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TOPIC 18
ENVIRONMENT AND
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AUSTRALIAN ROAD TRACK COST RECOVERY: AN INTERNATIONAL COMPARISON

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Abstract

ARRB has completed estimates of attributable road wear, pavement and bridge cost portions of the road track costs (state road agency costs) for Australia's arterial roads. ARRB's estimates of attributable costs are compared with those derived from the road track cost attribution practices of the US, the UK, South Africa and New Zealand.

INTRODUCTION

Since 1990 ARRB Transport Research Ltd. (formerly the Australian Road Research Board) has undertaken research into the allocation of road track costs (road agency expenditures) to Australia's arterial road users. Initially, a limited review and comparison was undertaken (Martin 1991) of the existing road track cost allocation practices of New Zealand (NZ), United Kingdom (UK), United States (US) and South Africa (SA). Subsequent to this ARRB has completed two cost allocation studies (Martin 1992, 1994) in finalising estimations of Australia's attributable road track costs.

The allocation of road track costs to the users of Australia's arterial roads is currently proposed within the context of a pay-as-you-go (PAYGO) process where costs are attributed to those who give rise to them. PAYGO attributes costs to users by average variable costing rather than by marginal costing. This approach is pragmatic but the cost consequences of road use are averaged out and not paid for by those individually responsible. The PAYGO approach uses the annual road track expenditure as a proxy for the annual cost of road use (NRTC 1993) which implies that expenditures are equivalent to costs which is not always the case in practice.

The road track cost allocation practices of NZ, UK, US and SA are based on PAYGO, use average variable costing, and treat annual road track expenditures as current costs. NZ, UK and US are now considering applying marginal costing to some road track and external costs (van Geldermalsen 1991; LTT 1994; Small et al. 1989). SA currently has a unique approach in estimating annual road track costs as it converts past and present capital road infrastructure expenditures to an equivalent annual cost (Prins 1988; SA DOT 1991). This approach accounts for the life-cycle cost nature of road infrastructure expenditure as it allows for deterioration (depreciation) and opportunity cost.

Australia's estimated attributable road track costs are compared with those of NZ, UK, US and SA. This comparison is limited to the following road track costs:

- road maintenance cost; and
- road pavement and bridge (provision and replacement) cost.

The international comparison of the attributable road maintenance, pavement and bridge costs provides some information about the relative levels of road infrastructure investment and ongoing maintenance cost commitments. This comparison is based on the assumption that there is a sound basis for each country's practice of allocating costs, and that each practice is compared on the same basis.

AUSTRALIA'S ATTRIBUTABLE ROAD TRACK COSTS

Attributable maintenance costs

Maintenance costs are defined as the expenditures incurred in preserving and restoring the existing road infrastructure to a level of performance that does not exceed that of the original design. Maintenance expenditure was assumed to involve the following activities: pavement related routine maintenance (pothole patching, shoulder grading and pavement drainage), periodic maintenance (resealing, surface corrections, asphalt regulation and thin overlays) and limited major patching.

Attributable maintenance was assumed to equal load-related road wear, that is, road wear due to heavy vehicles. The following approaches were used to estimate the attributable maintenance cost:

- Field measurement of load-related wear on 45 arterial road samples in all states except Queensland, Tasmania and South Australia. The load-related road wear estimates from 14 local roads were also used in producing a relationship between load-related road wear and the factors considered to influence it. Some 1% of Australia's sealed arterials made up the load-related road wear samples.

- The variable portion of the annual average maintenance expenditure relationship. The maintenance expenditure relationship was developed by relating the annual average maintenance expenditure with heavy vehicle road use and pavement age, using 255 arterial road samples across Australia. These maintenance expenditure samples are around 5% of Australia's sealed arterials.

Attributable maintenance cost by load-related road wear measurement

The field measurement of load-related road wear assumed that pavements are elastic and homogeneous, and that all road wear was reflected by some form of structural deformation. Load-related wear estimation was based on measuring the road roughness changes along and between specified heavy vehicle wheel paths, using the profilometer and the Falling Weight Deflectometer (FWD). The average percentage load-related wear was estimated along one lane of each sample arterial road and related to a number of independent variables in an attempt to produce a relationship for load-related road wear. The resulting relationship (Martin 1994, Table 3.2) had a poor goodness of fit (coefficient of determination $R^2 = 0.18$), although it had some statistical significance ($p \leq 0.05$ for 't' and 'F' tests).

Field measurement of load-related road wear along multi-lane urban arterials (Martin 1995) found substantial variations in the individual estimates of load-related wear. These substantial load-related wear variations reflect the generally non-homogeneous nature of pavements. The non-homogeneity of pavements was probably accentuated on multi-lane urban arterials as the magnitudes of the measured road roughness changes are often relatively low. The roughness changes may be masked by variations in pavement and surface conditions. In view of the above results, the assumptions upon which measurements were based and the limited number of samples used, the estimation of attributable maintenance cost via a load-related road wear relationship was not used.

Attributable maintenance cost estimate

A maintenance expenditure relationship for Australia's arterials was based on the relationship between annual average maintenance expenditure, the dependent variable, and one independent road use variable from linear regression (Al-Suleiman et al. 1991) and pavement age. Pavement age was selected as an independent variable as it may influence the timing and magnitude of maintenance expenditure.

Statistically significant maintenance expenditure relationships were found for most state's rural arterials samples and a combined state urban arterials sample (Martin 1994, Table 3.4). The maintenance expenditure relationship representing Australia's rural arterials was based on using the heavy vehicle annual vehicle kilometres travelled (AVKT) of each state to re-proportion each state's samples.

A general hyperbolic relationship for the percentage attributable maintenance cost was derived from the variable and total expenditure portion of the maintenance expenditure relationships. The hyperbolic relationship for attributable maintenance cost meets the boundary conditions by being zero when the road use variable is zero and asymptotes to 100% when the road use variable approaches infinity (Martin 1994). An estimate of Australia's attributable maintenance cost was based on the variable and total expenditure portion of the maintenance expenditure relationship for Australia's rural arterials. This estimate used a value for average national rural/urban heavy vehicle road use substituted in the hyperbolic attributable maintenance cost relationship (Martin 1994, Appendix B.3).

Attributable pavement and bridge cost estimation

Pavement and bridge costs are defined as the expenditures incurred in constructing, reconstructing and rehabilitating pavements and bridges, respectively. The attributable pavement and bridge costs were estimated by the following approaches:

(i) a two step incremental cost method applied to six road construction projects and five bridges in New South Wales and Victoria; and

(ii) deriving pavement and bridge expenditure relationships based on their relevant design variables using a total of 82 samples (47 pavements and 35 bridges) from Victoria, New South Wales, Queensland and Western Australia.

Approach (i) is usually based on the assumption that road networks are generally designed for light vehicles and that any additional expenditures required to accommodate heavy vehicles should be directly attributed to them. The main concern with approach (i) is how these additional expenditures, once identified, are allocated to the various groups of road users.

Approach (ii) seeks to build relationships between expenditure and the design variables that define the variations in this expenditure.

Approach (i) was used to estimate the attributable bridge cost because of the particularly poor statistical fit obtained for the bridge expenditure relationship by approach (ii). Approach (ii) was used to estimate the attributable pavement cost because of the greater number of pavement samples available.

Attributable bridge cost by the incremental cost method

Non-linear cost relationships were developed between the dependent variable, the percentage variable bridge cost found from the incremental cost method, and one nominal bridge design variable. An estimate of the attributable bridge cost on Australia's arterial roads was determined using the percentage variable bridge cost relationship with a bridge design variable for average national rural/urban road use (Martin 1994, Appendix B.3).

Attributable pavement cost using expenditure relationships

The pavement expenditure, the dependent variable, was related to one independent pavement design variable by a regression analysis. A non-linear relationship for pavement expenditure was found to best fit the data. The variable and total expenditure relationships for pavements were substituted into a hyperbolic relationship for percentage attributable pavement cost, in the same manner as that used for attributable maintenance cost. The estimate of attributable pavement cost for Australia used the percentage attributable pavement cost relationship with the variable and total pavement expenditure relationship for Australia's rural/urban arterials. The pavement expenditure relationship representing Australia's rural/urban arterials was based on using the heavy vehicle AVKT of each state to re-proportion each state's samples. A pavement design value for average national rural/urban heavy vehicle road use was substituted in the hyperbolic attributable pavement cost relationship.

Summary of Australia's attributable cost estimates

The attributable cost estimates summarised in Table 1 are rounded off to the nearest 5% due to the size of their 95% confidence limits. The figures in brackets are the 95% confidence limits of the attributable cost estimates. Although the supporting data was diverse and difficulty was experienced in developing prediction models that adequately fitted the data, all the relationships used in estimating Australia's attributable costs are statistically significant. In the cases of maintenance and pavement costs, the levels of attributable cost are strongly related to heavy vehicle road use as a result of the hyperbolic attributable cost relationships.

Table 1 Summary of Australia's attributable road track cost estimates

Road Track Costs	% Attributable	Attribution Variable
Maintenance		
– Routine maintenance (pavement related)	50 (±7)	GVM.km
– Periodic maintenance		
– Limited major patching		
Bridges		
– New and replacement	15 (±5)	PCU.km
Pavements		
– New and replacement	45 (±6)	ESA.km
– Reconstruction		
– Rehabilitation		

INTERNATIONAL COMPARISON OF ATTRIBUTABLE ROAD TRACK COSTS

A common definition of road track cost

A comparison of the attributable road track costs from NZ, UK, US, and SA with those estimated for Australia was made from a common basis of road track cost definition. Earlier ARRB work (Martin 1991) estimated road track cost concordances between these other practices and that of the Australian Transport Advisory Council (ATAC). The development of these concordances was largely judgemental in nature, consequently the basis of these comparisons is not precise but is the only basis currently available.

The comparison of attributable road track costs was made by relating the ATAC road track cost definitions to the definitions used by ARRB's attributable road track cost study. The following summarises the relationship between the ARRB road track costs and the ATAC road track cost definitions:

ARRB Road Track Costs	ATAC Road Track Costs
Maintenance expenditure	*Maintenance expenditure*
Routine maintenance (pavement)	B1
Periodic maintenance	B2
Limited major patching	0.2D
Pavement expenditure	*Pavement expenditure*
New/replacement pavements	F2, G1
Reconstruction (existing pavements)	0.8D
Major pavement rehabilitation	0.8D
Bridge expenditure	*Bridge expenditure*
New/replacement bridges	G2
Widening bridges	F3
Other expenditure	*Other expenditure*
—	A, B3, C1, C2, E, F4, G3, H1, H2, H3, H4

As shown above, a number of the ATAC expenditures were not covered by the ARRB study. The fractional relationship between the ATAC major rehabilitation (D) and the ARRB limited major patching was based on a sample of five consecutive years of expenditure in these related areas. When the above relationships were applied to the existing concordances with the ATAC cost definitions, the ARRB cost definitions were related to those of NZ, UK, US, and SA.

Comparison of road track cost allocation practices

Using the ARRB road track cost definitions, the magnitude and type of cost attribution variables used in the NZ, UK, US, and SA practices were compared with those from the ARRB study. Table

2 summarises this comparison using average estimates of the cost attribution variables where more than one type of road is covered by each country's practice.

In the above comparison, the attributable cost variables were taken as ESA.km, GVM.km and PCU.km. In the UK and SA, the PCU.km variable attributes road track costs designated as non-attributable (fixed costs). When making comparisons between practices, the distinction between attributable costs and non-attributable costs should depend on the variable used to attribute the costs, rather than the arbitrary designations made by the individual practices. The PCU.km attribution variable can therefore be treated consistently as an attributable cost variable when all non-attributable costs are attributed by vehicle kilometres travelled (VKT). In all practices, except that of SA, the majority of the non-attributable costs are attributed on the basis of VKT.

Table 2 Road track cost allocation practices (US, UK NZ, SA and Australia)

	Attributable Cost Variables								
	Maintenance			Bridges			Pavements		
Country	ESA .km	GVM .km	PCU .km	ESA .km	GVM .km	PCU .km	ESA .km	GVM .km	PCU .km
US* Indiana State Hwys & Local Roads	80	-	2	-	65	-	94	-	6
UK* Motorways,Trunks, Principals and others	30	5	-	-	15	85	30	10	60
SA* National, Provincial & Municipal	40	-	5	15	-	80	37.5	-	59
NZ* State Hwys & Local Authority Roads	25	23	-	-	60	-	42	6	-
AUST. State/National Hwys, Rural & Urban Arts.	-	50	-	-	-	15	45	-	-

Note:
*Average of attribution variables used.

Source: Fwa et al. 1990; US DOT 1982; UK DOT 1990; SA DOT 1991; NZ MWD 1984; Martin 1994.

Comparisons of attributable costs

Comparisons of total attributable cost

The different attributable road track cost practices were compared by applying them to Australia's average road track expenditure on arterial roads from 1989//90 to 1991//92 (expressed in 1992/93 $s, NRTC 1992). Only some 43% of this expenditure fell within the ARRB road track cost definitions listed earlier. The remaining expenditures were not amenable to attributable cost estimation by ARRB (ATAC categories A, B3, C1, C2, E, F4, G3, H1, H2, H3 and H4).

The various practices gave quite a range of estimates of total attributable road track cost. In terms of total road track cost, the percentage attributable cost varied from 18% (Australia) to 36.9% (US) (see Figure 1 and Table 3).

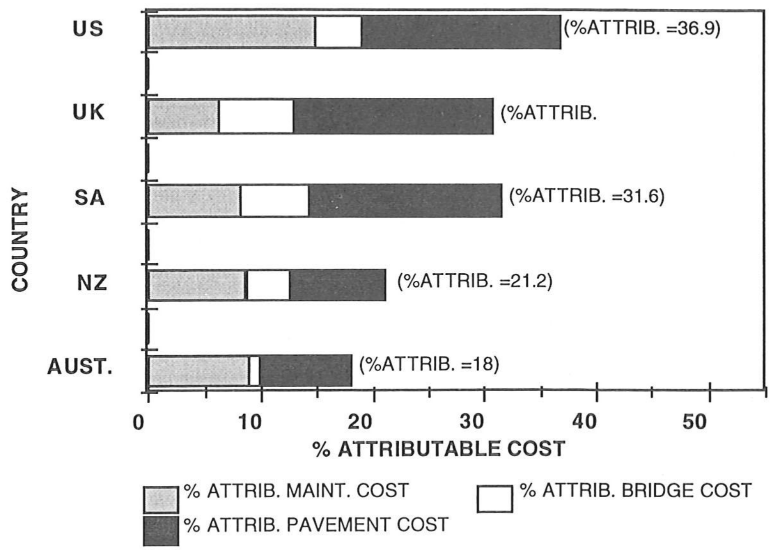

Figure 1 **% Attributable maintenance, pavement, bridge costs as a % of total road track cost**

Table 3 **Attributable Road Track Cost Comparisons (US, UK, NZ, SA & Aust)**

	% Total Road Track Expenditure (Aust. 92/93)								Attrib. Maint/ Pave. Cost (d)/(b)	ESA Costs/ Total Attrib. Cost (a)/(c)	Heavy Vehicle AVKT (10^6) (km)
	ESA Attributable Costs				Total Attrib. Cost (c)	Attrib. Maint. Cost (d)	Attrib. Bridge Cost	Attrib. Pave. Cost			
	Total (a)	Pave. (b)	Maint.	Bridge							
US	31.2	16.8	14.4	-	36.9	14.7	4.3	17.9	0.88	0.85	1,003,413 (1991)
UK	10.8	5.4	5.4	-	30.8	6.3	6.6	17.9	1.17	0.35	66,200 (1991)
SA	14.9	6.7	6.7	1	31.6	8.1	6.2	17.3	1.21	0.47	27,014 (1987)
NZ	12.0	7.5	7.5	-	21.2	8.6	4.0	8.6	1.15	0.57	2,290 (1990)
Aust	8.1	8.1	8.1	-	18.0	9.0	1.0	8.1	1.11	0.45	22,814 (1991)

Comparisons of attributable maintenance cost

The attributable maintenance costs of the practices are compared in Figure 2 and Table 3. The attributable maintenance costs range from 6.3% (UK) to 14.7% (US) of total road track cost. However, if the US practice is excluded, the attributable maintenance costs only range from 6.3% to 9% of total road track cost. The higher attributable maintenance cost for the US may be due to greater heavy vehicle use in the US relative to the other practices (see Table 2) in a generally more aggressive environment.

The variables used to attribute maintenance cost ranged from PCU.km to ESA.km (see Figure 2). Current research suggests that ESA.km based on the second power law are appropriate for the levels of flexible pavement distress that initiate maintenance intervention (Evenson and Senstad 1992). This is equivalent to the attributable maintenance variable lying somewhere between GVM.km and ESA.km. The above research implies that the attributable maintenance variable should reflect the maintenance intervention practices which set the average levels of pavement distress.

The US is the only practice to adopt the exclusive use of ESA.km to attribute maintenance costs. This exclusive use of ESA.km in attributing US maintenance costs is probably due to the higher levels of heavy vehicle road use with its consequent effect on pavement deterioration. Frequent maintenance intervention to reduce pavement deterioration may not be viable on a life-cycle cost basis if the costs of delays exceed other vehicle operating cost benefits.

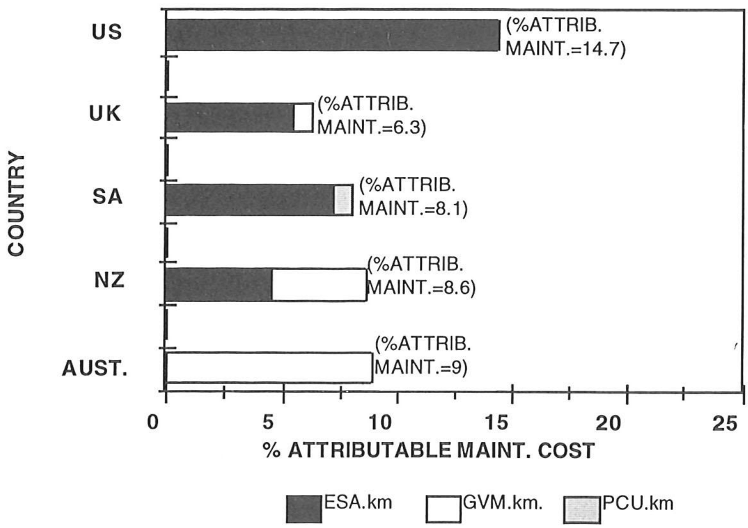

Figure 2 % Attributable maintenance cost as a % of total road track cost

Comparisons of attributable bridge cost

The attributable bridge costs of the practices are compared in Figure 3 and Table 3. The attributable bridge costs range from 1% (Australia) to 6.6%.(UK) of total road track cost. When Australia is excluded, the attributable bridge cost only ranges from 4% to 6.6% of total road track cost. The usual attribution variables for bridge cost are GVM.km and PCU.km. SA uses ESA.km as a bridge cost attribution variable as part of a broad approach to all capital cost attribution (SA DOT 1991) which does not discriminate between the different capital cost items.

The use of PCU.km to attribute bridge cost in Australia is a consequence of Australian bridge design practice (AUSTROADS 1992). The lower level of attributable bridge cost in Australia is probably associated with the limited range of the PCU.km attribution variable relative to the GVM.km attribution variable. Over the full range of road users, PCUs range from 1 to 2.5 per vehicle, while GVMs range from 1 to 84 tonnes per vehicle (Taylor and Botterill 1992).

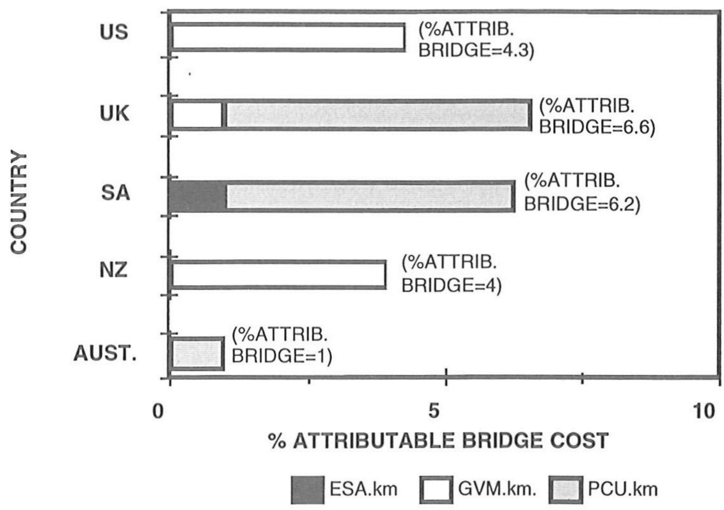

Figure 3 % Attributable bridge cost as a % of total road track costs

Comparisons of attributable pavement cost

The attributable pavement cost of the practices are compared in Figure 4 and Table 3. The attributable pavement costs range from 8.1% (Australia.) to 17.9% (US and UK) of total road track cost. The common pavement cost attribution variable is ESA.km which determines pavement thickness and therefore dictates pavement cost. When the US practice and the GVM.km and PCU.km attribution variables are excluded, the attributable pavement cost, based on ESA.km, ranges from 5.4% to 8.1% of total road track cost.

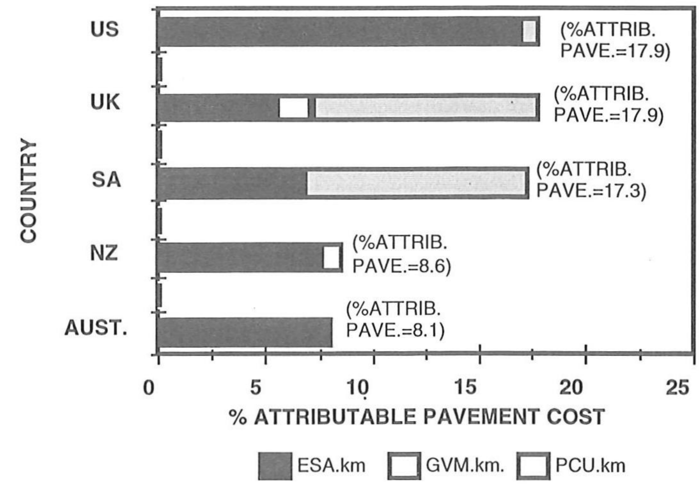

Figure 4 % Attributable pavement cost as a % of total road track cost

The higher attributable pavement cost for the US is again probably due to the higher heavy vehicle use in the US relative to the other practices (see Table 3). The use of GVM.km and PCU.km in attributing pavement costs in the UK is part of a broad approach to all new capital cost attribution (UK DOT 1990) which does not discriminate between different capital cost items. All the overseas practices use PCU.km in attributing some pavement costs. This variable probably accounts for variations in pavement costs due to vehicle width effects.

Relationship between ESA based attributable cost and heavy vehicle road use

All the ESA based attributable costs of each road track cost allocation practice were summed and compared with the estimated heavy vehicle AVKT in each country (IRF 1993). A simple linear relationship was derived between the ESA based attributable costs and AVKT. The relationship has a high goodness of fit ($R^2 = 0.86$) and is statistically significant (based on 't' and 'F' tests) even with a limited sample of five. The relationship is as follows:

$$\text{Total ESA based attributable cost} = 9.5 + 1.5\text{E-}11 \times \text{AVKT} \quad (1)$$
(% of total road track cost)

Because the ESA based attributable cost and heavy vehicle AVKT of the US is significantly greater than that of the other practices, it has the major influence on the above relationship. Although the above relationship is significant, it may not necessarily provide a sound explanation of the overall level of ESA based attributable cost with heavy vehicle AVKT because of the limited number of samples.

Summary of an international comparison of attributable road track costs

The attributable road track costs from the practices of NZ, UK, US, and SA were compared with those of Australia on a common expenditure basis. The various practices gave a range of attributable road track costs (see Figure 1) that varied from 18% (Australia) to 36.9% (US).

The attributable maintenance cost of the practices varied from 6.3% (UK) to 14.7% (US) of total road track cost (see Figure 2). The variables used to attribute maintenance cost ranged from PCU.km to ESA.km.

The attributable bridge cost varied from 1% (Australia) to 6.6% (UK) of total road track cost (see Figure 3). The variables used to attribute bridge cost varied from PCU.km to GVM.km.

The attributable pavement cost varied from 8.1% (Australia) to 17.9% (US and UK) of total road track cost (see Figure 4). The variables used to attribute pavement cost varied from PCU.km to ESA.km.

The ESA.km based attributable costs of the road track cost attribution practices appear to be directly proportional to heavy vehicle road use as estimated by the heavy vehicle AVKT.

INFERENCES DRAWN FROM AN INTERNATIONAL COMPARISON OF ATTRIBUTABLE ROAD TRACK COSTS

The inferences drawn below are based on the assumptions that the road track cost allocation practices are compared on the same basis, that is, the concordances developed between cost definitions of each practice and the estimated average levels of attributable cost are valid and representative, and that each road track cost allocation practice reflects the costs the road users actually cause.

As there will always be some doubt about the validity of the above assumptions, the results of the following analyses should be treated with caution.

Levels of attributable maintenance relative to attributable pavement cost

An indication of the trade offs between the ongoing costs associated with maintenance and initial pavement construction cost may be assessed by the ratio of attributable maintenance to the ESA based attributable pavement cost. The ESA based attributable pavement costs were used as they largely determine pavement thickness and pavement cost. As noted earlier, all new capital costs in the UK practice (UK DOT 1990) are attributed on the basis of GVM.km and PCU.km which makes the above ratio less applicable for the UK, although ESA.km are used in attributing pavement reconstruction and major rehabilitation costs in the UK.

The ratios of attributable maintenance to ESA based pavement costs for all practices vary from 0.88 (US) to 1.21 (SA) in Table 3. When the ratio for the US practice is excluded, the ratio only ranges from 1.11 to 1.21 indicating a fairly consistent approach across the practices in the trade off between ongoing maintenance and initial construction costs. The ratio is lower presumably for the US because of the higher heavy vehicle use in the US relative to the other practices. In addition, higher costs of initial pavement construction on highly trafficked roads reduces the frequency of maintenance intervention and avoids costly delays to traffic.

The ratio of attributable maintenance to ESA based pavement cost is the highest for SA probably because this practice has the largest percentage of unsealed roads than any other practice (IRF 1993).

The above consistency of the ratios of attributable maintenance to ESA based pavement costs across all practices, except that of the US, is surprising considering the varying levels of heavy vehicle road use and the environmental differences represented in the practices. However, this consistency of the ratio of attributable maintenance to ESA based pavement costs may also indicate that the cost allocation practices are not necessarily an accurate reflection of the maintenance and investment strategies used by the various road agencies.

Levels of ESA based attributable cost

The ratio of ESA based attributable cost to total attributable cost provides a measure of how sensitive the cost attribution practice is to heavy vehicles with high axle loads, as axle loads influence the magnitude of the ESAs. The ratio of ESA based attributable cost to total attributable cost across all practices varies from 0.35 (UK) to 0.85 (US) (see Table 3). There may be two reasons for this wide variation. Firstly, the level of ESA based attributable cost is expected to increase with heavy vehicle use as discussed earlier. This explains why the US has the highest ratio of ESA based attributable cost to total attributable cost.

The second reason for the variation in the above ratio are the peculiarities of each road track cost allocation practice. The UK does not use ESA.km to attribute initial pavement construction costs, while SA uses ESA.km to attribute bridge costs which raises their relative level of ESA based attributable expenditure. Most practices, except Australia, use ESA.km in attributing some maintenance costs.

Summary of inferences from the international comparison

Initial construction cost vs maintenance cost

The trade off between ongoing maintenance cost and initial construction cost may be assessed by the ratio of attributable maintenance cost to the ESA based attributable pavement cost. The ratios of attributable maintenance cost to ESA based pavement costs for all practices vary from 0.88 (US) to 1.21 (SA) in Table 3. When the ratio for the US practice is excluded, the ratio only ranges from 1.11 to 1.21 indicating a fairly consistent approach across the practices in the trade off between ongoing maintenance and initial construction costs. This consistency of the ratio of attributable maintenance cost to ESA based pavement cost may also indicate that the cost attribution practices are not necessarily an accurate reflection of the maintenance and investment strategies used by the various road agencies.

ESA based attributable cost

The ratio of ESA based attributable cost to total attributable cost provides a measure of how sensitive the cost allocation practice is to heavy vehicles with high axle loads. The ratio of ESA based attributable cost to total attributable cost across all practices varies from 0.35 (UK) to 0.85 (US) (see Table 3). When the US practice is excluded, this ratio only ranges from 0.35 to 0.57, indicating that the majority of practices are not particularly sensitive to heavy vehicles with high axle loads.

CONCLUSIONS

Australia's estimated attributable maintenance, pavement and bridge costs were compared with those adopted by the cost allocation practices of the US, the UK, South Africa and New Zealand. These cost allocation practices were applied to the same annual road track cost and gave quite a range of cost that is attributable. In terms of total road track cost, the percentage of attributable road track cost varied from 18% (Australia) to 36.9% (US).

Similar variations within the levels of estimated attributable maintenance, pavement and bridge cost were also found across the cost allocation practices. The evidence suggests that these levels of attributable cost are related to levels of heavy vehicle road use. In addition, variations in the variables used to attribute the maintenance, pavement and bridge costs were found across the cost allocation practices.

Most of the above countries appear to make similar decisions in the trade off between ongoing maintenance cost and initial construction cost if the ratio of attributable maintenance to the ESA based attributable pavement cost is a reliable guide to practice. This outcome assumes that all cost allocation practices actually reflect the investment and maintenance strategies used.

The ratio of ESA based attributable cost to total attributable cost across all practices indicates that all the cost attribution practices, except the US, are not particularly sensitive to heavy vehicles with high axle loads. A number of cost allocation practices have their own peculiarities, particularly in the treatment of attributable pavement and bridge costs, which may also account for this lack of sensitivity to heavy vehicle loads.

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GLOSSARY OF TERMS

AVKT	Annual Vehicle Kilometres Travelled
ESA	Equivalent Standard Axle, the measure of the relative effect of any load and axle configuration on a pavement in terms of the number of passes of a standard axle.
ESA.km	Equivalent Standard Axle kilometres
GVM	Gross Vehicle Mass
GVM.km	Gross Vehicle Mass kilometres
PCU	Passenger Car Unit, the measure of the amount of road space occupied by a vehicle under given conditions relative to a standard passenger car
PCU.km	Passenger Car Unit kilometres
VKT	Vehicle Kilometres Travelled