Cost of aviation accidents in Australia

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Abstract:

Following the methodology developed by Steadman and Bryan (1988) for road accidents, this study expands the methodology to estimate the costs of aviation accidents in Australia. In Australia in 1988 there was a total of 328 aviation accidents resulting in a cost of some $45 million to Australian society. Costings are presented for all aviation accidents and on a per accident basis.

Some discussion of the "human capital" approach methodology is included and assumptions specific to aviation accidents are reviewed. Refinements to the methodology using Australian tables of working life are also discussed and comment on the extension of the basic methodology to other modes of transport is invited.

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Introduction

Cost information is important in assessing the cost effectiveness of programs directed toward the reduction of accidents of various types and the reduction in severity of accidents which do occur. Road accidents in particular, have been shown to impose a substantial cost on the community, such that periodical updating of these costs is now required.

The estimation of the cost of aviation accidents is the second component of a larger study of the social cost of transport accidents. The first component, road accidents, addressed methodological issues which have been used to provide 1985 estimates and annual updates (Steadman and Bryan 1988), the most recent of these was BTCE (1989). This second component, on aviation accidents, also serves to update the pioneering study by Brownbill (1984) of cost estimates of 1980 aircraft accidents in Australia.

The definitions of the terms; Accident, Fatal injury, Serious injury, Minor injury, Destroyed, Substantial damage, and Minor damage used to classify aviation accidents were derived from "International Standards and Recommended Practices" of the International Council of Aviation Organisations (ICAO, 1981). In keeping with standard practice, aviation accidents are classified according to the most severe injury occurring in that accident. For example, a serious injury accident is one where the most severe injury occurring was one classified as "serious". Other, less severe, injuries may also have occurred and there may be more or less hull damage.

As in Atkins (1981), Brownbill (1984) and Steadman and Bryan (1988), the ex-post cost framework is used, that is, the measurement of costs resulting from accidents which have already occurred. This approach is taken rather than the more theoretically orthodox approach of measuring the amount society would be willing to pay to decrease the risk of accidents occurring in the future, the ex-ante approach. The reasons for this are, as in the above mentioned studies, practical problems of data availability and reliability.

The social cost of aviation accidents which is derived here is an estimate, in dollar terms, of everything involved, which society values. Such an estimate can vary greatly depending on what costs are included and how such costs are treated. The basic framework for the estimation includes costs related to the loss, or partial loss, to society of accident victims, the resources expended in accident related activities and an estimate of pain and suffering.

Loss or partial loss of the victim refers to the loss to society of the victim's future productivity both in terms of earnings and productive, but unpaid work, for the family and the community. Accident generated activity includes: damage or loss of

the aircraft; insurance administration costs; hospital, medical and rehabilitation costs; losses to others, not victims; accident investigation costs; and search and rescue costs. These factors, along with an estimate of the pain and suffering of the victim, provide the framework for the presentation of the cost estimation

Aviation Accidents

Table 1 Number of reported accidents, aircraft and persons injured in total and per accident by accident class, Australia, 1988

Measure	Accident class				
	Fatal	Serious	Minor	Nil	Total
Total					
Accidents	37	35	24	232	328
Aircraft	41	36	24	233	334
Fatalities	70	..	..	..	70
Serious injuries	7	40	..	..	47
Minor injuries	8	9	38	..	55
Nil injuries	6	15	30	410	461
Accidents	(11.3)	(10.7)	(7.3)	(70.7)	(100.0)
Per accident					
Aircraft	1.11	1.03	1.00	1.00	1.02
Fatalities	1.89	..	..	..	.21
Serious injuries	0.19	1.14	..	..	.14
Minor injuries	0.22	0.26	1.58	..	.16
Nil injuries	0.16	0.43	1.25	1.77	1.41

Source: BASI information supplied to BTCE

Notes: Due to rounding figures may not add to totals
.. Not applicable
( ) Numbers in parentheses are percentages

Aviation accidents occurring in 1988 have been chosen for analysis Table 1 presents a summary of aviation accidents, injuries and involvement rates used as the basis for the calculation of accident costs overall.

Loss or incapacitation of the victim

Calculation of foregone earnings

The largest single cost item in this type of study has been the loss or partial loss of future productivity of accident victims (30% for road accidents (BTCE, 1989)). Future productivity is represented as the present value of future earnings of accident victims.

Previous studies of the cost of accidents in Australia (Atkins, 1981; Steadman and Bryan,1988) have calculated foregone income as an opportunity cost, i.e. accident victims were estimated to have foregone income amounting to their future total income weighted by the age and gender distribution of the victims, discounted to present values from a retirement age, usually 65, with an adjustment for productivity gains in the future. Steadman and Bryan (1988) introduced a refinement in the form of an adjustment for age and gender specific employment rates.

In this analysis a further refinement has been introduced by estimating future age and gender specific mortality probabilities together with probabilities of entry and exit from the labour force in years to come, using working life tables for Australia, 1981, developed by Anderson & Ross (1987). These working life tables use 1981 Australian mortality profiles and projected rates of labour force participation to yield age and gender specific expectations, in years of working life and retired life, of persons in the labour force.

By applying these expectations to all victims, we assume that all persons are in the labour force or we attribute a wage to them as an opportunity cost This assumption was also used by Atkins (1981) As the labour force status of accident victims is rarely recorded, it could be argued, as do Steadman and Bryan (1988), that some average labour force status or average income, including those not in the labour force should be used However, in this analysis persons who are not in the labour force at the time of their accident are assumed to be as potentially productive as those who are in the labour force. In this way all lives are valued on the assumption that society would be willing to pay at least the value of the lost productive potential to avoid the loss.

The earning estimates used for each age and gender are those estimated in ABS (1988). Earnings for full time employees in their main job is used as an estimate of the productivity foregone. The actual figure used is an annualised median weekly earnings.

The age and gender specific earnings are then applied to the number of years remaining in the labour force as a discounted (7%) earning stream and adjusted for annual productivity gains (2%) over the appropriate period. This yields expected earnings for each age and gender category for the remainder of working life. Such an estimate is appropriate to persons of known ages who die in accidents or who are permanently incapacitated.

The exact age and gender of all passengers and crew involved in aviation accidents were not available. The average foregone income of accident victims of known age and gender for 1987 and 1988 was applied to all 1988 victims of unknown age and/or gender, for each injury severity level, to derive the total cost of foregone income and average cost per accident.

Fatalities equate to a total loss of earning capacity. The situation of other injury categories is less clear. While the accident victim is hospitalised or disabled, productivity and earning capacity are also lost to the community. At this time no information on the length of the period of total or partial disability is available, nor is the length of stay in hospital for 1988 aviation accident victims. The unavailability of these data, point to research areas which would improve the statistical base for all accident costing studies and indeed safety research generally.

In the absence of more recent or specific data, Brownbill's (1984) finding that serious injury victims of aviation accidents spent from 6 months to 2 days in hospital with an average stay of 37 days has been utilised.

Each minor injury was estimated to involve one day of lost output. Based on the ICAO (1981) definition of injuries, a minor injury can be assumed to be one which involves no more than 48 hours in hospital and taking the mid point of this duration, one day in hospital is assumed.

Only lost productivity during hospital stay is considered and the real but unknown cost of lost productivity while disabled and recuperating is not added to the estimates. Thus, the estimate may be considered as a lower bound figure. In addition, the estimate has not been adjusted to reflect the higher earnings of aviation accident victims assumed by Brownbill (1984) based on Canadian findings (Peat, Marwick and Associates, 1981). While the aviation accidents which occur in Australia are almost exclusively in the area of general aviation, in the Canadian study, airline passenger and crew earnings were used to inflate the incomes of victims. As general aviation passengers are not necessarily the same as airline passengers and general aviation pilot

Table 2 Estimated lost earnings by accident class, Australia, 1988
(dollars)

Cost per accident	Accident class				
	Fatal	Serious	Minor	Nil	Total
Fatalities	403 923	...	...	...	403 923
Serious injuries	350	2 114	...	...	2 464
Minor injuries	11	13	79	...	103
Total	404 284	2 127	79	...	406 490
Total all accidents	14 958 505	74 450	1 900	...	15 034 855

Source: Derived from distributions presented in Table 1 and BTCE estimates of foregone earnings using life table methods and BASI accident reports.

Notes: Due to rounding figures may not add to totals
... Not applicable

salaries are not the same as airline pilot salaries, the inflation of victim earnings is not considered appropriate to Australian experience.

Table 2 shows the results of these calculations. Lost earnings for all casualties of some $15 million constitutes a substantial loss in productivity and this loss is largely the product of the losses due to fatalities, over $404 000 per fatal accident or 99% of the lost earnings.

Family and community losses

A large amount of productive but unpaid work is performed by both employed and non-employed persons. This work includes work done for the household and voluntary community work. The ABS 1987 survey of time use (ABS, 1990a) estimated an average of 2 hours per day for male, full time workers and 4 hours per day for female, full time workers was spent in family and community work. In addition, non-employed males and non-employed females were estimated to spend 3 and 6 hours respectively in family and community work.

Table 3 Family and community loss by accident class, Australia 1988
(dollars)

Cost per accident	Accident class				
	Fatal	Serious	Minor	Nil	Total
Fatalities	190 645	...	...	...	190 645
Serious injuries	165	998	...	...	1 163
Minor injuries	5	6	37	...	49
Total	190 815	1004	37	...	191 857
Total all accidents	7 060 170	35 139	897	...	7 096 206

Source: Derived from distributions presented in Table 1 and BTCE estimates of foregone family and community production using life table methods and BASI accident reports.

Notes: Due to rounding figures may not add to totals
... Not applicable

When a person is killed or incapacitated this production is also foregone and can be expressed as a social cost. The estimated dollar value of family and community work during both working life and retirement has been calculated by using the working life table. The number of hours of family and community service is treated as a proportion of the average number of hours per week worked by male (40.6) or female (29.3), full time, employed wage and salary earners (ABS, 1990b). These hours are then converted into annualised age and gender specific earnings based on the same annualised median weekly earnings of full time employees in their main job and treated as a discounted earning stream for the number of years of expected working and retirement life.

The impact of this additional loss to the community is substantial, reflecting the 52 to 62 per cent of GDP which the ABS (1990a) estimated for unpaid family and community work. Table 3 shows the extent of these losses to be some $7 million. Again fatalities are the major source of losses.

Accident generated activities

Aircraft damage/loss cost

Probably the most tangible of accident costs, aircraft damage and loss involves a significant proportion of the costs of aviation accidents. Information on such costs was derived from aviation insurance claims as follows

Aviation industry insurance sources provided data for the 750 aircraft related insurance claims in the two years 1987 and 1988. The aircraft insurance claims were matched against the BASI records for the same two years using the aircraft registration numbers. Importantly, not all aircraft insurance claims involve an air accident. Hence there were fewer BASI accident records, 623 aviation accidents involving 631 aircraft, than insurance claims. Only 96 (13%) of insurance claims were able to be matched with a BASI aviation accident report. These claims were distributed according to class of accident. The average cost of damage to aircraft was then estimated for each category of personal injury accident for these known insurance claims (see Table 4).

Table 4 Aircraft loss and damage costs by accident class for matched cases, Australia, 1987 and 1988

(dollars)

	Accident class				
	Fatal	Serious	Minor	Nil	Total
Average cost per aircraft	122 646	21 107	29 193	31 296	40 211
Standard error per aircraft	85 624	11 404	27 887	32 017	49 179
	(70)	(54)	(96)	(102)	(122)

Source: BASI reports and Australian Aviation Underwriting Pool

Notes: Due to rounding figures may not add to totals
( ) Numbers in parentheses are percentages

Table 5 Aircraft loss and damage costs by accident class, Australia, 1988
(dollars)

	Accident class				
Cost	Fatal	Serious	Minor	Nil	Total
Average per accident	135 905	21 710	29 193	31 430	42 014
Total all accidents	5 028 486	759 852	700 632	7 291 735	13 780 705

Source: Derived from Table 1 and Table 4

Note: Due to rounding figures may not add to totals

As the standard errors for the matched sample are very high, no great confidence can be placed in these estimates of average cost. Future studies will need to address this important issue.

In the absence of more reliable data, the average cost of hull damage per aircraft in each accident class in Table 4 was adopted for 1988 to give the total cost of hull damage by class of accident (see Table 5). The high damage cost in fatal accidents arises out of the more substantial damage occurring in these accidents and the larger number of aircraft per accident, ie more collisions between aircraft. Total hull damage for 1988 is estimated to be $13.8 million.

Insurance administration costs

Insurance industry statistics for 1988 (Insurance and Superannuation Commission, 1988) indicate that the proportion of expenses to the value of claims incurred for the insurance industry, in aggregate, was of the order of 42%. Applying this percentage to the figure of estimates in Table 5 yields an estimate of $5.8 million as the administrative expenses relating to aviation accident insurance in total. Table 6 shows the distribution of this expense, by numbers of aircraft and accident class.

Insurance industry sources (A. Ward, Australian Aviation Underwriting Pool, pers. comm., 1990) indicate that there are few legal cases associated with nil injury accidents. Among accidents where legal costs are incurred, those accruing to insurance companies are included in their administration costs as estimated below. Those legal costs borne by other parties have not been estimated.

Table 6 Aircraft insurance administration costs by accident class, Australia, 1988
(dollars)

Average cost	Accident class				
	Fatal	Serious	Minor	Nil	Total
Per aircraft	51 757	8 907	12 319	13 206	17 412
Per accident	57 352	9 162	12 319	13 252	17 730
Total cost	2 122 021	320 659	295 667	3 077 112	5 815 458

Source: Derived from Table 5 assuming that administration costs are equal to 42.2% of individual claim costs

Note: Due to rounding figures may not add to totals

Hospital, medical and rehabilitation costs

Brownbill (1984) estimated average daily in-patient hospital charge as $130 in 1980. This figure did not include specialist surgery and other services and must be regarded as a low estimate. Inflating this estimate by the health and personal care component of the consumer price index, produces a figure of $263 in 1988 prices.

As for the estimates of lost productivity, 37 days is assumed to be the average length of hospital stay in a serious injury. Likewise, a stay of 1 day is assumed for a minor injury. On the assumption that fatalities may involve post mortems and associated services, each fatality was assigned a hospital cost equivalent to five days in hospital and a zero medical cost. Estimated hospital costs per accident and in total are summarised in Table 7.

Brownbill derived average medical and rehabilitation costs from Atkins' (1981) estimates of road accidents. Atkins' estimates have been adjusted using the health and personal care component of the consumer price index to give 1988 prices. This yields an estimated $597 per accident or about $196 000 for medical costs. (see Table 7)

Rehabilitation costs were only assigned to the serious injury category. Table 7 shows that a total of $50 510 is estimated for total rehabilitation costs.

Table 7 Hospital, medical and rehabilitation costs by accident class, Australia, 1988

(dollars)

Cost per accident	Accident class				
	Fatal	Serious	Minor	Nil	Total
Hospital					
Fatalities	2 493	..	..	..	281
Serious injuries	1 845	11 144	..	..	1 396
Minor injuries	57	67	417	..	44
Total	4 394	11 211	417	..	1 692
Total all accidents	162 293	392 404	10 014	..	565 019
Medical					
Serious injuries	363	2 194	..	..	275
Minor injuries	415	494	3 040	..	322
Total	778	2 688	3 040	..	597
Total all accidents	28 801	94 082	72 962	..	195 844
Rehabilitation					
Serious injuries	203	1 229	..	..	154
Total all accidents	7 523	24 987	..	..	50 510

Source: Derived from Table 1, average length of stay, daily in-patient charge Atkins (1981) and unpublished ABS data on the Health and Personal Care component of the CPI

Notes: Due to rounding figures may not add to totals
.. Not applicable

Table 8 Losses to others due to aviation accidents, Australia, 1988
(dollars)

	Accident class				
	Fatal	Serious	Minor	Nil	Total
Cost per accident	7 141	196	18	..	827
Total all accidents	264 224	6 849	420	..	271 493

Source: Derived from Table 1, Table 2, Table 3, and Steadman and Bryan (1988)

Note: Due to rounding figures may not add to totals
.. Not applicable

Losses to others

Losses to others include costs of visiting, transport and home care of accident victims and labour replacement costs. This analysis uses the approach used in National Highway Traffic Safety Administration (1972). Costs of losses to others are expressed as percentages of total foregone earnings of 15 per cent in a minor injury accident 6.25 per cent in a serious and 1.2 per cent in a fatal accident. Estimates for aviation accidents in 1988 using these percentages are given in Table 8.

Accident investigation cost

The primary function of BASI is to investigate aviation accidents occurring within Australian flight information regions. The cost of accident investigation was derived from data provided by BASI which related to each accident investigated in 1988. This data comprised the cost of goods and services provided by BASI in the course of the accident investigation and the travel expenses of the investigators. The cost component attributed to BASI is a marginal cost and is based on the assumption that BASI would have existed even if no accidents had occurred in 1988 (see Table 9).

The cost of police investigation and coronial enquiries into fatal accidents has not been included in our estimates. These costs can be substantial in individual accidents, however it has not been possible to obtain data for this investigation.

Table 9 Accident investigation costs by accident class, Australia, 1988
(dollars)

	Accident class				
	Fatal	Serious	Minor	Nil	Total
Cost per accident	1 148	66	230	165	270
Total all accidents	42 459	2 298	5 528	38 255	88 540

Source: Derived from BASI (1990) data

Search and rescue costs

Search and rescue costs were derived from data provided by the Civil Aviation Authority. Search and rescue costs amounted to $329 000, or $985 per aircraft in 1988. This amount was distributed proportionately among all accidents that occurred in 1988 according to the number of aircraft involved and displayed in Table 10.

Table 10 Search and rescue costs by accident class, Australia, 1988
(dollars)

	Accident class				
	Fatal	Serious	Minor	Nil	Total
Cost per accident	1091	1013	985	989	1 003
Total all accidents	40 365	35 442	23 628	229 389	328 824

Source: Derived from Civil Aviation Authority (1990) data and Table 1

Table 11 Pain and suffering by accident class, Australia, 1988
(dollars)

Cost per accident	Accident class				
	Fatal	Serious	Minor	Nil	Total
Fatalities	...	...	...	...	...
Serious injuries	7 530	45 486	...	...	...
Minor injuries	748	890	5 478	...	...
Total	8 278	46 375	5 478	...	6 283
Total all accidents	306 280	1 623 140	131 480	...	2 060 900

Source: Derived from Table 1 and Steadman and Bryan (1988)

Notes: Due to rounding figures may not add to totals
... Not applicable

Pain and suffering of victim

Estimates for pain and suffering were derived from Steadman and Bryan (1988). They used court awards for general damages (which included pain and suffering of the victim, loss of amenities of life and loss of expectation of life) as a proxy for pain and suffering. To estimate the loss due to pain and suffering, Steadman and Bryan (1988) drew on data from Britts (1973) which related to a sample of 213 court awards for 1985 and 1986 for various types of accidents involving multiple injuries. They calculated mean award amounts for each Abbreviated Injury Scale (AIS) category with the exception of the fatality category which was assigned a pain and suffering loss of zero.

For the purposes of this study, the AIS "critical", "severe -life threatening" and "severe - non-life threatening" injury categories used by Steadman and Bryan, were grouped together and assumed to correspond to the BASI "serious" injury category while the AIS "moderate" and "minor" injury categories were aggregated and assumed to correspond to the BASI "minor" injury category. Using Steadman and Bryan's figures, weighted average estimates for pain and suffering were calculated for these

two injury groupings and adjusted to 1988 prices, using the CPI (see Table 11). This resulted in an estimate of the value of pain and suffering of $39 800 per serious injury and $3 460 per minor injury. Using these estimates, costs per accident for pain and suffering were derived for each of the accident classes.

Summary

Aviation accidents in 1988 generated losses to society of some $45 million, or $138 000 per accident. Nearly half of this cost is made up of the loss to society of the productive capacity of the victims of aviation accidents, particularly the fatalities. Another 30% is attributable to damage to the aircraft involved in accidents. The other major component is the insurance administration cost, which accounted for some 13% of the total cost, with the remaining 8% being made up of a range of other cost factors. Table 12 shows the total cost associated with the various cost categories by class of aviation accident. Table 12 also shows the per accident cost of aviation accidents by accident class. Fatal accidents were the most costly at some $811 000 per accident and $353 000 per casualty.

This paper points out a number of deficiencies in the data which make our accident costing estimates somewhat problematic. In addition to those deficiencies already noted, several issues remain to be addressed. Labour on-costs are one such issue. Abelson (1986) and Rice, Mackenzie and Associates (1989) recognise the validity of certain labour on-costs in valuing lost output. They argued that the production lost to society by a premature death is at least equal to the individual's wage and on-costs.

On-costs may be derived from ABS (1990c). Excluding most taxes in the calculation, on-costs are estimated at 21.2 per cent of total labour costs. On-costs, which have not previously been used in Australian accident costing studies, add some $3 million to the total cost of aviation accidents.

Defining and measuring household and volunteer work also presents difficulties. The two approaches generally used are based on replacement cost or opportunity cost. This study uses the latter approach which tends to give a somewhat higher estimate. For further discussion see ABS (1990a).

This analysis has adapted life table methods to the costing of lost productivity. This approach appears to add rigor and precision to the largest single element in such costing exercises. A thorough examination of this new approach is now required if it is to become widely used in the costing of lost productivity and similar calculations.

Table 12 Summary of costs by accident class, Australia, 1988
($ thousands)

Cost category	Accident class				
	Fatal	Serious	Minor	Nil	Total
Lost productivity					
Earnings	14 959	74	2	..	15 035
Family and community	7 060	35	1	..	7 096
Accident generated activities					
Aircraft damage	5 028	760	701	7 292	13 781
Insurance Administration	2 122	321	296	3 077	5 815
Hospital	162	392	10	..	565
Medical	29	94	73	..	196
Rehabilitation	8	43	..	..	51
Loss to others	264	7	+	..	271
Accident investigation	42	2	6	38	89
Search and rescue	40	35	24	229	329
Pain and suffering	306	1 623	131	..	2 061
Total all costs	30 020	3 386	1 244	10 636	45 289
Per accident	811	97	52	46	138
Per aircraft	732	94	52	46	136
Per person involved	330	53	18	26	72
Per casualty[(a)]	353	69	33	..	263

Source: Bureau of Transport and Communications Economics estimates

Notes: Due to rounding figures may not add to totals
.. Not applicable
\+ Less than $1 000
(a) Casualty refers to any person killed or injured

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