same in each area. That depends on the criterion by which the national government distributes its grants. We discuss such criteria in the next section.

4. CRITERIA FOR GRANT DISTRIBUTION

First of all, how do, or should, governments choose p and k for each area? There are many possibilities, especially if, contrary to our initial assumption, we were to allow local governments as well as national governments to have discretion. One theoretical possibility would be to choose the p's and k's so as to maximise total net economic benefit without constraint. This is never adopted in practice, because it requires a subsidy to the road system from taxpayers generally, but it is interesting as a theoretical benchmark. Another possibility is to maximise total net economic benefit subject to a zero-subsidy constraint. Again this is mainly of theoretical interest, although we have calculated what the net economic benefit is under this constraint, and we mention the result in section 5.

If we leave aside these theoretical benchmarks, the obvious policies to consider are those which resemble the actual policies of governments. One such policy is that the national government sets the value of p at an arbitrary level, which is high enough to bring in substantially more revenue than it requires to finance the grants for local roads. The same value of p applies in all local government areas. In the calculations below we assume that the national government sets p arbitrarily at $0.06 or 6 cents per vehicle-kilometre. The national government then decides what the total of grant/expenditure shall be, and finally how to distribute this total among the various local governments. For the moment let us suppose that the national government sets the total amount of grant/expenditure arbitrarily. We continue to assume that grants are the only source of funds for local roads, so that grant and expenditure are equal.

We now consider how the national government might distribute such an arbitrary total grant/expenditure among the local government areas. This is the problem addressed by the Cameron Committee (1986) and similar bodies in other countries. Although the Cameron Committee concluded that the concepts of efficiency and equity could not be applied in the world of real governments and real roads, these concepts do have a clear meaning within our model, and indeed are the leading contenders as principles of distribution.

<u>Efficiency</u>

First we consider efficiency. The distribution according to the efficiency principle is that which maximises total net economic benefit in the country as a whole, subject to the given grant/expenditure total and with the given value of p. In other words it maximises the sum of expressions (7) over all local government areas. This requires that the marginal net economic benefit per $ of expenditure is equal in all local government areas. This equalised marginal rate of net benefit may be positive, zero, or negative, depending on what the total expenditure is. The higher the grant/expenditure is, the lower is the equalised marginal net benefit, because increasing expenditure gives diminishing returns, through equation

(3). If the grant/expenditure is such that the equalised marginal net benefit is zero, it is at the level which maximises total net economic benefit in the country as a whole. In the calculations below, we assume that total grant/expenditure is indeed set at this level, mainly to avoid having another arbitrary figure, but the same principles of distribution apply at any level of grant.

Fiscal Equalisation

The efficiency principle is often advocated for resource allocation, but it is open to serious objection as a principle for distributing inter-governmental grants. The objection is that it may lead to very different levels of net economic benefit per head in different local government areas, or, in more general language, different levels of service. Low-density areas tend to get lower levels of service. This is inequitable, and is widely regarded as unacceptable unless the areas with poor levels of service have some form of compensation, such as lower tax rates. For this reason the efficiency principle is not generally used for the distribution of inter-governmental grants. Instead, the leading contender is an equity principle, known as "fiscal equalisation". (See King, 1984, for a general discussion.) The fiscal equalisation principle is that grant should be distributed so that all local areas are able to provide the same level of service for the same tax rate. This principle governs most inter-governmental grants in Australia (but not tied roads grants), although in the official statements the words "not appreciably different" are used instead of "same" in the previous sentence (Commonwealth Grants Commission, 1988). Fiscal equalisation also governs the distribution of the inter-governmental Rate Support Grant in Britain, including that for road maintenance.

The principle of equity or fiscal equalisation again has a clear interpretation in our model. This is partly because the economic model is so simple, and what might be different interpretations of the phrase "same level of service" all give the same results in our model. Nevertheless, even with more complex models, any reasonable interpretation of fiscal equalisation will give a different result from the efficiency principle. First, we should note that because p is set by the national government, the road tax rate in our model is already the same everywhere. The fiscal equalisation principle then requires that service levels are the same everywhere. One interpretation of this in the terms of our model is that consumer surplus per head should be the same everywhere, because consumer surplus represents the benefit that people get out of their local road systems. An alternative interpretation is that k, representing the average standard of local roads, should be the same everywhere; yet another is that the generalised cost per vehicle-kilometre should be the same everywhere. Fortunately, with our simple model all these interpretations give the same result. We present the results for our imaginary countries A and E in the next section. Not surprisingly, the distribution favours the low-density areas as compared with the efficiency principle. However, it should be noted that although fiscal equalisation equalises k, the average annualised fixed cost per kilometre of road, it does not equalise total grant/expenditure per kilometre. This because total expenditure includes avoidable expenditure (the term M.q in (7)), and avoidable expenditure per kilometre is higher in high-density areas.

Equity by Compensation

Fiscal equalisation leads to an expenditure distribution which is inefficiently high in low density areas, and inefficiently low in high-density areas. Total net economic benefit is therefore less than the maximum possible for any given level of expenditure. The numerical calculations in the next section suggest that the loss of net economic benefit is slight in country E, which has a fairly high density everywhere, but much greater in country A, which has some very low-density areas. Therefore, while the efficiency principle is open to the objection that it is not equitable, fiscal equalisation is open to the objection that it is not efficient. Is it possible to combine the merits of both? The answer is "no" if we assume, as hitherto, that road grants and expenditures in each area are equal, but "yes" if we drop this assumption. This means allowing the possibility that grants given on account of roads are not actually spent on roads. We now discuss this possibility.

First, efficiency requires that all local government areas actually spend at the efficient level, or in other words up to the point at which the marginal net benefit is zero, but not beyond this point. This distribution of spending is in accordance with the efficiency principle. As discussed above, this gives an uneven distribution of consumer surplus per head, which is inequitable. However, if grant is now separated from expenditure, we can use the grant distribution to compensate for this inequity. The national government would distribute grant so that, assuming that local governments spend in accordance with the efficiency principle, the per capita sum of grant net of expenditure and consumer surplus is equalised. The effect of this would be that high-density areas would be expected to spend relatively highly on roads, but the grant would fall short of this expenditure, the balance of the expenditure being made up from local taxes. These areas would generate more consumer surplus per head than average from their local road systems, but the excess would effectively be transferred away through the higher local taxes. By contrast, low-density areas would be expected to spend relatively less on local roads, because to spend more would be wasteful, but receive more grant than they spend. The balance of the grant would be used to reduce local taxes, which would be compensation for the lower consumer surplus generated from their local roads. We give some numerical examples of this grant distribution in the next section.

Although the author is not aware of any grant system which explicitly adopts this idea, the whole system of lower-tier governments with local tax-raising powers and untied grants could be viewed as a mechanism for allowing this kind of trade-off. On the other hand, one has to have one's tongue in one's cheek to suggest that departments of transport and highway authorities might allocate some of their hard-won money in the expectation that it would be spent on another service.

5. ILLUSTRATIVE RESULTS

We now present some calculations to illustrate the results of the three different grant distribution principles for the two imaginary countries mentioned in the introduction, A resembling Australia and E resembling England. The main purpose of presenting these results is to demonstrate that the model is workable. We shall look at the results in a broad-brush way, but, because the model is over-simple and the parameter values are mere guesses, there is no point in going into detail.

Tables 1 and 2 give data and results for countries A and E respectively. In each country we assume that the local governments are of a size to be responsible for 5,000 kilometres of local roads. This is about the size of an English county, but there is no equivalent in Australia. We assume that there are four different kinds of local government area in country A and three in country E. Each country comprises a number of each kind of area; the numbers are shown at the top of Tables 1 and 2. In country A the kinds of area range from metropolitan areas, each with a population of 1 million in an area of 2,100 square kilometres, some of which may be contiguous, to deep rural areas, each with a population of 10,000 in an area of 70,000 square kilometres. Each of these is itself more than half the total area of Country E. The local

TABLE 1. RESULTS FOR COUNTRY A

Type of Area	Metropolitan	Country Towns	Rural	Deep Rural	Whole Country
Number of areas of this this type	10	11	50	40	111
CHARACTERISTICS OF EACH LOCAL GOVERNMENT AREA					
Local Road length (km)	5,000	5,000	5,000	5,000	555,000
Population (000's)	1,000	200	50	10	15,100
Area (sq km)	2,100	25,000	50,000	70,000	5,596,000
Road Tax Rate, p ($ per veh-km)	0.06	0.06	0.06	0.06	
FIXED COMPONENT OF ROAD EXPENDITURE, k ($ per kilometre)					
Efficiency	2,100	930	460	200	560
Fiscal Equal'n	570	570	570	570	570
Equity by Compn	2,100	930	460	200	560
TOTAL ROAD EXPENDITURE ($ per kilometre)					
Efficiency	8,160	2,130	750	260	1,380
Fiscal Equal'n	6,480	1,760	870	630	1,380
Equity by Compn	8,160	2,130	750	260	1,380
GRANT ($ per head)					
Efficiency	40.8	53.3	75.4	128.0	50.7
Fiscal Equal'n	32.4	43.9	87.0	316.8	50.7
Equity by Compn	31.2	55.6	99.4	205.5	50.7
CONSUMER SURPLUS PLUS GRANT NET OF EXPENDITURE ($/head)					
Efficiency	1010.3	998.3	976.7	923.2	1000.7
Fiscal Equal'n	985.1	985.1	985.1	985.1	985.1
Equity by Compn	1000.7	1000.7	1000.7	1000.7	1000.7
NET ECONOMIC BENEFIT ($ per head)					
Efficiency	1090.7	1064.8	1018.5	906.0	1070.1
Fiscal Equal'n	1070.8	1059.4	1016.3	786.5	1052.6
Equity by Compn	1090.7	1064.8	1018.5	906.0	1070.1

TABLE 2. RESULTS FOR COUNTRY E

Type of Area	London-like	Other Metropolitan	Non-Metropolitan	Whole Country
Number of areas of this this type	2	6	36	44
CHARACTERISTICS OF EACH LOCAL GOVERNMENT AREA				
Local Road length (km)	5,000	5,000	5,000	220,000
Population (000's)	3,100	1,900	800	46,400
Area (sq km)	700	1,200	3,400	131,000
Road Tax Rate, p ($ per veh-km)	0.06	0.06	0.06	
FIXED COMPONENT OF ROAD EXPENDITURE, k ($ per kilometre)				
Efficiency	3,700	2,900	1,880	2,100
Fiscal Equal'n	2,100	2,100	2,100	2,100
Equity by Compn	3,700	2,900	1,800	2,100
TOTAL ROAD EXPENDITURE ($ per kilometre)				
Efficiency	22,570	14,440	6,720	8,490
Fiscal Equal'n	20,890	13,620	6,950	8,490
Equity by Compn	22,570	14,440	6,720	8,490
GRANT ($ per head)				
Efficiency	36.4	38.0	42.0	40.3
Fiscal Equal'n	33.7	35.8	43.4	40.3
Equity by Compn	32.7	35.9	43.7	40.3
CONSUMER SURPLUS PLUS GRANT NET OF EXPENDITURE ($/head)				
Efficiency	1014.5	1012.9	1009.1	1010.8
Fiscal Equal'n	1010.3	1010.3	1010.3	1010.3
Equity by Compn	1010.8	1010.8	1010.8	1010.8
NET ECONOMIC BENEFIT ($ per head)				
Efficiency	1099.8	1096.5	1088.2	1091.8
Fiscal Equal'n	1097.8	1095.7	1088.1	1091.2
Equity by Compn	1099.8	1096.5	1088.2	1091.8

government areas of country E range from London-like to non-metropolitan. The London-like areas each have a population of 3.1 million in an area of 700 square kilometres; both these figures are about half those of the real London, so there are two such areas in country E. The non-metropolitan areas have densities which are less than those of the metropolitan areas of country A, but much greater than those of the other areas of country A. Apart from these geographical differences, we suppose that countries A and E are alike: they have the same demand functions, costs, and road tax rate of $0.06 per vehicle-kilometre.

The results given for each type of area in Tables 1 and 2 are the annualised fixed component of road expenditure per kilometre, k; the total road expenditure per kilometre, that is including the traffic-related, or avoidable, cost; the grant per head; consumer surplus per head; and net economic benefit per head. The difference between the last two is the national government's surplus per head, because tax revenue exceeds road expenditure.

As mentioned in Section 3, an important general point about the results is that the order of magnitude of the consumer surpluses, at about $1,000 per person per year, is much greater than that of road expenditure, which is about $50 per person per year in country A and $40 per person per year in country E; these expenditures are those which give maximum net economic benefit if distributed according to the efficiency criterion. The percentage variations in the consumer surplus in different circumstances are slight, but they sometimes give appreciable figures in relation to government spending. We may note also that the national government net surplus, at about $70 per person per year in country A and $80 per person per year in country E, is also small relative to consumer surplus, but it is large in relation to public expenditure. In passing, it is worth noting that if the government surplus were eliminated by suitable reductions in the road tax rate, net economic benefit in this model would rise by only about $4 per head per year. This implies that the deadweight loss on the element of general taxation in the road tax rate is only about 5 per cent of net revenue raised. This makes road taxation a relatively efficient way to raise general government revenue.

We now look at the road expenditures. In country A, on the efficiency criterion the average annualised fixed cost per kilometre of local road, k, varies by a factor of 10 between the metropolitan and deep rural areas ($2,100 to $200 in Table 1, though no weight should be given to the specific figures). This is consistent with the fact that sealing is efficient for most metropolitan local roads, but various forms of unsealed road are more efficient in rural areas. The corresponding variation for country E is much less ($3,700 to $1,880), which is consistent with the fact that there are few unsealed local roads in high-density countries. The average total road expenditure, including the traffic-related costs, varies between areas by a greater factor than fixed expenditure, because of variations in traffic intensity. In country A the variation between the metropolitan and deep rural areas is a factor of about 30; this is broadly consistent with the cost variations in the Cameron Report (1986, p124); our parameters were chosen to make them so.

We now compare the results of the fiscal equalisation criterion for the distribution of grant and expenditure with the efficiency criterion. There are interesting differences between the two countries A and E. In both countries fiscal equalisation forces the fixed road expenditure per kilometre, k, to be the same in all areas, but this has a much greater effect in country A than E, because there would otherwise be greater variation in A. In country A, fiscal equalisation forces fixed expenditure down to about one quarter of its efficient level in metropolitan areas, and up to about three times its efficient level in deep rural areas. This results in a substantial waste of resources, which shows up in the bottom right-hand corner of Table 1 as a difference of $17.5 per head per year in the national average net economic benefit. This is equivalent to about one third of total local road expenditure, too large a sum to ignore. On the other hand, as also shown in Table 1, fiscal equalisation succeeds in its aim of equalising consumer surplus per head, whereas the efficiency criterion leaves deep rural inhabitants worse off than metropolitan ones by $87 per year. Therefore in country A the tension between equity and efficiency is a real one, and this makes escape routes such as equity by compensation seem relatively attractive. By contrast, in country E the tension between equity and efficiency is much weaker, because the efficiency losses from adopting fiscal equalisation are much less, about $0.6 instead of $17.5 per person per year. This is because country E has a higher and more uniform density than A. Therefore country E could afford to adopt fiscal equalisation with few qualms.

6. CONCLUSIONS

This paper is theoretical, not empirical. Its main purpose has been to demonstrate that it is possible to develop a respectable intellectual framework in which to consider principles of grant distribution for local roads. This framework consists of an area-wide, policy-level, economic model of road taxation and investment. The model is similar to previous policy-level economic models of roads, with the very important difference that the motive for road investment in our model is not to relieve congestion, as it was in the previous models, but to reduce user costs directly. This is consistent with the typical rural (or local) cost-benefit study.

There is a close parallel between our economic model for roads and recent policy-level models of public transport. The user benefits from road investment in our roads model (but not in the previous roads models) correspond with the so-called "frequency benefit" in public transport models. However, although the structure of our roads model is similar to that of public transport models, the parameters and the policy issues are different. This is manifest most obviously in the fact roads generate substantial surpluses for governments, whereas public transport often does the opposite.

Within the economic model, the concepts of efficiency, equity, and fiscal equalisation all have a clear meaning. With a more complex model some of this clarity would disappear, but nevertheless such a model would still provide a framework for considering the value judgements that are inescapable in grant distribution. There is no single correct principle for grant distribution, but this kind of model is valuable in demonstrating the nature and consequences of the choices involved.

We have brought the model to life and shown that it is workable by guessing values for the parameters, and carrying out calculations to demonstrate the results of three principles of grant distribution for two imaginary countries, chosen to have geographical characteristics resembling Australia and England. Two conclusions follow from these calculations. First, it is possible to find parameter values which give results that appear to be reasonably consistent with the real world; presumably one might do better with a more sophisticated model and proper estimation methods. Secondly, and this is the nearest we get to an empirical conclusion, it seems that the tension between equity and efficiency in the use of resources for roads is much more acute in countries like Australia with enormous low-density areas than in the more dense European countries.

REFERENCES

Abelson, P (1986). The Economic Evaluation of Roads in Australia. Australian Professional Publications.

Committee of Inquiry into the Distribution of Federal Road grants (Cameron Report) (1986). Report. Australian Government Publishing Service.

Commonwealth Grants Commission (1988). Report on General Grant Relativities. Australian Government Publishing Service.

Evans, A (1985). Equalising Grants for Public transport Subsidy. Journal of Transport Economics and Policy, 19, 105-138.

Glaister, S (1984). The Allocation of Urban Public Transport Subsidy. In J Le grand and R Robinson (eds): Privatisation and the Welfare State. George Allen and Unwin.

Keeler, T E and Small, K A (1977). Optimal Peak-Load Pricing, Investment and Service levels on Urban Expressways. Journal of Political Economy, 85, 1-25.

King, D N (1984). Fiscal Tiers: the Economics of Multi-Level Government. George Allen and Unwin.

Luck, D P and Martin, I J (1988). Review of Road Cost Recovery. Bureau of Transport and Communications Economics Occasional Paper 90. Australian Government Publishing Service.

Newbery, D M (1988). Road User Charges in Britain. Economic Journal (Conference 1988), 98, 161-176.

Starrs, M M and Starkie, D N M (1986). An Integrated Road Pricing and Investment Model: A South Australian Application. Australian Road Research, 16, 1-9.

Travers Morgan (1985). South Australian Cost Recovery Study. South Australian Department of Transport.

University of Tasmania (1981). Transport Economics centre. Pricing Tasmania's Roads.