APPENDIX A-1

A REVIEW AND OUTLINE OF RECENT COST ESTIMATION STUDIES

FOX, J.C., GOOD, M.C. and JOUBERT, P.N. (1979)

Collisions with Utility Poles
Report CR1, Office of Road Safety,
Department of Transport (pp.423)

Summary

This report covers a major Australian study of road accidents in the metropolitan area of Melbourne involving collisions with roadside utility poles. The collision data cover the period 1976/77, and the study involved an in-depth evaluation of pole accident characteristics, leading to the development of an accident predictor model which estimates annual accident numbers at specific pole sites based on site measurements.

Detailed information on injuries and vehicle damage was used to estimate the societal costs associated with various injury levels for Australian conditions. This study developed three alternative bases for the estimation of the social cost of road accidents. Use of the latter basis showed that the annual social loss from pole accidents in Melbourne was $23 million. These social cost estimates are utilised in benefit-cost evaluations of selected accident countermeasures.

The Cost of Pole Accidents

This review is confined to the accident cost estimation portion of the report contained in Chapter 5, with brief reference to applications of these estimates elsewhere in the study.

In Chapter 5, Fox *et al.* develop three alternative bases for accident cost calculations, using data from the study, and a cost framework arrived at, after reviewing a range of recent studies concerned with estimates of the social cost of road accidents.

TABLE 27

ESTIMATED ANNUAL COST OF POLE ACCIDENTS: MELBOURNE*

Costing Method	Annual Cost $m	Average Cost per Accident $
Current resource costs:	7.0	3,371
Total costs *net* of consumption:	16.9	8,186
Total costs:	23.1	11,175

* *From Table 5.13 (p.260) in Fox et al.*

The report notes that estimates of road accident costs are widely used in benefit-cost analyses, (e.g. of transport expenditure), but have also served as measures of accident severity in the priority ranking of accident remedial projects. Such accident severity measures are needed to permit comparison of programmes which involve reductions in accidents with differing mixtures of accident severity.

It also notes the existence of several schools of thought as to the conceptual framework and as to components to be properly charged to road accident costs. Fox *et al.* adopted the *ex post* method of estimating accident costs: *after* the event, rather than the *ex ante,* before the event or willingness-to-pay, concept. The report adopted three alternative concepts of costs for which estimates were made, namely: *current resource costs* only; *total accident costs (direct and indirect)* including foregone future income *net* of consumption; and *total accident costs (direct and indirect)* including foregone future income.

The *average costs per accident* used by Fox *et al.* to derive their estimates are reproduced in Tables 28 to 30. Table 28 shows average costs on a *current resource cost* basis.

TABLE 28

AVERAGE ACCIDENT COSTS BY INJURY LEVEL
FOX *et al.* (1979) CURRENT RESOURCE COSTS

COST CATEGORY	A.I.S.(Scale) Injury Level $						Property Damage Only
	6	5	4	3	2	1	
Lost Work Time	0	4200	2800	1370	740	55	0
Hospital	807	5924	2626	1168	293	42	0
Medical	295	813	584	252	135	34	0
Rehabilitation	50	4050	2050	45	40	35	0
Legal & Court	2600	2000	1300	900	200	150	10
Insurance Administration	350	350	350	300	250	70	40
Accident Investigation	100	100	100	100	100	100	0
Vehicle Damage	2400	2360	2290	2290	2230	2080	1790
Pole & Utility Damage	180	180	180	180	180	180	180
TOTAL	6782	19977	12280	6605	4168	2746	2020

Source: Table 5.9 (p.252) in Fox et al: A.I.S. is the Abbreviated Injury Scale.

The *direct* components of accident costs consist of property damage, medical expenses, and lost income resulting from accidents. *Indirect costs* include such factors as the value of pain and suffering, losses incurred by others (family, employers, etc). Fox *et al.* note that both in their study and in the literature the major source of variation in overall estimate of accident cost is the treatment of the value of lost income or production resulting from death or injury. In the *current resource cost* approach adopted in Table 28, future income losses are exluded, and thus form the lower bound of the cost estimates presented.

In Table 28 accident fatalities (AIS class 6) at under $7,000 are valued significantly less than major injury accidents (AIS classes 4 and 5). Fox *et al.* comment that the *current resource cost* approach ".... seems to grossly understate the relative societal value of a fatality."

Average *Total Accident Costs (Direct and Indirect)* showing foregone future income *net* of consumption are shown in Table 29.

TABLE 29

AVERAGE ACCIDENT COSTS BY INJURY LEVEL
FOX *et.al.* (1979) TOTAL COSTS (NET OF CONSUMPTION) $

COST CATEGORY	A. I. S. (SCALE) INJURY LEVEL						PROPERTY DAMAGE ONLY
	6	5	4	3	2	1	
1 Market Earnings	84800*	46640*	21200	780	420	30	0
2 Family, Community	25444*	14000*	6360	230	120	10	0
3 Hospital	807	5924	2626	1168	293	42	0
4 Other Medical etc.	295	813	584	252	135	34	0
5 Rehabilitation	50	4050	2050	45	40	35	0
6 Legal & Court	2600	2000	1300	900	200	150	10
7 Insurance Administration	350	350	350	300	250	70	40
8 Accident Investigation	100	100	100	100	100	100	0
9 Losses to Others	1400	1500	700	120	60	10	0
10 Vehicle Damage	2400	2360	2290	2290	2230	2080	1790
11 Traffic Delay	100	75	75	200	200	200	200
12 Other Costs	180	180	180	180	180	180	180
TOTAL:	118526	77992	37815	6565	4228	2941	2220

Source: Table 5.10 (p.254) in Fox et.al; A.I.S. is the Abbreviated Injury Scale.
"Other costs" represent pole and utility damage.
* *Discounted at 7% p.a. after allowing for 3% p.a. productivity.*

This table contains several additional cost components, namely:

(a) production (i.e. income) losses *net of consumption* for
 (i) the accident victim, and
 (ii) family and community;

(b) losses to others (employers etc.); and

(c) traffic delay costs.

Table 29 shows a much higher average cost level for both fatalities and major injuries, at about $119,000 and $78,000, respectively. Most of the increase results from the value of foregone income of fatalities and reduced earning capacity of major injuries, discounted to a present value over their remaining life expectancy at a discount rate of 7% p.a. Average incomes were incremented by 3% p.a. to allow for productivity increases, and the overall calculations took into account the age and sex distribution of road accident casualties, thus determining a weighted average cost for each injury level.

Average *Total Accident Costs* (Direct and Indirect) including lost future income, are contained in Table 30.

TABLE 30

AVERAGE ACCIDENT COSTS BY INJURY LEVEL
FOX *et.al.* (1979) TOTAL COSTS (DIRECT & INDIRECT) $

COST CATEGORY	A.I.S. (SCALE) INJURY LEVEL 6	5	4	3	2	1	PROPERTY DAMAGE ONLY
1 Market Earnings	151000*	83300*	37900	1370	740	55	0
2 Family, Community	45300*	24990*	11370	400	220	15	0
3 Hospital	807	5924	2626	1168	293	42	0
4 Other Medical, etc.	295	813	584	252	135	34	0
5 Rehabilitation	50	4050	2050	45	40	35	0
6 Legal & Court	2600	2000	1300	900	200	150	10
7 Insurance Administration	350	350	350	300	250	70	40
8 Accident Investigation	100	100	100	100	100	100	0
9 Losses to Others	1400	1500	700	120	60	10	0
10 Vehicle Damage	2400	2360	2290	2290	2230	2080	1790
11 Traffic Delay	100	75	75	200	200	200	200
12 Other Costs	180	180	180	180	180	180	180
TOTAL	204582	125642	59525	7325	4648	2971	2220

Source: *Table 5.11 (p.257) "Other costs" represent pole and utility damage; A. I. S. is the Abbreviated Injury Scale.*

* *Discounted at 7% p.a. after allowing for 3% p.a. productivity.*

Table 30 is basically similar to Table 29, except that average consumption is not deducted from foregone income. The results of these estimates are conceptually similar to the U.S. official estimates of Faigin (1976), and are generally of the same order of magnitude. The average cost of a fatality is about $205,000, or over 70% larger than in Table 29.

In a discussion of previous accident studies, Fox *et al.* noted that the majority of such studies included directly related costs, including property damage, medical and hospital costs, the value of lost work time (but did not always include lost future earnings), legal and court costs, loss of vehicle use, and court damage awards above known costs.

The value of lost future production resulting from a fatality or permanent disability, was included as a cost in the *Total Cost* studies. Reynolds (1956) in the U.K. was noted as one of the earlier studies to acknowledge this cost item, although adopting a value *net* of average consumption. Subsequently Dawson (1967) in the U.K. and Troy and Butlin (1971) and Paterson (1973) in Australia adopted the *net* income concept for their cost estimates.

Although all such methods involved the calculation of a present worth of the estimated *net* or *gross* future income stream by discounting at some nominated interest rate, some variation between results was introduced by taking the age distribution and average earnings for each age group of casualties into account, leading to a weighted average lost income figure for each accident class. Also, the treatment of those not in the workforce, mainly females, varied in that some were attributed average earnings, in other cases incomes of those employed were averaged over the total in each age group.

Fox *et al.* drew extensively on the methodology of the detailed U.S. accident cost study by Faigin (1976). This was supplemented in the Melbourne pole accident study with detailed survey cost data relating to vehicle damage, pole and utility damage, and hospital and medical costs.

Vehicle damage costs were obtained for each of the 879 accident cases studied by Fox *et al.* When the repair costs exceeded the market value of the vehicle, the latter value was obtained from a trade guide and used as the accident cost. After adjustment, the average Melbourne vehicle damage costs ranged between $1,790 for a property-damage-only accident, to $2,400 for a fatality accident.

Because of the focus of this study, pole and utility damage costs were reviewed in some detail, and estimated at an average of $180 per accident.

Hospital and medical costs were obtained from the Motor Accident Board of Victoria, a government agency established in 1973 to administer "no-fault" compensation for those injured in road accidents.

Accident Costs Used by Fox et al.

The cost estimates derived by Fox *et al.*, as shown in Tables 28 to 30, were disaggregated by injury severity class (according to the six-class Abbreviated Injury Scale - AIS - developed by the American Medical Association), which was seen as a necessary factor in applying such cost data to the evaluation of accident countermeasures.

In the current resource cost estimates of Table 28, utilising the format of the U.S. study of Faigin (1976), Fox *et al.* used local data where available, but otherwise adapted the U.S. 1975 average cost figures, with the objective of establishing "order-of-magnitude" estimates for all three cost frameworks.

Current resource cost estimates for *lost work time* were based on the U.S. 1975 data on average days lost, and Australian earning statistics. *Medical, hospital* and *ambulance costs* were derived from

Motor Accidents Board and survey data; *legal and court costs, insurance administration,* and *accident investigation costs* were derived from the U.S. study.

Vehicle damage was obtained in the study and estimated as discussed below.

The *Total Accident Costs* (net of consumption) in Table 29 include estimates of lost *future* earnings of fatalities and casualties with permanent disabilities.

These estimates make no distinction between accident victims in or out of the workforce, thus non-income earners (mainly housewives) are attributed a full average market income. The estimates of percentage impairment for AIS categories 4 and 5 in Faigin (1976) were adopted, together with Australian income and consumption data for calculation of lost income for injury cases. Fox *et al.* also used the Faigin discount and productivity rates of 7% and 3% *per annum* respectively.

The unit values of *Losses to Others,* and *Traffic Delay Costs* are also derived from the U.S. study.

Table 30, containing *Total Accident Costs (Direct and Indirect),* is similar in content to Table 29 except that average consumption is *not* deducted from foregone earnings.

None of the estimates compiled by Fox *et al.* contains estimates of the costs of *pain and suffering* resulting from road accidents. It is noted that the U.S. NHTSA study of 1971 included such estimates, and Faigin (1976) acknowledges its validity as a social cost, but considered that available data were too poor for estimation.

Application of Estimates to Accident Categories

Fox *et al.* then applied these average costs to seven classes of pole accidents to investigate the pattern of cost differentiation. Partly because of small sample sizes, it was necessary to reduce the range of accident categories which showed cost discrimination to two: *intersection* and *non-intersection* pole accidents.

Fox *et al.* were able to show the cost levels of a wide range of accident characteristics measured in that study, including impact direction, as a guide to vehicle crashworthiness improvements. The study concludes (in respect of the cost estimation exercise) that social cost estimates are a necessary basis for rational decision making about accident remedial programmes.

LAWSON J.J. (1978) "The Costs of Road Accidents and their Application in Economic Evaluation of Safety Programmes" Paper to *Annual Conference of the Roads and Transportation Association of Canada (Ottawa, September 1978)*. (pp.20)

Summary

The author is on the staff of Transport Canada and in this paper reviews past approaches to the estimation of road accident costs and concludes that present cost measurement methods can only provide minimum estimates of safety benefits. It is recognised that road safety measures require comparative evaluation involving assessment of their social cost and benefits. Estimates of the "material" costs of road accidents in Canada are presented for 1976 and 1978, but include three components only: property damage, lost work efforts, and health care, and these estimates involve a significant level of uncertainty. The usefulness of these accident cost estimates in recommending acceptance or rejection of any safety programme is found to be limited in practice mainly because the social worth of road safety benefits may vary with the nature of the specific accident risk involved.

I Estimated Cost of Road Accidents in Canada for 1976 and 1978.

Lawson provides estimates of "minimum" accident costs for Canada in 1976 and 1978 following "conventional measurement practices". The three major areas of *property damage, productive work efforts, and health care* are the basis of the estimates, summarised in Table 31.

TABLE 31

ESTIMATED COST OF ACCIDENTS CANADA: 1976 & 1978 (in $Canadian)

(i)	Minimum Total Accident Costs	1976 $m	1978 $m
	Property Damage (and compensation admin.)	1,500	
	Lost Productive work effort	900	
	Health care	100	
	Total	$2,500 million	
(ii)	Minimum Average Accident Costs (per victim)	$	$
	Fatality	130,000	150,000
	Injury	1,500	1,800
	Average victim	$4,800	$5,600
(iii)	Minimum Average Cost (per accident)		
	Fatal accident	160,000	180,000
	Injury accident	5,000	5,500
	Property damage accident	1,300	1,500
		$4,000	$4,500

TABLE 32

VALUE OF PRODUCTIVE WORK EFFORTS: CANADA 1975						
	MALES			FEMALES		
Age Group (Years)	Average Earnings	Workforce Participation Rate	Value of Total Work efforts plus 10%	Average Earnings*	Workforce Participation Rate	Value of Total Work effort plus 50% (participants)
	$	%	$	$	%	$
15-24	4,830	63.6	3,379	3,599 (6,863)	48.7	8,534
25-34	11,879	96.4	12,596	6,141 (8,858)	49.9	11,068
35-44	14,579	97.2	15,554	5,999 (8,627)	48.2	10,706
45-54	13,851	93.7	14,276	6,130 (8,617)	43.6	10,496
55-64	11,788	80.1	10,386	5,624 (8,141)	29.0	9,321
65+	6,546	17.4	1,253	2,557 (8,000)	4.8	8,192

** Average earnings of full-time females shown in parentheses.*

An increase of 10% for males and 50% for (non-housewife) females is allowed for the estimated value of "additional home and family services".

For males, calculation (15-25 yrs.) is (4830) x (0.636) x (1.10) = 3379; for females (e.g. 25-34 yrs.) calculation is (8858) x (0.499)x (1.5) + (8858) x (0.501) = 11068

TABLE 33

PRESENT VALUE OF FUTURE WORK EFFORTS: CANADA 1975

Age	Males $	Females $
0	33,042	40,056
5	48,549	58,856
10	71,334	86,478
15	104,813	127,064
20	132,595	132,628
25	173,417	140,803
30	174,999	136,760
35	177,324	130,820
40	161,997	124,385
45	139,479	114,930
50	114,488	102,368
55	77,760	83,911
60	48,463	64,235
65	5,403	35,325
69	1,253	8,192

Source: assuming constant cross-section of earnings as adjusted, for accident victims, and a productivity increase of 2% p.a. (to allow for expected growth in real GDP per capita, as in 1961-1975 period), and life expectancy of 70 years, the present value of future work efforts (X_j) for a representative individual of age j is computed as:

$$X_j = \sum_{i=j}^{70} Y_i \; [(1 + r)^{-(i-j)}]$$

where Y_i is annual value of work effort at age i; and r is the appropriate discount rate (net of 2% productivity).

Vehicle Damage and other Property Damage

Social losses in this category include *all* vehicle and property damage occurring in road accidents (whether or not reported, repaired or compensated). Official records are incomplete, but insurance claim reports are relatively comprehensive.

Using separate data from both private and public insurance records, Lawson obtained 1976 property damage estimates (per vehicle) of $132 and $115 respectively (including costs of compensation administration).

Source	Number of vehicles	Average cost per vehicle C$	Total cost C$m
Private Insurance companies	9,107,000	132.08	1202.8
Public Insurance companies	2,932,000	114.97	337.1
	12,039,000	127.91.	1539.9m

This total includes: $900 million actually compensated by insurance companies; $100 million deductible (i.e. "no-claim excess"); and $500 million estimated damage to uninsured vehicles.

Because of the uncertainty surrounding the estimates for uninsured vehicles, Lawson rounds off the total at $1500 million. Police estimates of damage costs by severity of *reported* accidents are:

	Cost per accident C$
fatal accident	5,000
injury accident	2,500
property damage	1,300

Using these figures, a total cost of $1,000 million is obtained, leaving $500 million occurring in unreported accidents.

Lost Productive Employment and other Work Efforts:

Cross-sectional data on earnings by sex and age for 1975 were the basis of these estimates, which are summarised in Tables 32 and 33. Thus, given the age and sex distribution of road accident fatalities, an average loss figure per accident victim was computed as follows (based on Average Lost Work Efforts per Fatality of $126,000):

Total Lost Work Efforts:		1976 Fatalities C$m
(i)	paid work efforts	500
(ii)	housewives' services	90
(iii)	other unpaid services	70
		$660 million

Lawson notes that some 24% of these fatality costs consist of "essentially arbitrary" estimates of the value of "unpaid" work. However, the effect ofthe discount rate upon these estimates is very marked, so that the present value figure of C$126,000 for lost work at 8% (i.e. 10% less 2% productivity) falls to aboutC$88,000 at 12% p.a., and rises to about C$440,000 at zero interest rate.

Lawson applied results of the U.S.A. study (Faigin, 1976) to estimate the work-loss effects of differing injury severities, combined with Canadian hospital data on road accident cases, to derive an estimate of the value of lost work effort due to accidents in 1976. These estimates were then distributed according to the U.S. "Abbreviated Injury Scale" (AIS), as shown in Table 34.

TABLE 34

LOST WORK EFFORTS OF ROAD ACCIDENT INJURIES: CANADA 1976

A.I.S. Class ∅	Proportion of Cases	Number of Casualties	Average Loss $	Total Loss $m
1	0.840	171,394	56	9.7
2	0.100	20,404	740	15.1
3	0.041	8,366	1,380	11.5
4	0.014	2,857	31,000	88.6
5	0.005	1,020	71,000	72.4
Total (classes 1-5)	1.000	(204,040)	(967)	(197.3)

∅ *The AIS classification of work losses adopted were: AIS(1): 1-6 days loss; AIS(2): 21 days; AIS(3): 39 days; AIS(4): 25% impairment; AIS(5): 57% impairment.*

The estimates in Table 34 were rounded to an average loss of C$1,000 and total lost work efforts of C$200 million.

Health Care Costs

Although separate hospital treatment costs of road accident cases are not available for Canada as a whole, detailed estimates for two Provinces (Quebec and Ontario) were utilised to arrive at rounded estimates:

Total health care costs
(for 200,000 cases in 1976): C$100 million

Average costs per victim
in 1976: C$500

Other Material Accident Losses

Lawson considers that because of the uncertainty present in the estimates of the larger cost components of lost work efforts and of lost property damage, the estimation of other material losses such as the cost of police services at road accidents, loss of use of vehicles, inconvenience to family etc. in caring for casualties, would result in relatively small figures which would be within the rounding error of the main estimate (this, he considers, is likely to be true of health costs also).

Conclusions

In presenting these accident cost estimates, Lawson concludes that the "art of measurement of accident costs can only provide *minimum* estimates of 'true' social values of safety improvements".....and, that it is also likely that these minimum estimates yield differing proportions of the true values in differing accident severities and risk situations.

Lawson thus considers that the use of such minimum estimates in benefit-cost or cost-effectiveness analyses is severely restricted when recommendations as to the acceptability of, or priorities among, safety programmes are concerned.

"Calculations of minimum benefits ....and...of simple cost-effectiveness may still aid decisions within safety programmes, but there appears to be no substitute currently for administrative or political judgement as to the nature of social priorities between differing 'types' of risk".

II - Outline of Paper:

Introduction

Lawson notes that road safety absorbs a considerable level of both public and private resources and is a component of many expenditure programmes. The *benefits* from such programmes arise from the reduction of accidents, casualties and consequent disabilities, suffering and anxiety - and perhaps also from increased mobility and vehicle life. The public expenditure evaluation technique of benefit-cost analysis appears therefore to offer a prospect of solving some complex decisions in road safety planning. These include the comparative evaluation of quite diverse activities, and the determination whether individual programmes should be implemented or rejected (on economic grounds) and also to suggest the "justifiable size" of the road safety budget in relation to other social objectives.

The major problem encountered is the determination of appropriate monetary values for changes in accident levels and their consequences. A common approach in practice is the measurement of those social costs which would be avoided if accidents are prevented or reduced. In *benefit-cost applications* such cost reductions have been utilised by government agencies as measures of the benefits from improved safety.

If monetary valuation of accident *benefits* is considered to be not possible, *cost-effectiveness* analysis of road safety measures is often used to determine programme priorities, in terms of accident reduction per unit of cost. However, Lawson suggests that it is still necessary to attach different relative importance to accident severities (fatalities, injuries and property damage involvement) in order to compare safety programmes which affect these severities in different proportions. The paper then examines the appropriateness of the use of measures of the social costs of accidents in the evaluation of safety programmes, identifying some major objections to such use, and finally, defines a limited basis for the use of accident costs in the Canadian context.

Accident Costs as Measures of Benefits from Safety Improvements:

Lawson notes that the analyst needs to know how much of its resources society would be willing to give up to obtain safety improvements, whilst recognising other competing demands. Such values need to be stated in money terms, compatible with other prices and costs. Usually this is achieved by adjusting market prices to corrected social values, but it is evident that no simple market for safety exists to guide this assessment. Some fairly obvious components of accident costs have monetary values, including vehicle damage, medical care, and by extension it is often reasoned that if *all* social losses associated with accidents can be identified and measured, then the social value of their *avoidance* can be revealed. It can then be inferred that a rational society would be willing to pay at least the amount of the accident losses incurred to *avoid* accidents. Hence there has been much research into measures of the social costs of accidents. Lawson cites twelve accident cost studies including the two official U.S. studies, NHTSA (1972) and Faigin (1976) and the Australian study of Troy and Butlin (1971). He notes that typically they begin by listing *material losses (i.e* vehicle and property damage, health care, police and emergency services, lost productive effort, legal and court costs, administration of insurance and compensation). Non-monetary accident losses, such as pain, suffering or mental anguish of victims, etc. are recognised as social effects which present great difficulty in their measurement.

Lost Income: A major debate exists in the literature over identification of "lost productive effort". One issue is the question whether the social loss, e.g. resulting from a fatal accident, should include *net* production (*i.e.* only that contribution enjoyed by others) or whether it should include the full amount of the foregone production (*i.e.* gross income taking no account of consumption). Lawson concludes that this debate has been resolved by Mishan (1971) who reasons that only the *gross income* concept is correct since this concept is consistent with a society *including* the potential victim (since it includes his consumption), while the *net* income concept excludes the potential victim. Lawson notes that several major studies, including Reynolds (1956) and Dawson (1967) in the U.K.and Troy and Butlin (1971) in Australia, use the "incorrect" net income production concept. However Lawson also raises the problem of the potential offsetting of any lost productive effort resulting from accidents by their replacement by equivalent skills (or, from an increase in population), which may cancel out the accident losses. Acceptance of this view seems to involve the error cited by Mishan (*op.cit.*), namely that the normal economic and social adjustment processes which occur *after* a road accident resulting in loss of life or impairment of earning capacity (and hence, an absolute fall in *ex ante* welfare) are not relevant in "before the event" valuations of accident avoidance.

Intangible Losses: Most identification and measurement problems arise from *intangible* accident losses. These are defined as those effects which have no direct market valuation, including the services of housewives, family and community services rendered by an accident victim, and especially the value of pain and suffering (which Lawson considers "a truly intangible cost" in the sense that we wish to avoid them and "would be willing to pay to do so even if accidents involved...[no] material losses". Various accident cost studies have attempted to include an estimated monetary value for pain and suffering, including Dawson (1967) and NHTSA (1972), although these latter intended only to provide minimum values. Lawson notes that the later NHTSA estimates for the U.S.A. in 1975 abandoned the 1972 attempt to value pain and suffering. He considers that the "apparent confusion of concepts and imprecision in measurement" in some of the major studies of accident costs has reduced the usefulness of such estimates. For example, the NHTSA (1972) estimates for the U.S.A. in 1971 of $46 billion contrast with the National Safety Council (N.S.C.) estimate of $15.8 billion. The difference is mainly due to the N.S.C. exclusion of both "non-monetary" losses of accident victims and their consumption expenditure from lost earnings. In response to the criticism of such studies that measurement of accident costs is "heartless or immoral and that human life has infinite value", Lawson notes the counter argument that implicit values for death and injury are always involved in public decisions to improve safety: this is most apparent if any safety programmes are rejected on grounds of cost or effort - where estimation of *explicit* values should lead to more rational assessment of safety programmes. Lawson arrives at the conclusion that estimates of material losses due to accidents are only partial estimates of the social and economic loss of accidents.

Recent Theories of the Value of Safety Improvements:
Lawson points to a more fundamental objection to the use of accident costs in the evaluation of safety programmes: namely that such estimates are not consistent with the theoretical economic requirements of benefit-cost analysis. Mishan (1971) is cited as pointing out that the measure of *"willingness to pay"* (e.g. for road safety) in benefit cost analysis is that of *compensating variation,* which need not agree with an accounting of costs imposed by accidents. Thus estimates of the monetary value of accident costs may *not* represent the social value of avoiding these accidents. This is especially true for intangibles like pain, grief, and suffering. Schelling [1968] argued that such cost calculations as discounted lifetime earnings are only relevant to ordinary market place decisions (e.g. involving consumption, saving, a new job etc), and do not indicate *willingness to pay* for reducing *the probability* of death or injury.

There is also the question of whose valuations should be sought.

Schelling here makes the important distinction between "statistical death" and the deaths of individuals: the relevant impact to be measured in social evaluation of accidents is the *change* in risk of death or injury to *all* members of society. Therefore, it is necessary to identify the "population at risk" and find out their aggregate valuations. Such a calculation will go far beyond those directly affected.

The *value of reduction in risk* approach advocated by Schelling recognises the variability of the value of safety to individuals - which is overlooked in the *loss-accounting* approach. Society may be more adverse to some risks than others, and this should be reflected in differing *willingness to pay* to reduce differing risks. Schelling suggests that this is a rational approach, and does not arise simply from misperception or ignorance as often regarded by the analyst. Such preferences are apparent from casual observations of individual behaviour in relation to road safety which suggest broad differences in risk aversion (e.g. a higher perception of risk as a passenger rather than as driver).

It is difficult to derive reliable values of risk-reduction directly from individuals. Such a process is subjective and often unsystematic, but it is possible to infer *collective values of risk reduction* from past public decisions on safety expenditure. Mooney (UK, 1978) suggests that such collective values from past decisions could be used for future safety planning but Lawson disagrees, arguing that these inferred values for collective risk reduction are highly unreliable, variable and inconsistent...and could also "compound" earlier errors in public risk assessment. Drèze (1962), Schelling, and Mishan however are optimistic that individual valuations of risk reduction can be successfully obtained through careful development of direct questioning procedures. Mishan (1971) states that there is more to be said for rough estimates of the precise concept than precise estimates of economically irrelevant concepts , but Lawson notes that such techniques in practice are often extremely obscure and demanding of both the respondent and the analyst and no sustained success has so far been reported in the literature. However, he concedes that - "the concept that the appropriate value of a safety improvement is the value which the *population at risk* places on the reduction in risk is extremely persuasive"...and has received some measure of acceptance in recent economic literature, though it is virtually unknown among safety planners. However, he emphasises that no method of systematically revealing these values has so far been satisfactorily developed.

The Appropriate Role for Accident Cost Measures in Safety Programme Evaluation

Lawson poses the question - can a conceptual relationship be established between the commonly-used *accounting* sums of accident costs and the "true" values which would be placed on risk reduction? And in particular, are these measurable accident costs *minimum estimates* of appropriate values of safety improvements?

It is possible to reason that material accident losses *in part* determine what individuals would pay for risk reduction, and that such losses provide *minimum* estimates of the values of risk reduction. Following Mishan (1971), it is possible to separate the risks into "direct" risks, borne by the individual, and "indirect" risks borne by others. Also it is feasible to define another dimension which separates risk of material or"financial" loss and emotional or "psychic" loss.

It can be argued that an informed rational individual will value risk of *material* loss at its mathematical expectation and the aggregation of such valuations can be obtained by measuring across those at risk - and their dependents. Such a valuation is equivalent to material losses avoided. Thus material accident losses avoided can be argued to represent *partial*, and therefore *minimum*, estimates of the values which would be placed on reduced risks. Conley (1976) reached this same conclusion by more formal economic analysis.

But the value to society of the other component of reduced risk, *emotional loss*, remains completely obscure. Lawson concludes that "no guidance can be provided on its likely magnitude",...moreover the true value is also likely to vary with the nature of the risk. It is not considered possible therefore to arrive at an average value of emotional losses per accident or casualty which is defensibly a minimum.*

Lawson also cites support for a *minimum* estimate approach in Schelling (1968), Jones-Lee (1969), and Joksch (1975), in which estimates of material accident losses avoided may be used as minimum estimates of the benefits from safety improvements. But their usefulness in economic evaluations is severely limited. For example, in benefit cost analysis, minimum estimates of benefits can be used to demonstrate the acceptability of a programme on economic grounds were minimum benefits exceed programme costs. However, they *cannot demonstrate unacceptability*, because if minimum total benefits do *not* exceed total costs, then a judgement is required of the unmeasured intangible benefits to establish whether they are sufficient to lead to overall acceptance of the programme.

Lawson reaches the important conclusion that benefit-cost analysis will not provide at present the definitive guidance on programme acceptability which was hoped for, nor therefore can it determine the

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* In relation to this issue, D. Collard, in a review of Pearce (ed.) (1978) in the *Economic Journal*, June 1979 said "...perhaps well-being really is multi-dimensional, and there is no 'trade-off' between losing my best friend and gaining consumer durables...[i.e.] my utility is not a *function* of friendship, goods, and my state of health...[but] my 'well-being' is a *set* consisting of the friendships I have,...the 'utility' I derive from goods, and my state of health. These affect but do not trade-off against one another. On this view, attempts to put a monetary value on the non-monetary elements of the set are misconceived, and alternative techniques [e.g. interviews, surveys, etc.] should be encouraged."

justifiable size of the safety budget. Lawson also considers that the use of limited "feasible" benefit-cost analyses to determine priorities among programmes can be strongly challenged, because if the value of risk reduction *does* vary between the components of a road safety programme (*i.e.* owing to differing risk aversions), the minimum measurable risk will reflect differing *proportions* of true benefits for each component and may lead to incorrect selection of priorities. Joksch (1975) noted that the proportion of "true benefits" measured will vary with accident severity. Lawson argues that the minimum measurable risk character of existing cost estimates makes benefit-cost analysis a *weak* decision criterion and he notes errors of other studies in failing to recognise the existence of unmeasured benefits.

For example, Lawson cites the 1972 U.S. motor vehicle safety standards in which the implication was given that it would be 'uneconomic' to spend more on safety than the values of measured accident losses: this concept of "maximum economic benefit" clearly uses a definition of *economic* as purely material which is quite inappropriate. Social evaluations must be performed using social benefits and costs which extend beyond the material to all forms of satisfaction and dissatisfactions.

But it is noted the "official" estimates of accident costs in both the U.S.A. and the U.K. recognise that these values can only be used as minimum estimates of programme benefits, and both now recognise the theoretical arguments in favour of valuing *reductions in risk* rather than *avoided accident losses*.

For example in the U.S.A. (NHTSA 1972) "we have not quantified all losses associated with ... a highway accident...we are not arguing that it is unwise to spend more [to avoid an accident] than the amounts calculated", and for the U.K. (see U.S. Department of Transportation, Proceedings of the fourth I.C.A.S. 1975, p.158). "The fact that [the fatality figure] is a minimum figure must be borne in mind when a cost benefit calculation reaches the conclusion that the input costs of a proposed policy cannot be justified by the expected casualty savings".

Thus in the United States and in Britian, accident cost estimators have argued reasonably that imprecise minimum estimates are useful if they can allow at least *some* programmes to be demonstrated effective in economic terms but administrative judgement must be exercised in decision-making if the benefit-cost calculation does not demonstrate positive measured benefits.

Both the U.S. and U.K. agencies in their past practice appear to retain faith in the ability of cost-benefit analysis to determine programme priorities. Lawson considers that his present assessment denies this capacity to benefit-cost analysis using conventional estimates, and if the programmes being compared impact different types of risk or different severities of accidents, then the calculated cost benefit comparisons will not correctly indicate priorities. These arguments also apply equally to the application of *cost-effectiveness* analysis techniques to safety programmes.

Cost-effectiveness is recognised as a second-best alternative to benefit-cost analysis as a decision tool in road safety planning since no guidance as to the absolute acceptability of safety programmes (relative to other use of resources) is given, but *the intention is that priorities among programmes are suggested* by their relative ratios of accident casualty reductions to cost *(vide* U.S. 1976 *National Highway Safety Needs Report).*

Cost-effectiveness can only consider *one* physical objective against which costs are compared: Lawson notes that this is an important qualification, since it necessarily ignores other programme benefits. Also, casualty accidents of *differing severities* represent effectively, *different objectives* and therefore it is necessary to undertake, for example, a cost-effectiveness study of fatalities alone; or, "average injuries", alone; or the various severities must be weighted and combined into a composite effectiveness measure, as for example the U.S. Department of Transportation has a weighting of one fatality for 30 injuries "for reference purposes" (which is approximately equal to the relevant ratios in the NHTSA reports).

Lawson further notes that these partial cost estimates for the various accident severities will not provide "correct" weightings unless the proportion of total costs which are measured is the same for each severity. He does note that if the percentage of unmeasured costs rises as severity increases, some indication of *appropriate* relative weightings can be gained from relative measured costs, *e.g.* for U.S.A. if the ratio of measured costs of injuries to fatalities is 1:30 (and measured costs are higher for a fatality than an injury) then 1:30 is a lower bound estimate of the "true" equivalent weight of a fatality in terms of injuries.

Lawson concludes..."that the role of measures of accident losses in evaluation of safety programmes is very limited [but] measures of material accident losses are minimum estimates of social values of reductions in road accident risks...and can be used to recommend programme acceptability when benefits exceed costs by a suitable margin".

However, he also considers that to date there has been no success in measuring the non-material, emotional component of the benefits from reducing accident risks, and therefore an excess of programme costs over measured benefits is not *sufficient* to recommend a programme as unacceptable, except where such programmes address the same type of risk and their impacts have similar severity distributions. Also, the next best procedure, cost effectiveness analysis, cannot avoid these limitations.

THE JAPAN RESEARCH CENTRE FOR TRANSPORT POLICY (1978) *Social Losses from Road Accidents* Traffic Safety Research Project (pp.55).

The Japan Research Centre for Transport Policy (JRCTP) published estimates of the "social losses" arising from road accidents in Japan for the year 1974. For that year, Japan recorded

2,317,522	vehicle accidents involving
647,404	injuries and
15,448	fatalities.

Definition of Social Losses

The JRCTP report defines "objective social losses" from road accidents as the consumption of "objective social resources" including scarce manpower, vehicles and services. The report recognises the existence of *subjective social losses,* such as grief, pain etc., but excludes them from the estimates. The cost estimates consist of *lost income, medical costs, vehicle damage,* and a range of *other costs* including insurance administration, police, ambulance and judicial services and traffic congestion). The results of this study are summarised in Table 35 (Yen values are converted to Australian dollars).

TABLE 35

ESTIMATED SOCIAL LOSSES FROM ROAD ACCIDENTS: JAPAN 1974*					
Cost Item	Total Cost			Average Cost	
		A$m	%	A$	
Lost Net Income:					
Fatalities	603			39,020	per fatality
Earning capacity	430			9,440	reduced earning capacity per disability/injury
Work time	369	1,402	34.3		
Medical:		554	13.5	470	per injury
Vehicle Damage:		1,372	33.5	310	per vehicle
Other Costs:					
Insurance Admin.	654				
Ambulance	24				
Police	50			170	per vehicle
Judicial	23			330	per accident
Traffic delay	13	764	18.7		
Total:		A$4,092	100%	A$930 ($1,766	per vehicle per accident)

* *Yen values are converted to $A at the 1974 rate of ¥399=A$1*

The JRCTP report notes the difficulty of comparing the value of human life and that of a vehicle on the same dollar scale. The use of these estimates in guiding accident programmes is apparently envisaged..."However, the necessity of quantitative analysis of the damage caused by traffic accidents cannot be denied...when many accidents are occurring and measures should be urgently taken to deal with the situation".

The report also separates subjective from objective values and deals only with the latter ..."subjective losses such as grief, pain etc. caused by death and injury are compensated for by monetary compensation, at least partially in the real world, but such losses are not treated in this report".

The major significance of this report is seen as the establishment of an appropriate accident cost estimation methodology for Japan.

Discussion of Methodology

Official statistics of road accidents, casualties and fatalities are available in Japan for casualty accidents. Most information about injuries, medical treatment and property damage resulting from traffic accidents in Japan is derived from insurance records. Some insurance (e.g. "automobile liability insurance") is compulsory, insurance of property damage liability and fatality or injury is voluntary. Statistics from both sources were available for the JRCTP study.

Details of the total number of accident casualties and fatalities were available by sex and age groups. However, no direct data on casualties classified by sex, age and *severity of injury* was available, and the JRCTP report derived detailed estimates of severe injuries (with permanent disabilities) according to 14 classes of severity mainly from insurance data. These detailed breakdowns of accident victims form the basis of estimates of lost income and related accident losses.

Lost Income of Accident Victims:

(i) Fatalities:

In the case of a fatality or serious injury, which impairs earning ability,the expected future income which is foregone as a result of the accident is considered to be a *social loss, or cost*. However, the JRCTP report consider that for fatalities only 60% of such future income represents a social loss, since the resources represented by the individual's consumption are saved: this is the *net income* concept used in the U.K. studies of Reynolds (1956) and Dawson (1967). The JRCTP report also notes..."There seems to be no established practice as to the evaluation of housewives' labor, and it is assumed in this report that they earn income similar to those earned by female wage earners of the same ages."

The report calculates lost income of fatalities as shown in Table 36.

TABLE 36

ESTIMATED LOST INCOME: ACCIDENT FATALITIES - JAPAN 1974						
Age Group	Percentage in Employment		Average Annual Income of Accident Victims		Total Lost Income of Fatalities*	
(Years)	Male %	Female %	Male A$	Female A$	Male A$	Female A$
0-14	-	-	-	-	28,768	26,499
15-19	35.1	35.1	851	754	64,402	33,953
20-29	83.6	80.7	3,295	2,252	66,889	33,504
30-39	93.6	90.2	5,309	2,648	61,573	28,865
40-49	93.8	90.7	5,981	2,810	46,989	21,472
50-59	92.5	86.0	5,678	2,570	26,621	11,964
60-69	80.4	57.9	3,240	1,443	15,446	6,877
70+	-	-	-	-		
Total					45,551	17,728

Source: Based on tables 2-3-1 to 2-3-3, and 2-4-2 of J.R.C.T.P.Report. Yen values converted to $A at ¥399 = A$1. The annual incomes of accident victims were estimated by applying the employment proportion to the earnings level in each age group, e.g. for males aged 20-29 years 83.6% of $3,941 = $3,295.

* *Discounted at 5% p.a.*

The life expectancy of accident victims based on Japan Life Tables ranged from 72 to 76 years for males, and 77 to 80 for females. The JRCTP report used a method (the "Hoffman method") of calculating the present value of expected future net income for remaining years of life expectancy at the time of accident (children up to 14 years are assumed to cost $502 p.a.; and an allowance is also made for unemployment in the 15-19 years age group).

Total losses from fatalities in 1974 were calculated at:

	Number	Value A$m
Males	11,823	538.5
Females	3,625	64.3
Total	15,448	602.8

and the average income loss per fatality was $39,020.

(ii) Injured Victims with Permanent Disabilities

Income losses for those with some permanent disability were:

	Income Loss	Number	Average Income Loss
			$m
Males	309.7	29,040	10,663
Females	120.5	16,544	7,286
	430.2	45,584	9,437

In these calculations, it was assumed that future income earning capacity varied directly with the percentages of the 14 grades of disability (e.g. classes 1-3: 100%; 4-7 from 92% to 56%; etc., of income lost). Therefore those estimates take into account the range of actual injury severity in 1979.

(iii) Lost Work Time:

These calculations rely on insurance statistics which provided details of the number of days of medical treatment by age and sex (e.g. for those with permanent disabilities, this averaged 70.5 days). These time losses were multiplied by (a) the workforce participation rate (as in Table 2), and (b) by the average income for each age group, to arrive at the following estimate:

	Value of Lost Work Time	Number of Persons*	Average Cost
	$m		$
Males	293.0	321,657	911
Females	75.8	114,775	660
	368.8	436,432	845

* *representing 68.7%, 64.0%, and 67.4% of the actual number of male, female and total injured persons after applying the factor for workforce participation.*

(iv) Medical Costs

Public and private insurance statistics, after adjustment, provided data on total medical costs and length of treatment of accident victims.

Number of injuries:	647,404
Average cost of treatment:	$722
Total medical costs:	$467.5 million

(v) Attendant Costs (medical-related)

These costs were also derived from insurance records:

Average "Attendant" costs	$120
No of injuries	647,404
Total:	$77.7 million

(vi) *Property Damage*

The JRCTP study ignored minor vehicle damage, and utilised adjusted insurance claim statistics to provide the following estimates:

Vehicle Property Damage: 1974

Number of Accidents	Average Costs A$	Total Costs A$m
2,093,516 *(vehicle to vehicle)*	544	1,138.3
224,006 *(one car accidents)*	348	78.0
133,676 *(cycles etc.)*	28	3.8
		1,220.1

Indirect Costs of Traffic Accidents

(vii) *Ambulance Services*

In Japan these services are mainly run by the Fire Brigade: recorded statistics show that 20.4% of ambulance usage is for traffic accidents. This proportion of total service expenses (including wages, depreciation, operation and maintenance expenses) provided a cost estimate of $24.1 million.

(vii) *Police*

In 1974, police attended 1,156,343 traffic accidents of which 490,452 were casualty or fatality accidents, and 665,891 were property-damage-only accidents. Estimated average time per casualty accident was 17.6 hours, and 4.1 hours for vehicle damage, yielding an estimated total police cost (@ $4.08 per hour) of $49.6 million.

(ix) *Judicial*

The report allocated 10% of total judicial costs to traffic accidents: $22.9 million.

(x) *Insurance Administration*

Based on the operating expenses of (compulsory) automobile insurance and voluntary insurance, an estimate of $654.3 million was arrived at.

(xi) *Traffic Congestion*

The costs of traffic congestion are defined as the extra time and fuel used as a result of accidents. The JRCTP report arbitrarily selected an estimate of 10 minutes delay per annum at $1.50 per hour, giving an annual estimate of:

25×10^6 (vehicles) x 1.8 (persons/vehicle) x 10 mins/vehicle x (150/60) ¢ minutes = $12.5 million.

SHERWIN, M.A. (1977) "Road Accident Costs" in *The Cost of Road Accidents: Papers and Report from a Workshop on Cost of Road Accidents*, March 1977, Wellington, New Zealand (National Roads Board, 1978). pp.5-32.

Summary

This paper is a summary of a report on "The Economics of Road Accidents" to the Road Research Unit of the National Roads Board of New Zealand. The study includes a review of literature on the estimation of road accident costs, an assessment of concepts and application, an appraisal of New Zealand data resources, and some generalised estimates of road accident costs for New Zealand. Total accident costs for New Zealand in 1975 were estimated at between $160m to $170m. of which property damage represented 42% at $70 million; medical and hospital costs ranged between $8m. and $16m., and the foregone income of fatalities was $27 million (in 1973).

Discussion of Issues

Sherwin adopts the perspective that road accidents are very low probability events which result from a diversity of causes, making the task of preventing them difficult. He notes that accident estimation *methodologies* can be categorised as *macroscopic* - involving the application of aggregate data to form cost estimates, including the use of survey and insurance statistics to derive unavailable estimates. The *microscopic* approach (e.g. Troy and Butlin,[1971]) involves a detailed examination of *all* accidents in a given region.

Some five *cost categories* are recognised:

(i) *Property Damage:* is mainly confined to the repair costs of damaged vehicles. Since only injury accidents are officially recorded, survey data and studies in other countries are used to estimate that 320,000 vehicles were damaged in 1975 (assuming that approximately 85% to 90% of all accidents are property damage *only*), with an average repair cost of $225.

(ii) *Loss of Output Due to Fatalities:* is recognised as a measure of social loss, subject to some controversy in measurement. Sherwin notes that three concepts are available: the "implicit value" approach (based upon previous political decisions about safety levels); the "insurance principle" based on the individual's willingness to pay for some specified reduction in risk of death; and the discounted future earnings approach.

Sherwin recognises certain limitations, but adopts the third or present value method, using the "life model" basis in Paterson (1973) in which Gross National Expenditure is taken as the measure of national productivity, averaged over the productive age group (defined as all males *and* females between 20 and 64 years). Education expenditure is allocated to the 0-19 years age group, and both flows are discounted to a present value figure using a discount rate of 10% p.a. (as recommended for public projects by the N.Z. Treasury). Unlike the Paterson study, Sherwin does *not* deduct average annual consumption from these income flows, to avoid the absurdities of negative values for children and the aged, and emphasises that these estimates do not attempt to put a valuation upon human life, but (after Paterson *op.cit.* p.28) "simply indicate the average contribution of an individual in a manner which is logically consistent with national accounting concepts."

However, it is noted that the critical factors influencing the magnitude of estimates of the present value of future output are the discount rate selected and the treatment of consumption expenditures. For the 843 road fatalities in 1973, the present value (in 1973) of foregone income was $27.1 million, or a weighted average of $32,100. The age-specific present value estimates of lost income range from $37,000 at age 3, to a maximum of $82,000 at age 25, to zero at age 65.

The lost work capacity due to *injury disabilities* should be based on a similar approach to that of fatalities, but appropriate data on lost work time, disabilities and their duration was not adequate. Therefore only the injury cost results of "microscopic" studies were considered to provide satisfactory estimates.

(iii) *Medical and Hospital* costs were noted as comprising a surprisingly small part of total accident costs. Nevertheless, the available data sources were noted as very deficient for this purpose.

(iv) *Incidental costs* (including emergency services, insurance, administration, legal and court costs etc.), with the possible exception of insurance administration ($21m) consist of a large number of relatively small costs for which data is difficult to obtain and for which the estimation error of the major cost components may exceed the total for this item.

(v) *Subjective elements:* it is generally accepted that pain, suffering and grief are real costs - despite the dollar valuation problem - since it is clear that society would be willing to expend real resources to avoid the consequences of accidents - injuries and fatalities. But unique and acceptable quantification does not yet seem possible, and most available estimates are somewhat arbitrary.

Conclusion

Sherwin notes that it is relatively easy to derive *aggregate* accident cost estimates, but points both to the conceptual problems and to the dominant characteristic of accident statistics - namely that they often are represented by highly skewed distributions. Thus the use of simple cost averages is often meaningless, and thus limits the usefulness of aggregate accident cost data in the decision-making process.

Sherwin considers that there is a need to identify those factors which determine cost magnitudes and sensitivity to changes. There is also a need to separate accident costs according to a standardised classification of accident types (*e.g.* after Troy and Butlin's seven-way classification).

FAIGIN, B.M. (1976) *1975 Societal Costs of Motor Vehicle Accidents* United States Department of Transportation, National Highway Traffic Safety Administration, Washington D.C. (pp.35)

Summary

This report presents estimates of the societal costs of accidents in 1975 for the United States of America, and is a revision and up-dating of the N.H.T.S.A. report for 1971 (NHTSA: 1972). The report estimates that total societal costs of road accidents in the U.S.A. for 1975 were:

	Number	Total Societal Cost US$ billion	Average Societal Cost US$
Fatalities:	46,800	13.44	287,200
Injuries:	4,000,000	12.75	3,200
Property Damage (only):	21,900,000	11.40	520
	Total	$37.59 billion	

The concept of societal loss employed is defined as a decrease in community and individual welfare: it goes beyond the concept of economic welfare in the inclusion of qualitative as well as quantitative measures of accident effects. The report also recognises that adequate quantification of all accident effects is not possible.

The estimates presented are mainly seen as indicators magnitude of the road accident problem, and their use in specific benefit-cost analyses is considered to provide only part of the criteria needed in accident programme evaluation.

Two cost concepts are embodied in the study, namely *(i) current resources consumed* as a result of accidents, and *(ii)* the loss of production and consumption available to society. Some losses are incurred by individuals and firms, others are incurred by the community external to the individual. Much effort in this report is devoted to the estimation of accident costs by a range of injury severity classes (The Abbreviated Injury Scale: AIS, see Table 38).

Details of the conceptual basis and the method of calculation of each cost item, are outlined in the report. Faigin notes that only a slight improvement in the cost data base available had occurred between 1971 and 1975, and that much improvement in basic data was needed to increase the reliability of the component estimates.

In reviewing the need for further research, Faigin notes that the U.S. does not yet support a continuing cost recording system which covers fatality, injury and property damage costs, and it is necessary to seek the results of studies of accident components. Improvements in

accident recording consistent with the generally accepted Abbreviated Injury Scale (AIS) classification are also needed.

U.S. Cost Estimates

The principal findings of the Faigin study covering a detailed range of average societal costs in 1975 per fatality and injury by Abbreviated Injury Scale (AIS) level, and vehicle for property damage *only* accidents, are contained in Table 37.

TABLE 37

AVERAGE ACCIDENT COSTS BY INJURY LEVEL
NHTSA U.S.A. (FAIGIN) 1975 (7% DISCOUNT RATE) $US

	COST CATEGORY	INJURY SEVERITY (A.I.S.)						Property Damage Only
		6	5	4	3	2	1	
1	Market Earnings	211,820*	126,650*	55,550*	1,645	865	65	0
2	Family, Community	64,470*	37,995*	16,660*	425	310	20	0
3	Hospital	275	5,750	2,250	1,095	450	45	0
4	Other Medical etc.	290	5,520	2,160	525	165	55	0
5	Rehabilitation	0	6,075	3,040	0	0	0	0
6	Legal & Court	2,190	1,645	1,090	770	150	140	7
7	Insurance Administration	295	295	285	240	220	52	30
8	Accident Investigation	80	80	70	45	35	28	6
9	Losses to Others	3,685	4,180	1,830	260	130	32	0
10	Vehicle Damage	3,990	3,990	3,960	2,920	1,865	1,595	315
11	Traffic Delay	80	60	60	160	160	160	160
	TOTAL	287,175	192,240	86,955	8,085	4,350	2,192	518

Source: Table 1 (p.2) in Faigin.
** Discounted at 7% p.a.*

These costs are classified according to the *Abbreviated Injury Scale* (AIS) developed jointly in 1971 by the American Medical Association, the Society of Automotive Engineers, and the American Association of Automative Medicine in response to the needs of multidisciplinary accident research. The AIS has since gained wide acceptance in U.S. accident research.

The 1976 revision of the AIS classification is shown in Table 38

Faigin notes that in 1976 there were few direct AIS accident cost records in use, and it was necessary to allocate most existing cost data to AIS classes.

TABLE 38

ABBREVIATED INJURY SCALE*	
A.I.S. Code	Injury Severity
1	Minor
2	Moderate
3	Severe (not life-threatening)
4	Severe (life-threatening: survival probable)
5	Critical (survival uncertain)
6	Fatal (severity currently untreatable)

* *1976 Revision*

Discussion of Cost Components

The largest unit cost items in the 1975 estimates are those of *foregone market earnings*, also referred to as "production losses". The concept adopted is that future potential production and consumption of persons killed or disabled in road accidents is a direct loss to the social welfare of the community. The best proxy measure of this loss is average market compensation (earnings) for the market portion, and the value of outside employment contribution to both the family and the community. These two components are shown separately. For market earnings, Faigin collected average *income* data, classified by age and sex.

These average income figures were applied both to those accident casualties in the workforce ("market employed") and others including e.g. housewives ("non-market employed") in accordance with the principle that such non-marketed work should be valued at its opportunity cost. Because the age and sex distribution of accident fatalities and injuries differs significantly from the overall population distributions (e.g. 73% of fatalities were males in 1975), a weighted average value of lost income is calculated for each estimation year, and casualty group.

The method of estimation of lost income for fatalities is summarised as follows: assume production-earnings starts at age 20 and ends at age 65; increment age and sex - specific average income levels by 3% per annum to allow for long-term productivity increase; for the *median* age in each group calculate the discounted present value of the projected stream of income from age at time of accident to age 65 (since average life expectancy exceeds 65 in all cases) using a discount rate of 7% per annum. These calculations were repeated for each age group (zero income was imputed for ages 0-19, and for those over 65 years), and a weighted-average total was then calculated, based on the proportion in each age group.

For non-fatal injuries, a detailed review and assessment of medical and cost information on the effects of impairment by AIS injury severity class was undertaken. The resultant production losses adopted by Faigin are summarised in Table 39.

TABLE 39

SUMMARY OF LOST INCOME: NON-FATAL INJURIES 1975				
A.I.S. Level	Mean Income (1973) $	Mean Lost Work Days	1975 Loss per day $	Value of Lost Income 1975 $
1 (Minor)	9,036	1.6	40	56
2 (Moderate)	9,274	21	42	865
3 (Severe - I)	9,523	39	—	1,645
	*p.v.of income**	*% Impairment**		
4 (Severe - II)	(193,120)	25%		126,650
5 (Critical)	(193,120)	57%		211,820

**For A.I.S.categories 4 and 5, a percentage impairment of future earning capacity was calculated and applied to the present value of lifetime incomes.*

Losses to Others assume an opportunity cost concept, based on time spent by others in visiting patients, care etc. These were generally assessed as a proportion of market losses as in the NHTSA (1972) report.

Legal and Court Costs were based on the concept of resources consumed in response to accidents, including both public and private legal actions. Because such data are not classified by injury severity, Faigin assigned levels of legal action from estimates based on accident details. *Accident investigation costs* were available from a separate study.

Vehicle damage costs are a major component of societal costs, and are assumed to be a direct social loss measured by the cost of repairs. Using samples of insurance records, and official statistics, estimates were compiled for each AIS category.

Property damage only accidents comprise nearly 90% of all accidents: using official estimates of the *number* of these accidents, costs were apportioned by AIS category.

Traffic delay costs resulting from accidents were computed by assigning accident numbers and characteristics to peak commuter traffic flows, and computing lost time per accident.

Pain and suffering costs are considered conceptually to be a valid loss in well-being for the individual and for society, but no suitable basis for estimating the magnitude of pain and suffering has yet been devised in the view of Faigin, and it is excluded from the estimates as a *non-quantified cost*. The use of court damages awards as a proxy for the societal value of pain and suffering was considered to be inadequate without further research.

Sensitivity of Results to Discount Rate

The choice of an appropriate discount rate for estimating the present value of future social costs and benefits has been the subject of some controversy. Faigin selected 7% p.a. for the main unit cost estimates shown in Table 1, but also calculated a second set of average costs at 10% p.a. discount rate, shown in Table 40. The use of this higher rate has the effect of reducing the *total* accident cost estimates from $37.6 billion to $32.8 billion in 1975.

TABLE 40

AVERAGE ACCIDENT COSTS BY INJURY LEVEL
U.S.A. 1975 NHTSA (FAIGIN) (10% Discount Rate) $

COST CATEGORY	A.I.S. INJURY SEVERITY						Property Damage Only
	6	5	4	3	2	1	
1 Market Earnings	145,670*	82,250*	36,075*	1,645	865	66	0
2 Family, Community	44,780*	24,675*	10,820*	425	310	20	0
3 Hospital	275	5,750	2,250	1,095	450	45	0
4 Other Medical etc.	290	5,520	2,160	525	165	55	0
5 Rehabilitation	0	6,075	3,040	0	0	0	0
6 Legal & Court	2,190	1,645	1,090	770	150	140	7
7 Insurance Administration	295	295	285	240	220	52	30
8 Accident Investigation	80	80	70	45	35	28	6
9 Losses to Others	3,685	4,180	1,830	260	130	32	0
10 Vehicle Damage	3,990	3,990	3,960	2,920	1,865	1,595	315
11 Traffic Delay	80	60	60	160	160	160	160
TOTAL	201,335	134,520	61,640	8,085	4,350	2,193	518

Source: Table 57 (p.30) in Faigin
** Discounted at 10% per annum*

PATERSON, JOHN (1973) *A Review of the Cost of Road Accidents in Relation to Road Safety,* John Paterson Urban Systems Pty.Ltd., Report No. NR/23 for the Department of Transport, Australian Government Publishing Service, Canberra, pp.122 + (xii).

This report contains an estimate of road accident costs in Australia for 1969 of $480 million comprised of vehicle damage, medical/hospital costs, lost income of fatalities, and other costs associated with road accidents (police, legal and court and insurance administration costs). The Paterson study framed its cost estimates in strict national accounting terms, including the use of lost incomes *net* of consumption for fatalities, and drew extensively on the earlier work of Troy and Butlin (1971) both for cost concepts and estimation methods. These estimates are summarised in the following table.

TABLE 41

ROAD ACCIDENT COST COMPONENTS: AUSTRALIA 1969

		$ million	%	Average Cost $
Vehicle Repairs (and loss of value)		199.7	41.5	$222 per vehicle *($420 per collision)*
Injuries:				
Medical, hospital, etc.	15.9			
Short-term earnings loss	22.0			
Residual pain & suffering and long-run reduction in earning capacity	52.7			
Total Injury Costs:		90.6	18.9	$1028 (per injury)
Fatalities:		88.7	18.5	($25328) per fatality *($8706-pedestrian $30468 non-pedestrian)*
Other Costs:				
Police & Court costs	7.6			
Legal costs	34.3			
Insurance-Admin.	59.9	101.4	21.1	$213 (per collision)
TOTAL COSTS		$480.3m	100%	$1012 (per collision)

The cost estimates in Table 41 are based on 1969 estimates of 475,000 collisions involving 900,000 damaged vehicles, and reported statistics of 62,596 casuality accidents, 87,864 persons injured and 3,502 fatalities.

The Paterson study used *indirect* methods to estimate the cost of collisions in Australia for 1969. These cost estimates are distributed by State and by accident type. It is noted that most attempts to measure national accident costs have relied on indirect data sources, such as insurance statistics, medical cost estimates, and legal awards etc., which have provided appropriate estimation ratios. The use of *direct* cost data was preferred, and the report has therefore drawn heavily on the work of Troy and Butlin (1971) to derive the various estimation ratios which the Paterson report applied to published accident data. It is noted that official statistics generally record only accidents involving casualties. Troy and Butlin (1971) found that about 90% of all collisions in the Australian Capital Territory did *not* involve personal injury, and are not therefore included in national statistics.

TABLE 42

ESTIMATED TOTAL NUMBER OF COLLISIONS: AUSTRALIA 1969

Casualty Accidents (by type)		*Ratio of total collisions to casualty accidents*	*Estimated Total Collisions: 1969*
Between vehicles	33,744	8.227	277,612
Overturned	9,639	4.067	39,202
Pedestrian collision	10,002	1.323	13,233
Fixed Object	8,236	16.722	137,722
Other	975	7.301	7,118
Total	62,596	(7.5865)	474,887

Source: from Tables 8 and 9 in Paterson (1973). The ratios are derived from Troy and Butlin (1971) Table 7.1; and the classification of casualty accidents from re-arrangement of official accident statistics.

The principal ratios used to derive accident cost estimates in the Paterson study are shown in Table 42. The resultant *unit* accident costs in 1969 are shown by accident type in Table 43.

TABLE 43

UNIT COSTS OF ACCIDENTS: 1969 (1)		
Casualty Accident (type)	*Repair Costs 2 (per accident) $*	*Injury Costs 2 (per casualty) $*
Collisions between vehicles	463	271
Overturned or left road	518	497
Pedestrian collision	96	1227
Fixed object	337	412
Other	440	390
TOTAL	440	390

Notes: (1) from Table 12 of Paterson (1973); (2) based on Troy and Butlin (1971) Tables 7.1 and 7.4, reproduced in Table 11 of Paterson op.cit.

The original 1965/66 cost estimates have been increased by a factor of 1.122, representing price increases between 1965/66 and 1969 as measured by the GNP implicit price index.

Estimates of the Cost of Fatal Accidents:

The Paterson study used a different concept to that of Troy and Butlin to estimate the costs of fatalities. The latter distinguished between the *ex ante*, or before the event, perception of accident costs, and the *ex post*, or after the event concept, and adopted a case by case approach for each fatality in the A.C.T. study.

The Paterson report develops a model of the average economic person which envisages periods of withdrawal and addition to the income-expenditure flow of the community at various phases of a person's life. This approach assumes that from birth to age 19 years, the individual makes demands in excess of average consumption when society (and/or family) pay for education which is also regarded as an investment leading to future income-earning capacity. From 19 to 65 years, the individual makes a net productive contribution, while the over 65 years group is considered to make a net withdrawal from the national income stream. The Paterson study also averages the household incomes of male and female income earners, and attributes this average income to all accident victims. Thus it in effect attributes a somewhat higher income to housewives than imputed housekeeping wage rates, but the net effect is to bias lost income estimates downward, because it does not allow for the effects of the sex distribution of road accident casualties (which are male dominated).

TABLE 44

THE ECONOMIC LIFE CYCLE OF THE AVERAGE PERSON: 1969					
1969 Population Age	Number ('000)	Average Consumption *per capita* $ p.a.	Educational Investment *per capita* $ p.a.	G.N.E. *per capita* 20-64 yrs group $ p.a.	NET Contribution to Economy *per capita* $ p.a.
0-19	4,651		279	-	-1,846
20-64	6,615	1,567	-	4,363	+2,796
65 +	1,030		-	-	-1,567
TOTAL	12,296	(1,567)	(106)	(2,347)	(+ 674)

Source: Chapter 1 of Paterson (1973) espec. Table 16.

The basis of the Paterson report calculation is outlined in Table 43: using Australian National Income figures, consumption (exclusive of education expenditure) is averaged over the total population; educational expenditure is imputed to the 0 to 19 years age group only; and all productive contributions are averaged over the 20 to 64 years age group. These "contribution" and "withdrawal" rates are averaged over the total population in each age group, not the workforce.

By discounting these "net contribution rates" over the life expectancy of each age group in the population, the Paterson study arrives at the range of values of lost *net* economic contributions of accident fatalities as contained in Table 45.

TABLE 45

LOST ECONOMIC VALUE OF FATALITIES NET OF FUTURE CONSUMPTION (AT 5% DISCOUNT RATE)						
Age of Fatality Group	Representative age	Unit Value (at 5% p.a. discount Rate)	Non-Pedestrian % in Age Group	Value	Pedestrian % in Age Group	Value
		$	%	$	%	$
0-4	3	540	1.9	10.2	8.7	47.0
5-6	6	6,435	0.4	25.7	4.6	296.0
7-16	11	18,427	8.1	1,492.6	9.0	1,658.4
17-20	19	44,863	21.6	9,690.4	3.4	1,525.3
21-29	25	46,847	23.6	11,055.9	5.2	2,436.0
30-39	35	41,141	12.7	5,224.9	5.8	2,386.2
40-49	45	31,427	9.7	3,048.4	10.5	3,299.8
50-59	55	14,752	9.3	1,371.9	12.7	1,873.5
60+	68	-12,100	12.0	-1,452.0	39.8	-4,815.8
Totals			100.0	30,468	100.0	8,706

Source: Table 17 (p.27) of Paterson (1973)

The report argues that the values of Table 45 "are logically compatible with data published in the Australian National Accounts and can be used as proportions or ratios to National Account Statistics." *(op.cit.* p.28).

The discount rate selected of 5% p.a. was lower than both the prevailing long-term bond rate (of about 5.9%) and the social time preference rate. It thus had the effect of increasing these estimates of the present value of lost earnings of fatalities. This was offset to some extent both by the use of income levels averaged over the population rather than the workforce (see Table 44), and the use of a *net* income concept exclusive of consumption.

The three cost components of vehicle damage, injury costs, and fatality costs, totalling $326.2 million, or about 68% of the estimated total accident costs, were allocated by five classes of collision type as shown in Table 46.

TABLE 46

COSTS ALLOCATED BY ACCIDENT TYPE: 1969

Type of Collision	*Number*	*Vehicle Repair Costs*	*Injury Costs*	*Fatality Costs*	*Total*
		$m	*$m*	*$m*	*$m*
Between Vehicles	277,612	128.5	14.1	42.6	185.2
Overturned or left road	39,202	20.3	6.7	21.4	48.4
Pedestrian	13,233	1.3	12.0	7.1	20.4
Fixed Object	137,722	46.4	4.7	16.0	67.1
Other	7,118	3.1	0.4	1.4	5.1
Total:	474,887	199.7	37.9	88.4	326.2

Source: from Table 18 (p.29) of Paterson (1973), which also allocates the above costs across States and Territories. This total excludes $134.1 million of unallocated costs.

Other Costs:

Some 32% of total accident costs, or $154.2 million, were not allocated to collision type. These items and their basic of estimation were:

		$ million
(i)	*Police and Court Costs*: (based on an estimate of $16 per collision)	7.676
(ii)	*Insurance Overheads:* (equivalent to 20% of motor vehicle comprehensive *and* third party claims)	59.470
(iii)	*Legal Costs:* (assumed as 25% of third party claims)	34.291
(iv)	*Residual Pain and Suffering* (and long-term earnings loss)	52.718
	Total "other" costs:	$154.155 million

The estimate of *Police and Court* costs from the Troy and Butlin study, of $30.20 per collision, was considered too high and the figure used of $16 per collision, was selected judgementally. The *Police* component, based on Thorpe (1970) was calculated as $7 per reported accident.

Although Thorpe (1970) suggested that third party and comprehensive administration represented about 33% of insurance claims paid, the Paterson report considered this too high, and selected a figure of 20%. Troy and Butlin suggested that up to 30% of third party insurance payments in the A.C.T. were for legal expenses. Because this has been disputed, the Paterson study adopts the lower figure of 25% of such claims to represent *legal costs*.

The *injury costs* in Table 46 do *not* include long-term earnings loss: the Paterson study notes that the distribution of long-term losses would be significantly skewed towards severe injury accidents, and in the absence of direct data it is not appropriate to attempt an allocation of these costs. The A.C.T. estimate of Troy and Butlin was adopted after adjustment to a 1969 average value of $600 per injury. This results in an estimate of $52.7 million, or slightly less than the alternative estimate of 45% of total third party payments cited in Thorpe (1970), who did not consider pain and suffering to represent true economic losses to the community.

The Paterson study estimates do not include any costing of factors such as the *cost of traffic delays* resulting from road accidents, nor the effects of pain and suffering upon family and friends of accident victims.

Average costs derived from the Paterson report estimates (*as in Table 46*) are shown in Table 47.

TABLE 47

*AVERAGE "ALLOCATED" COSTS PER ACCIDENT: 1969**				
Collision Type	*Vehicle Repair Costs (per collision)*	*Injury Costs (a) (per casualty accident) $*	*(b) (per injury) $*	*Fatality Costs (per fatal accident) $*
1 Between Vehicles	463	418	271	30,494
2 Overturned or left road	518	695	496	29,805
3 Pedestrian	98	1,200	1,228	8,690
4 Fixed object	337	571	410	30,476
5 Other	436	410	360	31,111
Total:	420	605 (1,448)ø	431 (1,031)ø	25,243

* *"Allocated" Cost data is based on Table 18 in Paterson (1973) and the accident statistics in Table 3 (p.4A op.cit.).*

ø *Note that this table covers only 68% of total accident costs. The vehicle repair and fatality costs are complete, but only 42% of injury costs were allocated to collision type: the average total injury costs per casualty accident and per injury are shown in parentheses.*

Although the average injury costs are highest for pedestrian casualties, the approach adopted to foregone income for fatalities in the Paterson study (as shown in Table 45) has resulted in a low "economic" value for older accident victims, and an overall low estimate of "cost" for fatalities in general, and pedestrian fatalities in particular.

Discussion of Paterson Cost Estimates

Most of the Paterson report 1969 cost estimates relied on unit cost and other relationships adapted from the Troy and Butlin study of the A.C.T. The report suggests, however, that these 1969 total cost estimates may be compared with insurance and other aggregative data to derive comparative cost proportions for future cost estimation. The report does not offer much interpretation of the effects of its unusual method of valuing fatalities, which significantly differentiates the overall estimates from the Troy and Butlin study, and makes comparison with other empirical studies somewhat difficult.

The Paterson study also concluded that it was not possible to provide separate 1969 estimates of the cost of *fatal, casualty, or property damage accidents* with then available data. Official statistics of fatal accidents were not available, and the Troy and Butlin study indicated that injury costs comprised a markedly *skewed* distribution, so that the use of average values was restricted.

The Paterson study also noted major gaps in existing accident data, especially in relation to cross-classification of data by accident type, and a total absence of official cost data. The potential task was considered so large that the use of occasional statistical sampling procedures to supplement official coverage was considered to be the most feasible policy.

Review of Literature

The Paterson report also contains a comprehensive review and an annotated bibliography of accident cost literature over the period 1953-1972. (This present study is intended to provide a complementary review and bibliography which brings the Paterson report listings up to date).

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION (1972)
Societal Costs of Motor Vehicle Accidents, Preliminary Report, (April, 1972) United States Department of Transportation, National Highway Traffic Safety Administration, (NHTSA), Washington D.C. (pp. 8 & 46).

Summary

This preliminary report of the U.S. National Highway Traffic Safety Administration (NHTSA) presents estimates of the direct and indirect costs to society of motor vehicle accidents in the U.S.A. for 1971. The estimates are based on the principle that quantifiable losses are experienced by society regardless of whether all such effects have been converted into accepted economic values via market transactions.

The principal categories of social loss included are:

property damage;
medical costs;
productivity losses;
insurance administration;
losses to others;
community services, funeral costs;
pain and suffering.

The report estimates that there was a total loss to the U.S.A. of $46 billion in 1971, implying an average cost for *all* accidents of about $1,700. However, fatalities resulted in an average societal loss of about $200,000 and the average cost of non-fatal injuries was $7,300. The total cost estimates are shown in Table 48.

TABLE 48

ACCIDENT COSTS BY SEVERITY TYPE: U.S.A. 1971				
	Fatality Accident	Injury	Property Damage Only	Total
Average Cost:	$200,700	$7,300	$300	$1,650
Number of Occurrences	55,000	3.8 million	24 million	.
Total Cost (% of Total)	$11.0 billion (24%)	$27.6 billion (60%)	$7.4 billion (16%)	$46.0 bil (100%)

The composition of the accident cost estimates in Table 48 is outlined in detail in Table 49.

TABLE 49

AVERAGE ACCIDENT COSTS BY INJURY LEVEL
U.S.A. NHTSA 1971 (7% Discount Rate) $

	COST CATEGORY	Fatality	Permanent Disability	Partial Disability	No Permanent Disability	Property Damage Only
1	Market Earnings	132,000*	139,000*	36,000*	200	0
2	Family,Community	45,900*	44,000*	10,800*	50	0
3	Hospital	700	5,000	1,600	115	0
4	Other Medical etc	425	2,800	1,200	200	0
5	Rehabilitation	0	0	0	0	0
6	Legal & Court	3,000	3,000	1,000	150	3
7	Insurance Administration	4,700	4,300	4,300	800	100
8	Accident Investigation	0	0	0	0	0
9	Losses to Others	2,500	11,200	1,300	150	25
10	Vehicle Damage	1,500	1,000	900	700	180
11	Traffic Delay	0	0	0	0	0
12	Other Costs ø	10,000	50,000	10,000	100	0
	TOTAL	200,725	260,300	67,100	2,465	308

ø *"Pain and suffering"*

* *Discounted at 7% p.a.*

The National Highway Traffic Safety Administration *Preliminary Report* notes the inclusion of certain items comprising economic costs of accidents which are controversial, and also equally controversial is the basis of valuation of some components. As the 1972 Report states..."The approach taken here is that even when empirical information on a component is lacking, a reasonable approximation of costs should be made. *Omitting the component altogether essentially assumes a zero cost for that item.*" [Italics added].

Discussion of Cost Estimates

This report argues that many of the previous studies of economic losses from motor vehicle accidents have included only readily calculable dollar costs defined very narrowly, and that in reality such limited cost concepts cover only a small part of the total societal losses resulting from accidents. Because fatality and injury costs are more difficult to measure in economic terms, there is a danger that road safety agencies will devote a larger than optimal amount of resources towards *property damage* countermeasures rather than fatalities and injuries - when this does not correctly reflect society's preferences. However, the report emphasises that they have not attempted to place a unique value on a human life: it is *not* therefore suggested that it is unwise to spend more than $200,000 upon avoiding a fatality. These estimates simply represent *minimal* amounts of society should be willing to spend to reduce accidents and not be worse off in economic terms. It is recognised that society's programmes to reduce pain, suffering, and grief are unlikely to be based solely upon economic criteria. The report notes that *societal welfare,* as affected by road accidents, is a more embracing concept than the lesser measures of economic values embodied in national income statistics.

The *Preliminary Report* rejects the concept of the value which an individual places upon his or her own life as not relevant to useful application.

The principal significance of using dollar valuations of unlike accident components as a standard of measurement "...is that it does permit some amount of analysis of multiple goals by providing comparability among relatively unlike phenomena (e.g. fatalities, injuries, and property damage)".

The *value of foregone earnings* is considered to be an appropriate measure of social loss *without* deducting an estimate for consumption. Housewives' services have been imputed a market value equal to average female earnings on the opportunity cost principle.

Earnings losses for fatalities and permanent disablement injuries were calculated as the present value of future earnings, assuming that income was earned between ages 20 and 65, and that the median age adult fatality had 20 years remaining (*i.e.* is aged 45). Average full-time incomes for adult males and females ($11,000 and $6,200 in 1971, respectively) were incremented at 3% per annum to allow for productivity increases. For *injuries*, information on the relationship of injury severity to degree of disablement and loss of income was used to estimate percentages of productivity loss for three severity classes (total, partial, and *no* permanent disability) and four ranges of earnings loss (100%, 50%, 25% and none beyond one year). Age and sex distributions of accident victims were used to calculate weighted average estimates of foregone income, with discount rates of 5%, 7% and 10% per annum (although only those results using the 7% figure are published).

Medical and hospital costs were obtained from a Department of Transportation study of vehicle insurance compensation and data from the Social Securities Administration, respectively. These studies provided a frequency distribution of medical costs according to the four classes of injury severity, from which average costs according to accident severity were estimated.

Legal and court costs were based on two surveys, although some arbitrary allocation between injury severity classes was necessary. As with *insurance administration costs* a constant proportion of property damage costs was assumed.

Property damage costs were based on three available accident cost studies, which allowed reliable allocation of property damage costs between the main accident categories of fatal, injury and property damage only, but further distinctions between injury severity classes required less reliable approximations. *Family and community* losses are estimated at 25% and 5% respectively, of foregone income.

Pain and suffering is defined as the loss of welfare suffered by the individual in excess of other compensation, and applies both to fatalities and injuries. For fatalities, the NHTSA report used data on jury awards for pain and suffering as "the most reasonable expression we have of societal preference".

An average award of $9,700 was derived for fatalities, and a similar analysis of court awards to injured accident victims led to an estimate of $5 per day, which was then applied to the (previously derived) estimates of impairment.

In respect of these valuations, the National Highway Traffic Safety Administration report observes:

> *"The basic question is whether an estimated value for pain and suffering is more or less realistic than no value. Any value, including a zero value is entirely subjective, but that is not to say that attempts should not be made to derive a value."*

APPENDIX A-2

SUPPLEMENTARY TABLES

TABLE 50

AVERAGE ACCIDENT COSTS BY INJURY SEVERITY LEVEL
AUSTRALIA 1978: PRELIMINARY ESTIMATES (7% Discount Rate)

COST CATEGORY	Abbreviated Injury Scale (AIS) Level:						Property Damage Only
	6 *Fatal*	5 *Critical*	4 *Severe*[2]	3 *Severe*[1]	2 *Moderate*	1 *Minor*	
	$	$	$	$	$	$	$
1. Foregone Income	162,250*	93,220*	40,890*	1,210	650	50	-
2. Family, Community Losses	*48,680**	*27,970**	*12,270**	*385*	*195*	*15*	-
3. Hospital	670	36,000	11,900	7,100	1,900	150	-
4. Medical	310	3,120	1,730	1,000	380	75	-
5. Rehabilitation etc.	800	3,300	1,320	560	235	50	-
6. Legal & Court	*2,200*	*1,650*	*1,100*	*800*	*150*	*140*	*10*
7. Insurance Admin.	865	865	865	740	610	170	100
8. Accident Investig.	*200*	*200*	*100*	*100*	*50*	*50*	-
9. Losses to Others	*1,400*	*1,500*	*700*	*120*	*60*	*10*	-
10. Vehicle Damage	3,000	4,000	3,000	2,600	1,400	1,400	350
11. Traffic Delay	*80*	*60*	*60*	*160*	*160*	*160*	*160*
TOTAL	220,455	171,885	73,935	14,755	5,790	2,270	620

**Calculated using a 7% discount rate (and 3% p.a. "productivity")*
2 *AIS Class 4 "Severe: life-threatening";* 1 *AIS Class 3 "Severe: not life-threatening"*

TABLE 51

AVERAGE ACCIDENT COSTS BY INJURY SEVERITY LEVEL
AUSTRALIA 1978: PRELIMINARY ESTIMATES (13% Discount Rate)

COST CATEGORY	Abbreviated Injury Scale (AIS) Level:						Property Damage Only
	6 *Fatal*	5 *Critical*	4 *Severe* [2]	3 *Severe* [1]	2 *Moderate*	1 *Minor*	
	$	$	$	$	$	$	$
1. Foregone Income	86,640*	47,920*	21,020*	1,210	650	50	-
2. Family, Community Losses	*25,990**	*14,380**	*6,310**	*365*	*195*	*15*	-
3. Hospital	670	36,000	11,900	7,100	1,900	150	-
4. Medical	310	3,120	1,730	1,000	380	75	-
5. Rehabilitation etc.	800	3,300	1,320	560	235	50	-
6. Legal & Court	*2,200*	*1,650*	*1,100*	*800*	*150*	*140*	*10*
7. Insurance Admin.	865	865	865	740	610	170	100
8. Accident Investig.	*200*	*200*	*100*	*100*	*50*	*50*	-
9. Losses to Others	*1,400*	*1,500*	*700*	*120*	*60*	*10*	-
10. Vehicle Damage	3,000	4,000	3,000	2,600	1,400	1,400	350
11. Traffic Delay	*80*	*60*	*60*	*160*	*160*	*160*	*160*
TOTAL	122,155	112,995	48,105	14,755	5,790	2,270	620

**Calculated using a 13% discount rate (and 3% p.a. "productivity")*
[2] AIS Class 4 "Severe:life-threatening"; [1] AIS Class 3 "Severe:not life-threatening"

TABLE 52

SUMMARY OF TOTAL ACCIDENT COSTS - AUSTRALIA 1978
(7% Discount Rate)

Cost Category	Fatalities	Injuries			Property Damage Only	Total
		Major	Minor	Total		
	$m.	$m.	$m.	$m.	$m.	$m.
Foregone income	601.1	64.3	19.1	83.4	-	684.5
Losses to family, community	180.4	19.3	5.7	25.0	-	205.4
Hospital,medical	6.6	57.5	79.6	137.1	-	143.8
Vehicle damage	11.1	14.0	129.7	143.7	322.8	477.5
Other costs	17.6	11.2	61.1	72.3	249.1	339.0
TOTAL	816.8	166.3	295.2	461.5	571.9	1,850.2

TABLE 53

SUMMARY OF TOTAL ACCIDENT COSTS - AUSTRALIA 1978
(13% Discount Rate)

Cost Category	Fatalities	Injuries Major	Injuries Minor	Injuries Total	Property Damage Only	Total
	$m.	$m.	$m.	$m.	$m.	$m.
Foregone income	321.0	35.4	19.1	54.5	-	375.5
Losses to family, community	96.3	10.6	5.7	16.4	-	112.7
Hospital, medical	6.6	57.5	79.6	137.1	-	143.8
Vehicle damage	11.1	14.0	129.7	143.7	322.8	477.5
Other costs	17.6	11.2	61.1	72.3	249.1	339.0
TOTAL	452.6	128.7	295.2	424.0	571.9	1,448.5

TABLE 54

SUMMARY OF AVERAGE ACCIDENT COSTS - AUSTRALIA 1978
(7% Discount Rate)

Cost Category	Fatalities	Injuries Major	Injuries Minor	Injuries Total	Property Damage Only	Total
	$	$	$	$	$	$
I. PER PERSON & PER VEHICLE						
Foregone Income	162,250	12,520	200	850	-	-
Losses to family, community	48,680	3,760	60	260	-	-
Medical etc.	1,780	11,220	860	1,400	-	-
Vehicle damage	3,000	2,730	1,400	1,470	350	-
Other costs	4,740	2,190	660	740	270	-
TOTAL	220,450	32,420	3,180	4,720	620	-
II. PER ACCIDENT						
Foregone income	183,950	18,010	300	1,220	-	1,230
Losses to family, income	55,200	5,400	90	370	-	370
Medical etc.	2,020	16,140	1,230	2,020	-	260
Vehicle damage	3,400	3,930	2,010	2,110	670	860
Other costs	5,360	3,150	950	1,060	510	600
TOTAL	249,930	46,630	4,580	6,780	1,180	3,320

TABLE 55

SUMMARY OF AVERAGE ACCIDENT COSTS - AUSTRALIA 1978 (13% Discount Rate)						
Cost Category	Fatalities	Injuries			Property Damage Only	Total
		Major	Minor	Total		
	$	$	$	$	$	$
I- PER PERSON & PER VEHICLE						
Foregone income	86,640	6,890	210	560	-	-
Losses to family, community	26,000	2,070	60	170	-	-
Medical etc.	1,780	11,220	860	1,400	-	-
Vehicle damage	3,000	2,730	1,400	1,470	350	-
Other costs	4,740	2,190	660	740	270	-
TOTAL	122,160	25,100	3,190	4,340	620	-
II- PER ACCIDENT						
Foregone income	98,230	9,900	300	800	-	680
Losses to family, community	29,470	2,980	90	240	-	200
Medical etc.	2,020	16,140	1,230	2,020	-	260
Vehicle damage	3,400	3,930	2,010	2,110	670	860
Other costs	5,380	3,150	950	1,060	510	600
TOTAL	138,500	36,100	4,580	6,230	1,180	2,600

TABLE 56

TOTAL ACCIDENT COSTS BY CATEGORY AND BY INJURY LEVEL : AUSTRALIA 1978 10% Discount Rate ($millions)								
COST CATEGORYø	Injury Severity Level (AIS Class)*							TOTAL
	6	5	4	3	2	1	P.D.O.	
1. Market Earnings	420.56	13.09	27.64	4.76	15.72	3.42	0	485.19
2. Family, Community	*126.16*	*3.93*	*8.29*	*1.44*	*4.72*	*1.03*	*0*	*145.55*
3. Hospital	2.48	7.38	11.75	27.95	45.96	10.26	0	105.77
4. Other Medical etc.	1.15	0.64	1.71	3.94	9.19	5.13	0	21.75
5. Rehabilitation	2.96	0.68	1.30	2.20	5.68	3.42	0	16.25
6. Legal & Court	*8.15*	*0.34*	*1.09*	*3.15*	*8.63*	*3.57*	*9.22*	*35.15*
7. Insurance Admin.	3.20	0.18	0.85	2.91	14.75	11.62	92.24	125.77
8. Accident Investign	*0.74*	*0.04*	*0.10*	*0.39*	*1.21*	*3.42*	*0*	*5.90*
9. Losses to Others	*5.19*	*0.31*	*0.69*	*0.47*	*1.45*	*0.68*	*0*	*8.79*
10. Vehicle Damage	11.12	0.82	2.96	10.24	33.86	95.73	322.85	477.58
11. Traffic Delay	*0.30*	*0.01*	*0.06*	*0.63*	*3.87*	*10.94*	*147.59*	*163.40*
TOTAL	582.00	27.41	56.43	58.09	140.04	155.22	571.91	1591.10

ø Figures in italic type represent estimates derived from other studies (principally Faigin, 1976, for the U.S.A.)
** Classified by the "Abbreviated Injury Scale" (AIS): see text. "P.D.O." is Property Damage Only.*

TABLE 57

TOTAL ACCIDENT COSTS BY CATEGORY AND BY INJURY LEVEL : AUSTRALIA 1978
13% Discount Rate ($millions)

COST CATEGORY ∅	Injury Severity Level (AIS Class)*							TOTAL
	6	5	4	3	2	1	P.D.O.	
1. Market Earnings	321.00	10.20	21.55	4.76	15.72	3.42	0	376.66
2. *Family, Community*	*96.31*	*3.93*	*6.47*	*1.44*	*4.72*	*1.03*	*0*	*113.02*
3. Hospital	2.48	7.38	11.75	27.95	45.96	10.26	0	105.77
4. Other Medical etc.	1.15	0.64	1.71	3.94	9.19	5.13	0	21.75
5. Rehabilitation	2.96	0.68	1.30	2.20	5.68	3.42	0	16.25
6. *Legal & Court*	*8.15*	*0.34*	*1.09*	*3.15*	*3.63*	*9.57*	*9.22*	*35.15*
7. Insurance Admin.	3.20	0.18	0.85	2.91	14.75	11.62	92.24	125.77
8. *Accident Investign*	*0.74*	*0.04*	*0.10*	*0.39*	*1.21*	*3.42*	*0*	*5.90*
9. *Losses to Others*	*5.19*	*0.31*	*0.69*	*0.47*	*1.45*	*0.68*	*0*	*8.79*
10. Vehicle Damage	11.12	0.82	2.96	10.24	33.86	95.73	322.85	477.58
11. *Traffic Delay*	*0.30*	*0.01*	*0.06*	*0.63*	*3.87*	*10.94*	*147.59*	*163.40*
TOTAL	452.60	23.66	48.52	58.09	140.04	155.22	571.91	1450.05

∅ Figures in italic type represent estimates derived from other studies (principally Faigin,1976,for the U.S.A.)

** Classified by the "Abbreviated Injury Scale"(AIS): see text."P.D.O." is Property Damage Only.*

TABLE 58

THE EFFECTS OF AGE GROUP WEIGHTING ON DISCOUNTED INCOMES
AUSTRALIA 1978

Age Group	Present Value of Future Income at Median Ages: 7% discount; 3% productivity				
	Male	Female	Total I: weighted by fatalities	Total II: weighted by Injuries	Total III: population weighted
	$	$	$	$	$
0-4	139,432	60,941	97,168	103,935	101,208
5-6	156,315	68,321	124,637	120,372	113,286
7-16	196,463	85,868	152,359	150,595	142,692
17-20	255,987	107,468	224,731	209,458	183,000
21-29	262,376	96,499	233,962	206,788	180,225
30-39	231,779	87,671	194,837	174,099	161,735
40-49	176,236	68,970	141,610	130,037	124,260
50-59	94,712	37,067	75,436	68,823	66,072
60 +	50,542	17,873	36,371	34,636	33,666
AVERAGE TOTAL INCOMES Compared:		Male:	201,534	214,840	175,132
		Female:	66,178	79,462	67,499
		Total:	162,264	163,548	121,428

**Based on average gross incomes: the present value of male and female incomes is the same for all these calculations. The differences between Totals I, II, and III are entirely the result of differences between the age and sex composition of fatalities, injuries, and the overall population.*

The row totals show the effects of variations in the male-female proportions for each age group, while the weighted average column totals reflect the proportion of the total number in each age group.

Both accident samples differ markedly from the population proportions (e.g. 71% of fatalities and 61% of Injuries are male compared with 50% for the total population. Also, the 17 to 19 years age group represented 43% of fatalities and 47% of Injuries , but comprises only about 22% of the total population).

TABLE 59

REMAINING LIFETIME ADJUSTED INCOME:(1) ROAD ACCIDENT INJURIES AUSTRALIA 1978							
Age Group	Number of Injuries (1977) (2)	Present Value of (remaining) Lifetime Income (Averaged over population groups)(3)					
		Disc: 7% Prod: 2.5%	7% 3%	7% 3.5%	10% 2.5%	10% 3.0%	10% 3.5%
		$	$	$	$	$	$
0-4	2,691	71,656	83,804	98,260	31,184	35,860	41,321
5-6	1,606	85,420	98,508	113,893	40,264	45,656	51,879
7-16	10,900	109,803	122,973	138,097	61,125	67,311	74,289
17-20	21,278	165,140	178,645	193,776	111,857	119,080	127,054
21-29	21,698	166,276	177,605	190,103	119,305	125,860	133,007
30-39	10,155	135,604	142,560	150,045	104,640	109,201	114,075
40-49	6,940	93,834	97,090	100,506	78,210	80,644	83,190
50-59	6,150	41,597	42,334	43,089	37,770	38,401	39,046
60 +	6,486	16,297	16,450	16,604	15,468	15,609	15,752
AVERAGE LIFETIME INCOME per injury		125,573	135,006	145,551	87,842	92,990	98,651

Average incomes were multiplied by the workforce participation rate for each age group (to average incomes over the population in each age group).

(1) Calculated as at median age for each age group, assuming an income earning period from 15 to 64 years of age. The totals are weighted averages of the incomes for each group.

(2) The total number of Injuries in 1977 was 91,616: the table excludes 3712 injuries with age not specified. The year 1977 is the latest available year for which the A.B.S. has published Australia-wide statistics for injuries classified by age.

(3) Discounted to 1978 values at discount rates as shown, also, incomes were incremented by annual productivity increases at the rates indicated for each column.

TABLE 60

REMAINING LIFETIME NET INCOME(1): ROAD ACCIDENT INJURIES - AUSTRALIA 1978							
Age Group	Number of Injuries 1977 (2)	Present Value of Lifetime Income less Consumption Expenditure at: (3)					
		7%(disc.) 2.5% (prod)	7% 3%	7% 3.5%	10% 2.5%	10% 3.0%	10% 3.5%
		$	$	$	$	$	$
0-4	2,691	27,523	32,217	37,824	12,008	13,791	15,877
5-6	1,606	32,333	37,312	43,189	15,291	17,315	19,654
7-16	10,900	41,651	46,681	52,482	23,260	25,580	28,202
17-20	21,278	59,917	64,925	70,567	40,493	43,100	45,991
21-29	21,698	59,797	64,105	68,882	42,224	44,646	47,299
30-39	10,155	51,120	53,973	57,058	38,630	40,447	42,397
40-49	6,940	38,825	40,316	41,887	31,768	32,856	33,999
50-59	6,150	20,920	21,337	21,764	18,767	19,121	19,483
60+	6,486	10,637	10,737	10,838	10,097	10,189	10,282
AVERAGE LIFETIME NET INCOME per injury :		47,081	50,699	54,760	32,784	34,720	36,854

Based on 31% of gross incomes for all age groups to exclude consumption expenditure; and

(1) calculated as at median age for each age group, assuming an income earning period from 15 to 64 years of age. The totals are weighted averages of the incomes for each age group.

(2) The total number of Injuries in 1977 was 91,616: the table excludes 3712 injuries with age not specified. The year 1977 is the latest available year for which the A.B.S. has published Australia-wide statistics for injuries classified by age.

(3) Discounted to 1978 values at discount rates as shown, also, incomes were incremented by annual productivity increases at the rates indicated for each column.

TABLE 61

LIFETIME *NET* ADJUSTED INCOME:[1] ROAD ACCIDENT INJURIES
AUSTRALIA 1978

Age Group	Number of Injuries [2]	Present Value of Net Adjusted Lifetime Income at: [3] Disc: 7% Prod: 2.5%	7% 3%	7% 3.5%	10% 2.5%	10% 3.0%	10% 3.5%
		$	$	$	$	$	$
0-4	2,691	22,213	25,979	30,460	9,667	11,116	12,809
5-6	1,606	26,480	30,537	35,306	12,482	14,153	16,082
7-16	10,900	34,038	38,121	42,810	18,948	20,866	23,029
17-20	21,278	51,193	55,379	60,070	34,675	36,914	39,386
21-29	21,698	51,546	55,058	58,932	36,985	39,017	41,232
30-39	10,155	42,037	44,194	46,514	32,438	33,852	35,363
40-49	6,940	29,089	30,098	31,157	24,246	25,000	25,790
50-59	6,150	12,893	13,122	13,356	11,707	11,902	12,103
60 +	6,486	5,052	5,099	5,147	4,795	4,832	4,883
AVERAGE LIFETIME NET INCOME [1] per Injury :		38,927	41,852	45,120	27,231	28,827	30,581

(1) Based on 31% of gross incomes (to exclude consumption expenditure) and multiplied by workforce participation rates by age groups (to average net incomes across the total population in each age group);

(2) The total number of Injuries in 1977 was 91,616: the table excludes 3712 injuries with age not specified. The year 1977 is the latest available year for which the A.B.S. has published Australia-wide statistics for injuries classified by age.

(3) Discounted to 1978 values at discount rates as shown; also, incomes were incremented by annual productivity increases at the rates indicated for each column.

TABLE 62

TOTAL ACCIDENT COSTS BY CATEGORY AND BY INJURY LEVEL : AUSTRALIA 1978
7% Discount Rate ($millions)

COST CATEGORY ø	Injury Severity Level (AIS Class)* 6	5	4	3	2	1	P.D.O.	TOTAL
1. Market Earnings	601.14	19.11	40.36	4.76	15.72	3.42	0	684.51
2. Family, Community	*180.36*	*5.73*	*12.11*	*1.44*	*4.72*	*1.03*	*0*	*205.38*
3. Hospital	2.48	7.38	11.75	27.95	45.96	10.26	0	105.77
4. Other Medical etc.	1.15	0.64	1.71	3.94	9.19	5.13	0	21.75
5. Rehabilitation	2.96	0.68	1.30	2.20	5.68	3.42	0	16.25
6. Legal & Court	*8.15*	*0.34*	*1.09*	*3.15*	*3.63*	*9.57*	*9.22*	*35.15*
7. Insurance Admin.	3.20	0.18	0.85	2.91	14.75	11.62	92.24	125.77
8. Accident Investign	*0.74*	*0.04*	*0.10*	*0.39*	*1.21*	*3.42*	*0*	*5.90*
9. Losses to Others	*5.19*	*0.31*	*0.69*	*0.47*	*1.45*	*0.68*	*0*	*8.79*
10. Vehicle Damage	11.12	0.82	2.96	10.24	33.86	95.73	322.85	477.58
11. Traffic Delay	*0.30*	*0.01*	*0.06*	*0.63*	*3.87*	*10.94*	*147.59*	*163.40*
TOTAL	816.79	35.24	72.97	58.09	140.04	155.22	571.91	1850.26

ø Figures in italic type represent estimates derived from other studies (principally Faigin, 1976, for the U.S.A.)

** Classified by the "Abbreviated Injury Scale" (AIS): see text. "P.D.O." is Property Damage Only.*

TABLE 63

APPROXIMATE SEVERITY CLASSIFICATION OF VICTORIAN INJURY DATA 1977-78			
A.I.S.* Class:	Number of Accident Cases	%	International Classification of Diseases (ICD) code:
5 "Critical" } 4 "Severe(2)"	653	(3.3%)	Fractured skull, -vertebrae (with spinal cord lesion), -(no spinal cord lesion), amputations ICD 800,801,803,805,885-887,895-897
3 "Severe(1)"	4,067	(20.4%)	Fractured pelvis,-upper limbs,-lower limbs ICD 808,810-817,820-826.
2 "Moderate"	2,230	(11.2%)	Ill-defined fractures, dislocations, sprains, ICD 809,818,819,827-829,830-839,847
1 "Minor"	8,457	(42.5%)	Lacerations etc. ICD 871-884,890-894, 900-907,910-918,920-929.
	4,487	(22.6%)	(Unallocated) ICD 850-854,807,860-862,863-869, 870,950-959
TOTAL	19,894		

* *Abbreviated Injury Scale*

Source: *based on Table 7 (p.8) in 1977-78 Bulletin of Statistics, Motor Accidents Board, Victoria, June 1980.*

TABLE 64

FOREGONE INCOME for 1973 FATALITIES in U.S.A.
COMPARISON OF FAIGIN RESULTS WITH PRESENT STUDY (1)

Age Group	Fatalities No.	(%male)	Average Foregone Income (2) per fatality (1973 present value) 1. U.S. Study	2. Method in present study
			$	$
0-4	2000	(58.0)	103,935	108,505
5-9	2005	(61.4)	127,100	154,628
10-14	2120	(67.6)	175,320	166,629
15-19	9310	(74.4)	201,965	208,288
20-24	8725	(80.1)	237,960	244,839
25-29	5115	(78.7)	244,155	249,588
30-34	3505	(76.8)	229,805	240,777
35-39	2740	(75.2)	213,245	222,222
40-44	2655	(72.4)	172,020	196,602
45-49	2740	(72.8)	156,720	164,714
50-54	2705	(70.4)	120,720	130,580
55-59	2435	(70.0	79,365	85,563
60-64	2340	(65.7)	31,700	39,857
Overall Average direct productivity loss per fatality:			184,110	196,927

(1) All data except column 2 are from Table 4 of Faigin(1976): column 2 attempts to reproduce Faigin's figures, using the method and parameters outlined in that document (pp. 3-6).

(2) A discount rate of 7% p.a. is used to convert income estimates to 1973 values; also mean incomes are incremented by 3% p.a. for productivity increase (see Faigin op. cit. pp. 5-6)

The differences are relatively small, and may result from small changes in the time and income parameters used, associated with the relatively complex computations involved.

TABLE 65

1. PRODUCTIVITY CALCULATIONS - AUSTRALIA 1967-1978

Year	(1) A.B.S. Employment Index (1974/75=1000)	(2) Civilian Non-farm Employment ('000)	(3) Household Income $m	(4) Income Per Employee (3)÷(2) $	(5) Implicit Price Index (P.C.E.) (1974/75=100)	(6) Income per Employee Constant 1974/75 Prices $
1966/67	807	3,922	18,107	4,617	57.6	8,015
1967/68	831	4,038	19,048	4,717	59.6	7,915
1968/69	857	4,164	21,425	5,145	61.2	8,407
1969/70	894	4,344	23,634	5,441	63.7	8,541
1970/71	926	4,500	26,543	5,898	67.5	8,738
1971/72	939	4,563	30,002	6,575	71.9	9,145
1972/73	959	4,660	34,417	7,386	76.2	9,692
1973/74	996	4,840	42,338	8,748	85.3	10,255
1974/75	1,000	4,859	52,534	10,812	100.0	10,812
1975/76	1,006	4,889	61,362	12,551	115.5	10,867
1976/77	1,017	4,942	70,990	14,365	128.7	11,161
1977/78	1,024	4,976	78,459	15,767	140.5	11,222

Column (2) from The Australian Economic Review "Employment and the Labour Market" 4th quarter 1979 (pp 51-55);

Column (3) & (5) from Australian National Accounts, National Income and Expenditure 1977-78, A.B.S. Canberra.

Column (6) = [column(4) ÷ column(5)] X100

2. A fitted exponential curve of form: $Y = ae^{bx}$ to the data of Column (6), (using ordinary least squares method), results in:

$$Y = 695.4\ e^{.036x};\ (R^2 = 0.969)$$

resulting in an estimated *average productivity increase* of 3.67% p.a. between 1966/67 and 1977/78

i.e. = $\ln^{-1}0.036$

3. Alternative calculations are:

(i) Average growth in *Real Income per capita* for the period 1966/67 to 1977/78

= 4.18% p.a. ($Y = 2534e^{.0409x}$; $R^2 = 0.967$); and

(using Data from Aust. National Accounts 1977-78, incl. the implicit private consumption price index as deflator)

(ii) Average growth in *Gross Product per person employed* for the period 1966/67 to 1977/78 (at constant 1974-75 prices): = 2.29% p.a.

($Y = 182e^{.0226x}$; $R^2 = 0.98$)

APPENDIX A-3

STATISTICAL DISTRIBUTIONS FITTED TO ACCIDENT COST FREQUENCIES

APPENDIX A-3

STATISTICAL DISTRIBUTIONS FITTED TO ACCIDENT COST FREQUENCIES

This appendix presents a brief account of, together with some preliminary results of, the fitting of theoretical probability distributions to some of the accident cost data obtained for this study. The purpose of this investigation is to provide a more general basis for estimating the range and value of accident cost classes based on probability of occurrence. The potential application of this work is briefly indicated in Chapter 3, (*vide* section 3.3) and the cost frequency distributions are discussed in section 3.2.

Purpose of probability distributions:

The objectives of relating accident cost data to probability distributions are twofold: (i) to obtain a generally useful and powerful technique for summarising and interpreting accident costs (For example the distributions of many road accident characteristics including costs are known to be asymmetrical (positively skewed), such that the use of simple *average* values may be quite misleading; and (ii) that the ability to subdivide accident costs into intervals of known probability of occurrence is in itself a useful analytical device, and in the present study may provide a suitable basis for estimating *injury severity* levels (such as the Abbreviated Injury Scale classification: *vide* section 3.3 and Table 39).

The cumulative probabilities used to estimate cost ranges for injury severity levels in this report were applied directly to the empirical cost distributions for vehicle damage claims, and medical etc. claims paid by the Motor Accidents Board of Victoria.

Statistical Properties of the Gamma Distribution: (*vide* Mood & Graybill [1963], Thom [1958])

Road accident costs have values which range between zero and are virtually unlimited at the upper end of the range. These properties of accident costs as statistical phenomena are consistent with several asymmetrical probability distributions, notably the *gamma distribution* and the *log-normal distribution*, which both have a zero lower bound and are unlimited at the upper end of their ranges. In addition, both distributions are positively skewed (i.e. have high frequencies at the lower end of the range of cost values with a long "tail" of higher values) which is also characteristic of accident costs.

In this Appendix the results of *gamma distributions* fitted to samples of accident cost data are presented. These preliminary results suggest that the gamma distribution appears to provide a good approximation to accident cost frequencies. The gamma distribution has found wide application in meteorology and hydrology involving the prediction of floods, droughts and other relationships based on climatological variables.

The formula for the probability density function of the gamma distribution is:

$$f(x) = \frac{1}{\beta^{\gamma}\Gamma(\gamma)} x^{\gamma-1} e^{-x/\beta} \quad ; \ldots\ldots\ldots (1)$$

(defined for $\gamma > 0$*;* $\beta > 0$*; zero elsewhere)*
Where $\Gamma(\gamma) = \gamma\Gamma(\gamma - 1)$ *; is the gamma function defined for both integer and non-integer values of* γ.

This is a two-parameter distribution, where γ is the shape parameter, and β is a scale parameter. It is readily fitted to sample distribution data by the method of moments, i.e.:

The mean

$$\mu_1 = \beta\gamma \quad ; \ldots\ldots\ldots (2)$$

and the variance

$$\mu_2 = \beta^2\gamma \quad ; \ldots\ldots\ldots (3)$$

This method is not as statistically efficient as the method of maximum liklihood (M.L.), and may often give unacceptable results. The M.L. method yields equations which are not readily solved, however a 1958 paper by Thom provides a convenient method of parameter estimation based on the M.L. approach which produces a superior fit to the moment method, and which has wide application in hydrologic and meteorological models (*vide* Thom [1958]). Thom's estimation equations, in summary are:

$$\hat{\gamma} = \frac{1 + \sqrt{1 + 4A/3}}{4A} \quad ; \ldots\ldots (4)$$

where

$$A = log_e\bar{x} - \frac{1}{n}\Sigma log_e x \quad ; \ldots\ldots\ldots (5)$$

The γ parameter is also subject to a small correction factor provided in Thom's paper and β is derived from equation (2) above. Using Thom's method, gamma distributions were fitted to sample data on road accident costs for insurance claims for vehicle damage from several companies, and medical and hospital claims paid by the Motor Accidents Board of Victoria.

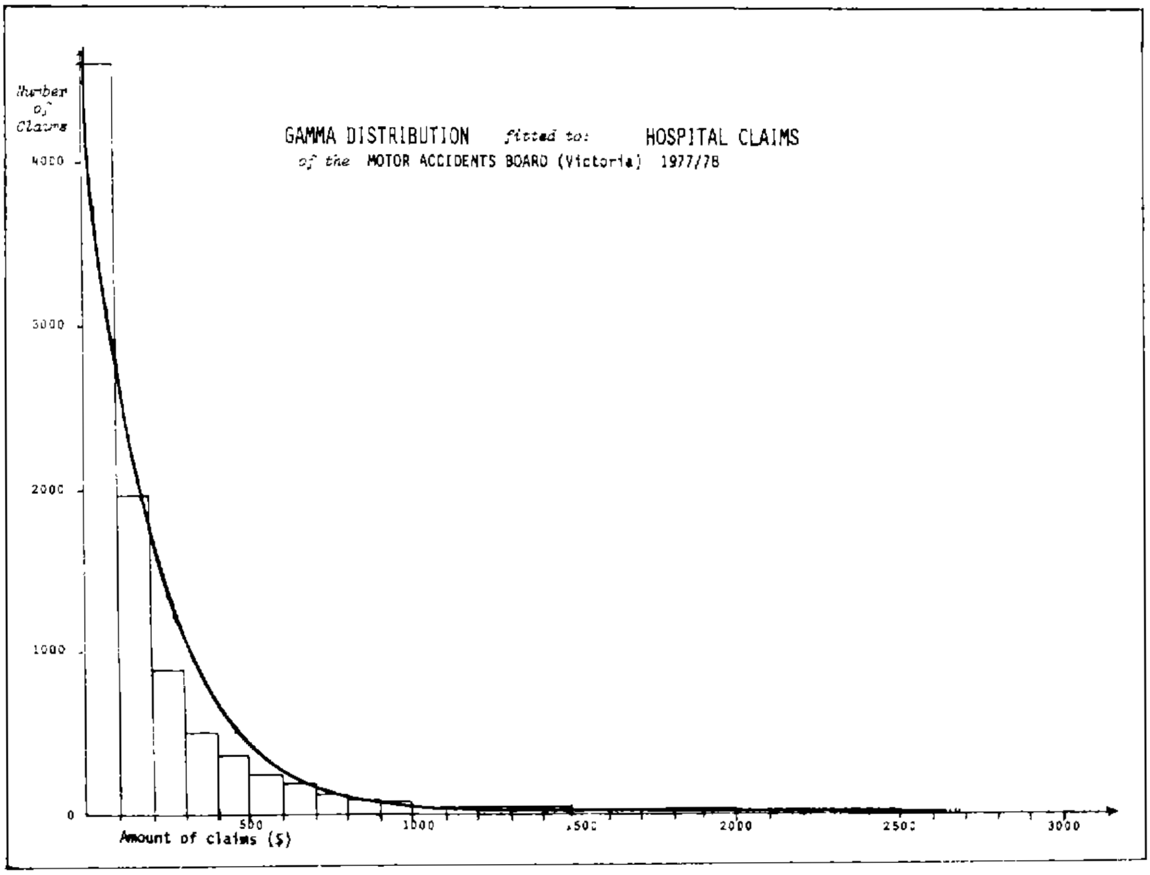
The main concern of this exercise is not with the fitted gamma distribution itself (equation [1]), but with the *probability* values derived from the integral of equation (1). The latter is an intractable expression which is usually found as a series expansion (as in the present study). It will be noted that for values of the γ (i.e. shape) parameter less than 1 the shape of the distribution is exponential. For large values of γ (e.g. $\gamma > 30$), the shape of the distribution approaches that of the normal distribution.

The well known chi-square distribution is in fact a special case of the gamma distribution *(where $\chi^2/2$ is a gamma variate with $\gamma = \frac{n}{2}$ and $\beta=1$).*

Preliminary results with road accident data: the results of fitting the gamma distribution to several sets of road accident cost data are shown in Figures A-1, A-2 and A-3, and their properties are briefly outlined.

Figure A-1 shows an exponential form of the gamma distribution fitted to 1977/78 hospital claims' data of the Motor Accidents Board of Victoria.

FIGURE A-1



This curve is exponential in form because the "gamma" parameter is less than 1 ($\hat{\gamma}$ = 0.702 and β =1901). Because of the restricted range of the data this particular curve does not provide a good basis for estimation of the higher levels of hospital costs, and an extended frequency distribution range is being prepared by the M.A.B. (for hospital, medical and other accident costs recorded by the Board).

The histogram plottings in Figure A-1 show the actual MAB hospital data in $100 class intervals, and the gamma distribution curve shows the continuous curve which is fitted to the data by the method indicated above. Once the distribution of best fit is known, it is then possible to determine the probability of occurrence of any given hospital cost level (on the horizontal axis). In the present study the accident cost intervals were calculated as probabilities equivalent to the Abbreviated Injury Scale (AIS) classes (*vide:* chapter 3, section 3.3). The preliminary results are shown below for AIS classes 1 to 5:

M.A.B. Hospital Claims 1977/78

A I S Level	Cumulative probability (%)	Predicted Range of claims($)	Actual Values used in Table 1 ($)
1	70.00	0 - $1545	150
2	94.77	$1545-$4460	1900
3	98.79	$4460-$7040	7100
4	99.80	$7040-$10270	11900
5	100.00	$10270 +	36000

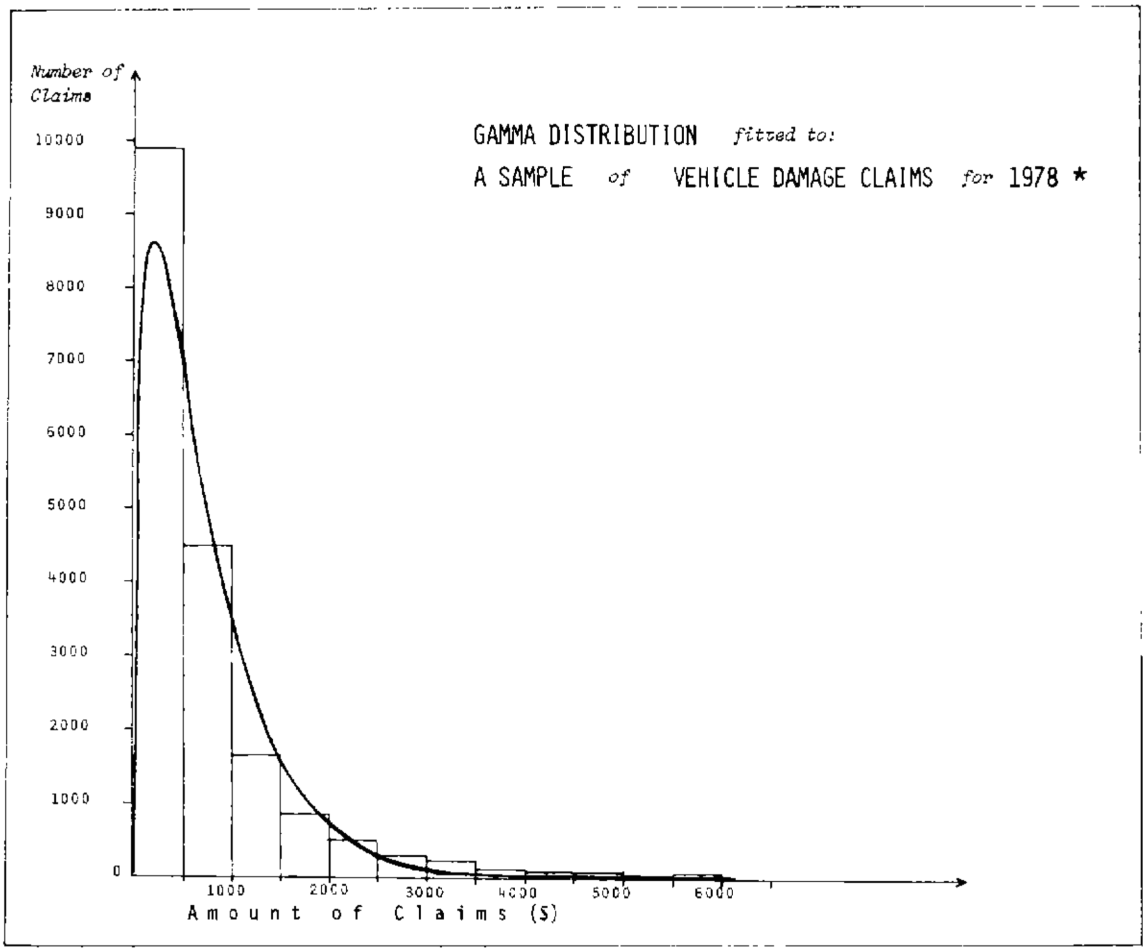
These preliminary results were based on incomplete data and are not used as the basis of Table 1 hospital cost estimates.

Vehicle Damage Claims: The range of claim sizes consistent with the AIS class probabilities for vehicle damage claims, is shown in Figure A-2. These results were based on Victorian data relating to over 17,000 insurance claims in 1978 involving a total payment of $12.9 million.

Vehicle Damage Claims Sample 1978 ($\hat{\gamma}$ = 1.326 ; $\hat{\beta}$ = 561)

A I S Level	Predicted Range of Claims	Mean (of range)	Median (of range)	Actual Values used in Table 1
	$	$	$	$
1 (& PDO)	0 - 900	330	380	(350 PDO (1,400 AIS 1
2	900 - 2,000	1,320	1,250	1,400
3	2,000 - 2,900	2,380	2,280	2,600
4	2,900 - 3,900	2,980	3,190	3,000
5	3,900 +	5,160	4,330	4,000

FIGURE A-2



* *based on State Insurance Office of Victoria vehicle insurance claims.*

Except for AIS level 1 (which was based on the survey results of Fox et al. [1979], the mean of these cost ranges is close to the actual estimates in Table 1. The *median* value for each range (*i.e.* that value with 50% of cases in that range above and below it) is also shown for comparison with the *mean* to indicate the skewed nature of the distribution.

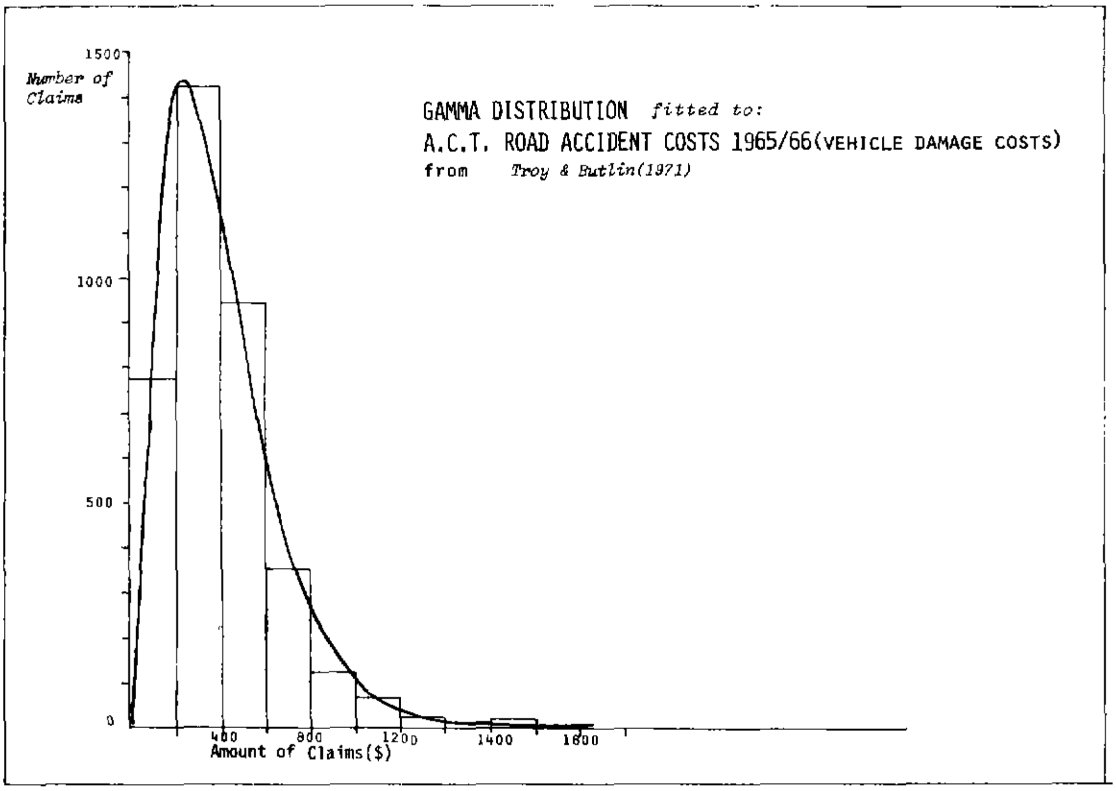
The AIS probabilities (as cumulative probabilities) are utilised in the gamma distributions as follows, where the expression Pr [G>$900] = 0.300 is interpreted as: the *probability* of obtaining vehicle damage costs of up to $900 *or greater* is 30.0%. In other words the chance of incurring vehicle damage claims between 0 and $900 is (1-0.30)% = 70%. Using this notation:

Pr[G>$900] = 0.300; i.e. 30% of claims are over $900; 70% below;
Pr[G>$2000] = 0.052; i.e. 5.2% of claims are over $2000; 94.8% below;
Pr[G>$2900] = 0.012; i.e. 1.2% of claims are over $2900; 98.2% below;
Pr[G>$3900] = 0.002; i.e. 0.2% of claims are over $3900; 99.8% below;

These four probabilities thus provide the cost range boundaries for the estimated injury severity classes, AIS levels 1 to 5.

A.C.T. Vehicle Damage Costs 1965/66 (Figure A-3): to indicate the ability of the gamma distribution to represent accident costs over time, the vehicle damage cost data in Table 17 of chapter 3 drawn from the Australian Capital Territory accident study by Troy and Butlin [1971] was used to fit a gamma distribution, and the results are shown in Figure A-3.

FIGURE A-3



The A.C.T. data in Figure A-3 relates to 3758 collisons with estimated total vehicle damage costs of about $1.5 million in 1965/66. Using gamma distribution probabilities (as above) to determine AIS class cost ranges, the following results were obtained.

ACT Vehicle Damage Claims 1965/66 ($\hat{\gamma}$ = 2.417; $\hat{\beta}$ = 165)

AIS Level	Predicted Range of Claims $	Mean Claim based on 1978 Sample $	Annual Cost Increase (1966-1978)
(PDO & 1)	0 - 480	250	2.8%
2	480 - 880	670	6.1%
3	880 - 1180	1,090	7.2%
4	1180 - 1530	1,090	7.2%
5	1530 +	1,550	7.8%

The mean claim sizes in the third column are obtained by finding the claim sizes within the 1965/66 distribution based on the probabilities of the Table 1 estimates drawn from the 1978 distribution of Figure A-2. The purpose of this computation is to investigate the stability of the cost intervals over time: for example the implicit (%) growth rates between column 3 values and the vehicle damage cost estimates in Table 1 are shown in the fourth column. These cost increases range from about 3% to 8% per annum over the 12 year period 1966 to 1978.

Asymmetrical Properties of Accident Data: Skewness and Kurtosis

A brief outline and comparison is presented of the *skewness* of accident cost data for the three examples considered in this Appendix.

In a symmetrical probability distribution such as the normal distribution, measures of central tendency such as the *mean, median and mode,* all co-incide (the *mean* is the average value, the *median* divides the upper and lower half of observed values (ranked in magnitude), and the *mode* is the value with the greatest frequency).

In a positively skewed distribution, such as the gamma distribution the mode and the median tend to be to the left of the mean.

The following comparison of the distributions in Figures A-1, A-2, and A-3 emphasizes that for distributions of this type (which include accident costs), knowledge of the *mean* value alone (i.e. of average accident costs) indicates very little about the respective accident cost characteristics in each distribution.

Distribution	Mean* $	Median $	Mode $	Moment Coefficients of:* Skewness	Kurtosis
Hospital Costs (1978)	1307 (34%)	769 (50%)	∞ (0)	2.37	11.41
Vehicle Damage (1978)	744 (38%)	568 *(50%)*	183 *(84%)*	1.74	7.52
Vehicle Damage (1966)	399 (41%)	345 *(50%)*	234 *(70%)*	1.22	5.23

* *Percentages for each of these three statistics show the proportion of costs greater than the tabled value; the moment coefficents compare with zero skewness and Kurtosis = 3 for the normal distribution (vide Spiegel [1966] and Thom [1958]).*

In summary, although much additional investigation is needed of the predictive ability of gamma distribution models of accident costs, together with access to extended data series, these preliminary results suggest that the use of this statistical distribution may provide a useful basis for accident cost analysis and determination of class intervals.