Cost of Road Accidents in Australia

Occasional Paper

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Subject
Series
Date
A to Z
Search
Results
Print
Exit
GO BACK

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Cost of Road Accidents in Australia

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ABSTRACT

The cost of road accidents is an important and controversial issue. However, it is difficult to derive an acceptable measure of these costs, and it has been some years since an attempt has been made to quantify these costs to Australia.

This Paper presents a discussion of the methodologies used to produce estimates of the cost of road accidents (or the value of reducing their number), focusing on the major issues of contention, and provides estimates for Australia for the year 1985.

The estimates are in the main based on the framework and methodology established by A S Atkins in his 1981 report 'The Economic and Social Costs of Road Accidents in Australia'. An important improvement is the inclusion of an, albeit tentative, estimate of the cost associated with the pain and suffering of road accident victims.

Costs are presented as average unit costs and total costs, using three alternative methodologies, with a preference stated. Cost estimates are provided by cost category and by the level of injury severity sustained by the victims.

FOREWORD

Following discussions with the Federal Office of Road Safety, the Bureau of Transport and Communications Economics agreed to undertake a limited review of the methodologies used to produce estimates of the cost of road accidents and provide updated estimates for Australia. This Paper presents a discussion of alternative costing approaches, focusing on the major issues of contention, and estimates of the cost of road accidents in Australia for the year 1985.

This Paper was written by Ms L. Steadman and Mr R. Bryan.

The assistance of the numerous organisations who provided data in relation to several of the cost items included in this Paper is gratefully acknowledged.

M. HADDAD
Director

Bureau of Transport and Communications Economics
Canberra
April 1988

CONTENTS

TABLES

FIGURES

SUMMARY

The cost of road accidents is an important and controversial issue; however, it has been some years since an attempt has been made to quantify these costs to Australia. The Bureau of Transport and Communications Economics (BTCE) therefore agreed to a Federal Office of Road Safety (FORS) request to examine the issues involved and produce an updated set of cost estimates. The study on road accident costs by A. S. Atkins sponsored by FORS (Atkins 1981) was used as a basis. A limited review of alternative approaches and methodologies was carried out, and estimates produced for Australia for the year 1985 using a modified methodology.

There are two basic approaches to costing road accidents. The most common approach involves measuring the costs resulting from accidents which have already occurred, and is referred to as the ex-post approach. The other relates to the amount society would be willing to pay to decrease the risk of accidents occurring in the future, and is called the ex-ante or willingness to pay approach.

The most suitable approach to use depends on the reason the estimates are being prepared. Where the costs are to be regarded as the potential benefits of measures which reduce road accidents, and weighed against the costs of those measures, the willingness to pay approach is the correct approach to use. It is designed to measure the amount society is prepared to pay to lessen risk, and incorporates social welfare issues, which generally the ex-post approach does not. This said, actually measuring this willingness to pay presents numerous difficulties, and in the past costs have usually been estimated using the ex-post approach, with some allowance for social welfare issues where it was thought appropriate.

However, the term ex-post approach is very general and there are no definitive statements about which cost items should be included and how they should be calculated. For this Paper, a selection of previous ex-post cost studies were examined, and major issues of contention are identified and discussed.

After examining the alternative approaches and methodologies, three primary sets of cost estimates have been produced. The willingness to pay approach was considered the most appropriate way to cost road accidents; however, it was not feasible to derive estimates using this approach. Instead, a set of indicative estimates was produced using an approach known as the adjusted willingness to pay/human capital (WTP/HK) approach, which is purported to provide a link between the two basic approaches.

The main sets of estimates were produced using a version of the ex-post approach, referred to as the social human capital approach. Two methods were used; the adjusted income method, which is the preferred method, and the opportunity cost method, which most resembles the method used in the majority of previous studies. These estimates were produced using the framework and methodology used by Atkins (1981) as a basis. The detailed calculations involved in the derivation of the estimates are given to enable a clear understanding of what the cost estimates represent, and to allow them to be easily updated.

It is estimated (using the adjusted income method) that the cost of road accidents in Australia in 1985 was approximately $5000 million. Costs were estimated for each of 10 cost categories, with vehicle damage accounting for the largest proportion at approximately 30 per cent of total costs. The items relating to the loss of the victims themselves (as opposed to the cost of accident-generated activities) also account for around 30 per cent of the total cost. The estimate in relation to the pain and suffering of the victim represents almost 20 per cent of the total cost.

Cost estimates are also presented as average unit costs. The average unit costs range, in round terms, from $400 000 for a fatality to $1000 for a vehicle involved in an accident resulting in property damage only.

Comparisons of the estimates produced using the different approaches and using alternative values for the more debatable parameters are provided. The WTP/HK approach estimates are shown to be up to three times larger than the estimates produced using the social human capital approach. For this latter approach, changes in the discount rate used, the distribution of injured persons across severity levels used to derive total accident costs, and changes in the estimate of the number of vehicles involved in accidents resulting in property damage only, each produced large changes in the estimate of total costs. The addition of an estimate in relation to the pain and suffering of the victims also had a major effect on the size of the resulting cost estimates. The size of the effect of these changes

illustrates the strong dependence of the estimates on values which there is no conclusive evidence to support. Consequently, the estimates are far from indisputable, and there is a need for further research, in relation to both methodologies and data sources.

The estimates presented in this Paper should provide a useful indication of the costs of road accidents. One major use is envisaged to be in the analysis of road safety programs. However, cost estimates such as these should not be regarded in total as potential savings. There is a possibly large proportion of the estimated costs which cannot be saved because people are not prepared to suffer what they see as the inconveniences of the measures which might be required to produce a substantial reduction in road accidents.

CHAPTER 1 INTRODUCTION

Road accidents impose substantial costs on society, and there is considerable interest in establishing what these costs are. One of the more important uses of such information is in assessing the cost effectiveness and efficiency of measures aimed at reducing the occurrence of road accidents, including better road construction and road safety programs. However, these measures also impose costs, both tangible and intangible. Governments need to determine the most appropriate balance of these costs to determine the amount of the limited public resources that should be allocated to such measures and to ensure these limited resources are used in the most effective way possible. Such a cost-benefit analysis cannot be made without some measure of the cost of road accidents. Where road safety or engineering programs have the potential to alter the numbers of particular types of accidents or injuries, information on costs by type of accident or injury is desirable. Information broken down in this way can assist in determining the most effective way to allocate funds, while estimates of total costs can assist in determining the optimum size of a budget allocation for accident reduction programs. Recent research has indicated that the magnitude of accident costs estimates can, in most cases, have a marked effect both on the ranking of transport projects and the magnitude of net benefits from any given project (Hills & Jones-Lee 1983).

In 1979, the Federal Office of Road Safety (FORS), which is part of the Department of Transport and Communications, commissioned A. S. Atkins to prepare a report on the social costs of road accidents. The report (Atkins 1981) presents a review of recent cost estimation studies, a model for the valuation of road accidents in Australia, and preliminary cost estimates for Australia for 1978. The stated aim of the study was to extend the coverage and measurement of road accident costs in Australia to reflect a comprehensive concept of social cost and welfare. Cost estimates for eleven cost categories were derived, broken down by the injury severity level of the victims (including no injury, that is property damage only (PDO)).

Following discussions with FORS, the Bureau of Transport and Communications Economics (BTCE) agreed to review the methodology used by Atkins (1981) and provide updated estimates of the cost of road accidents.

STRUCTURE OF THE PAPER

A summary and discussion of the alternative approaches to accident costings is presented in Chapter 2. An account of the methodologies used for past studies is given. Contentious issues are identified and the various treatments of them canvassed.

Chapter 3 contains cost estimates for 1985 produced for each of three methods. An explanation is given of the basis of each of the methods. A summary analysis of the effect on the results of changes in the major input parameters is contained in Chapter 4.

Concluding remarks are made in Chapter 5. The limitations of the estimates are emphasised, as is the need for more research into methodologies and data sources to improve the reliability of the estimates.

CHAPTER 2 SUMMARY OF APPROACHES TO ACCIDENT COSTING

Assuming that the objective of a study of the costs of road accidents is to assist in determining how much expenditure is warranted to reduce their number and/or severity, two basic approaches exist:

- examination of the costs of accidents which have already occurred, assuming that society would pay at least this average amount per accident for them not to have occurred; and
- seeking to determine the amount the community would pay to reduce road accidents in the future.

These basic approaches, upon which there are many variations, are referred to as the 'ex-post' and 'ex-ante' approach respectively.

EX-POST APPROACH

The ex-post approach involves summing component costs resulting from the occurrence of a road accident to derive a total cost to society. The three broad types of cost are the costs incurred in accident-generated activities, the loss or partial loss of the victim and the intangible cost of pain and suffering.

Costs relating to accident-generated activities are derived by estimating costs for each resource used. Items include vehicle damage, hospital and medical services, accident investigation, insurance administration, legal and court proceedings and traffic delay.

The loss or partial loss of the victim to society can be estimated in a variety of ways. Some common measures are:

- the amounts awarded by the courts to victims or their families by way of compensation;
- the value of life implicit in past public sector decisions on safety programs or legislation; and
- the amount of the victim's production capacity lost (or forgone income) as a result of the accident.

This last measure, added to the costs of accident-generated activities, is frequently referred to as the 'human capital' approach and has to date been the approach most commonly adopted. It usually relates to a limited, mostly tangible range of cost items.[1]

EX-ANTE OR WILLINGNESS TO PAY APPROACH

The ex-ante approach, more commonly referred to as the willingness to pay approach, attempts to measure society's willingness to pay for a reduction in risk of an unfavourable event, in this case a road accident. It implicitly includes all aspects of the 'cost' of accidents to the individual's (and, therefore, to society's) wellbeing. Theoretically, income, the value of leisure, the value of avoiding pain and suffering and aversion to a particular kind of risk are all taken into account. Estimates of individuals' willingness to pay (which are traditionally aggregated to represent society's willingness to pay) are derived by direct survey or analysis of accepted compensation (payment) for voluntary assumption (reduction) of risk. The costs of accident-generated activities can be calculated separately and included if desired.

LINK BETWEEN HUMAN CAPITAL AND WILLINGNESS TO PAY APPROACHES

The notion that the human capital and willingness to pay approaches can be linked is discussed by Landefeld and Seskin (1982). The two approaches have been linked 'by specifying a priori what rational individuals (given sufficient time and information) should be willing to pay to avoid the financial losses associated with small risks to life'. The assumptions made are that the individual's sole objective is to maximise expected lifetime income and that they are at least as adverse to economic loss due to risk to life as they are to economic loss due to risk to assets. Using such models, it can be demonstrated that within the bounds of these assumptions, the lower bound on the value of statistical life is equivalent to the expected value of future income.

Landefeld and Seskin (1982) derive an approach, referred to as the WTP/HK approach, which embodies characteristics of both the basic approaches. It relates only to financial loss, as does the standard

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1. In practice, the scope of this human capital approach can vary. For example, future consumption of the victim can be deducted from future income, non-market production can be assigned different values, and an amount for pain and suffering can be included or excluded. These issues are discussed later in this chapter.

human capital approach, but is based on willingness to pay for small changes in risk from the perspective of the individual, as is the willingness to pay approach. Although this approach is relatively new and somewhat experimental, it is considered worthy of comment. Accordingly, WTP/HK estimates have been included in this Paper, albeit in a crude form, to complement the main discussion on the two basic, and more established, approaches to 'cost' estimation.

FACTORS IN DETERMINING APPROPRIATE APPROACH

The answer to the question of which of the two basic approaches is the most appropriate to use is related to the purpose for which the estimates are being derived. In their discussion of this fundamental point, Hills and Jones-Lee (1983) argue that if the estimates are required to assess the effect of accidents on national output, a different measure is needed than if the estimates are required for investment planning and allocative decision-taking. In the latter case, a wider view of society's welfare may be warranted.

Four broad classes of objectives for economic planners are identified in Hills and Jones-Lee (1983):

- national output objectives, such as maximisation of Gross National Product (GNP);
- other macro-economic objectives, such as maximisation of employment or minimisation of the rate of inflation;
- social welfare objectives, including the pursuit of general 'quality of life' objectives (in this case the setting of safety standards or reduction of road fatalities); and
- mixed objectives, since rarely is only one of the other goals applicable.

Considerable attention is devoted to discussing the relevance of the various costing approaches to these four broad objectives. Hills and Jones-Lee (1983) consider that the national output and social welfare objectives are the most common. On the whole, their assessments of which approaches are the most relevant to these objectives are in agreement with those of other researchers in this field.

National output objectives

A commonly used measure of national output in Australia is Gross Domestic Product[2] (GDP). In the Australian National Accounts, it

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2. GDP equals GNP plus net income paid overseas.

relates to a very specific and narrow definition of output. It basically only takes account of market economic activity; non-market production, such as home duties and community service, is excluded. The GDP measure is regarded as too restrictive to be of relevance in assessing the cost to national output of road accidents; however, it is frequently referred to and so is included in this discussion of accident cost measures.

The human capital approach is considered by Hills and Jones-Lee (1983) to be the most relevant to national output objectives. As pointed out in Landefeld and Seskin (1982), the approach is implicitly based upon the maximisation of society's present and future production, since the value to society of an individual is measured in these terms.

In practice, the scope of the estimates derived from the human capital approach can differ substantially from the GDP concept of national output. For example, they frequently include an estimate for non-market production. More fundamentally, though, the effect of road accidents on GDP is a net effect whereas any ex-post approach (including the human capital approach) cost estimates include the sum of the absolute values of the victims' production capacity and the resources spent on accident-generated activities.[3] Human capital approach estimates, therefore, while relating to national output, overestimate the effect of road accidents on GDP.

In fact, there are some grounds for the proposition that the cost of a road accident fatality (the highest cost category in human capital approach estimates) to GDP would be very small, especially when there exists a reasonably high level of unemployment. In these circumstances, the average time to labour replacement is short and, while some retraining and recruitment costs are incurred, unemployment benefits are saved: output is relatively uninterrupted. If the accident had not occurred, the 'victim's' production would have continued and any resources consumed in accident-generated activities would theoretically have been deployed elsewhere to approximately the same levels, that is, total output would remain basically the same. Accident-generated activities make some contribution to GDP and it is possible (although not probable) that reducing the number of accidents

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3. The net effect is the difference between the amount that deploying resources in accident-generated activities has contributed to GDP and the amount that could have been contributed had the resources been deployed elsewhere.

could cause a slight reduction in GDP. However, indications are that society considers a reduction in the number of accidents desirable, if only because of the value it places on saving human life. Clearly, the effect on GDP is inappropriate as a measure of the cost of road accidents, since it does not take account of everything society values and maximising GDP as measured in the National Accounts is inappropriate as an objective when considering these costs.

In recognition of this divergence between limited economic measures and social attitudes, most human capital approach estimates include component items which are not included in GNP but which society values (such as unpaid services and, in some instances, quality of life factors) and also include total resources expended on accident-generated activities (on the assumption that society would benefit from the deployment of these resources in more 'constructive' activities). In other words, most human capital approach estimates go beyond those items measured in GDP to incorporate some social welfare aspects. (For the sake of clarity, this broader concept will be referred to as the social human capital approach).

Social welfare objectives

For the social welfare objectives they describe, involving cost-benefit analysis or analysis of efficiency of resource allocation, the only costing considered in Hills and Jones-Lee (1983) to be unequivocally relevant is willingness to pay, since it is designed for cost-benefit analysis. Particularly following the work of Mishan (1971), researchers generally agreed that the only economically justifiable concept by which to define social gain is potential Pareto improvement. A potential Pareto improvement is said to exist where all persons in the community exposed to the extra risk can be compensated and net benefit still be obtained. This concept is the rationale for all cost-benefit calculations. The aggregate willingness to pay measure is consistent with this concept. Despite some inherent difficulties in the concept of potential Pareto improvement, willingness to pay is still widely regarded as the correct measure of the value to be placed on road safety.

METHODOLOGIES USED FOR PAST STUDIES

Studies examined

There has been a decline over recent years in the preparation of cost estimates for road accidents. Instead, there have been comments on the limitations of existing methodologies and attempts to establish general willingness to pay methodologies. Consequently, in this

Paper, comparisons between human capital approach estimates have been based on those studies reviewed by Atkins (1981), that is, those by:

- the National Highway Traffic Safety Administration (NHTSA 1972) (United States of America);
- John Paterson Urban Systems Pty Ltd (JPUS 1972) (Australia)[4];
- Faigin (1976) (United States of America);
- Sherwin (1977) (New Zealand)[4];
- the Japan Research Center for Transport Policy (JRCTP 1978) (Japan);
- Lawson (1978) (Canada); and
- Fox, Good and Joubert (1979) (Australia).

To this list was added the South Australian study by Somerville and McLean (1981) and several more recent commentaries on road accident costings. Particular emphasis was given to the studies by Atkins (as the major subject of this review), Somerville and McLean (as the only other recent major Australian study), and Faigin (upon which Atkins based a substantial part of his work). Detailed descriptions and reviews of the studies completed prior to 1981 are included by Atkins (1981) and provide a background for the discussion presented in this Paper.

Objectives and approaches adopted

The more recent of these costs studies have, in the main, addressed social welfare objectives, and willingness to pay has been stated as the preferred measure. However, as a result of the considerable practical and conceptual difficulties in obtaining a willingness to pay valuation, researchers have tended to adopt the human capital approach. It is this basic approach which is used by Atkins (1981) and underlies the other studies, with some differences in scope.

As would be expected, the studies have tended to reflect a broad notion of 'costs'. Adherence to limited economic cost approaches, such as the human capital approach without allowance for non-market production or intangible quality of life issues, would appear to have

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4. This study is not a human capital approach estimate as defined in this Paper, since it does not use forgone income to estimate the loss of the victim, but it is included as it is produced by similar ex-post methods.

lost favour. That the more well-known studies have adopted the same broad cost approach is evidenced by the large degree of interrelation between many of the more recent studies. A diagramatic representation of the link between some recent studies as presented by James (1987), is reproduced at Figure 2.1.

Atkins (1981) falls in with this main group. Having stated a social welfare objective, he justifies his use of the social human capital approach by arguing that:

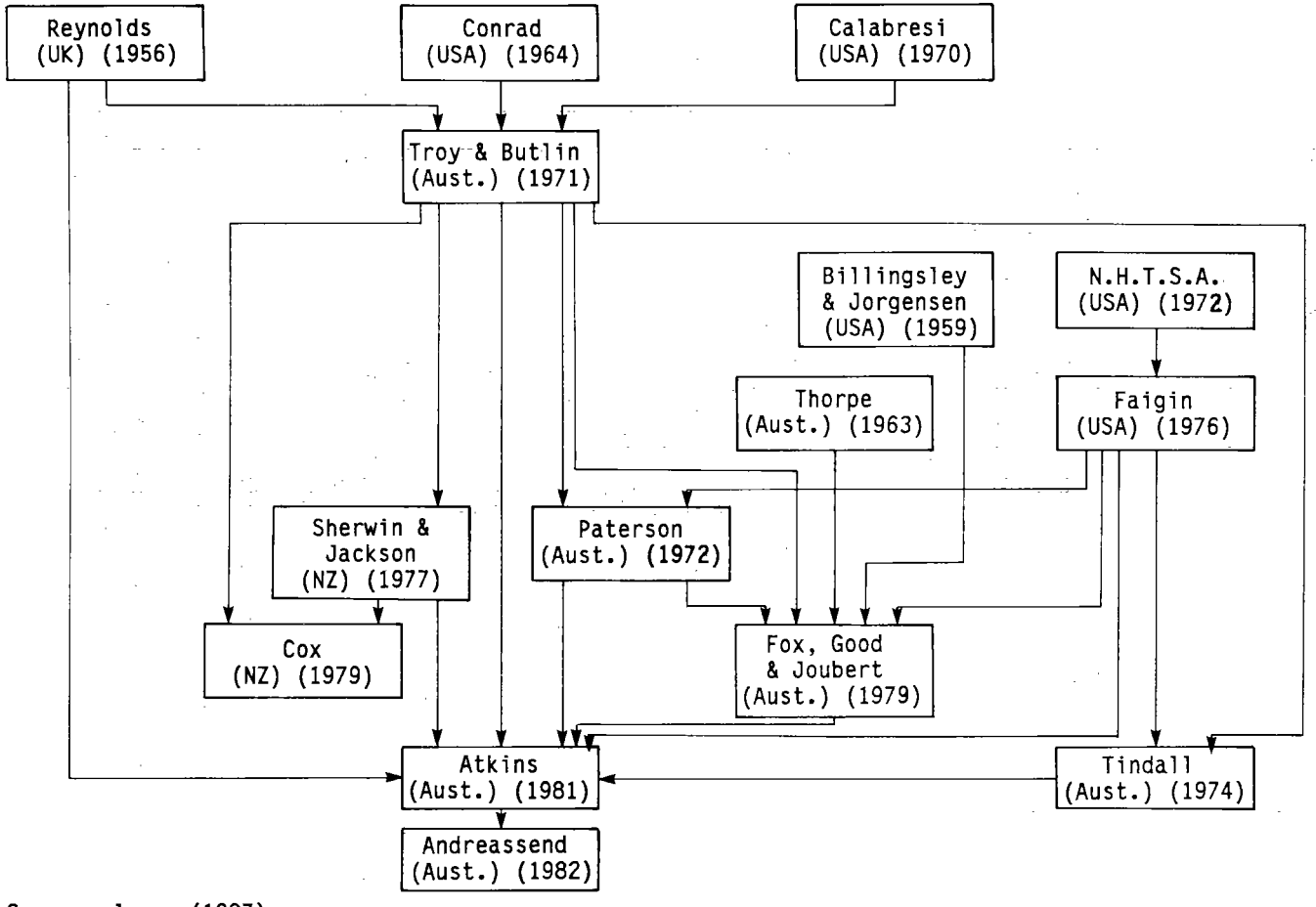
> until a breakthrough occurs in the area of direct measurement of the aggregate demand for reduction in risk it is considered desirable to continue to extend and refine the previous 'economic' cost frameworks ... towards the expanded social (or 'societal') cost framework proposed in Faigin (1976).

Breakdown of costs by injury level of victims

It has been frequently pointed out that costs are not uniform across all accidents and that by far the highest costs result from accidents where more severe injury occurs. In circumstances where costs are to be used in the evaluation of road safety programs, which may affect the incidence of one kind of accident more than another, the overall average cost per accident does not provide a very accurate measure of resources to be saved. Accordingly, all of the studies examined provided a breakup of accident costs either by type of accident or, as in most cases, by the severity of the injuries received by the victim. Unit costs broken down in this manner vary substantially, especially in relation to the loss or partial loss of the victim, and hospital and medical costs. However, there is some general concern expressed by Wigan (1982a), that the categorisation of costs by injury severity scales may not reflect the true nature of cost differences and that the amount of estimation needed means that within-category variance may exceed between-category variance.

Breakdown of costs by type of accident

Costs are sometimes also broken down by type of accident. It is considered by some researchers that expressing costs in this manner provides a clearer and more useful picture than costs per injured person by injury level, as the benefits of any remedial action are likely to relate more to particular accident types than injury levels.



Source James (1987).

Figure 2.1 Interrelationship between investigations of traffic accident costs by various authors

DERIVATION OF ESTIMATES: THEORY AND REALITY

While the human capital and willingness to pay approaches may each be appropriate in theory for commonly held objectives, there are considerable difficulties in obtaining measures which correctly reflect their theoretical bases.

Willingness to pay estimates

Willingness to pay estimates have been produced by researchers, but mostly in relation to general risk-taking, not to road accidents in particular. In the main, they have been produced in one of two ways:

- as responses by individuals, obtained by direct survey; or
- by analysis of individuals' accepted compensation (payment) for voluntary assumption (reduction) of risk.

General problems

These techniques establish, with some limitations, particular individuals' willingness to pay or be paid for risk reduction or assumption. One limitation is that the resulting estimates may not be representative, or in other words, may be related to the characteristics (such as the risk aversion or income distribution) of those individuals assessed. Further, the measure should relate to the value of a 'statistical' life, as measured by the sum of the amounts individuals are willing to pay to achieve small reductions in the probability of their own death, and not to the value they place on their own life or the life of somebody close to them. Measures are also needed in relation to injury (as opposed to death); however it is not clear whether individuals can distinguish this risk well enough to provide a reasonable response.

More importantly, though, what is required from the point of view of investment in road safety measures is an estimate of society's rather than individuals' willingness to pay. Since in considering these measures, government needs to consider them on behalf of society generally and not on behalf of particular members of society. With these methods the individuals' estimates are aggregated and used as a measure of society's willingness to pay. Other problems aside, where the provision of a merit good is involved, these two amounts are not equal. In economic terms, a merit good is one which is not necessarily desired by members of society individually, but nonetheless is desired by society as a whole. Safety, in particular road safety, appears to have become a merit good. In these circumstances, aggregating individuals' willingness to pay underestimates society's willingness to pay.

Method-specific problems

Landefeld and Seskin (1982) point out that, in addition to the general problems described above, the two methods of obtaining willingness to pay estimates (that is, by direct survey and by analysis of acceptance of voluntary risk) involve problems which are method-specific. The survey method allows the individual to provide a considered response in an environment where no risk is involved. This presents two main difficulties. First, lack of information or threat may lead individuals to respond quite differently than they would if confronted with a true situation. And second, individuals may bias their response depending on what they see may be the effect of their response.

This latter problem is particularly important where the result affects the provision of a public good. If the respondent believes they will have to contribute according to their willingness to pay then they may deliberately understate their true willingness to pay. If, however, they feel they will not have to contribute fully, then they may overstate their willingness to pay to promote the provision of the public good (in economic terms, they will 'free-ride').

As to obtaining willingness to pay values by analysis of acceptance of voluntary risk, Landefeld and Seskin (1982) describes problems which can be summarised as relating to: the non-representativeness of the sample selected; the influence of factors other than risk, for example incomplete information on risks; imperfections in the labour market; and difficulties in separating risk values for injury and death. To avoid these problems, there have been some attempts at measuring tradeoffs made in consumption activities, for example highway driving speeds (versus accident risk) and the purchase of smoke detectors (versus risk of undetected fire). However, in addition to the problem of extraneous influences, there is a lack of quantitative data on the level of risk imposed (or counteracted) by these activities.

These difficulties have in the past led to the general abandonment of the willingness to pay approach in favour of the more easily measured ex-post (in particular, the social human capital) approach.

Social human capital approach estimates

If one is willing to accept that the ex-post approach is legitimate in relation to some of the objectives for obtaining accident costs, then the fundamental problem becomes what should be included as costs. The difficulties in, and more importantly the inappropriateness of, restricting costs to those which affect GDP have already been

addressed. A broader concept of cost is needed. Further, if the estimates are to take full account of everything society values, then it may be appropriate to include more items than just those related to output, such as the value of leisure time, or the cost associated with pain and suffering.

As indicated previously, estimates based on the social human capital approach can vary markedly in the scope of costs included, but basically incorporate costs related to the loss or partial loss of the victim, the resources expended in accident-generated activities and sometimes pain and suffering. Some approaches to and difficulties in measuring each of these types of costs in practice are described below.

Loss or partial loss of the victim

The discounted value of the victim's forgone income is included in human capital estimates as a proxy for the loss of the victim to society in some sense, either as a measure of lost production capacity or, more abstractly, as a proxy for the loss of the victim personally, depending on what objectives are being addressed.[5]

The concept of using forgone income as a measure of lost production capacity is based on the need to find a uniform measure of the value of production for disparate products, where it is assumed that market remuneration represents the value of production. While, in reality, market remuneration may not be an accurate measure of the worth of a victim's production, since not only do external factors influence payment but the extent of that influence may vary across sectors, it is nonetheless the most appropriate measure available.

This said, forgone income may or may not be a good measure of lost production, depending on whether the lost income is calculated for a period approximating the period of lost production. Where, for example, the loss for fatalities is calculated over what would have been the expected remainder of the victim's life, instead of until such time as their productive effort would be replaced, the resulting estimates clearly overstate the 'true' cost of lost production.

In some studies, a measure of production capacity is regarded more abstractly, as a proxy for the loss of the victim personally to society. The reasoning is that losses in production decrease

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5. The concept of discounting is discussed later in this chapter.

consumption levels available to society, and social welfare is therefore reduced. Accordingly, it has been argued that society would be prepared to pay at least the value of lost production for the loss of the victim not to have occurred. However, the method is considered to underestimate the 'true' social cost of the loss of the victim since often no estimate is made for the intangible quality of life aspects of the loss.

If forgone income is most directly a measure of lost production capacity in relation to the working week, then two questions arise: how to treat the work done by employed persons outside working hours in the home and community, and how to treat those victims who are not employed in the market economy. More particularly, the question is what value, if any, do we assign to this 'production'? Clearly, the value of this 'production' is not included in GDP, yet it is generally considered of value to society.

In relation to the working week, Faigin (1976) argues that each victim should be assigned a value for lost production because society has incurred the loss of their 'life activity'. On a practical level, adopting different approaches for victims depending on their employment status is not possible, since this is rarely indicated in accident records. In such circumstances, a value equivalent to the average income for persons with the same sex and age as the victim is assigned to the victim. In some studies, full-time income averaged over the number of full-time workers is used to represent the working week 'production' of all persons. This is the economic concept of opportunity cost, which Faigin (1976) argues provides a proxy value that best reflects the value of non-market production and enables all production to be considered on a consistent basis. This approach is in line with the Law Reform Commission (1986) recommendation that in order to rectify the inadequate recognition which had been given by the courts to the economic worth of unpaid housework, assessments for compensation be made on the basis of gross median weekly earnings. In other studies, income averaged over the number of both working and non-working persons is used. The different approaches used to calculate average income are discussed later in this chapter.

The value of the loss of work performed outside the working week is most often taken to be, on an hour for hour basis, the amount which could have been earned if the person had spent the same number of hours working in the market economy, that is the opportunity cost of such work. This approach is widely used, although there are some differences in the various estimates of the number of hours worked at home and in the community for which the opportunity cost is calculated.

Estimates of the costs of accident-generated activities

In human capital estimates, it is usual to include as the costs of accident-generated activities the summed values of the resources expended in these activities. As discussed previously, this methodology produces a result which does not equate with the effect on GDP. Instead, an estimate is made of amount of resources which could be deployed elsewhere if the accidents had not occurred. In stating these as costs, there is an implicit assumption that had the accidents not occurred, these resources would have been fully utilised in some way to increase social welfare. This assumption may not always be justified; nonetheless, the method is widely used.

Accepting this underlying philosophy, there are still numerous problems in the scope and measurement of individual cost items. These problems have led to large variations in estimates ostensibly produced using the same approach. These differences are discussed in detail later in this chapter.

Pain and suffering

Pain and suffering is considered, in theory, to be a legitimate cost by most researchers professing social welfare objectives. Wigan (1980, 1982b) notes that, although generally excluded from American and Australian cost estimates, valuations for grief, pain and suffering have been included by others to increase costs derived by ex-post methods to more closely align with values implied by public attitudes. He cites the British Department of Transport's recommendation to increase by 50 per cent all accident values used by the Department which do not take account of pain and suffering.

In practice, the deciding factor on whether an allowance for pain and suffering is included or excluded has been a judgment of whether or not the available data were reliable enough. If a value is omitted, however, essentially a zero cost is assumed for that item. NHTSA (1972) argues, therefore, that a best estimate is better than none.

There is general agreement that the jury system (and, therefore, court awards) is the most reasonable approximation of society's valuation of pain and suffering. However, there are difficulties with this measure in practice. Faigin (1976) argues that court awards only provide a reasonable proxy for societal preference when the award is based on the extent of the pain and suffering and not the guilt or culpability of the defendent, and when the sample of cases is large enough to eliminate any potential judicial bias.

TREATMENT OF SPECIFIC COST ITEMS IN RECENT SOCIAL HUMAN CAPITAL APPROACH STUDIES

In view of the widespread application of the social human capital approach, and its consequent use as the basis for the estimates included in this Paper, it is important to identify the differences observed in the scopes and methodologies used to produce earlier estimates.

The most important differences in terms of their effect on the magnitude of the estimates resulting from the social human capital approach are in the calculation of the value of the victim's loss or partial loss to society. As has been discussed, this is primarily measured using forgone income, but is calculated in different ways in different studies. There are also differences in the scope and method of calculation of the various costs of accident-generated activities and pain and suffering (where included).

Loss or partial loss of the victim

Forgone income

Lost production capacity or lost production?

Most of the studies examined professed to be measuring social welfare objectives, including Atkins (1981), Somerville and McLean (1981) and Faigin (1976). These studies include estimates of what could be regarded as lost production capacity, rather than lost production. In other words, forgone income was calculated for fatalities and permanent injury victims for the period over which it was considered income would have been earned, rather than for the number of days of production expected to be lost before return to work or replacement.

This procedure was also used in cases where the estimates were described as 'objective social losses' (JRCTP 1978) and 'material costs' (Lawson 1978). Sherwin (1977) and JPUS (1972) used other than forgone income to calculate the loss of the victim per year but still calculated for the expected remainder of life.

Of the cost studies examined, only Fox, Good and Joubert (1979) produced an estimate close to the concept of lost production, which they included in addition to estimates of lost production capacity. They derived what they considered conservative estimates of the number of working days lost during convalescence after serious injury as a ratio to the number of days spent in hospital, using data presented in Faigin (1976), and applied this to their own hospital-stay data. It should be noted that the resulting estimates reflected working days lost by the victim and not production losses as such. Accordingly,

zero days lost are assigned to fatalities. The estimates for the loss of the victim produced in Fox, Good and Joubert (1979) using this method are less than one-tenth of the amount they calculate for lost production capacity.

Income or earnings?
Although earnings, rather than income, is the market remuneration for production, at least in an immediate sense, it has been widely argued that income is the better measure when valuing production losses. This is because income includes the return on production and it is considered these returns should be included to properly account for all losses on future production. However, it should be noted that available income measures generally include some income which is out of scope from a production point of view.

Income was the measure most commonly used in the studies examined. Atkins (1981), Somerville and McLean (1981) and Faigin (1976) all used income in their calculations. Sensitivity analysis indicates that, in practice, the two measures produce very similar results (see Chapter 4).

Net or gross income?
One of the issues in the calculation of forgone income is whether gross or net income, that is after deduction of the victim's own consumption, should be included as a cost. Some net estimates have been produced (for example, Troy and Butlin (1971), JPUS (1972) and JRCTP (1978)); however, the net measure appears to have lost favour in recent years.

There are two basic justifications put forward for use of the gross measure. In assessing the cost of road accidents, consideration of society as it was before the accident is required; that is, society is defined so as to include the victim. Thus the gross measure indicates the true worth of preventing accidents before their occurrence. From another point of view, Wigan (1982b) argues that after the accident the loss to the remaining members of society is equal to the income which would have gone to the victim's dependents plus the victim's own future consumption, since it has a value to society of at least as much as to the victim himself.

Productivity rate
In most years, there is an increase in the amount of production in the economy expressed per person. The productivity rate is used to take account of this increase, by increasing yearly income (when calculating forgone income) to an extent judged to be equivalent to

the rise in productivity each year. Atkins (1981) calculated three alternative measures for productivity - average growth in real income per (civilian non-farm) employee, average growth in real income per capita, and average (real) growth in Gross Product per person employed - each calculated for the period 1966-67 to 1977-78. He adopted the first measure, as it provided a middle estimate of 3 per cent. Three per cent was also the measure used for Australia by Somerville and McLean (1981) and Fox, Good and Joubert (1979). Among recent studies, only JRCTP (1978) did not use a productivity rate in the forgone income calculations.

Discount rate

A discount rate is used in the calculation of forgone income to enable future monetary values to be related to current prices. The higher the discount rate, the lower the present value.

There are several different concepts which can be referred to as a discount rate and there is general acknowledgement that the choice of concept depends on the meaning to be attached to the cost estimates. However, it is not clear which concept is appropriate in which circumstance, nor is there a specific rate agreed as representing a particular concept.

Faigin (1976) argues that for income calculations, the appropriate rate should relate to incidence of the loss (that is, individuals) and so the return faced by individuals (estimated at 7 per cent) rather than the average rate of return faced in all markets (estimated at 10 per cent) should be used. To be consistent with other government analysis, and despite some reservations about its suitability for the purpose, Atkins (1981) used a rate (10 per cent) considered appropriate for use in cost-benefit analysis of public projects. Faigin's choice relates to the nature of the data to which the rate is being applied, while Atkins' choice reflects the use envisaged for the estimates, that is evaluating road safety programs.

Landefeld and Seskin (1982), in their discussion of the human capital and willingness to pay approaches, consider in some detail the appropriateness of the various discount rates in relation to the conceptual basis of the two approaches. The individual time-preference rate is cited as the correct approach for the willingness to pay approach, while the social opportunity cost of investing in life-saving programs is seen as appropriate for the human capital approach (for which a social perspective for the incidence of the loss is assumed).

Even given a particular perspective on the discount rate issue, however, there is no definitive way to identify a unique rate. For example, 7 per cent and 10 per cent might both be considered reasonable rates for use in public sector cost-benefit analysis.

The final point to note about the discount rate is that the choice of rate can affect the relative values of victims in different age groups. The lower the discount rate, the higher the valuation of young victims relative to older ones and vice versa.

Valuation of victims not employed in the market economy

Most cost studies examined included a value for some victims not employed in the market economy. However, there are differences in the extent to which various categories of victims are included.

Faigin (1976) considers that all persons not in the workforce should be assigned an opportunity cost equivalent to the average market remuneration for their sex and age. This opportunity cost principle is widely supported and is followed by Atkins (1981) and Somerville and McLean (1981).[6] All accident victims are assigned a forgone income value (per year of calculation) equivalent to the annual full time mean income for their age and sex. To reflect market remuneration, income is averaged only over the number of persons earning incomes, not the total population.

Income (by age and sex) averaged over the number (by age and sex) in the total population represents expected income loss, as opposed to opportunity cost, for any victim. This method is often referred to as the adjusted income method, and produces a lower estimate of forgone income, the extent of the difference dependent on employment rates. Although this lower amount is assigned to all victims, in reality the estimate of total loss incorporates zero value for working week production outside the market economy. JPUS (1972) used this method to derive values for the loss of victims, although not using forgone income as the measure.

Several other studies adopted methods which assigned values to housewives but not to other non-earners of working age. JRCTP (1978) included a value equivalent to a full income for housewives only. Lawson (1978), in obtaining an average income, averaged female earnings over the number of female earners, but male earnings over the

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6. Further support for this principle has been provided by Wigan (1982a).

total number of males, in effect assigning a value to female non-earners only. NHTSA (1972) adjusted for 5 per cent unemployment. (In updating this latter work, Faigin (1976) argues that the unemployed should be assigned the value of full time workers, basically because they possess a wide range of skills of value and have a variety of reasons for labour non-participation, which did not diminish their production capacity.)

Weighting of income by age and sex

Calculation of an estimate of the loss of future income incurred by accident victims requires estimates of average incomes and the time period over which income would have been earned by the victims had the accident not occurred.

There is no uniformity among the various studies as to the age range used to calculate lost income. Faigin (1976) used from 20 to 65 years of age. Atkins (1981) and Somerville and McLean (1981) used from 15 to 65 years of age.[7] A terminating age of 65 years has been used most frequently, although its basis is somewhat arbitrary. An exception was JRCTP (1978) in which expected future (net) income was calculated for the remaining years of life expectancy.

The terminating ages should relate to the concept being measured by the forgone income estimates. The loss to society may be best represented by calculating income to average age at death. If measuring losses in production, then income until average retirement age may be more appropriate, if a significant amount of income after this age is received from sources other than those related to past production.

To obtain a better estimate of the average loss of income per victim, the averages for each sex and age group are weighted. One possible method of weighting is to use the age and sex distribution of the population as a whole. However, this results in an estimate of average lost income which is lower than could be expected, since there are proportionally more young males as accident victims than in the population. To account for this, all the studies examined weighted average remaining income by the age and sex distribution of accident

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7. Atkins (1981) may have made some modification to this for older victims.

victims, although different numbers of age categories were used.[8] Atkins (1981) further adjusted the proportions of the 15 to 19 and 60 to 64 year old groups relative to the other groups in the calculation of forgone income for the injury categories which did not involve a degree of permanent incapacity to take account of the lower work force participation rates for people of these ages.

Family and community losses

Most of the studies examined included an estimate for the loss of the victim's contribution to the family and community, although there has generally been a lack of quantitative information on which to base estimates of the number of hours involved. These losses are assigned an opportunity cost equivalent to the average market remuneration on an hour by hour basis.

NHTSA (1972) adopted what was regarded as a conservative estimate of ten hours per week, or 25 per cent of the number of working hours, spent on home and family duties and a further 5 per cent of the number of working hours spent on community services. These proportions were applied to forgone income to derive a value for lost family and community services. Faigin (1976) reviewed these estimates by examining estimates of the contribution these activities would or do make to GDP and concluded these percentages were supportable. In the absence of Australian estimates, Atkins (1981) used these same percentages. Somerville and McLean (1981) derived an estimate of 35 per cent of forgone income for work and services outside working hours.

Lawson (1978) used as the value of home work lost, forgone income proportions of 10 per cent for working males and 50 per cent for working females. This approach is in line with the results of studies by Mercer (1985) and ABS (1983) which indicated significant differences in the amount of time spent on household and community work by men as opposed to women (as well as by those in the workforce as opposed to those not in the workforce).

Costs of accident-generated activities

In terms of accident-generated activities, the differences between the various social human capital estimates examined revolve around the

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8. Atkins (1981) showed that forgone income estimated in this manner was approximately 30 per cent higher than when weighted by the sex and age proportions for the population as a whole.

list of costs included and the methods by which the estimates were derived. The major discrepancies, with particular reference to the two major Australian studies by Atkins (1981) and Somerville and McLean (1981), are discussed below. Costs are referred to by the names used in Atkins (1981).

Hospital, medical and rehabilitation

All of the ex-post estimates examined included some account of health care costs resulting from road accidents; however it is not always clear whether all relevant costs are included.

Faigin (1976) made use of detailed data from various sources to obtain average hospital, medical and rehabilitation costs for accident victims. Similar data for Australia was not available, so Atkins (1981) made use of Victorian data on payouts by the Motor Accidents Board (MAB)[9] for hospital, medical and other (rehabilitation) costs to establish average costs.

A problem noted with both these methods of estimation is that long-term problems (and therefore costs) may not have been identified in the period to which the data relates. In addition, the data used by Atkins (1981) relates to claimed (and therefore charged) costs only. This is likely to result in an underestimation of costs where the health care system does not operate on a cost recovery basis, but is subsidised by government, as in Australia. Somerville and McLean (1981) go part of the way to overcoming this latter problem by using an imputed average cost which includes some of the costs not charged to patients.

Legal and court proceedings

Estimates of legal and court costs are commonly included in ex-post accident costings (although notably, Lawson (1978) excluded these and other smaller costs on the grounds that in magnitude they were probably less than the error component of the major cost estimates).

Faigin (1976) again made use of previous estimates and numerous data sources on costs to derive average costs for accident citations and tort actions. Despite differences in legal systems, Atkins (1981) adopted these estimates in the absence of Australian data. Somerville and McLean (1981) provide estimates of legal and court costs in relation to the South Australian third party insurance system. Unlike Faigin (1976) (and, therefore, Atkins (1981)), only plaintiff costs

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9. In January 1987 MAB became the Transport Accident Commission.

were included, as it was argued that defendant costs were incorporated in insurance administration costs.

Insurance administration

Along with others of the smaller cost items, it is sometimes difficult to tell what is included in the various cost estimates as insurance administration costs. The best example of differences in approach is provided by contrasting the estimates of Atkins (1981) and Somerville and McLean (1981).

In deriving an average cost, Atkins (1981) included total management expenses attributable to road accidents. Somerville and McLean (1981), on the other hand, argue that the relevant measure is 'incremental administrative costs' resulting from accident claims. The costs involved in writing the insurance policies are excluded from this latter study on the assumption that they would have been written whether or not the accident occurred.

Atkins (1981) restricted the scope of expenses included to those related to motor vehicle comprehensive insurance only. Somerville and McLean (1981) derived estimates based on data for both motor vehicle comprehensive and compulsory third-party administration expenses. As previously mentioned, defendant legal costs are incorporated in third-party costs. The end result of adopting the incremental concept as well as the broader scope is that the estimates of insurance administration costs produced by Somerville and McLean (1981) are about half the magnitude of those produced by Atkins (1981).

Losses to others

Losses to others are by their nature difficult to measure and estimates vary widely. Atkins (1981) found no data available on the cost of visiting, transport and home care of accident victims, or on accident-generated labour replacement costs. Consequently, Atkins (1981) adopted the proportions of forgone income assigned to this cost component in NHTSA (1972), which themselves are based on very limited data. Somerville and McLean (1981) found there was insufficient accurate information for these activities and only include estimates of travelling costs incurred in visiting and transporting a patient.

Vehicle damage

There are large differences in the estimates of vehicle damage included in the various cost estimates, particularly in relation to accidents which involve little or no personal injury. The major difficulty in deriving reasonable estimates is that there is no comprehensive data on the number of PDO accidents which occur. Some accidents are not reported at all, some are reported to the police but

not to insurance companies, some are reported to insurance companies but not to police, and some are reported to both. The damage incurred may or may not be repaired, and in either case, may or may not be claimed against insurance.

Atkins (1981) produced estimates of vehicle damage using data on the value of motor vehicle repairs. Use of this data source means the estimates are understated by the value of damage not repaired (both claimed and unclaimed), but is overstated by the value of repairs not resulting from road accidents. The estimates of average cost produced by Somerville and McLean (1981) are biased upwards since their study encompassed only those vehicles involved in accidents to which an ambulance was called. Such vehicles are likely on average to have suffered more damage than vehicles involved in accidents overall.

Traffic delay

As is the case with other cost items, the lack of comprehensive data on the cost of traffic delays has meant that estimates included for this item do not match well the theoretical scope of the item. At the extreme, lack of data has led to the complete omission of an estimate for traffic delay, as in Somerville and McLean (1981). Other estimates are based on limited empirical data. Faigin (1976) used estimates of the cost to individuals (that is, excluding business) resulting from traffic delays based on data relating to peak hour accidents on a freeway. Despite reservations about its applicability to Australian conditions, Atkins (1981) adopted these estimates directly.

Pain and suffering

Pain and suffering involves an (indirect) cost to society in terms of social welfare. However, few of the studies examined included an estimation of the cost of pain and suffering to the victims or others, basically because of the difficulties inherent in finding an acceptable measure for such intangible costs. Where an estimate was produced, data were generally obtained from court records of the amount of compensation awarded to accident victims for pain and suffering or as general damages (of which pain and suffering is a component).

NHTSA (1972) used court records for various types of accident cases where amounts were awarded either at the discretion of the jury or by use of a formula. Faigin (1976) did not include an estimate on the basis that a reliable estimate could not be derived from court records because it was considered that the criteria under which court awards could be regarded as 'a reasonable proxy for societal preference' were not met by court proceedings.

Atkins (1981), too, excluded an estimate of the cost of pain and suffering in the absence of a generally accepted basis of valuations but notes the existence of large court awards and the need for further research. In preference to providing no estimate, Somerville and McLean (1981) produced 'orders of magnitude' estimates on the basis of third party awards, adjusted to exclude the effect of the degree of guilt involved.

Breakdown of costs by injury level of victims

Since the NHTSA (1972) study, accident costings have commonly been broken down by the injury level of the victims, average costs being provided for each of several injury severity categories. Faigin (1976) refined the NHTSA (1972) categorisation of injury severity levels by using the 1976 revision of the Abbreviated Injury Scale (AIS), at the same time drawing attention to two major drawbacks of the AIS scale:

- it is based on life-threatening criteria rather than on cost-based criteria; and
- the lack of data tabulated by AIS, making it necessary to split total costs by injury level arbitrarily.

Atkins (1981) adopted the AIS scale and estimated costs for the different injury levels, in the main by adopting a slightly modified version of the proportional split of injury numbers between the AIS levels established in Faigin (1976). In some cases, costs were estimated by equating the distribution of injuries to the distribution of costs, that is, costs were assumed to increase with level of injury severity. In reality, this assumption may not be well founded, particularly for the more minor levels of injury severity.

Somerville and McLean (1981) cross-classified costs by Injury Severity Score (ISS), which is derived from the AIS by rating each injury with the AIS then adding together the squares of the highest AIS rating for each of the three most severely injured body regions. Data is presented for seven ISS ranges, from 0 (no injury, that is, PDO) to fatal. The distribution of injury victims across ISS levels derived in Somerville and McLean (1981) relates to those victims taken to hospital, of whom about half were admitted and half received casualty treatment and were released.

Per accident costs derived from injury level costs

Where presented in previous studies, costs on a per accident basis have been derived from per injury costs. Somerville and McLean (1981)

obtained per accident costs, along with the per injury costs, from the examination of the consequences of a sample set of accidents. However, where per injury costs are derived from aggregated cost data, such as in Atkins (1981), information on the number and extent of injuries per accident type must be used to convert costs from a per injury to a per accident basis.

Andreassend (1982, unpublished) showed that the method of conversion employed in Atkins (1981) is in error. Andreassend (1985) used information for reported accidents in Victoria to illustrate an alternative methodology.

Breakdown of costs by type of accident

Very few studies included a breakdown of costs by type of accident, presumably because information by this classification is not generally available. Somerville and McLean (1981) presented costs by type of accident, since by using a methodology which involved collecting data for a sample of accidents, they were able to obtain the required information. Some investigatory work on deriving the costs from more general information is presented in Andreassend (1985).

CHAPTER 3 ROAD ACCIDENT COST ESTIMATES FOR 1985

A whole range of accident costings would be required if account was to be taken of each of the philosophical and methodological approaches possible. However, this would be neither practical nor particularly meaningful. Instead, for this Paper three primary costings have been produced, with a preference stated. They are intended to be illustrative of the order of magnitude of estimates produced using different approaches.

It is generally agreed that whether a particular approach to accident costings is appropriate or not depends on the objectives for which the organisation is producing the estimates. Further, there is support for the comment by Hills and Jones-Lee (1983) that national output and social welfare objectives are the most common, and that the human capital approach and the willingness to pay approach respectively are the appropriate methods by which to measure costs with regard to these objectives (although what exactly should be included in the human capital approach is open to debate).

The desirability of producing estimates based on the willingness to pay approach is indisputable. However, apart from the difficulties inherent in the approach, the production of such estimates requires special data collection, which was not possible within the resource constraints of this project. Therefore, effort was concentrated on identifying and producing estimates using the social human capital approach. In addition, indicative estimates were produced using the relatively new WTP/HK approach put forward by Landefeld and Seskin (1982).

Cost estimates are presented in this chapter using each of two versions of the social human capital approach, namely the adjusted income method and the opportunity cost method[1], and the WTP/HK approach. Details of the methodologies used and calculations made for

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1. Full details of the differences between the two methods are given in Appendix II.

each set of estimates are provided in Appendix II. Examination of these details provides the best understanding of what each of the costings actually represents. On a broader level, a summary of the estimates produced and a basic description of each costing is provided below.

SUMMARY OF ESTIMATES

Average unit costs and total estimates of the cost of road accidents in Australia in 1985 are given in Table 3.1 based on each of the three calculation methods used.

It is recommended that the estimates produced by the adjusted income method be regarded as the primary estimates. They are considered to provide the best estimate of costs, given the limitations of readily available data. They give a more 'realistic' estimate of production capacity lost than the estimates produced using the opportunity cost method, as average income is adjusted for employment rates. Opportunity cost method estimates are provided to enable comparisons with the adjusted income method estimates and because they are the most comparable with previous estimates. The WTP/HK approach estimates are given as an indication of the order of magnitude of willingness to pay estimates. The estimates referred to in the remainder of this summary discussion are those produced by the adjusted income method unless stated otherwise. In practice the opportunity cost method estimates are generally quite similar to the adjusted income method estimates, in any case.

It is estimated that the cost of road accidents in Australia in 1985 was approximately $5000 million. Vehicle damage is the highest cost category, accounting for approximately 30 per cent of the estimated total cost of road accidents. The items relating to the loss of the victim, that is forgone income together with family and community losses, also account for around 30 per cent of the total cost. The estimate in relation to the pain and suffering of the victim represents almost 20 per cent of the total cost. These proportions vary significantly between the injury severity levels.

Cost estimates are also presented in Table 3.1 as average unit costs per injured person (or per vehicle in the case of PDO accidents). It should be noted when examining these estimates that most attention was given to revising and producing estimates at the total level, and that many of the assumptions upon which the injury level estimates have been based have not been re-examined in detail. Accordingly, the cost estimates for each of the AIS levels of injury should be regarded as indicative only.

TABLE 3.1 SUMMARY OF ROAD ACCIDENT COSTS: AUSTRALIA, 1985

Accident cost approach	*Abbreviated injury severity (AIS) level*						*Property damage only*	*Total*
	6 Fatal	*5 Critical*	*4 Severe*[a]	*3 Severe*[b]	*2 Moderate*	*1 Minor*		
	Average unit costs ($)							
Social human capital								
Adjusted income method	398 803	350 161	164 582	45 099	19 964	4 893	988	..
Opportunity cost method	451 307	380 087	177 707	46 135	20 522	4 936	988	..
WTP/HK[c]	1 164 700	786 721	356 056	na	na	na	na	..
	Total costs ($ million)							
Social human capital								
Adjusted income method	1 173.3	160.4	376.7	415.9	1 131.8	783.9	945.5	4 987.4
Opportunity cost method	1 327.7	174.1	406.8	425.5	1 163.4	790.8	945.5	5 233.7
WTP/HK[c]	3 426.5	360.3	815.0	na	na	na	na	4 601.9[d]

a. AIS level 4 'severe: life threatening, survival probable'.
b. AIS level 3 'severe: not life threatening'.
c. Calculated using the methodology described by Landefeld and Seskin (1982). The costs of accident-generated activities and pain and suffering cost estimates from the social human capital approach have also been included.
d. Total of AIS levels 4, 5 and 6 only.
.. Not applicable.
na Not available.

Note The methodology described by Landefeld and Seskin (1982) does not provide estimates for lower levels of injury.

Source BTCE estimates.

Total costs per injured person for the broad injury groupings of fatalities (AIS level 6), major injuries (AIS levels 3, 4 and 5) and minor injuries[2] (AIS levels 1 and 2) were also calculated, as these groupings are often used to report road accident costs. Details are not included in the tables; however, in round numbers, costs were estimated at $400 000 for a fatality, $80 000 for victims who received major injury, and $9000 for victims who received minor injury. The cost per vehicle where property damage only is incurred was estimated at around $1000 for 1985.

Use of the opportunity cost method resulted in estimates approximately $250 million, or 5 per cent, higher in total than the adjusted income method estimates. Estimates produced using the WTP/HK approach for AIS levels 4, 5 and 6 are up to 3 times the adjusted income estimate for the same level.

SOCIAL HUMAN CAPITAL APPROACH ESTIMATES

The two social human capital approach estimates presented utilise the same list of component items and the same estimates for the costs of accident-generated activities and pain and suffering. The difference between them is in the method of calculation of forgone income and the scope of the item relating to family and community losses. Average unit cost estimates and total cost estimates for 1985 produced using the adjusted income method and the opportunity cost method are given in Tables 3.2 to 3.5.

In calculating forgone income for the opportunity cost method each victim is assigned the average income for full time workers of their age and sex. This most closely resembles the methodology used by Atkins (1981). In the adjusted income method, victims are assigned the average income for their age and sex, that is, income averaged over the entire population rather than just full-time workers. The opportunity cost method uses a measure of the amount of production capacity society could have lost (rather than did lose) with the loss of the victim. That is, it is assumed that each victim could have been producing an equivalent amount to a full time worker. In the adjusted income method, it is assumed that the victim would have been

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2. The term 'minor injuries' for the broad grouping of AIS levels 1 and 2 has been retained because it has been widely used in the past for this combination of AIS levels. However, care should be exercised when using this term as injury level AIS 1 is also described as 'minor'.

TABLE 3.2 AVERAGE[a] UNIT ACCIDENT COSTS BY INJURY SEVERITY LEVEL: AUSTRALIA, 1985, ADJUSTED INCOME METHOD
(dollars)

Cost category	*Abbreviated injury scale (AIS) level*						*Property damage only*
	6 Fatal	*5 Critical*	*4 Severe*[b]	*3 Severe*[c]	*2 Moderate*	*1 Minor*	
Loss of victim							
Forgone income	213 350	121 610	53 338	1 365	735	56	..
Family and community losses	167 424	95 432	41 856	1 512	814	62	..
Accident-generated activities							
Hospital, Medical, Rehabilitation	1 938	24 943	8 791	5 092	1 479	162	..
Legal and court proceedings	2 302	3 385	3 385	2 584	1 052	317	0
Insurance administration	1 419	1 419	1 419	1 214	1 000	279	164
Accident investigation	1 908	636	636	562	488	254	25
Losses to others	3 680	4 370	1 916	277	149	23	0
Vehicle damage	6 698	8 136	8 011	7 263	5 017	3 010	625
Traffic delay	84	230	230	230	230	230	174

TABLE 3.2 (Cont.) AVERAGE[a] UNIT ACCIDENT COSTS BY INJURY SEVERITY LEVEL: AUSTRALIA, 1985, ADJUSTED INCOME METHOD

(dollars)

Cost category	*Abbreviated injury scale (AIS) level*						
	6 Fatal	*5 Critical*	*4 Severe*[b]	*3 Severe*[c]	*2 Moderate*	*1 Minor*	*Property damage only*
Pain and suffering of victim	0	90 000	45 000	25 000	9 000	500	0
Total	398 803	350 161	164 582	45 099	19 964	4 893	988

a. Average is per fatality for AIS level 6, per injured person for AIS levels 1 to 5, and per vehicle for property damage only accidents.
b. AIS level 4 'severe: life threatening, survival probable'.
c. AIS level 3 'severe: not life threatening'.
.. Not applicable.

Note A discount rate of 7 per cent and a productivity rate of 2 per cent were used.

Source BTCE estimates.

TABLE 3.3 TOTAL[a] ACCIDENT COSTS BY INJURY SEVERITY LEVEL: AUSTRALIA, 1985, ADJUSTED INCOME METHOD
($ million)

Cost category	*Abbreviated injury scale (AIS) level*						Property damage only	Total
	6 Fatal	*5 Critical*	*4 Severe*[b]	*3 Severe*[c]	*2 Moderate*	*1 Minor*		
Loss of victim								
Forgone income	627.7	55.7	122.1	12.6	41.7	9.0	..	868.7
Family and community losses	492.6	43.7	95.8	13.9	46.1	9.9	..	702.1
Accident-generated activities								
Hospital Medical Rehabilitation	5.7	11.4	20.1	47.0	83.8	26.0	..	194.0
Legal and court proceedings	6.8	1.6	7.7	23.8	59.6	50.8	0.0	150.3
Insurance administration	4.2	0.6	3.2	11.2	56.7	44.7	156.9	277.6
Accident investigation	5.6	0.3	1.5	5.2	27.7	40.7	23.9	104.8
Losses to others	10.8	2.0	4.4	2.6	8.4	3.7	0.0	31.9
Vehicle damage	19.7	3.7	18.3	67.0	284.4	482.2	598.1	1 473.5
Traffic delay	0.2	0.1	0.5	2.1	13.0	36.8	166.5	219.4

TABLE 3.3 (Cont.) TOTAL[a] ACCIDENT COSTS BY INJURY SEVERITY LEVEL: AUSTRALIA, 1985, ADJUSTED INCOME METHOD
($ million)

Cost category	*Abbreviated injury scale (AIS) level*						*Property damage only*	*Total*
	6 Fatal	*5 Critical*	*4 Severe*[b]	*3 Severe*[c]	*2 Moderate*	*1 Minor*		
Pain and suffering of victim	0.0	41.2	103.0	230.6	510.2	80.1	0.0	965.1
Total	1 173.3	160.4	376.7	415.9	1 131.8	783.9	945.5	4 987.4

a. Totals calculated by multiplying average unit costs by fatality numbers for AIS level 6, numbers of injured persons for AIS levels 1 to 5, and vehicle numbers for property damage only costs.
b. AIS level 4 'severe: life threatening, survival probable'.
c. AIS level 3 'severe: not life threatening'.
.. Not applicable.

Note A discount rate of 7 per cent and a productivity rate of 2 per cent were used.

Source BTCE estimates.

TABLE 3.4 AVERAGE[a] UNIT ACCIDENT COSTS BY INJURY SEVERITY LEVEL: AUSTRALIA, 1985, OPPORTUNITY COST METHOD
(dollars)

Cost category	*Abbreviated injury scale (AIS) level*						*Property damage only*
	6 Fatal	*5 Critical*	*4 Severe*[b]	*3 Severe*[c]	*2 Moderate*	*1 Minor*	
Loss of victim							
Forgone income	306 637	174 783	76 659	2 769	1 491	114	..
Family and community losses	126 641	72 185	31 660	1 144	616	47	..
Accident-generated activities							
Hospital, Medical, Rehabilitation	1 938	24 943	8 791	5 092	1 479	162	..
Legal and court proceedings	2 302	3 385	3 385	2 584	1 052	317	0
Insurance administration	1 419	1 419	1 419	1 214	1 000	279	164
Accident investigation	1 908	636	636	562	488	254	25

TABLE 3.4 (Cont.) AVERAGE[a] UNIT ACCIDENT COSTS BY INJURY SEVERITY LEVEL: AUSTRALIA, 1985, OPPORTUNITY COST METHOD

(dollars)

Cost category	*Abbreviated injury scale (AIS) level*						*Property damage only*
	6 Fatal	*5 Critical*	*4 Severe*[b]	*3 Severe*[c]	*2 Moderate*	*1 Minor*	
Losses to others	3 680	4 370	1 916	277	149	23	0
Vehicle damage	6 698	8 136	8 011	7 263	5 017	3 010	625
Traffic delay	84	230	230	230	230	230	174
Pain and suffering of victim	0	90 000	45 000	25 000	9 000	500	0
Total	451 307	380 087	177 707	46 135	20 522	4 936	988

a. Average is per fatality for AIS level 6, per injured person for AIS levels 1 to 5, and per vehicle for property damage only accidents.
b. AIS level 4 'severe: life threatening, survival probable'.
c. AIS level 3 'severe: not life threatening'.
.. Not applicable.

Note A discount rate of 7 per cent and a productivity rate of 2 per cent were used.

Source BTCE estimates.

TABLE 3.5 TOTAL[a] ACCIDENT COSTS BY INJURY SEVERITY LEVEL: AUSTRALIA, 1985, OPPORTUNITY COST METHOD
($ million)

Cost category	*Abbreviated injury scale (AIS) level*						*Property damage only*	*Total*
	6 Fatal	*5 Critical*	*4 Severe*[b]	*3 Severe*[c]	*2 Moderate*	*1 Minor*		
Loss of victim								
Forgone income	902.1	80.1	175.5	25.5	84.5	18.3	..	1 286.0
Family and community losses	372.6	33.1	72.5	10.6	34.9	7.5	..	531.1
Accident-generated activities								
Hospital, Medical, Rehabilitation	5.7	11.4	20.1	47.0	83.8	26.0	..	194.0
Legal and court proceedings	6.8	1.6	7.7	23.8	59.6	50.8	0.0	150.3
Insurance administration	4.2	0.6	3.2	11.2	56.7	44.7	156.9	277.6
Accident investigation	5.6	0.3	1.5	5.2	27.7	40.7	23.9	104.8
Losses to others	10.8	2.0	4.4	2.6	8.4	3.7	0.0	31.9
Vehicle damage	19.7	3.7	18.3	67.0	284.4	482.2	598.1	1 473.5
Traffic delay	0.2	0.1	0.5	2.1	13.0	36.8	166.5	219.4

TABLE 3.5 (Cont.) TOTAL[a] ACCIDENT COSTS BY INJURY SEVERITY LEVEL: AUSTRALIA, 1985, OPPORTUNITY COST METHOD
($ million)

Cost category	*Abbreviated injury scale (AIS) level*						*Property damage only*	*Total*
	6 Fatal	*5 Critical*	*4 Severe*[b]	*3 Severe*[c]	*2 Moderate*	*1 Minor*		
Pain and suffering of victim	0.0	41.2	103.0	230.6	510.2	80.1	0.0	965.1
Total	1 327.7	174.1	406.8	425.5	1 163.4	790.8	945.5	5 233.7

a. Totals calculated by mulitplying average unit costs by fatality numbers for AIS level 6, numbers of injured persons for AIS levels 1 to 5, and vehicle numbers for property damage only costs.
b. AIS level 4 'severe: life threatening, survival probable'.
c. AIS level 3 'severe: not life threatening'.
.. Not applicable.

Note A discount rate of 7 per cent and a productivity rate of 2 per cent were used.

Source BTCE estimates.

producing an equivalent amount to the population average, allowance being made for the levels of unemployment and workforce participation in the community. It should be noted that neither method attempts to provide a measure of the actual production lost, that is, until the replacement of the victim in the workplace by another employee. Rather, forgone income is an indirect proxy for the lost production capacity (expected or possible) of the victim.

Note that within each method, all accident victims are assigned the same average income, but this average is different for each of the two methods. The averages are derived using different weightings for the various employment, age and sex categories. In particular, in the adjusted income approach, only production in the market economy is valued in the forgone income item.[3]

The adjusted income method is considered to provide a more 'realistic' measure of the loss of the victim in relation to the working week and is the preferred method. The opportunity cost method estimates are included to enable comparisons over time (with Atkins (1981)) and between methods.

Calculation methodologies adopted

Numbers of injured persons and accidents

The actual number of persons injured as a result of road accidents in Australia is unknown. The Australian Bureau of Statistics (ABS) publishes national figures for fatalities and victims admitted to hospital only. These are the first two levels of a five-level classification issued by the ABS and adopted by the road traffic authorities in the various States. However, data for the lower levels of injury are not considered reliable enough to use. Individual States do release additional information on the number of victims requiring medical treatment. However, the scope of the data is not well defined and there appears to be a significant level of undercoverage.

To obtain a better estimate of the number of injured persons who incur health care costs as a result of road accidents, a comparison was made between the 1985 ABS Victorian Office number of injured persons and the number of people claiming health care costs from the MAB of Victoria, which at that time handled all claims for health-related

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3. Family and community work by those not employed is included, but as family and community losses rather than forgone income.

road accident costs for incidents involving Victorian registered vehicles. The level of under-reporting in State data evident from this comparison was significant and taken to be representative of the situation in all States. Numbers of injured persons obtained from State sources were adjusted in accordance with the estimate of the extent of under-reporting demonstrated in Victoria. The number of injury accidents reported in State publications was similarly inflated.

It is recognised that by using MAB data on the number of claimants, there is still some amount of undercoverage. However, as there was no minimum for the amount which could be claimed from MAB, it is assumed that, on the whole, if costs were incurred they would be claimed. Further, it is considered that if a victim was injured but did not incur medical costs, this should not be counted as an injury.

Producing a reasonable estimate of the number of PDO accidents was not as straightforward. The application of different damage value limits below which accidents need not be reported in the different States means that there are no reliable, consistent data on which to base an estimate of PDO accidents. The accuracy of the estimate has a significant impact on the total accident cost estimate, since although the cost per vehicle is relatively small, the total cost of PDO accidents constituted over one-third of the total cost of road accidents as estimated by Atkins (1981).

Atkins (1981) indexed estimates obtained from the ABS 1971 Survey of Motor Vehicle Use (SMVU) by the increase in registered motor vehicles and the change in the accident rate. The resulting ratio of the number of PDO accidents to the number of injured persons (based on ABS State data) is 6.8 to 1.

In the absence of a more direct method, an estimate of the number of PDO accidents was produced for this Paper by applying a factor of 7 to 1 to the appropriate number of injured persons. Since the ratio was obtained in relation to ABS State data on injured persons, this same data source (rather than the modified estimate as outlined above) was used for the number of injured persons.

Loss of victim

Forgone income

As mentioned, forgone income is measured as a maximum or expected loss associated with production capacity, but is frequently regarded as a minimum value for the loss of the victim to society. Note that the measure of expected loss is calculated for what would have been the expected remainder of the victim's life (or working life in the case

of the opportunity cost method). It does not represent lost production, that is, until time of replacement. (An estimate of this loss is included as part of the sensitivity analysis in Chapter 4.)

In this Paper, an income (rather than earnings) measure is used, to include returns on past earnings. The distortion caused by the inclusion of income which does not relate to past production is assumed not be be significant. Gross income is used for the reasons stated in Chapter 2. In line with Atkins (1981), the opportunity cost method estimates are calculated up to the statutory age of retirement. The adjusted income method estimates are calculated until what would have been the expected age at death, to ensure the inclusion of all returns to the victim on past earnings. It is recognised that returns on earnings continue after the death of the person who earned them; however, calculation of income to expected age at death is considered to be sufficient for the purposes of measuring lost production capacity.

The income estimates are weighted by the age and sex distribution of accident victims to take into account the relatively high proportion of young males. This provides an estimate which reflects the most probable magnitude of forgone income per victim.

Data on income by age group were derived from ABS data relating to 1981-82. Employment rates were also derived from ABS data. For the purposes of this study, a discount rate of 7 per cent was chosen arbitrarily. Sensitivity analysis has been performed using discount rates of 4 per cent and 10 per cent (see Chapter 4). A productivity rate of 2 per cent was used, as being in the middle of ranges given in Indecs (1986).

Family and community losses

The family and community losses item provides a measure of the losses to the family and home and to the community which result from accident victims being unable to perform their normal activities in these areas. These losses are valued per hour at a rate equivalent to the income of a full time worker. Both the opportunity cost method and the adjusted income method estimates employ the same hourly rate; however, the opportunity cost method includes the 'production' of house-workers during the working week in forgone income and so only estimates home and community work outside the working week as family and community losses. The adjusted income method includes, as family and community losses, an estimate for all hours spent performing activities for the home and in the community by both workers and non-workers.

Hours are expressed as a proportion of the working week and, therefore, as a proportion of forgone income. Forgone income, as calculated using the opportunity cost method, is used to estimate family and community losses for both methods, since the average income of full time workers, and not income averaged over the whole population, provides a measure of the opportunity cost of family and community activities.

Data from Mercer (1985) were used to estimate the number of hours spent in home duties. ABS (1983) data were used to estimate the number of hours spent on community services.

Costs of accident-generated activities

The costs of accident-generated activities are estimated in the same way for both methods. The items included in these estimates are the same as those used by Atkins (1981). The calculation methodologies and data sources used for each item are described briefly below and in detail in Appendix II.

Hospital, medical and rehabilitation

There is no ready source of information on health care costs incurred by accident victims. Some hospital records are kept, including injury descriptions, length of stay and cost. However, transfer of patients from one hospital to another makes interpreting average length of stay information difficult. It is also difficult to determine an average bed day cost because of the variations in cost between hospitals.

Hospital, medical and rehabilitation costs for injured persons were calculated by adjusting the cost estimates by Atkins (1981) to agree with an estimate of the total cost for Australia for 1985 derived by extrapolating MAB data from Victoria to Australia in proportion to the respective total injury numbers. An average cost of health care services per fatality was taken directly from the MAB data. Being based on MAB data, the estimates suffer the same limitations as those included by Atkins (1981), that is, they relate only to costs identified up to the time the data were compiled, and only to the amount charged by the provider. No estimate was made of the amount of hidden subsidies.

Legal and court proceedings

No sources of information on legal and court costs were found which could enable cost estimates to be directly determined. Surveys of fees charged would be the most appropriate method of determining cost estimates. However, surveys of court cases or insurance cases where legal services are required, are beyond the scope of this Paper.

For this Paper, the cost estimates produced by Somerville and McLean (1981) were inflated to 1985 levels and broadly aligned to the AIS scale of injuries. The estimates relate to South Australia but are taken to be relevant to Australian conditions. Difficulties in determining national legal and court costs occur because some States operate a 'no-fault' accident insurance scheme which would produce substantial legal and court cost savings.

The estimates include only costs to the plaintiffs. Somerville and McLean (1981) state that defendent costs are included in third-party motor vehicle management expenses, which are included in this Paper in the insurance administration item.

Insurance administration

Insurance administration costs form part of the premiums paid by consumers of insurance policies. Road accidents generally increase the amount of administration and processing of claims and serve to increase costs.

To produce an estimate for insurance administration costs, statistics on management expenses from the Office of the Insurance Commissioner (1986) were used. Management expenses for third-party and comprehensive motor vehicle insurance have been included.

While not all claims made for damage to comprehensively insured vehicles are accident-related, it was assumed that the vast majority were. No attempt was made to reduce the estimates of these costs to allow for the processing of non-accident claims. All management expenses involved with writing policies, rather than incremental amount due to the existence of road accidents, have been included. Apart from any other reasons, it would be extremely difficult to estimate how many policies are taken out in response to the accident rate alone.

Accident investigation

There are little Australian data available on accident investigation costs. The estimates presented by Somerville and McLean (1981) were adopted for this Paper as it was considered preferable to use Australian estimates wherever possible. These estimates relate to the cost of police resources required for the investigation of road traffic accidents in South Australia. Although other resources, such as fire fighting teams, may be involved with the investigation of traffic accidents, no estimate of these costs is available. A check of police wage rates and procedures indicated that the South Australian estimates could reasonably be taken to be representative of Australian average unit costs.

Losses to others

This cost category covers costs to friends, relatives and employers of accident victims, including time spent travelling and visiting, transport costs, home care costs and labour replacement costs. No study was found that addressed each of these cost items, so the procedure used by Atkins (1981) was also used for this Paper, that is, the same fixed percentages were applied to the forgone income estimates to provide an estimate of losses to others.

Vehicle damage costs

In the majority of accident cost reports vehicle damage represents one of the largest component items. Atkins (1981) found that vehicle damage costs accounted for 30 per cent of the estimated total cost of road accidents. Direct estimation of the total cost of vehicle damage is not possible as no information currently exists on the extent of unrepaired damage. By applying an average cost per vehicle to the estimated total number of vehicles involved, an estimate was made in this Paper of the aggregate of both the total cost of repairs made to vehicles, and the total amount of depreciation to vehicles which has resulted from damage left unrepaired. The average cost per damaged vehicle was derived from data on comprehensive motor vehicle insurance claims. The insurance data was adjusted to take account of the fact that the average value of vehicles which are comprehensively insured is higher than the average value of all vehicles.

It is recognised that vehicles are only one of the property items which can be damaged as a result of road accidents. However, in the absence of data on other types of damage, and in line with Atkins (1981), an estimate has not been included in this Paper for property damage other than to vehicles.

Traffic delay costs

Road traffic accidents may affect the flow of traffic in surrounding areas. High traffic volumes may cause large numbers of vehicles to be delayed and it is considered probable that most major delays occur during peak hours.

Traffic delay costs are comprised of:

- the cost to those individuals involved, of extra time spent in transit;
- the cost of extra fuel consumption; and
- the cost of business being lost from delays to both persons and commercial vehicles.

To estimate traffic delay costs would require data on:

- average length of delays to vehicles;
- average number of vehicles delayed;
- average occupancy rates;
- value of travel time for persons (during and after business hours) and for commercial vehicles;
- number of vehicles travelling for commercial purposes;
- average cost of business lost per vehicle hour delayed; and
- average cost of fuel used during delay.

It was not possible to estimate each of the above components as no detailed information on traffic delay costs was available. The fact that accidents are basically random events has made it difficult for researchers to study them. Police and rescue workers are not required to report on accident forms whether delays occurred and no Australian studies were identified.

The estimates of traffic delay costs in Atkins (1981) were obtained from Faigin (1976) and relate to the delays incurred by individuals (not businesses) as a result of peak hour accidents. The methodology of Faigin (1976) has been used in producing the estimates in this Paper with some alterations to adjust for increases in the value of travel time and differing proportions of accidents occurring in peak hours.

Pain and suffering

It is widely considered that an estimate for the pain and suffering caused should be incorporated as one of the costs of road accidents, where social welfare is an issue. In preference to completely neglecting this item, orders of magnitude estimates have been included in the results presented in this Paper.

The shortcomings of court awards as a measure of pain and suffering, pointed out by Faigin (1976), are recognised; however, in the absence of any other reasonable data, use of information relating to court awards was considered an appropriate proxy.

Information on court awards for pain and suffering, or general damages, was obtained for 1985 and 1986 court cases in Australia reported by Britts (1973) under the category of multiple injuries, as it was considered that road accident victims are most likely to have multiple rather than single injuries. The amounts for general damages were used without adjustment since they include pain and suffering,

loss of amenity, and loss of expectation of life, all of which are relevant as social costs. The court records used to provide the data relate to many types of accident in addition to road accidents, but it is considered that the pain and suffering awards would not be cause-related and therefore the information remains relevant.

Breakdown of costs by injury level of victims

In recognition of the skewed distribution of accident costs, the estimates in this Paper have been presented for each of several levels of injury severity. Following Atkins (1981), costs are given for each of the six AIS levels and PDO. However, as far as has been able to be determined, source records of costs are not categorised on this basis.

The lack of data by injury severity level has meant that in producing the estimates for this Paper, the proportional split across AIS levels given by Atkins (1981) has been somewhat arbitrarily maintained in most instances. In some cases, the estimates by ISS level produced by Somerville and McLean (1981) were adjusted from the ISS scale to the AIS scale and used. Details on the derivation of the split across AIS levels for individual cost components are given in Appendix II.

For the fundamental data on the number of injured persons and accidents by AIS level, the distribution percentages used by Atkins (1981) were maintained. A re-examination of the proportion of injured persons assigned to each injury level would require considerably more data than are readily available at present. Some fairly crude checks with MAB data on admissions to hospital resulting from road accidents for 1985-86 would seem to suggest that the numbers of injured persons attributed to the AIS levels are plausible.[4] The effect on the total cost estimates of using alternative distributions of injury numbers is examined in Chapter 4.

Per accident costs derived from injury level costs

Costs on a per accident basis are not presented in this Paper. If the required information on the distribution of injured persons per accident is obtained, per accident costs can be derived using the per injury estimates provided in this Paper and the methodology given in Andreassend (1985).

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4. During 1985-86 in Victoria, admissions to hospital roughly equated to 100 per cent of victims attributed to AIS levels 5, 4 and 3 and 32 per cent of victims in AIS level 2.

ADJUSTED WILLINGNESS TO PAY/HUMAN CAPITAL APPROACH ESTIMATES

The methodology described by Landefeld and Seskin (1982) was used to derive WTP/HK estimates. The methodology relates to willingness to pay for reduction in risk of financial loss and includes an allowance for the hours spent working at home and in the community. Thus to derive a total estimate of costs, the costs of accident-generated activities and pain and suffering costs (as calculated for the social human capital approach estimates) have been added to the estimates resulting from the WTP/HK formula. Estimates were derived for the fatality and most severe injury categories only, as the methodology is most valid in relation to risk of death or large loss of earning capacity. Average unit WTP/HK estimates (inclusive of the costs of accident-generated activities and pain and suffering costs) are given in Table 3.6. The methodology is similar to the calculation of forgone income and can be readily applied once the appropriate discount rate and risk aversion factor have been determined.

Landefeld and Seskin (1982) describe the discount rate for the WTP/HK approach as representing the 'individual's opportunity cost of investing in risk-reducing activities'. A discount rate of 3 per cent was used, which was determined by examining the after-tax real rate of return on householders' major economic assets. In the absence of readily available Australian data, the rate of 3 per cent has been adopted. The difference between this rate and the 7 per cent discount rate used for the social human capital approach estimates is considered reasonable in view of the similar difference between the

TABLE 3.6 WTP/HK ESTIMATES BY AIS LEVEL[a]: AUSTRALIA, 1985

Abbreviated injury scale (AIS) level	*Average impairment[b] (per cent)*	*WTP/HK estimates[c] (dollars)*
6	100	1 164 700
5	57	786 721
4	25	356 056

a. Estimates were calculated for AIS levels 6,5 and 4 only as the methodology described by Landefeld and Seskin (1982) relates to death of victims or large losses of earning capacity.
b. Impairment percentages were taken from Atkins (1981).
c. Includes the costs of accident-generated activities and pain and suffering as calculated in the social human capital approach.

Source BTCE estimates.

rates used in Landefeld and Seskin (1982) for the two approaches (3 per cent and 10 per cent).

The risk aversion factor can be estimated by examining the ratio of insurance premiums to payments, since individuals are generally willing to pay amounts in excess of the expected value of losses, especially when the potential loss is large. The ratio argued by Landefeld and Seskin (1982) to be the most appropriate relates to the ratio of life insurance premiums to payments, since life insurance relates to the potential loss resulting from the death of an income-earning household member. The risk aversion factor of 1.6 established by them has been used for the estimates in this Paper. The discount rate and risk aversion factor were applied to an estimate of after-tax income in the manner detailed in Appendix II.

UPDATING THE ESTIMATES

The estimates presented in this Paper are for the year 1985. There are unlikely to be new estimates available for each year, so where an estimate is required for a more recent year, a method of updating the estimates needs to be employed. One simple method is to apply a factor or factors to the component items to update for relevant movements in the economy. It is recommended that the pain and suffering item be updated by the rise in the Consumer Price Index (CPI) for the period in question, and all other component accident costs be updated by the rise in average weekly total earnings for all employees. The reasons for this recommendation are set out below.

The methodologies used for the cost categories forgone income, family and community losses, accident investigation and losses to others are based on income data. The methodology for the traffic delay item is based on a value of travel time, which is correlated with income. The items hospital, medical and rehabilitation; accident investigation; and vehicle damage all have large income (salary) components. Therefore, and because it is thought desirable to keep the number of factors to a minimum, it is considered that all these items should be updated by a factor relating to the rise in income. The rise in the average weekly total earnings (all employees) series produced by the ABS (Cat. No. 6302.0) was considered to provide the most relevant index for updating these cost components.

Pain and suffering awards attempt to compensate victims for intangible losses and disbenefits. Awards are not related to earning capacity. It is considered that variations in awards over time are most likely to vary with the 'value' of money. Hence for this cost category, the

CPI (ABS Cat. No. 6401.0) is regarded as the most appropriate index to use when updating the estimate.

These factors can be applied to either the total costs or alternatively to average unit costs which can then be multiplied by the numbers of casualties (or vehicles for PDO) for the year in question. It should be noted that where factors are applied to total costs, fatality, injury and PDO accident vehicle numbers are implicitly remaining static, whereas in reality these numbers are changing from year to year.

CHAPTER 4 SENSITIVITY ANALYSIS

Many of the factors and methods used to calculate the costs of road accidents are debatable. In order to present a set of primary estimates in this Paper, the alternatives have been considered and a judgment made as to the best factor or method to use. However, conceptual difficulties or lack of conclusive empirical data have meant that in some cases there were no strong grounds upon which to base such judgment.

For the major issues of contention, and where it was considered the outcome might be significant, the effect of using particular factors or methods instead of alternatives was examined and is outlined below. Detailed results are provided in Appendix III.

USE OF ADJUSTED INCOME METHOD OR OPPORTUNITY COST METHOD

The adjusted income method was used to produce the primary cost estimates presented in this Paper, as it is considered to produce the most relevant measure of lost production capacity. Estimates produced using the opportunity cost method are also presented, to enable comparison with past estimates and the adjusted income method.

The adjusted income method estimates are lower than the opportunity cost method estimates due to the lower average income assigned to victims. The difference is greatest for AIS level 6, for which the opportunity cost average unit cost estimate is around 13 per cent higher than the adjusted income cost estimate. In terms of total costs for all injury severity levels, the opportunity cost method estimate is around 5 per cent higher than the adjusted income method estimate. Although these methods are conceptually quite different, numerically the difference between the two sets of estimates is small when compared to the effect of changing other factors in the social human capital approach, such as the injury distribution used.

DISCOUNT RATE

The term discount rate covers several different concepts, and the rates associated with these concepts usually differ. Therefore, the

most appropriate concept needs to be established before a discount rate can be determined.

A further problem is that the percentage rate that is considered to be appropriate at the time the estimates are produced is, by virtue of the methodology, applied to the data for all future years which are discounted; that is, the rate is implicitly held constant. However, in reality the percentage discount rate which is most appropriate can, and does, change. For example, in Atkins (1981), a 10 per cent discount rate was considered appropriate, and was therefore applied to all income data relating to the year 1979 onwards. However, for this Paper, a rate of 7 per cent has been used for all years of future income from 1986 onwards. It is therefore important to be aware of both the discount rate used in the estimates and the effect on the estimates of changing the rate.

The discount rate does not affect the cost estimates for AIS levels 1, 2 and 3 because for these levels forgone income is calculated for less than a year and therefore is not discounted. The average unit cost estimate for AIS level 6 (that is, fatalities) is the most affected, since it involves the largest amount of forgone income.

Using the adjusted income method, estimates were recalculated with alternative discount rates of 4 per cent and 10 per cent.[1] Using a 4 per cent discount rate, the average unit costs for AIS level 6 rose by around 55 per cent (relative to the costs calculated using a 7 per cent rate), while use of a 10 per cent rate, as in Atkins (1981), resulted in a decrease of almost 30 per cent. In terms of total costs for all injury severity levels, use of a 4 per cent discount rate increased the estimates by almost $850 million, or around 17 per cent, while use of the 10 per cent rate decreased the estimates by around 9 per cent. Thus the discount rate used has a large influence on the size of the estimates produced.

USE OF DATA ON INCOME OR EARNINGS

The issue of whether it is more appropriate to use data on income or on earnings as a measure of lost production capacity has received a significant amount of comment in previous cost studies, and as a consequence is also addressed in this Paper. However, setting aside

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1. The percentage changes in the cost estimates resulting from changing the discount rate are similar for the opportunity cost method as for the adjusted income method.

the conceptual issues involved, the effect on the resulting cost estimates of using one measure instead of the other is small in magnitude. The effect on average unit and total cost estimates of using earnings instead of income was calculated, using the adjusted income method. Again, average unit cost estimates for AIS level 6 were the most affected, with estimates based on earnings 7 per cent less than those based on income. The effect on total costs for all injury severity levels was a decrease of around $100 million, or 2 per cent.

TERMINATING AGES FOR CALCULATIONS

Another factor in the calculation of forgone income is the age at which to terminate the calculations, that is the age up to which production capacity should be attributed to the victims of road accidents. Statutory retirement ages, median retirement ages and expected age at death are all possibilities. For the main estimates presented in this Paper, expected ages at death were used for the adjusted income method, while statutory retirement ages were used for the opportunity cost method.

The effect on the adjusted income method estimates of varying the terminating ages was calculated. Again, only the estimates for AIS levels 4, 5 and 6 were affected, and AIS level 6 was affected the most. Changing the ages from expected age at death to median retirement ages produced the largest effect, with a decrease of around 3 per cent in average unit costs for AIS level 6 and in the total costs for all injury severity levels.

It should be noted that the opportunity cost method is more sensitive to changes in the terminating ages than the adjusted income method, since it does not adjust for employment rates, which decrease sharply for persons over 50 years of age, and consequently utilises larger average income figures for these ages. Thus in changing the terminating age, a larger amount of income is involved than in the adjusted income method. The effect on total costs for all injury severity levels of changing the terminating age from statutory retirement ages to expected age at death when using the opportunity cost approach was an increase of 13 per cent.

ESTIMATE OF LOST PRODUCTION

Most road accident cost estimates, including the primary estimates presented in this Paper include the loss of production capacity of victims who are killed or permanently incapacitated. However, in reality these persons are probably most often replaced in their jobs

if they can no longer perform them, so that some number of days of production is actually lost rather than, a percentage of remaining working life. An estimate of production lost (using the adjusted income method), based on information in Fox, Good and Joubert (1979) on the number of days actually spent in hospital, was produced and compared to the estimates which represent lost production capacity.

The estimates for AIS levels 1, 2 and 3 remained the same as these were already based on working days lost. For fatalities (AIS level 6) the production loss was assumed to be zero, and so the average unit cost per fatality decreased in round terms, from $400 000 to $20 000, comprising only the costs of accident-generated activities. Average unit costs for AIS levels 4 and 5 were reduced by approximately 55 per cent and 60 per cent respectively. The estimate of total costs for all injury severity levels dropped by around $1400 million, or almost 30 per cent.

DISTRIBUTION OF INJURY NUMBERS

There is no conclusive evidence on the correct distribution of injured persons by injury level. The importance of this problem is heightened by the observation that the injury distribution used has a very marked effect on the magnitude of the resulting cost estimates.

In some instances, the cost estimates are built around the distribution used, that is the distribution itself is used to determine the average costs, so that the total is correct and if the distribution is changed, the average unit costs and not the total should change. However, most of the large cost items, such as those related to loss of victim, are derived independently of the injury distribution and so the effect of changing the injury distribution can be approximated by changing the numbers of victims in each injury level and multiplying these by the original average unit cost estimates.

This procedure was carried out for the adjusted income method using the distribution given in Atkins (1981) and two alternative distributions. The two alternatives were chosen fairly arbitarily, but account was taken of generally expressed opinions that there should be a decrease in the proportion attributed to AIS level 2 and an increase in the proportions attributed to AIS levels 3, 4 and 5, particularly AIS level 3. It was found that by increasing the percentages of injured persons assigned to AIS levels 3 to 6, with the major change being a movement from AIS level 2 to AIS level 3, total costs rose from almost $5000 million to around $6300 million, an increase of 27 per cent. The difficulty in assigning injured persons

to AIS levels, and the lack of clear delineation between neighbouring AIS levels means that either of these two distributions could be used to describe very similar groups of injured persons. However, the methodology used to derive some of the cost estimates means that substantially different average costs are assigned to the various AIS levels. The fact that the cost estimates would alter dramatically depending on which distribution was used indicates the potential size of the error margins of the estimates, and shows that beyond a certain point 'fine tuning' the estimates for the smaller cost items is not warranted.

PROPERTY DAMAGE ONLY VEHICLE NUMBERS

Another major unknown in the study of road accidents is the number of vehicles involved in accidents where property damage only occurs. Widely differing estimates have been put forward. PDO average unit costs are small; however, the magnitude of the number of vehicles involved means that the effect on the total costs of changing the number is comparatively large.

Estimates of PDO costs were calculated using 4 alternative ratios of PDO acidents to injury accidents. The resulting cost estimates ranged between $946 million and $2212 million. Total costs for all injury severity levels (including no injury, that is PDO) ranged from around $5000 million to $6300 million, an increase of 25 per cent on the lowest figure.

CHAPTER 5 CONCLUDING REMARKS

There is a great deal of interest in the cost of road accidents, both professional and casual. There is also a great deal of difficulty in deriving an acceptable measure of these costs.

The aim of the work undertaken for this Paper was to refine and update the methodology established by Atkins (1981). Given certain constraints, this has been done. In particular, the level of reliance on data from other countries, especially the United States of America, has been reduced. The addition of an (albeit tentative) estimate of the cost associated with the pain and suffering of the victims is also considered to be an important step toward improving available cost estimates.

This is not to say that the quality and extent of information relating to road accidents in Australia has much improved since the Atkins (1981) study. Somerville and McLean (1981) did provide some additional and valuable information, although it was derived from only a small sample of accidents. However, available data remains, on the whole, inadequate for the production of detailed estimates.

For example, information required to cross-classify costs into categories such as injury level and accident type, which greatly increases the usefulness of the cost estimates, is not generally available. It has not been possible to verify many of the assumptions used to produce injury level costs, and these estimates should be used with care. In particular, it has been established that changes in the percentage distribution used to allocate injury numbers across injury levels causes very large changes in the magnitude of the resulting estimates.

Only a limited amount of review of methodologies and data sources could be undertaken in producing this Paper. Consequently, and because of the absence of an agreed method of estimation, several methodologies, concepts and factors are presented in this Paper, with a preference given. The estimates are far from indisputable, but

should provide a useful indication of the magnitude of road accident costs.

Estimates of the cost of road accidents should not be regarded as absolute values in terms of the benefits to be gained from programs which lessen the number of road accidents. The estimates may well be conservative, in which case a program may clearly be indicated as acceptable when the estimated cost savings are greater than the cost of the program, but the decision is not so clear when the cost situation is reversed. Further, while it is theoretically possible to save the total amount of the costs, depending on the practicality of the measures proposed to achieve the elimination of road accidents, to date road safety measures have not been entirely effective. This is in part due to people's reluctance to give up certain activities involving risk. It is therefore likely that some level of road accidents will remain.

On the research side, much work remains to be done on costing road accidents, both in relation to methodologies and data sources. The willingness to pay approach is virtually still in the pioneering stage, and there is substantial scope for research to be undertaken to resolve some of the problems in measuring willingness to pay, especially in relation to road safety (or aversion to road accidents). However, as the widespread use of this approach would appear to be some way into the future, further investigation of the WTP/HK methodology would seem a worthwhile first step.

Until acceptable willingness to pay methodologies are developed, estimates based on the ex-post approach are likely to remain in use. Unless there is some major change in data availability, a thorough re-examination of the ex-post estimates is probably not justified. In these circumstances, updating the average unit estimates using the rise in average weekly earnings (or the CPI in the case of the cost associated with pain and suffering) as factors would appear to provide a reasonable measure of the rise in road accident costs.

In summary, this Paper provides estimates of the cost of road accidents in Australia in 1985, based on the framework and methodology given by Atkins (1981) and produced using a modified methodology. This methodology is considered to represent some progress in refining ex-post costings. However, there is still a long way to go and indications of problems which still remain with the ex-post approach and possible future directions, including the WTP/HK approach, are also provided.

APPENDIX I METHODOLOGY USED BY ATKINS (1981)

The study by Atkins (1981) was sponsored by the FORS. It proposes a social unit cost framework which, along with many of the calculations, was based on Faigin (1976). A detailed set of preliminary unit and total cost estimates for Australia for 1978 was provided. The estimates were based mainly on existing data sources as opposed to a survey methodology such as Somerville and McLean (1981). Costs were classified according to injury severity. Atkins considered that the accident cost estimates represented minimum social benefits to be gained from a reduction in road accidents.

Atkins (1981) obtained numbers of casualties, casualty accidents and accident vehicles for the year 1978 from ABS data. PDO accident numbers were obtained by dividing PDO vehicle numbers by 1.9, which represents the average number of vehicles per PDO collision. This factor was derived from Troy and Butlin (1971). PDO vehicle numbers were based on the number of vehicles repaired (reported and not reported to insurance companies) obtained from the ABS SMVU.

Atkins (1981) distributed injury and injury accident numbers across the AIS levels (see Table I.1) according to a distribution derived from Faigin (1976). The distribution was modified by Atkins (1981) to correspond more closely to the percentage of minor injuries obtained from MAB data for 1978. The lowering of the minor injury percentage resulted in corresponding higher percentages for AIS levels 2 to 5 compared to those in Faigin (1976). Injury numbers were based on ABS data on reported accidents and appear to have been significantly underestimated.

TABLE I.1 ALLOCATION OF NUMBER OF INJURED PERSONS TO AIS LEVELS

		Percentage of injuries	
AIS level	*Injury description*	*From Atkins (1981)*	*From Faigin (1976)*
5	Critical: survival uncertain	0.20	0.10
4	Severe: life-threatening	1.00	0.50
3	Severe: not life-threatening	4.03	2.01
2	Moderate	24.77	12.31
1	Minor	70.00	85.08

Source Atkins (1981).

METHODOLOGY USED FOR SPECIFIC COST ITEMS

Atkins (1981) calculated preliminary estimates for eleven cost categories. The framework used by Atkins (1981) is almost identical to that used in the then 'state of the art' work of Faigin (1976). The cost categories used by Atkins (1981) are:

- Forgone income
- Family, community losses
- Hospital
- Medical
- Rehabilitation
- Legal and court [proceedings]
- Insurance administration
- Accident investigation
- Losses to others
- Vehicle damage
- Traffic delay.

Atkins (1981) discussed the desirability of including pain and suffering estimates in the accident cost framework but was unable to include them because of the lack of available data.

Forgone income

Atkins (1981) calculated forgone income for full-time workers on the basis of their future total income (without deducting the victim's own consumption). Income was weighted by the age and sex distribution of accident victims. Two separate distributions were used; one for fatalities and one for injured persons. Those who were not full-time workers were attributed a rate of income equal to the full-time employed, as an opportunity cost. In the primary set of estimates presented by Atkins (1981) a discount rate of 10 per cent and a productivity rate of 3 per cent were used. Income was discounted from retiring ages of 65 years for males and females.[1] Estimates of the impairment resulting from accident injuries, by AIS level, were taken from Faigin (1976). Sensitivity analysis of the forgone income estimates for different discount rates was performed and Atkins (1981) also gives supplementary estimates using the net income approach (victim's own consumption deducted) and the adjusted income approach (adjusted for workforce participation).

Family and community losses

The family and community losses item provides an estimate of the losses to the family and home, and to the community which result from accident victims being unable to perform their normal activities in these areas. Atkins (1981) estimated these losses using information from Faigin (1976) on the average amounts of time spent by individuals in these activities outside the normal working week. Faigin (1976) estimated production outside the working week at 10 hours per week for the family and home and 2 hours per week for community work. These amounts collectively represent 30 per cent of the 40-hour working week used by Atkins (1981). Atkins (1981) estimated family and community losses at 30 per cent of forgone income, as an opportunity cost.

Hospital, medical and rehabilitation

Atkins (1981) estimated hospital, medical and rehabilitation costs by using data on frequency of claims by claim size supplied by MAB.[2] Claim numbers were matched to the cumulative proportion of casualty numbers by injury severity level to estimate average costs by AIS

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1. Atkins (1981) may have made some modification to this for older victims.
2. Rehabilitation costs includes costs such as chemist, dental, funeral, housekeeping and physiotherapy. It is unclear whether ambulance costs have been included in the Atkins (1981) estimate for this cost category.

level, assuming that on average the claim size increases with the injury severity level of the victim. MAB data relates to costs claimed by victims only and, therefore, excludes subsidies to hospitals.

Atkins (1981) estimated total hospital, medical and rehabilitation costs for Australia at $143.77 million. However, according to the data used (MAB 1978), hospital, medical and rehabilitation costs for Victoria were approximately $14.0 million. On this basis it appears that Atkins (1981) overestimated the total cost for Australia since Victoria's contribution to national accident statistics was approximately 20 per cent in 1978 (which when applied to the MAB data would give a total for Australia of approximately $70 million).

Legal and court proceedings

Atkins (1981) found no satisfactory source of recent Australian data on legal and court costs. He examined previous Australian work on expressing legal and court cost as a percentage of third-party insurance claims; however, he found this approach needed further research and instead adopted the 1975 estimates of Faigin (1976) without modification.

Insurance administration

The insurance administration cost estimates by Atkins (1981) were based on the total management expenses for motor vehicle comprehensive insurance for 1977-78. Management expenses for third-party insurance were not included. The distribution of average insurance administration costs presented by Fox, Good and Joubert (1979) was updated by Atkins (1981) to produce the 1977-78 total cost when the average costs were multiplied by 1978 casualty and vehicle numbers. The insurance administration cost estimates of Fox, Good and Joubert (1979) were based on Faigin (1976).

Accident investigation

Atkins (1981) estimated accident investigation costs by adjusting the estimates of Fox, Good and Joubert (1979) to match more closely the distribution of costs of Faigin (1976). Once again the estimates of Fox, Good and Joubert (1979) were based on those of Faigin (1976). It is not clear as to whether emergency and/or towing services were included in the Faigin (1976) estimate.

Losses to others

Atkins (1981) calculated this estimate as a percentage of forgone income. He states that the percentages used are based on the NHTSA (1972) study (the predecessor to Faigin (1976)).

Vehicle damage

The vehicle damage costs of Atkins (1981) are based on the estimated cost of vehicle repairs. ABS SMVU data for the year 1971 (which excluded repairs to motor cycles) was updated to 1977-78 by increase in vehicle registrations and the casualty accident rate. Average costs were calculated for AIS levels by applying the distribution of injury numbers to a frequency distribution of vehicle damage insurance claims, assuming that vehicle damage generally increases with accident injury severity.

Traffic delay

The Atkins (1981) estimate of traffic delay costs was taken directly from Faigin (1976). Faigin (1976) calculated this cost from information on average person hours of delay and a value of travel time (at 1973 US$2.63). These were applied to 'rush-hour' accidents and the cost was averaged over all accidents for each injury severity level. The major uncertainty in the estimation is the data on average hours of delay, which was obtained from a study of a freeway in the United States of America during morning rush hours.

AVERAGE UNIT ACCIDENT COSTS

Road traffic accident costs can be calculated as an average cost per casualty or per accident. The average accidents costs given on a per accident basis by Atkins (1981) have been shown to be in error by Andreassend (1982, unpublished). For example, Atkins (1981) used an average of 1.13 fatalities per fatal accident, giving an accident cost of 1.13 times the cost per fatality. However, the costs associated with the injuries that result from fatal accidents were omitted. On average there are approximately 0.9 injuries per fatal accident. Similarly, for serious injury accidents, there will also be associated minor injuries which increase the average cost per accident.

TOTAL ACCIDENT COSTS

Atkins (1981) provides an estimate of $1591.1 million for the total costs of road traffic accidents in Australia for 1978 (in $1978). Forgone income and vehicle damage are the largest cost categories each representing approximately 30 per cent of the total cost. Fatalities represent approximately 37 per cent of total accident costs. Costs of accidents involving property damage only represent a similar proportion at 36 per cent and, collectively, injuries (AIS levels 1 to 5) represent the remaining 27 per cent of the total cost.

APPENDIX II DETAILS OF THE CALCULATION OF ROAD ACCIDENT COST ESTIMATES FOR 1985

This appendix describes the sources of data, parameters and calculations used in deriving the cost estimates contained in this Paper. Current data have been drawn from direct sources wherever possible; however, it has been necessary to make use of the estimates produced by past researchers in some instances. Data sources and parameters are explained to assist in the interpretation of the estimates by providing detailed information on how they were obtained. Methodologies are described fully to enable reproduction or updating of the estimates in whole or in part, if desired.

The methods used in this Paper refer to the set of eleven cost categories used by Atkins (1981). The methods rely largely upon the same set of fundamental statistics.

FUNDAMENTAL STATISTICS REQUIRED FOR CALCULATIONS

To produce accident costs, fundamental statistics are required on the number of fatalities, injuries and PDO accidents. Additional information such as the number of accidents involving fatalities, injuries or no injury are also of assistance. The present study, among other things, attempts to reproduce (to a degree) the accident cost framework in Atkins (1981). To do so requires a breakdown of the number of injuries (once derived) into AIS categories. Information on the proportions of injuries to accidents and the number of PDO involvements, though important for many road safety projects, is difficult and, sometimes impossible, to obtain. These items have been derived by various factors and estimates being applied to basic accident information gained from the ABS, and other institutions in the States and Territories which maintain accident statistics. The reliability of even these 'basic' statistics is open to doubt as reporting criteria vary from State to State. Estimates of casualty, accident and vehicle numbers are given in Table II.1.

TABLE II.1 ALLOCATION OF CASUALTY, ACCIDENT AND VEHICLE NUMBERS BY INJURY SEVERITY LEVEL: AUSTRALIA, 1985

Injury severity	*AIS as a percentage of injuries*	*Number of casualties*[a]	*Number of accidents*	*Number of vehicles*
AIS level				
6		2 942	2 628	3 927
5	0.20	458	331	516
4	1.00	2 289	1 657	2 585
3	4.03	9 223	6 677	10 416
2	24.77	56 690	41 040	64 022
1	70.00	160 205	115 979	180 927
Total		231 806	168 312	262 393
PDO		..	503 664	956 962
Total		231 806	671 976	1 219 355

a. Casualties are defined as consisting of fatalities (AIS level 6) and injuries (AIS levels 1 to 5).
.. Not applicable.

Note Figures may not add to totals due to rounding.

Sources ABS (1986a). ABS (1986b). ABS (1986c). ABS (1986d). ABS (1986e). FORS (1987, unpublished). (Information relating to the number of road traffic accidents in the ACT was provided by the National Capital Development Commission.) Northern Territory Police Force (1986). South Australian Department of Transport Road Safety Division (1987, unpublished). Traffic Authority of NSW (1986).

Derivation of casualty numbers

The number of casualties for AIS level 6 (fatalities) for 1985 was obtained from ABS data on road traffic accidents involving casualties (admissions to hospital) (ABS 1986a).

The total number of traffic accident injuries in Australia was derived from injury numbers obtained from various State and Territory sources (see Sources, Table II.1). These injury numbers (95 759) were increased to allow for a degree of under-reporting which was estimated by comparing ABS Victorian Office injury numbers for Victoria (ABS 1986b) to those of MAB (MAB 1985, 1986). It was assumed that MAB data included all injuries with significant cost since during this period

persons in Victoria seeking to recover accident costs (no matter how small the claim size) lodged a claim with the MAB. MAB data (calculated for 1985 by adding half the injury numbers from each of the years 1984-85 and 1985-86) showed injury numbers which were 2.39 times those given in ABS (1986b), giving a total of 228 864 injuries for Australia in 1985, assuming that the degree of under-reporting was the same across Australia. These injury numbers were split into AIS categories using the proportions derived in Atkins (1981) (see column 2, Table II.1).

Derivation of accident numbers

The number of fatal accidents was obtained from ABS data on road traffic accidents involving casualties (admissions to hospital) (ABS 1986a).

To obtain the number of accidents involving injuries (AIS levels 1 to 5) accident statistics from sources in each State and Territory were totalled (see Sources, Table II.1) and adjusted for under-reporting by multiplying by the same factor (2.39) that was applied to injuries as shown above. Thus the injury accident numbers increased from 69 324 to 165 684. These numbers were also split into AIS levels 1 to 5 by using the proportions in Atkins (1981) (see column 2, Table II.1).

PDO accident numbers were estimated by applying a factor to the number of casualty accidents. The 'appropriate' factor depends on the scope of the casualty accidents number being used as a base. James (1987) states that previous researchers had found PDO to casualty accident ratios of 7 to 1 to 10 to 1, while he himself found a ratio of approximately 40 to 1. The variation in these estimates would stem, at least in part, from differences in the scope of casualty accidents included. The ratio of PDO to casualty accidents in Atkins (1981) is 6.8 to 1. This relates to a total casualty accidents number obtained from ABS State data (that is, not expanded for undercoverage as outlined above). A ratio of 7 to 1 PDO to casualty accidents has been used to produce estimates included in this Paper. In accordance with the manner in which the Atkins (1981) estimate of 6.8 was derived, this factor was applied to the number of casualty accidents as indicated by ABS State data (that is 71 952) and not the expanded estimate (that is 168 312). Since the ratio has a major effect on the resulting estimate of PDO numbers, and given the lack of empirical evidence to support any one estimate, sensitivity analysis has been performed to ascertain the effect of the ratio used on total cost estimates (see Chapter 4).

Derivation of accident vehicle numbers

The number of fatal accident vehicles was obtained from unpublished computer tabulations supplied by FORS from the National Mass Data System (FORS, 1987, unpublished).

The number of injury accident vehicles was obtained by multiplying the number of accidents in AIS levels 1 to 5 by a factor of 1.56. This factor was derived from ABS data and was used by Atkins (1981).

The number of vehicles involved in PDO accidents was obtained by multiplying the number of PDO accidents by 1.9 (after Atkins (1981)), a figure which represents the average number of vehicles per PDO accident. This figure has been substantially verified by the work of James (1987) who found a similar figure of 1.96.

SOCIAL HUMAN CAPITAL APPROACH ESTIMATES

Loss or partial loss of victim

Forgone income

Methodology used by Atkins (1981)

In Atkins (1981), forgone income was calculated for full-time workers on the basis of what would have been their future total income. Income was weighted by the age and sex distributions of accident victims. Those who were not full-time workers were attributed equal income as an opportunity cost. Future income was discounted to present values from a retiring age of 65 years. A productivity rate was also used in the calculations to allow for productivity increases in the future.

This opportunity cost method does not allow for enforced unemployment where the labour market is unable to sustain all those who may desire employment. To adjust for this, an alternative methodology was also adopted which endeavoured to model more closely the actual employment situation.

Alternative to Atkins (1981) methodology

For the estimates presented in this Paper forgone income was also calculated using future full-time income adjusted for employment rates. A zero value was therefore assigned to working-age victims not employed in the market economy. (Houseworkers' production was taken into account in the family and community losses cost category.) Income was weighted by the age and sex distributions of accident victims. Future income is discounted from the population expected age of death.

Information required for calculating forgone income
The information required was:

- age and sex distributions for road traffic accident victims;
- a discount and a productivity rate;
- income and employment rates by sex and age;
- a terminating age for the calculations; and
- an estimate of the average impairment to victims.

Age and sex distributions of accident victims
The age and sex distributions of traffic accident victims differ from those of the general population. Young males in particular feature more prominently in accident statistics than they do in the general population numbers. The effect of using the age and sex distributions for the general population was demonstrated in Atkins (1981) which showed a decrease in forgone income estimates of approximately 28 per cent.

Differences occurring from the use of age and sex distributions of fatalities as opposed to injuries were shown in Atkins (1981) to be less pronounced. Estimates of forgone income for fatalities (AIS level 6) using distributions of fatalities and injuries were given as $113 510 and $112 004 respectively. As a result the age and sex distribution of injuries (admitted to hospital) (ABS 1986a) was used for all calculations relating to forgone income. This is shown in Table II.2.

It was necessary to change the age groupings shown in Table II.2 so that they corresponded with those used in labour force statistics and income figures. Income can then be weighted by both employment rates and by the distribution of accident victims.

To change the age groupings given in Table II.2 a process of graphing the average number of accident victims per year of age (one graph each for males and females) against the mid-point of the age groups (as given in Table II.2) was used. After calculating the mid-points required for the alternative age groups the new averages were read from the graph and reconverted (by multiplying by the number of years in the new age group represented by each mid-point) to gain numbers of males and females in each new age group. The results of this process are presented in Tables II.3 and II.4.

Table II.4 shows the averages in Table II.3 reconverted to totals for each age group. Also shown in Table II.4 are percentages of male and

TABLE II.2 AGE AND SEX DISTRIBUTION OF PERSONS INJURED IN ROAD ACCIDENTS (ADMITTED TO HOSPITAL): AUSTRALIA, 1985

Age group (years)	*Mid-point (years)*	*No. of years in each age group*	*No. of males*	*Average no. of males per year of age*	*No. of females*	*Average no. of females per year of age*
0-4	2.5	5	345	69	251	50
5-16	11.0	12	2 217	185	1 388	116
17-20	19.0	4	4 123	1 031	1 687	422
21-25	23.5	5	3 756	751	1 541	308
26-29	28.0	4	1 750	438	701	175
30-39	35.0	10	2 306	231	1 178	118
40-49	45.0	10	1 214	121	864	86
50-59	55.0	10	910	91	734	73
$\geq$60[a]	70.0	20	1 246	62	1 326	66
Total[b]	..	..	17 867	..	9 670	..

a. For purposes of recalculating the distribution across alternative age groupings only (that is for Tables II.3 and II.4), it was assumed that the $\geq$60 age group extended to 80 years.
b. Excludes 1044 males and 690 females which were listed as having age groups not stated.
.. Not applicable.

Source ABS (1986a).

female road accident victims admitted to hospital in each age group as well as the percentages of the total number of victims that occur in each age group. It is these percentages that were used in the calculation of forgone income, by applying them to the age and sex distribution of income in the population as a whole.

Discount and productivity rates

For calculating forgone income the discount and productivity rates were combined into a single factor, called the effective discount factor (edf). For a discount rate of 10 per cent and a productivity rate of 2 per cent, the following edf results

$$\text{edf} = \frac{1 + 10/100}{1 + 2/100} = \frac{1.1}{1.02} = 1.078$$

TABLE II.3 AVERAGE NUMBER OF PERSONS INJURED IN ROAD ACCIDENTS (ADMITTED TO HOSPITAL) PER YEAR OF AGE: AUSTRALIA, 1985, ALTERNATE AGE GROUPINGS

Age group (years)	*Mid-point (years)*	*No. of years*	*Average no. of males per year of age*	*Average no. of females per year of age*
0-4	2.5	5	69	50
5-7	6.5	3	125	78
8-9	9.0	2	160	100
10-14	12.5	5	250	155
15-19	17.5	5	790	350
20-24	22.5	5	815	335
25-34	30.0	10	360	160
35-44	40.0	10	165	105
45-54	50.0	10	100	80
55-59	57.5	5	85	70
60-64	62.5	5	70	70
$\geq$65[a]	73.0	15	60	70

a. Assumes that the $\geq$65 age group extends to 80 years.

Source BTCE estimates.

The edf is used to convert income data to present values. (In the above example the 'net' discount rate is 7.8 per cent ([(edf - 1) x 100] %)).

For the estimates presented in this Paper a discount rate of 7 per cent and a productivity rate of 2 per cent were primarily used. The issue of appropriate discount and productivity rates is discussed in Chapter 2. Sensitivity analysis was performed using discount rates of 4 and 10 per cent (see Chapter 4).

Income and employment rates

Total income received from all sources by workers employed full-time for a full year was used in the forgone income calculations, either directly or after adjustment for employment rates, depending on the approach being taken. A discussion of the appropriateness of using income or earnings in the calculations is contained in Chapter 2.

The income figures before adjustment for employment rates are given in Table II.5.

TABLE II.4 AGE AND SEX DISTRIBUTION OF PERSONS INJURED IN ROAD ACCIDENTS (ADMITTED TO HOSPITAL): AUSTRALIA, 1985, ALTERNATE AGE GROUPINGS

Age group (years)	*No. of males*	*No. of females*	*Males in age group (per cent)*	*Females in age group (per cent)*	*No. of persons*	*Persons in age group (per cent)*
0-4	345	251	58.3	41.7	596	2.1
5-7	375	234	61.6	38.4	609	2.2
8-9	320	200	61.5	38.5	520	1.8
10-14	1 250	775	61.7	38.3	2 025	7.1
15-19	3 950	1 750	69.3	30.7	5 700	20.1
20-24	4 075	1 675	70.9	29.1	5 750	20.3
25-34	3 600	1 600	69.2	30.8	5 200	18.4
35-44	1 650	1 050	61.1	38.9	2 700	9.5
45-54	1 000	800	55.6	44.4	1 800	6.4
55-59	425	350	54.8	45.2	775	2.7
60-64	350	350	50.0	50.0	700	2.5
≥65	900	1 050	46.2	53.8	1 950	6.9
Total	18 245	10 084	64.4	35.6	28 329	100.0

Note Figures may not add to totals due to rounding. Totals vary slightly from Table II.2 due to estimation procedure.

Source Derived from ABS (1986a).

For the calculations using the opportunity cost method, the income figures do not need to be adjusted. For calculations using the adjusted income method, income was adjusted by using employment rates.

Employment rates were taken from ABS (1985). Labour force statistics are published quarterly by the ABS. The June quarter was taken to represent the full year 1985.

The employment rates were themselves adjusted before they were used to adjust the income. The adjustment of the rates was necessary because the rates given included both full-time and part-time workers. The adjusted employment rates include full-time workers and the full-time equivalent of part-time workers (calculated using information on the average number of hours worked).

Direct adjustment to employment rates for each age group was not possible because data by age group was not available. Therefore,

TABLE II.5 INCOME FIGURES USED IN THE CALCULATION OF FORGONE INCOME (FULL YEAR, FULL-TIME WORKERS): AUSTRALIA, 1985[a]

	Mean annual income (dollars)	
Age group	*Males*	*Females*
15-19	10 600	9 880
20-24	17 527	15 341
25-34	22 432	18 936
35-44	25 102	18 860
45-54	24 885	17 337
55-59	24 895	17 924
60-64	22 684	17 216
≥65	22 026	14 087

a. Income figures relating to the financial year 1981-82 were inflated to the calendar year 1985 by the rise in average weekly earnings for the period 1981-82 to 1985. The inflator used was 1.3.

Source ABS (1987a, unpublished), adjusted by BTCE.

TABLE II.6 VALUES USED IN THE CALCULATION OF ADJUSTED EMPLOYMENT RATES, 1985

	Values used	
Component	*Males*	*Females*
No.(FT)	3 821 300	1 600 500
No.(PT)	256 700	953 300
Hrs (FT)	40	36
Hrs (PT)	15	15
Multiplicative factor	0.96	0.78

Source Derived from ABS (1985).

employment rates were adjusted uniformly across age groups. Using the data on employment shown in Table II.6 the following multiplicative factor was calculated for each sex, and used to adjust the rates:

$$\frac{No.(FT) + No.(PT) \times (Hrs(PT)/Hrs(FT))}{No.(FT) + No.(PT)}$$

where

FT = Full-time workers
PT = Part-time workers
No.(.) = Number of (full-time or part-time workers)
Hrs(.) = The average number of weekly hours worked by (full-time or part-time workers).

The income figures required for calculating forgone income by the adjusted income method were produced by multiplying the mean income figures given in Table II.5 by the adjusted employment rates shown in Table II.7. The adjusted income figures are given in Table II.8.

TABLE II.7 EMPLOYMENT RATES, 1985

Age group (years)	*Employment rates (per cent)*		*Adjusted employment rates (per cent)*	
	Males	*Females*	*Males*	*Females*
15-19	48.2	46.9	46.3	36.6
20-24	79.1	66.1	75.9	51.6
25-34	87.4	53.1	83.9	41.4
35-44	89.5	57.7	85.9	45.0
45-54	85.5	48.2	82.1	37.6
55-59	71.2	25.9	68.4	20.2
60-64	39.4	13.2	37.8	10.3
≥65	9.3	1.9	8.9	1.5
Total	69.4	42.1	66.6	32.8

Source Derived from ABS (1985).

TABLE II.8 INCOME FIGURES USED IN THE CALCULATION OF FORGONE INCOME: 1985, ADJUSTED INCOME METHOD

Age group (years)	*Adjusted mean annual income (dollars)*	
	Males	*Females*
15-19	4 908	3 616
20-24	13 303	7 916
25-34	18 820	7 840
35-44	21 563	8 487
45-54	20 431	6 519
54-59	17 028	3 621
60-64	8 575	1 773
≥65	1 960	211

Source ABS (1987a, unpublished), adjusted by BTCE.

Terminating ages for calculations

Several candidates for terminating ages for the calculations exist. Expected age of death, statutory retirement age or median age of retirement can be used.

The expected ages of death for persons with ages equal to the average age of accident victims (28 years) are: 74 years for males and 80 years for females (ABS 1986f). Median ages of retirement were calculated to be 62 years for males and 56 years for females (derived from ABS (1987b)). Statutory retirement ages used were 65 years for males and 60 years for females.

Atkins used a retiring age of 65 years for both males and females for the forgone income calculations. For producing updated estimates for the opportunity cost method, statutory retirement ages were used.

For the adjusted income method expected ages of death have been used.

Average impairment to victims

Average impairment to accident victims was required for each AIS level. Forgone income (loss per day or total lifetime) was multiplied by days away from work or percentage impairment to produce estimates for each AIS level. The percentage impairment figures used were: AIS level 6, 100; AIS level 5, 57; AIS level 4, 25; and working days lost: AIS level 3, 39; AIS level 2, 21; AIS level 1, 1.6.

The percentage impairment and days lost were taken from Atkins (1981), and these in turn were drawn from Faigin (1976). At present, a survey of accident victims would need to be undertaken to produce Australian estimates of impairment. Some preliminary work on the feasibility of linking hospital patient records to traffic crash files is contained in Hunter Health Statistics Unit (1986). As yet only the pilot study has been performed; however, further work may produce useful data on average length of stay by injury severity for accident victims.

Forgone income calculations

For AIS levels 4, 5 and 6, future streams of income were discounted back to present values by use of the edf. For AIS levels 1, 2 and 3, discounting is not required as the average time off work is less than one year (a maximum of 39 days for AIS level 3). Therefore, forgone income was calculated in two different ways.

For AIS levels 1, 2 and 3, income was first weighted by the age and sex distribution of accident victims. (Table II.4 columns 4 and 5 multiplied by income figures in Table II.5 and II.8). This results in the weighted income figures shown in Table II.9.

Total income from Table II.9 was then divided by the number of working days to produce the loss per day, which, in turn, was used to calculate forgone income for AIS levels 1, 2 and 3 (corresponding working days lost being 1.6, 21 and 39 respectively).

For the opportunity cost method:

- average income equals $18 593 per year;
- loss per working day equals $18 593/(365 *5/7) or $71; and
- forgone income for AIS levels 1, 2 and 3 was therefore calculated at $114, $1491 and $2769 respectively.

For the adjusted income method:

- average income equals $9103;
- loss per working day equals $9103/(365 * 5/7) or $35; and
- forgone income for AIS levels, 1, 2 and 3 was therefore calculated at $56, $735 and $1365 respectively.

For AIS levels 4, 5 and 6, total forgone income to terminating age was calculated for each age group and sex. Once calculated, the income was weighted by the age and sex distributions given in Table II.4 and then multiplied by the percentage impairment for AIS levels 4, 5 and 6 to produce the estimates. Calculations were performed using both the opportunity cost and the adjusted income methods.

TABLE II.9 AVERAGE INCOME WEIGHTED BY SEX AND AGE GROUPS, 1985

	Opportunity cost method			*Adjusted income method*	
Age group (years)	*Income weighted by sex (dollars)*	*Persons in age group (per cent)*[a]	*Persons in age group (per cent)*[b]	*Income weighted by sex (dollars)*	*Persons in age group (per cent)*[c]
0-4	0	0.0	0.0	0	2.1
5-7	0	0.0	0.0	0	2.2
8-9	0	0.0	0.0	0	1.8
10-14	0	0.0	0.0	0	7.1
15-19	10 379	10.1	14.8	4 511	20.1
20-24	16 891	20.3	29.7	11 735	20.3
25-34	21 355	18.4	26.9	15 438	18.4
35-44	22 674	9.5	13.9	16 476	9.5
45-54	21 534	6.4	9.4	14 254	6.4
55-59	21 744	2.7	4.0	10 968	2.7
60-64	19 950	0.6	0.9	5 174	2.5
≥65	17 755	0.3	0.4	1 019	6.9
Average all ages	18 593[d]	68.3	100.0	9 103[f]	100.0

a. Intermediate column which totals 68.3 per cent as follows: persons in 0-14 age group are attributed zero per cent, persons in the 15-19 age group are attributed 50 per cent (to account for unemployment), 60-64 are attributed 25 per cent and ≥65 are attributed 5 per cent (to account for retirement) (based on ABS (1985a)) of the actual percentage shown in Table II.4. Atkins (1981) used 50 per cent for 17-20 year olds and 66.7 per cent for years ≥60.
b. The previous column is inflated to total 100.0 per cent, thus all accident victims are attributed the forgone income of accident victims who were full-time workers. This procedure was used by Atkins (1981).
c. Taken from Table II.4
d. Derived by weighting column 2 by column 4.
f. Derived by weighting column 5 by column 6.

Note Figures may not add to totals due to rounding.

Source Tables II.4, II.5 and II.8.

Forgone income is calculated for each age group n and sex by:

$$\text{forgone income (n)} = \sum_{m=SA}^{TA} \frac{\text{Income (m)}}{\text{edf}^p}$$

where

- SA is the starting age for calculations, usually the median age of group *n*
- TA is the terminating age for calculations
- Income (m) is income earned at age m
- edf is the effective discount factor
- p is the number of years discounting which varies with m, that is p = m - (median age of group n).

It was assumed that no income was earned by persons younger than 15 years, that is SA is always greater or equal to 15. Thus, the first year of income for individuals in age group with median age 9 years will be discounted 6 years. The median age for each age group was calculated by:

$$\text{median age} = \text{trunc}\left(\frac{\text{1st age + 1st age next}}{2}\right)$$

where:

- 1st age is the first age of the age group;
- 1st age next is the first age of the next age group; and
- trunc is a function which makes a number whole by leaving off any decimal places (that is trunc 2.5 equals 2).

A FORTRAN program was written to calculate forgone income. The program enabled sensitivity analysis to be performed by varying inputs such as the discount rate and terminating ages. Tables II.10 and II.11 give results for calculation of forgone income.

Percentages of impairment of accident victims used were AIS level 6, 100; AIS level 5, 57; AIS level 4, 25. Applying these to the forgone income totals (shown in Tables II.10 and II.11) produces the estimates shown in Table II.12. Also shown is forgone income for AIS levels 1, 2 and 3, for which average working days lost are 1.6, 21 and 39 days respectively.

TABLE II.10 FORGONE INCOME FOR EACH AGE AND SEX: OPPORTUNITY COST METHOD[a]

Age group (years)	*Forgone income (dollars)*		*Proportion of age group[b] (per cent)*		*Weighted forgone income (dollars)*	*Proportion of total ages[b] (per cent)*
	Males	*Females*	*Males*	*Females*		
0-4	203 772	153 100	58.3	41.7	182 642	2.1
5-7	246 762	185 400	61.6	38.4	223 199	2.1
8-9	284 858	214 022	61.5	38.5	257 586	1.8
10-14	328 835	247 064	61.7	38.3	297 517	7.1
15-19	394 944	292 616	69.3	30.7	363 529	20.1
20-24	425 498	314 561	70.9	29.1	393 215	20.3
25-34	420 637	308 153	69.2	30.8	385 992	18.4
35-44	368 727	248 569	61.1	38.9	321 986	9.5
45-54	266 590	153 414	55.6	44.4	216 340	6.4
55-59	160 738	66 825	54.8	45.2	118 289	2.7
60-64	64 922	0	50.0	50.0	32 461	2.5
≥65	0	0	46.2	53.8	0	6.9
Total	..	..	64.4	35.6	306 637	100.0

a. Using a 7 per cent discount rate, a 2 per cent productivity rate, terminating ages of 65 years for males and 60 for females, and unadjusted mean income.
b. From Table II.4
.. Not applicable.

Note Figures may not add to totals due to rounding.

Source BTCE estimates.

Family and community losses

Data obtained from a time use study (Mercer 1985) and a survey by the ABS (ABS 1983), were used to estimate costs due to family and community losses. Neither source featured the age distributions required for refined calculations and the prevalence of young males in accidents (many of whom may be single) could significantly lower the estimates. Data from Mercer (1985) and ABS (1983) related to years 1981 and 1982 respectively. It was assumed the data were suitable for use in calculations relating to 1985;, that is, participation in family and community work has not significantly changed from 1981 to 1985.

TABLE II.11 FORGONE INCOME FOR EACH AGE AND SEX: ADJUSTED INCOME METHOD[a]

Age group (years)	*Forgone income (dollars)*		*Proportion of age group[b] (per cent)*		*Weighted forgone income (dollars)*	*Proportion of total ages[b] (per cent)*
	Males	*Females*	*Males*	*Females*		
0-4	155 262	66 300	58.3	41.7	118 165	2.1
5-7	188 017	80 287	61.6	38.4	146 649	2.1
8-9	217 044	92 682	61.5	38.5	169 165	1.8
10-14	250 551	106 990	61.7	38.3	195 567	7.1
15-19	307 734	128 141	69.3	30.7	252 599	20.1
20-24	344 485	141 862	70.9	29.1	285 522	20.3
25-34	340 460	129 015	69.2	30.8	275 335	18.4
35-44	286 360	105 224	61.1	38.9	215 898	9.5
45-54	185 447	58 334	55.6	44.4	129 009	6.4
55-59	92 572	26 033	54.8	45.2	64 496	2.7
60-64	37 257	12 123	50.0	50.0	24 690	2.5
≥65	8 926	1 436	46.2	53.8	4 896	6.9
Total	..	..	64.4	35.6	213 350	100.0

a. Using a 7 per cent discount rate, a 2 per cent productivity rate, terminating ages of 74 years for males and 80 for females, and mean income adjusted for employment rates.
b. From Table II.4
.. Not applicable.

Note Figures may not add to totals due to rounding.

Source BTCE estimates.

Opportunity cost method

Average amounts of time spent on the family and home by male and female persons employed was 11.0 and 23.5 hours per week respectively (Mercer 1985).[1] Average time spent in volunteer work by full-time male and female workers was 0.8 and 0.4 hours per week, respectively (ABS 1983). The percentage of males and females in accident statistics was 64.4 and 35.6 respectively (Table II.4), and a 39-hour working week was used (ABS 1985).

1. Hours for persons employed (full and part-time) was used, as information on full-time workers only was not available.

TABLE II.12 FORGONE INCOME ESTIMATES[a] BY AIS LEVEL

AIS level	*Opportunity cost method*[b] *(dollars)*	*Adjusted income method*[c] *(dollars)*
6	306 637	213 350
5	174 783	121 610
4	76 659	53 338
3	2 769	1 365
2	1 491	735
1	114	56

a. Using a 7 per cent discount rate and a 2 per cent productivity rate.
b. Calculated using terminating ages of 65 years for males and 60 years for females.
c. Calculated using terminating ages of 74 years for males and 80 years for females.

Source BTCE estimates.

From these data the average time spent with the family or in community work was calculated to be 41.3 per cent of the working week, which was given a value equivalent to 41.3 per cent of forgone income.

Adjusted income method

Average time spent by earning and non-earning males and earning and non-earning females on family and home work was 11.0, 18.8, 23.5 and 41.1 hours respectively (Mercer 1985). The number of males and females in these categories was 4.078 million, 1.801 million, 2.554 million and 3.510 million respectively (ABS 1985). Therefore, on average, males spent 13.4 hours, and females spent 33.7 hours, on family and home work. On average, males spent 0.7 hours per week and females spent 0.6 hours per week in volunteer work. Total family and community work was therefore 14.1 and 34.3 hours per week for males and females respectively. This was weighted by the percentage of males and females in accident statistics (Table II.4) to give an average of 21.3 hours per week. This equals 54.6 per cent of the working week and, therefore, family and community losses were estimated at 54.6 per cent of forgone income. However, it was not forgone income calculated by the adjusted income approach that was used, but forgone income calculated by the opportunity cost method, since family and community losses were valued as a proportion of the average income of a full-time worker.

Cost of accident-generated activities

The costs included under this heading were calculated by methodologies that were often largely determined by the data available. The methods used by Atkins (1981) served as a model for calculations. Data was severely limited, making cross-checking impossible and reducing the accuracy of the estimates.

Hospital, medical and rehabilitation costs

Although it would appear reasonable to assume that a direct relationship between injury severity and hospital, medical and rehabilitation costs could be established, in practice it is difficult to determine the relationship.[2] This is due, at least in part, to the lack of inclusion of information on the severity of injuries in hospital records. Injuries are commonly described using the International Classification of Diseases, Ninth Revision (ICD-9) which focuses on the regions of the body which are injured as opposed to the severity of the injury.

Hospital, medical and rehabilitation costs for AIS levels 1 to 5 were calculated by adjusting the cost estimates in Atkins (1981) to agree with an estimate of the total cost for Australia for 1985. Thus the distribution of costs across AIS levels 1 to 5 derived in Atkins (1981) has been maintained. A value of $1938 for the cost of fatalities (AIS level 6) was obtained from unpublished data from MAB. This information relates to the financial year 1985-86 but was used as an estimate of 1985 costs.

Calculations

Total hospital, medical and rehabilitation costs for AIS levels 1 to 5 were estimated for Australia for 1985 by extrapolating MAB data (MAB 1985, 1986) from Victoria to Australia in proportion to the respective total injury numbers. MAB data from the financial years 1984-85 and 1985-86 were averaged to produce an estimate of $45.5 million for injuries and fatalities for Victoria 1985. This total relates to costs claimed by victims and, therefore, excludes subsidies. MAB casualty numbers were averaged for 1984-85 and 1985-86 to produce an estimate of 54 358 casualties for Victoria for 1985. The total number of casualties in Australia in 1985 was estimated at 231 806 (see Table II.1) which is approximately 4.3 times the Victorian total. On this basis, total hospital, medical and rehabilitation costs were estimated

2. In this cost category 'Rehabilitation' costs includes costs such as chemist, dental, funeral, housekeeping and physiotherapy. Ambulance costs were also included.

at $194.0 million. The known cost of fatalities ($1938 x 2942) was subtracted to give a total injury cost of $188.3 million.

The hospital, medical and rehabilitation costs for AIS levels 1 to 5 presented in Atkins (1981), when multiplied by the injury numbers in Table II.1, result in a total injury cost of $320.2 million. The required total of $188.3 million was produced by multiplying the average costs in Atkins (1981) by 0.588 (188.3/320.2). The resulting cost estimates are given in Table II.13.

Costs of legal and court proceedings

Atkins used the American legal and court cost estimates derived in Faigin (1976). For this Paper the cost estimates produced by Somerville and McLean (1981) were inflated to 1985 levels, by the rise in the CPI. Estimates were realigned from the ISS to the AIS scale of injuries.

The Somerville and McLean (1981) estimate includes only costs to the plaintiffs involved. Defendant costs are said to be included in third-party motor vehicle insurance management expenses. Therefore to adopt the estimates in Somerville and McLean (1981) in this study, third-party motor vehicle management expenses were included in the insurance administration section (Atkins (1981) included only comprehensive motor vehicle insurance management expenses). The derivation of the costs of legal and court proceedings used in this Paper is detailed in Table II.14.

TABLE II.13 HOSPITAL, MEDICAL AND REHABILITATION COSTS FOR AIS LEVELS 1 TO 5

AIS level	*Atkins (1981) average costs (1978 dollars)*	*Atkins (1981) average costs x 0.588 (1985 dollars)*
5	42 420	24 943
4	14 950	8 791
3	8 660	5 092
2	2 515	1 479
1	275	162

Sources Atkins (1981). Multiplicative factor (0.588) is BTCE estimate based on MAB data.

TABLE II.14 COSTS OF LEGAL AND COURT PROCEEDINGS BY INJURY SEVERITY LEVEL

ISS level	*Approximate corresponding AIS level*	*Somerville and McLean*	*Updated estimates*[a]
Fatal	6	1 545	2 302
15+	5	2 272	3 385
	4	2 272	3 385
9-14	3	1 734	2 584
5-8	2	706	1 052
2-4		227	
1	1	198	317[b]
0	PDO	0	0

a. The estimates in Somerville and McLean (1981) were updated to 1985 by the rise in the CPI from December 1980 to December 1985.
b. The 1980 estimates for ISS levels 1 and 2-4 were averaged to produce an estimate for AIS level 1.

Source Somerville and McLean (1981).

The costs in Table II.14 are average costs only. The cost of legal and court proceedings could be expected to differ widely from case to case. Difficulties in proving fault may arise (and thereby increase costs) for one case even when injuries are the similar or less severe than those of other cases.

Insurance administration costs

The Atkins (1981) estimates of this cost were based on ABS data on the total management expenses allocated to motor vehicle comprehensive insurance in Australia for the year 1977-78. The total thus obtained (which excluded third-party) was split into AIS levels according to the distribution of these costs produced by Fox, Good and Joubert (1979).

To update this cost, statistics from the Office of the Insurance Commissioner (1986) were used to produce a total for management expenses. Management expenses for third-party, as well as comprehensive motor vehicle insurance were included. This total was distributed over the AIS levels (and PDO) by the procedure described below.

Distribution of insurance administration costs across severity levels
The unit cost estimates in Atkins (1981) were multiplied by the corresponding 1985 number of injuries or PDO vehicles (given in Table II.1) to derive a total cost of $169.3m. This total was then compared to the 1985 total of $277.2m from the Office of the Insurance Commissioner (1986) and the resulting indexing factor of 1.64 (277.2/169.3) was applied to the unit cost estimates in Atkins (1981). This procedure was necessary to account for differences in the distribution of injury and PDO vehicle numbers since Atkins (1981) while maintaining the relative distribution of insurance administration costs across severity levels.

Accident investigation costs
In the absence of Australian data, Atkins (1981) used US estimates derived by Faigin (1976). For this Paper it was considered preferable to use Australian estimates wherever possible, hence the estimates produced in Somerville and McLean (1981) were adopted. Somerville and McLean (1981) produced estimates of police accident investigation costs from a time and motion study conducted by the South Australian police force. Table II.15 illustrates the range of activities which may be required of police in the investigation of road accidents, in this case a fatal accident. (Data for each of the ISS levels is given in Somerville and Mclean (1981).)

The items included in the South Australian time and motion study were checked with the NSW and ACT police. Although these comparisons were not detailed, it was possible to confirm that the South Australian time and motion study covered items similar to those quoted by NSW and ACT police. Therefore, there was some basis for adopting the South Australian estimates to represent the whole of Australia.

To update the accident cost estimates produced in Somerville and McLean (1981) the 1985 average salary rate of the level of police officer most often involved in the investigation of road traffic accidents was required. This was then multiplied by the accident investigation time estimates from the South Australian police force time and motion study.

Somerville and McLean (1981) used the salary rate of a first class constable (then $7.01 per hour) to produce the estimates. Figures on the comparative award rates of pay for police across the States and Territories (provided by the Australian Federal Police Association) showed that there was little variation in the rate of pay for first constables across Australia. The award rate (at the starting increment) for a first class constable in the ACT ($10.60 per hour)

TABLE II.15 SOUTH AUSTRALIAN POLICE INVESTIGATION, TIME AND MOTION STUDY: FATAL ACCIDENT EXTRACT

Accident investigation	*Number of hours*
Attendance at scene, rescue, assessment, photography, marking, provisional measuring, miscellaneous activity	5
Tow truck/police removal of vehicles, storage report	4
Advising next of kin and arranging identification of deceased after admission to mortuary	4
Chain of evidence: St John, hospital, mortuary, relative, police, coroner's staff, pathologist	8
Documentation at office, various forms, summary book, advising communications centre of details	2
Liaison with technical services regarding examination of clothing, vehicle components and so on, and actual work done	6
Examination of vehicles and reports	6
Interrogation of defendant, arrest, charge, cells, documentation/information	5
Witnesses, interview, statements at private addresses after location	20
Witnesses declarations to be signed and witnessed after typing	10
Re-attendance at scene in daylight, photography, measuring	4
Drawing scale plan and compiling report of observations and legend	5
Processing of photographs	3
Miscellaneous typing - PD.83, interrogation, statements, summary, preparation of file and submission for vetting.	8
Total time per police officer	90
Total time for two police officers	180

Note The fatal accident involved two vehicles, one fatality and included a rescue situation.

Source Somerville and McLean (1981).

was chosen to produce the 1985 updated estimates. Estimates were realigned from the ISS to the AIS scale of injuries. The resultant accident investigation cost estimates produced are shown in Table II.16. Overheads and costs other than wages are not included in the estimates.

Losses to others

In the absence of comprehensive Australian data, losses to others were estimated by applying percentages as used by Atkins (1981), which in turn were derived from NHTSA (1972), to the forgone income estimates produced by the opportunity cost method for each AIS level. The opportunity cost method was used as it most closely relates to the forgone income estimates from which losses to others were calculated by Atkins (1981). The percentages used were: AIS levels 1, 20 per cent; AIS levels 2 and 3, 10 per cent; AIS levels 4 and 5, 2.5 per cent and AIS level 6, 1.2 per cent. The values produced were used without adjustment in the adjusted income method estimates. The basis for this approach is provided in NHTSA (1972).

TABLE II.16 ACCIDENT INVESTIGATION COSTS, 1985

ISS level	*Approximate corresponding AIS level*	*Hours of investigation*	*Total cost ($)*
Fatal	6	180	1 908
15+	5	60	636
	4	60	636
9-14	3	53	562
5-8	2	46	488
2-4		34	
1	1	14	254[a]
0	PDO	7	25[b]

a. The hours of investigation for ISS levels 1 and 2-4 were averaged to produce the AIS level 1 cost.
b. Adjusted to take into account the low number of PDO accidents which are actually reported and required police action (in this case a rate of 1 in 3 has been assumed).

Note Costs estimated using salary rate of $10.60 per hour.

Source Derived from Somerville and McLean (1981).

Vehicle damage costs

For this Paper, an average vehicle damage cost per vehicle was derived from data on comprehensive motor vehicle insurance claims. This was applied to the estimated total number of vehicles involved in accidents to derive a total cost of vehicle damage, both repaired and unrepaired.

The approach utilised the assumption that vehicle damage increased with accident severity or more specifically, that vehicle damage increased with injury severity. The methodology matches cumulative percentages of the number of vehicles in each severity level to a ranking (by size) of insurance claims. National Roads and Motorists' Association (NRMA) data for the year 1986 were obtained and used for 1985 with modifications which attempt to adjust for under-reporting of low cost accidents, and the different profiles of insured and uninsured vehicles with respect to their value. Vehicles involved in fatal accidents were judged to be on average less damaged than vehicles involved in serious accidents (AIS level 3) because these accidents include many involving pedestrians and cyclists, and these may involve relatively minor vehicle damage. Therefore, in the cumulative percentage rankings AIS level 6 was placed immediately after AIS level 2.

Modifications made to the NRMA data on cost of claim by frequency of claim were:

- redistribution of claims above $8000 across remaining cost intervals; and
- recalculation of numbers to adjust for under-reporting of low cost accident claims.

Redistribution of claims above $8000 was considered necessary to prevent correlation of severe accidents, that is AIS levels 3, 4 and 5, with damage to expensive cars (the average agreed value was found to be $7700 making it unlikely that the average damage costs in any category would exceed this amount).

Recalculation of low cost claim numbers was considered necessary to adjust for under-reporting which occurs due to excesses on premiums and the effect of the loss of no claim bonuses. It was (arbitrarily) assumed that the number of claims in the $0-$200, $200-$400 and $400-$600 cost categories represented 40, 60 and 80 per cent of possible claims for insured vehicles respectively. Consequently these numbers are the result of dividing the actual number of claims by 0.4, 0.6 and 0.8 for the $0-$200, $200-$400 and $400-$600 claim intervals

respectively. The estimates for all claim ranges were also multiplied by 0.9 on the assumption that insured vehicles have higher values on average than uninsured vehicles. That is, the estimated 80 per cent of vehicles insured (Searles 1980) were assumed to represent 90 per cent of the total value of all vehicles.

Details of the calculation

The median cumulative percentages given in Table II.17 were used to calculate median costs of vehicle damage (repairs and write offs) from the adjusted NRMA data on the number of claims by cost interval shown in Table II.18.

TABLE II.17 VEHICLE NUMBERS: CUMULATIVE PERCENTAGE BY INJURY SEVERITY LEVEL, 1985

Injury severity level	*Number of vehicles*	*Cumulative percentage*	*Median cumulative percentage*
PDO	956 962	78.5	39.2
AIS level			
1	180 927	93.3	85.9
2	64 022	98.6	95.9
6[a]	3 927	98.9	98.7
3	10 416	99.8	99.3
4	2 585	100.0	99.9
5	516	100.0	100.0
Total	1 219 355	100.0	100.0

a. Vehicles involved in AIS level 6 accidents were judged to be on average less damaged than vehicles involved in AIS level 3 accidents and therefore in cumulative percentage rankings were placed immediately after AIS level 2.

Note The median cumulative per cent is the halfway point between AIS levels in terms of the number of vehicles, calculated by adding two adjacent cumulative percentages and dividing by two, starting at zero.

Source Table II.1.

TABLE II.18 ADJUSTED NUMBER OF MOTOR VEHICLE COMPREHENSIVE INSURANCE CLAIMS ON AN INSURANCE PROVIDER BY COST INTERVAL, 1986

Cost interval (dollars)	*Adjusted number of claims*	*Cost interval (dollars)*	*Adjusted number of claims*
0-200	13 350	2 000-2 500	8 646
200-400	17 118	2 500-3 000	6 339
400-600	14 556	3 000-3 500	4 632
600-800	10 909	3 500-4 000	3 451
800-1 000	9 550	4 000-4 500	2 468
1 000-1 250	9 798	4 500-5 000	2 007
1 250-1 500	7 970	5 000-6 000	2 438
1 500-1 750	6 588	6 000-7 000	1 497
1 750-2 000	5 608	7 000-8 000	1 043
Total			127 968

Source NRMA (1987, unpublished) adjusted by BTCE.

To calculate the median cost by injury severity level, the total adjusted number of claims was multiplied by the median cumulative per cent for the respective severity level. The resultant number of claims were 'counted off' from the lowest cost interval until all were subsumed. At this point the median cost was found. Often the number of claims to be 'used up' results in a proportion of the claims in an interval needing to be counted off. The number required divided by the number in the interval was multiplied by the interval size and this was then added to the previous cost interval's upper bound.

By way of example the median cost of PDO vehicle damage is calculated below:

PDO median cumulative per cent = 39.2

Total adjusted number of claims = 127 968

Number to be counted off = 0.392 x 127 968 = 50 163

Number of claims less than or equal to $600 = 45 024

Number remaining to be used = 50 163 - 45 024 = 5139

Number of claims in the next cost interval ($600 to $800) = 10 909

Median Cost
PDO($) $= 600 + \frac{5139}{10\ 909} \times (800 - 600)$

$= 694$

Median Cost by 0.9 = $625

The remaining median costs have been calculated in similar fashion and are given in Table II.19

TABLE II.19 VEHICLE DAMAGE COSTS, 1985

Injury severity	*Median cost per insured vehicle (dollars)*	*Median cost per vehicle (dollars)*	*Cost per injury*[a] *(dollars)*
AIS level			
6	6 585	5 927	6 698
5	8 000	7 200	8 136
4	7 877	7 089	8 011
3	7 141	6 427	7 263
2	4 933	4 440	5 017
1	2 960	2 664	3 010
PDO	694	625	..

a. The cost per injury was calculated from the cost per vehicle by multiplying by a factor of 1.13 which represents the average number of vehicles per casualty.
.. Not applicable.

Source BTCE estimates based on NRMA (1987, unpublished).

Traffic delay costs
The estimates of costs of traffic delay by Atkins (1981) were obtained from Faigin (1976). The methodology used in Faigin (1976) has been used for producing the estimates in this Paper, with some alterations to adjust for increases in the value of travel time and differing proportions of accidents occurring in peak hours. The methodology calculates costs to individuals involved in traffic delays during 'rush hours' and excludes costs to businesses.

The parameters adopted from Faigin (1976) were:

- vehicle hours lost per rush hour accident equals 340 hours;

- persons per vehicle during rush hour equals 1.4; and
- percentages of rush hour accidents occurring in urban areas.

The parameters derived from Australian data were:

- value of travel time equals $4.50 per hour (Hensher 1986); and
- percentages of accidents occurring in rush hours.

Table II.20 shows the estimated number of accidents occurring in urban areas in rush hours.

TABLE II.20 NUMBER OF ACCIDENTS OCCURRING IN URBAN AREAS IN RUSH HOURS, 1985

Injury severity	*Accidents occurring in rush hours (per cent)*	*Accidents occurring in urban areas*[a] *(per cent)*	*Number of accidents*[b]	*Number occurring in rush hours in urban areas*
AIS level 6	12.7[c]	34.9	2 628	116
AIS levels 1 to 5	22.2[c]	66.9	165 684	24 607
PDO	21.3[d]	72.6	503 664	77 886
Total	21.5	71.0	671 976	102 577

a. Faigin (1976).
b. Table II.1.
c. Derived from ABS (1986b). Rush hours were assumed to be between 8.00 and 10.00 am and 4.00 and 6.00 pm, Monday to Friday.
d. The percentage of AIS level 6, AIS levels 1 to 5, and tow-away accidents occurring in rush hours, Monday to Friday, totalled 21.5 per cent (Traffic Authority of NSW 1986). By assuming that tow-away accidents have a similar pattern of occurrence times to all PDO accidents, the percentage of PDO accidents occurring in rush hours was able to be determined. This was done by multiplying the percentages for rush hours for AIS level 6, AIS levels 1 to 5 and in total by the corresponding number of accidents. The number of PDO accidents in rush hours can then be deduced by subtracting AIS level 6 and AIS levels 1 to 5 numbers (rush hours) from the total (rush hours) which can then be expressed as a percentage (21.3) of all PDO accidents.

Note Figures may not add to totals due to rounding.

Sources Derived from Faigin (1976), ABS (1986b) and Traffic Authority of NSW (1986).

Traffic delay costs were calculated as follows:

Fatalities AIS level 6:	
number of rush hour accidents	116
person hours lost (340 x 1.4) per accident	476
total hours lost	55 216
cost per person	$4.50
total cost	$248 472
number of fatalities	2 942
average cost per fatality	$84
Injuries AIS levels 1 to 5:	
number of rush hour accidents	24 607
person hours lost per accident	476
total hours lost	11 712 932
cost per person	$4.50
total cost	$52 708 194
number of injuries	228 864
average cost per injury	$230
PDO:	
number of rush hour accidents	77 886
person hours lost per accident	476
total hours lost	37 073 736
cost per person	$4.50
total cost	$166 831 812
number of PDO vehicles	956 962
average cost per vehicle	$174

Pain and suffering of victim

Pain and suffering of the victim, loss of amenities of life and loss of expectation of life (collectively called general damages in court awards) have been included in this Paper under the heading of pain and suffering of victim.

To estimate this loss, a sample of 213 court awards for persons sustaining multiple injuries in Australia for the years 1985 and 1986 were examined. No specific indication could be found as to which cases in the data source (Britts 1973) related to road traffic accident injuries. Multiple injuries were chosen for investigation of awards on the basis that road traffic accidents are most likely to result in this type of injury. For many cases the awards were made two to five years after the injury was sustained. Awards for general damages are subjective and are likely to vary with State legal systems, different judges, the clarity of the effect of the injury, and the expertise with which the case is presented.

TABLE II.21 REPRESENTATIVE INJURY DEFINITIONS

AIS level	*Injury severity level*	*Representative injuries*
1	Minor injury	Superficial abrasion or laceration of skin; digit sprain; first-degree burn; head trauma with headache or dizziness (no other neurological signs).
2	Moderate injury	Major abrasion or laceration of skin; cerebral concussion (unconscious less than 15 minutes); finger or toe crush/amputation; closed pelvic fracture with or without dislocation.
3	Serious injury	Major nerve laceration; multiple rib fracture (but without flail chest); abdominal organ contusion; hand, foot, or arm crush/amputation Not life threatening.
4	Severe injury	Spleen rupture; leg crush; chest-wall perforation; cerebral concussion with other neurological signs (unconscious less than 24 hours). Life threatening, survival probable.
5	Critical injury	Spinal cord injury (with cord transection); extensive second or third degree burns; cerebral concussion with severe neurological signs (unconscious more than 24 hours).
6	Maximum injury (currently untreatable, immediately fatal)	Decapitation; torso transection; massively crushed chest.

Source Adapted from Kragh, Miller and Reinert (1986).

TABLE II.22 ESTIMATE OF PAIN AND SUFFERING OF VICTIM: MEAN AWARD AND PERCENTAGE CLAIMS BY AIS LEVEL, 1985

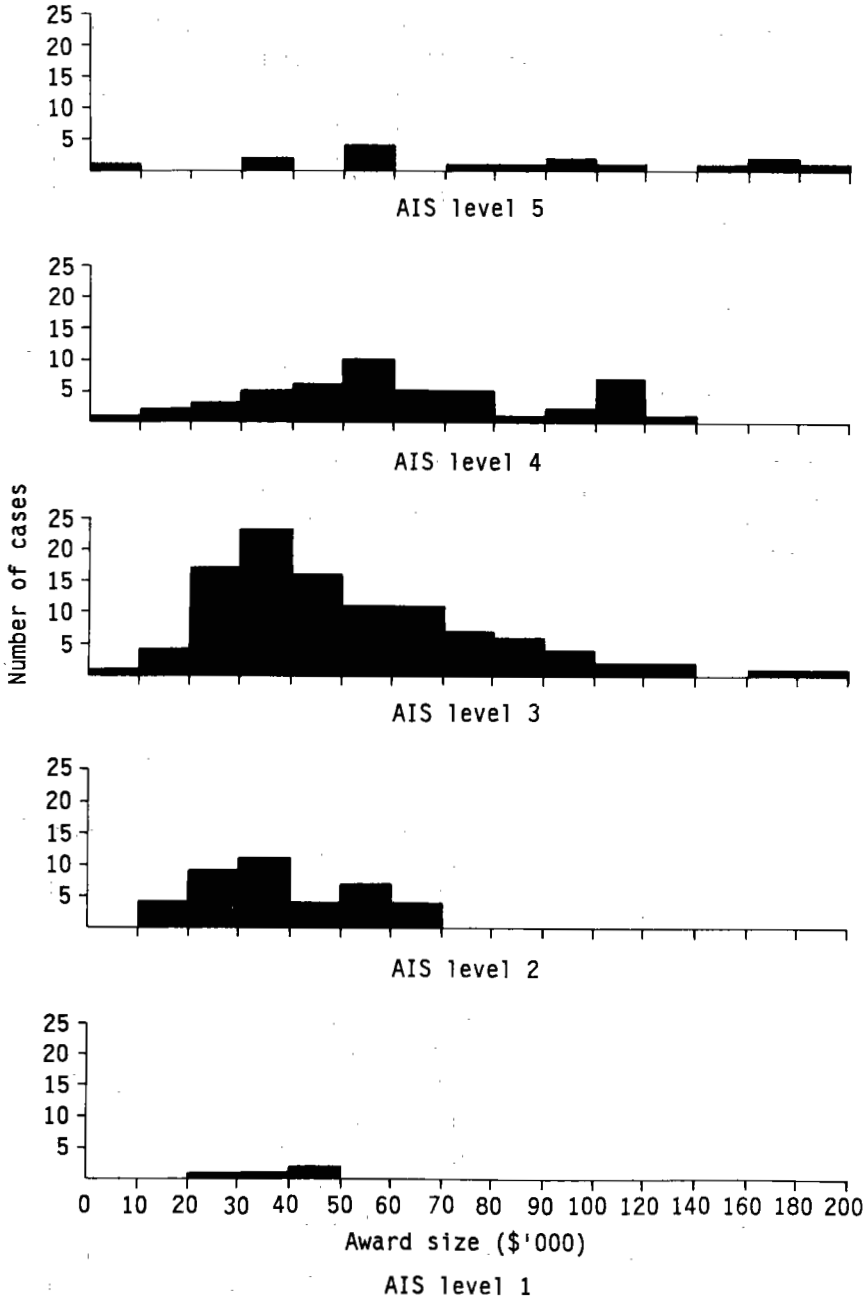
AIS level[a]	*Mean award (dollars)*	*Estimated percentage of injured persons claiming who are legally entitled (per cent)*	*Resultant pain and suffering estimates (dollars)*
5	88 900	100.0	90 000
4	60 300	75.0	45 000
3	50 300	50.0	25 000
2	35 800	25.0	9 000
1	35 000	1.5	500

a. AIS level 6 has no estimate of pain and suffering of victim. If pain and suffering of others were included then AIS level 6 would be expected to have significant cost.

Source BTCE estimates.

The representative injury descriptions for each AIS level shown in Table II.21 were used as a guide in assigning the injuries described in Britts (1973) to AIS levels. Figure II.1 shows the frequency of award size for AIS levels 1 to 5. The variation in awards was found to be large (for AIS level 5 from $5000 to $180 000) but generally the mean size of award increased with injury severity (see Table II.22).

Only a proportion of victims who are legally entitled to claim compensation do so. This proportion is considered to increase with injury severity. If it is assumed that victims who do not seek compensation but are entitled to do so, have not experienced a significant amount of pain and suffering, then the mean compensation awards need to be adjusted to produce an average award for all victims in that AIS level. No data could be found to establish the proportion of victims who seek compensation; therefore an 'order of magnitude' estimate was produced by arbitrarily assuming the percentages of persons shown in Table II.22. Use of this methodology means that victims who did not seek compensation are implicitly assigned a zero value of pain and suffering.



Source Derived from Britts (1973).

Figure II.1 Award size by number of cases by AIS level, 1985 and 1986

ADJUSTED WILLINGNESS TO PAY/HUMAN CAPITAL APPROACH ESTIMATES

The formula given in Landefeld and Seskin (1982) for WTP/HK calculations is given below:

$$WTP/HK = \sum_{t}^{T} \frac{Y_t}{(1+r)^t} \times \alpha$$

where:

T = remaining life time
Y_t = after-tax income
= $L_t + NL_t$
where: L_t = labour income (which may include the imputed value of nonmarket time spent on housekeeping activities)
NL_t = non-labour income
r = individual's opportunity cost of investing in risk reducing activities
α = risk aversion factor.

Source Landefeld and Seskin (1982).

This formula was adopted to produce the estimates presented in this Paper. In the absence of readily-available Australian data, the 3 per cent discount rate used in Landefeld and Seskin (1982) was adopted for producing the estimates presented in this Paper. The risk aversion factor of 1.6 (life insurance) used was also adopted for producing the present WTP/HK estimates.

The appropriate income figures are after-tax income from all sources. The income figures used so far in this Paper represent mean total income. No after-tax income figures were available, therefore an estimate was derived by applying taxation rates to the mean total income figures even though it was technically incorrect to do so as the distribution of incomes was unknown.

For full time-workers income was first taxed (taxation rates used are shown in Table II.23, estimated after-tax income shown in Table II.24) before multiplying by the percentage of persons, 15 years or over, estimated to be employed full-time (shown in Table II.25 along with adjusted after-tax income for full-time workers).

TABLE II.23 GENERAL RATES OF TAX: RESIDENT INDIVIDUALS, 1985-86
(dollars)

Total taxable income		
Not less than	*Not more than*	*Tax payable*
0	4 595	0
4 595	12 500	0 + 25 cents for each one dollar in excess $4 595
12 500	19 500	1 976.25 + 30 cents for each one dollar in excess of $12 500
19 500	28 000	4 076.25 + 46 cents for each one dollar in excess of $19 500
28 000	35 000	7 986.25 + 48 cents for each one dollar in excess of $28 000
35 000	and over	11 346.25 + 60 cents for each one dollar in excess of $35 000

Source Australian Taxation Office (pers. comm. 1987).

TABLE II.24 MEAN INCOME AND MEAN INCOME AFTER-TAX FOR FULL-TIME WORKERS, 1985

Age group (years)	*Mean income (dollars)*		*Mean income after-tax (dollars)*	
	Males	*Females*	*Males*	*Females*
15-19	10 600	9 880	9 089	8 559
20-24	17 527	15 341	14 043	12 512
25-34	22 432	18 936	17 007	15 029
35-44	25 102	18 860	18 449	14 976
45-54	24 885	17 337	18 332	13 910
55-59	24 895	17 924	18 337	14 321
60-64	22 684	17 216	17 143	13 825
≥65	22 026	14 087	16 788	11 635

Source Mean income, Table II.5.

TABLE II.25 PERCENTAGE OF INDIVIDUALS WORKING FULL-TIME AND ADJUSTED MEAN INCOME AFTER-TAX, 1985

Age group (years)	*Percentage of individuals working full time*		*Adjusted mean income after-tax (dollars)*	
	Males	*Females*	*Males*	*Females*
15-19	45.2	29.4	4 108	2 516
20-24	74.1	41.4	10 406	5 180
25-34	81.9	33.3	13 929	5 005
35-44	83.9	36.2	15 479	5 421
45-54	80.1	30.2	14 684	4 201
55-59	66.7	16.2	12 231	2 320
60-64	36.9	8.3	6 326	1 147
≥65	8.7	1.2	1 461	140
Total	65.1	26.4	..	..

.. Not applicable.

Source Percentages of individuals working full-time derived from ABS (1985).

For part-time workers, income was calculated by assuming that part-time workers did not pay tax (even though some will earn sufficient amounts to require payment of tax). Mean income figures (full-time) were multiplied by the percentage of the full-time working week that part-time workers work on average and then by the estimated percentage of part-time workers (see Table II.26).

The part-time workers and the full-time workers contributions to after-tax income were added together (Table II.27) and used in the WTP/HK estimate.

The methodology given in Landefeld and Seskin (1982) adds an imputed value of housekeeping services to total after-tax monetary income. In calculating family and community losses for this Paper average time spent by individuals on family, home and community work was found to be 54.6 per cent of the working week. Therefore 54.6 percent of mean total income (non-market income is not taxed by Landefeld and Seskin) was added to the after-tax income in Table II.27.

TABLE II.26 PERCENTAGE OF INDIVIDUALS WORKING PART-TIME AND ADJUSTED MEAN INCOME, 1985

Age group (years)	*Percentage of individuals 15 years or over working part-time (full-time equivalent)*		*Adjusted mean income (dollars)*	
	Males	*Females*	*Males*	*Females*
15-19	1.1	7.3	117	721
20-24	1.9	10.3	333	1 580
25-34	2.1	8.3	471	1 572
35-44	2.1	9.0	527	1 679
45-54	2.0	7.5	498	1 300
55-59	1.7	4.0	423	717
60-64	0.9	2.1	204	362
≥65	0.2	0.3	44	42
Total	1.6	6.5	..	..

a. Calculated by multiplying the percentage of individuals working part-time by the average fraction of the working week worked by part-time workers (15/40 for males and 15/36 for females).
.. Not applicable.

Source Percentages of individuals working part-time and average fraction of working week worked by part-time workers derived from ABS (1985).

The resulting estimates, by age and sex, are given in Table II.28. These estimates relate to the social human capital cost categories of forgone income and family and community losses. Therefore, to derive a total estimate comparable to those produced using the social human capital approach, the costs of accident-generated activities and pain and suffering costs (as calculated for that approach) have been added to the estimate resulting from the WTP/HK formula to produce total WTP/HK estimates.

Other parameters used in the WTP/HK calculations were 'terminating' ages equal to the expected ages of death of persons with ages equal to the average age of traffic accident victims (74 years and 80 years for males and females) and a productivity of 2 per cent.

TABLE II.27 INCOME USED IN WTP/HK APPROACH ESTIMATES

Age group (years)	*After-tax income (dollars)*		*After-tax income plus non-market income (dollars)*	
	Males	*Females*	*Males*	*Females*
15-19	4 225	3 237	10 013	8 631
20-24	10 739	6 760	20 309	15 136
25-34	14 400	6 577	26 648	16 916
35-44	16 006	7 118	29 712	17 416
45-54	15 182	5 501	28 769	14 967
55-59	12 654	3 037	26 247	12 824
60-64	6 530	1 509	18 915	10 909
$\geq$65	1 505	182	13 531	7 874

Source BTCE estimates.

TABLE II.28 ESTIMATES RESULTING FROM WTP/HK FORMULA BY AGE GROUP AND SEX[a]

Age group (years)	WTP/HK estimates (dollars)		Proportion of age group (per cent)		Weighted WTP/HK estimates (dollars)	Proportion of total ages (per cent)
	Males	Females	Males	Females		
0-4	1 457 128	913 722	58.3	41.7	1 230 528	2.1
5-7	1 515 110	950 080	61.6	38.4	1 298 138	2.1
8-9	1 560 106	978 296	61.5	38.5	1 336 109	1.8
10-14	1 606 432	1 007 349	61.7	38.3	1 376 983	7.1
15-19	1 654 224	1 029 675	69.3	30.7	1 462 487	20.1
20-24	1 620 976	1 010 037	70.9	29.1	1 443 193	20.3
25-34	1 428 642	889 534	69.2	30.8	1 262 597	18.4
35-44	1 099 746	694 997	61.1	38.9	942 299	9.5
45-54	718 411	472 080	55.6	44.4	609 040	6.4
55-59	442 274	331 110	54.8	45.2	392 028	2.7
60-64	271 957	242 011	50.0	50.0	256 984	2.5
≥65	106 166	97 429	46.2	53.8	101 465	6.9
Total	..	..	64.4	35.6	1 146 671	100.0

a. Using a 3 per cent discount rate, a 2 per cent productivity rate and 'terminating' ages of 74 and 80 years for males and females respectively.
.. Not applicable.

Note Figures may not add to totals due to rounding.

Source BTCE estimates.

APPENDIX III DETAILS OF SENSITIVITY ANALYSIS

The issues addressed in this appendix are the effect:

- of the discount rate on loss of victim costs and the estimated total cost;
- on loss of victim and total cost estimates of the use of earnings as opposed to income;
- on forgone income of using different terminating ages for calculations;
- on total costs of using production losses as opposed to the loss of the victim's production capacity;
- on the total cost estimate of using different injury number distributions; and
- on the size of the property damage only component and total cost estimate of using different PDO to casualty accident ratios.

FACTORS RELATING TO LOSS OF VICTIM

Conceptual differences or lack of conclusive empirical data has in the past led to debate over the appropriateness of many of the components used to calculate forgone income, and family and community losses. The sensitivity of the estimates presented in this Paper to the more important of these components is examined below.

Discount rates

Variation of the discount rate directly affects the forgone income estimates for AIS levels 4, 5 and 6. AIS levels 1, 2 and 3 are unaffected as no discounting is required for their calculation. Family and community losses are based on a percentage of forgone income so are affected by the discount rate. Losses to others, although also being based on forgone income, has not been subjected to analysis of the effect of varying the discount rate. In any case, the effect of a change in the discount rate on this relatively small item will itself be small.

Table III.1 shows the unit costs for the adjusted income method calculated using discount rates of 4, 7 and 10 per cent. For the opportunity cost method the effect of varying the discount rate (percentage change) is similar. Details for the adjusted willingness to pay/human capital approach are not given here; however, it was found that using a 2 per cent discount rate instead of a 3 per cent rate resulted in an increase in total costs for AIS levels 4, 5 and 6 of about $1000 million (from $4602 million), while use of a 4 per cent discount rate decreased the costs by a similar amount.

Use of data on income or earnings

The primary forgone income estimates given in Appendix II were calculated from mean total income. This item represents lost production capacity. Alternatively, lost production capacity can be calculated from mean earnings. Table III.2 shows estimates derived using both forgone earnings and forgone income.

Terminating ages for calculations

The forgone income calculations for the adjusted income method used terminating ages of 74 and 80 years for males and females respectively. These represent the expected age of death for males and females with ages equal to the average age of traffic accident victims. Statutory retirement ages, 65 and 60 years for males and females respectively, were used as the terminating ages in the opportunity cost method. Median retirement ages (62 and 56 years) are also possible ages for terminating forgone income calculations.

Tables III.3 and III.4 show forgone income calculated using the alternative terminating ages for the adjusted income and the opportunity cost methods respectively.

Estimate of lost production

An estimate of lost production for each AIS level has been produced using data derived from Fox, Good and Joubert (1979). These estimates exclude loss of future production in the case of permanent disability, or death. It was assumed that victims permanently incapacitated are replaced; however, the cost of replacement was not estimated. Non-market production losses in the family and community are included. Table III.5 compares the size of lost production with the estimates of lost production capacity of the victim calculated using the adjusted income method.

TABLE III.1 COMPARISON OF ESTIMATES CALCULATED USING ALTERNATIVE DISCOUNT RATES: ADJUSTED INCOME METHOD

Discount rate and cost category	*Average unit costs[a] (dollars)*							*Total cost ($ million)*
	AIS level							
	6	*5*	*4*	*3*	*2*	*1*	*PDO*	
4 per cent discount rate								
Forgone income	338 379	192 876	84 594	1 365	735	56	..	1 340.7
Family and community losses	267 127	152 262	66 782	1 512	814	62	..	1 078.5
All categories	623 535	478 257	220 764	45 099	19 964	4 893	988	5 835.9
7 per cent discount rate								
Forgone income	213 350	121 610	53 338	1 365	735	56	..	868.7
Family and community losses	167 424	95 432	41 856	1 512	814	62	..	702.1
All categories	398 803	350 161	164 582	45 099	19 964	4 893	988	4 987.4

TABLE III.1 (Cont.) COMPARISON OF ESTIMATES CALCULATED USING ALTERNATIVE DISCOUNT RATES: ADJUSTED INCOME METHOD

Discount rate and cost category	*Average unit costs[a] (dollars)*							*Total cost ($ million)*
	AIS level							
	6	*5*	*4*	*3*	*2*	*1*	*PDO*	
10 per cent discount rate								
Forgone income	149 688	85 322	37 422	1 365	735	56	..	628.3
Family and community losses	117 329	66 877	29 332	1 512	814	62	..	513.0
All categories	285 046	285 318	136 142	45 099	19 964	4 893	988	4 558.0

a. Average is per fatality for AIS level 6, per injured person for AIS levels 1 to 5 and per vehicle for PDO accidents.
.. Not applicable.

Note Calculated using a 2 per cent productivity rate, mean total income and terminating ages of 74 and 80 years for males and females respectively.

Source BTCE estimates.

TABLE III.2 COMPARISON OF ESTIMATES CALCULATED USING MEAN TOTAL INCOME WITH ESTIMATES CALCULATED USING MEAN EARNINGS[a]: ADJUSTED INCOME METHOD

	Average unit costs[b] (dollars)							
	AIS level							
	6	*5*	*4*	*3*	*2*	*1*	*PDO*	*Total cost ($ million)*
Earnings								
Forgone earnings	198 668	113 240	49 667	1 287	693	53	..	809.7
Family and community losses	156 146	89 003	39 036	1 448	780	60	..	656.7
All categories	372 843	335 362	158 091	44 957	19 888	4 888	988	4 883.0
Income								
Forgone income	213 350	121 610	53 338	1 365	735	56	..	868.7
Family and community losses	167 424	95 432	41 856	1 512	814	62	..	702.1
All categories	398 803	350 161	164 582	45 099	19 964	4 893	988	4 987.4

a. Mean earnings were derived from ABS (1986g), adjusted by adjusted employment rates used in Appendix II.
b. Average is per fatality for AIS level 6, per injured person for AIS levels 1 to 5 and per vehicle for PDO accidents.
.. Not applicable.

Note Calculated using a 7 per cent discount rate, a 2 per cent productivity rate, and terminating ages of 74 and 80 years for males and females respectively.

Source BTCE estimates.

TABLE III.3 FORGONE INCOME CALCULATED USING ALTERNATIVE TERMINATING AGES: ADJUSTED INCOME METHOD

Terminating ages for calculations (years)		*Average unit costs[a] (dollars)*							
		AIS level							
Males	*Females*	*6*	*5*	*4*	*3*	*2*	*1*	*PDO*	*Total cost ($ million)*
62	56	206 572	117 746	51 643	1 365	735	56	..	843.1
65	60	209 953	119 673	52 488	1 365	735	56	..	855.9
74	80	213 350	121 610	53 338	1 365	735	56	..	868.7

a. Average is per fatality for AIS level 6, per injured person for AIS levels 1 to 5 and per vehicle for PDO accidents.
.. Not applicable.

Note 1. Terminating ages of 62 and 56 years represent median retirement ages, 65 and 60 years represent statutory retirement ages, and 74 and 80 years represent expected ages of death for persons with ages equal to the average age of traffic accident victims.
2. Calculated using a 7 per cent discount rate and a productivity rate of 2 per cent.

Source BTCE estimates.

TABLE III.4 FORGONE INCOME CALCULATED USING ALTERNATIVE TERMINATING AGES: OPPORTUNITY COST METHOD

Terminating ages for calculations (years)		*Average unit costs*[a] *(dollars)*							
		AIS level							
Males	*Females*	*6*	*5*	*4*	*3*	*2*	*1*	*PDO*	*Total cost ($ million)*
62	56	294 897	168 091	73 724	2 769	1 491	114	..	1 241.7
65	60	306 637	174 783	76 659	2 769	1 491	114	..	1 286.0
74	80	350 203	199 616	87 550	2 769	1 491	114	..	1 450.4

a. Average is per fatality for AIS level 6, per injured person for AIS levels 1 to 5, and per vehicle for PDO accidents.
.. Not applicable.

Note 1. Terminating ages of 62 and 56 years represent median retirement ages, 65 and 60 years represent statutory retirement ages, and 74 and 80 years represent expected ages of death for persons with ages equal to the average age of traffic accident victims.
2. Calculated using a 7 per cent discount rate and a productivity rate of 2 per cent.

Source BTCE estimates.

TABLE III.5 LOST PRODUCTION AND LOST PRODUCTION CAPACITY: ADJUSTED INCOME METHOD

	Average unit costs[a] (dollars)							
	AIS level							
	6	*5*	*4*	*3*	*2*	*1*	*PDO*	*Total cost ($ million)*
Lost production[b]								
Forgone income	0	4 200	2 800	1 365	735	56	..	71.6
Family and community losses	0	4 652	3 101	1 512	814	62	..	79.3
All categories	18 029	141 971	75 289	45 099	19 964	4 893	988	3 567.5
Lost production capacity								
Forgone income	213 350	121 610	53 338	1 365	735	56	..	868.7
Family and community losses	167 424	95 432	41 856	1 512	814	62	..	702.1
All categories	398 803	350 161	164 582	45 099	19 964	4 893	988	4 987.4

a. Average is per fatality for AIS level 6, per injured person for AIS levels 1 to 5 and per vehicle for PDO accidents.
b. Lost production estimated by multiplying average days lost (derived from Fox, Good and Joubert (1979)) by average loss per day calculated for the adjusted income method in Appendix II.
.. Not applicable.

Note Calculated using a 7 per cent discount rate, a 2 per cent productivity rate, mean total income and for lost production capacity terminating ages of 74 and 80 years for males and females respectively.

Source BTCE estimates.

DISTRIBUTION OF INJURY NUMBERS

The distribution of injury numbers used in calculating the primary estimates for AIS levels 1 to 5 in Appendix II was taken from Atkins (1981). The distribution used has a direct effect on the total cost of accidents since average unit costs vary greatly from AIS level 1 to 5. The calculation of vehicle damage average unit costs is also affected by the injury number distribution used; however, only the change in total costs due to change in injury numbers has been investigated, that is average unit costs are held constant.

There is no empirical evidence on which to revise the distribution used, since there is little Australian data on the distribution of injury numbers by injury level and none related to the AIS scale. However, MAB data would seem to suggest that injury numbers in AIS levels 3, 4 and 5 may have been underestimated in the past.

Two alternative distributions (shown in Table III.6) were used for comparison with the one used in Appendix II. Both distributions feature relatively lower proportions for AIS level 2 and higher proportions in AIS levels 3, 4 and 5.

Table III.7 shows total costs calculated using each distribution.

PROPERTY DAMAGE ONLY VEHICLE NUMBERS

PDO vehicle numbers were estimated in Appendix II by first applying a ratio of 7:1 to casualty accident numbers to determine PDO accident numbers, and then multiplying these accident numbers by 1.9. The figure 1.9 represents the average number of vehicles per PDO accident (Atkins 1981).

Some accident cost studies mention alternative ratios, a selection of which were used to investigate their effect on total cost. The alternative ratios used were:

- 10:1 using the same casualty accident numbers as used in Appendix II as a base
- 40:1 using accidents resulting in death or an admission to hospital as a base
- 7:1 using the expanded number of casualty accidents (that is, casualty numbers adjusted for estimated under-reporting) as a base.

TABLE III.6 ALTERNATIVE DISTRIBUTIONS OF INJURY NUMBERS

	Distribution in Atkins (1981)		*Alternative 1*		*Alternative 2*	
AIS level	*Per cent of total injuries AIS levels 1 to 5*	*Injury numbers*	*Per cent of total injuries AIS levels 1 to 5*	*Injury numbers*	*Per cent of total injuries AIS levels 1 to 5*	*Injury numbers*
5	0.20	458	0.76	1 739	0.57	1 305
4	1.00	2 289	3.82	8 743	2.87	6 568
3	4.03	9 223	15.41	35 268	11.55	26 434
2	24.77	56 690	20.00	45 773	15.00	34 330
1	70.00	160 205	60.00	137 318	70.00	160 205
Total	100.00	228 864	100.00	228 864	100.00	228 864

Note Figures may not add to totals due to rounding.

Source BTCE estimates.

TABLE III.7 TOTAL COSTS RESULTING FROM USING ALTERNATIVE DISTRIBUTIONS OF INJURY NUMBERS: ADJUSTED INCOME METHOD

($ million)

Distribution used	*Injury severity level*							
	AIS level							
	6	*5*	*4*	*3*	*2*	*1*	*PDO*	*Total cost*
Atkins (1981)	1 173.3	160.4	376.7	415.9	1 131.8	783.9	945.5	4 987.4
Alternative 1	1 173.3	608.9	1 438.9	1 590.6	913.8	671.9	945.5	7 342.9
Alternative 2	1 173.3	457.0	1 081.0	1 192.1	685.4	783.9	945.5	6 318.1

Note Calculated using the adjusted income method.

Source BTCE estimates.

Casualty accident numbers used are:

- 71 952; casualty accidents which result in death or injuries which require surgical or medical attention
- 168 312; casualty accidents as defined in the previous point, but adjusted for estimated under-reporting
- 25 179; casualty accidents resulting in death or an admission to hospital.

Therefore, alternative PDO numbers are:

- 1 367 088 (10 x 71 952 x 1.9)
- 1 913 604 (40 x 25 179 x 1.9)
- 2 238 550 (7 x 168 312 x 1.9).

PDO vehicle numbers were estimated in Appendix II at 1 219 361.

Table III.8 shows estimates of the total cost of accidents using the various PDO vehicle numbers calculated above and the average unit costs given in Table 3.2.

TABLE III.8 TOTAL ACCIDENT COSTS RESULTING FROM USING ALTERNATIVE ESTIMATES OF PDO VEHICLE NUMBERS: ADJUSTED INCOME METHOD

PDO vehicle numbers	*PDO accident costs ($ million)*	*Total accident costs ($ million)*
956 962	945.5	4 987.4
1 367 088	1 350.7	5 392.6
1 913 604	1 890.6	5 932.6
2 238 550	2 211.7	6 253.6

Source BTCE estimates.

REFERENCES

ABS (1983), *Provision of Welfare Services by Volunteers, Victoria, Year Ended November 1982,* Cat. No. 4401.2, Melbourne.

__ (1985), *The Labour Force, Australia, June 1985,* Cat. No. 6203.0, Canberra.

__ (1986a), *Road Traffic Accidents Involving Casualties (Admissions to Hospitals), Australia, December Quarter, 1985*, Cat. No. 9405.0, Canberra.

__ (1986b), *Road Traffic Accidents Involving Casualties, Victoria, 1985*, Cat. No. 9406.2, Victoria.

__ (1986c), *Road Traffic Accidents, Queensland, 1985,* Cat. No. 9406.3, Queensland.

__ (1986d), *Road Traffic Accidents Involving Casualties Reported to the Police Department, Western Australia, 1985*, Cat. No. 9406.5, Western Australia.

__ (1986e), *Road Traffic Accidents Involving Casualties, Tasmania, Year Ended 31 December 1985,* Cat. No. 9406.6, Tasmania.

__ (1986f), *Deaths, Australia, 1985*, Cat. No. 3302.0, Canberra.

__ (1986g), *Weekly Earnings of Employees (Distribution), Australia, August 1985,* Cat. No. 6310.0, Canberra.

__ (1987a), computer tabulations of mean total income by age group and by sex, Australia, 1981-82, (unpublished).

__ (1987b), *Retirement and Retirement Intentions, Australia, November 1986, Summary,* Cat. No. 6237.0, Canberra.

Andreassend, D. C. (1982), letter to FORS on Economic and Social Costs of Road Accidents in Australia, by A. S. Atkins, (unpublished).

__ (1985), A Framework for Costing Accidents and Accident Types, *Accident Analysis and Prevention*, vol. 17, no. 2.

Atkins, A. S. (1981), *The Economic and Social Costs of Road Accidents in Australia: With Preliminary Cost Estimates for Australia 1978*, Centre for Environmental Studies, University of Melbourne, sponsored by Office of Road Safety, Department of Transport Australia, CR21.

Britts, M. G. (1973), *Comparable Verdicts in Personal Injury Claims*, The Law Book Company Limited, Sydney.

Faigin, B. M. (1976), *1975 Societal Costs of Motor Vehicle Accidents*, US Department of Transportation, National Highway Traffic Safety Administration, Washington.

Federal Office of Road Safety (FORS) (1987), computer tabulations of fatality vehicle numbers for 1985 from the National Mass Data System, (unpublished).

Fox, J. C., Good, M. C. & Joubert, P. N. (1979), *Collisions with Utility Poles,* Department of Mechanical Engineering, University of Melbourne, sponsored by Office of Road Safety, Commonwealth Department of Transport, CR1.

Hensher, D. A. (1986), Sequential and Full Information Maximum Likelihood Estimation of a Nested Logit Model, *The Review of Economics and Statistics*, vol. 68 no. 4, November 1986.

Hills, P. J. & Jones-Lee, M. W. (1983), The Costs of Traffic Accidents and the Valuation of Accident-prevention in Developing Countries, *Highway Investment in Developing Countries,* Thomas Telford Ltd, London.

Hunter Health Statistics Unit (1986), *Hospital Based Systems for Studying Road Crashes: Hunter Region Study,* Hunter Health Statistics Unit, sponsored by Federal Office of Road Safety, Federal Department of Transport, CR46.

Indecs (1986), *State of Play 4: The Indecs Economics Special Report,* Allen and Unwin, Sydney.

James. G. H. H. (1987), *A Study of Costs of Accidents by Type, 1978*, Civil Engineering Working Paper 87/4, Monash University, Victoria.

The Japan Research Center for Transport Policy (JRCTP) (1978), *Social Losses from Road Accidents,* Tokyo.

John Paterson Urban Systems (JPUS) (1972), *Review of the Cost of Road Accidents in Relation to Road Safety*, Expert Group on Road Safety, Department of Shipping and Transport, NR/23.

Kragh, B. C., Miller, T. R. & Reinert, K. A. (1986), Accident Costs for Highway Safety Decisionmaking, *Public Roads*, vol. 50 no. 1, June 1986.

Landefeld, J. S. & Seskin, E. P. (1982), The Economic Value of Life: Linking Theory to Practice, *American Journal of Public Health*, vol. 72 no. 6, June.

Law Reform Commission (1986), *Community Law Reform for the Australian Capital Territory: Second Report,* Report No. 32, AGPS, Canberra.

Lawson, J. J. (1978), The Costs of Road Accidents and their Application, *Economic Evaluation of Safety Programmes,* paper to Annual Conference of the Roads and Transportation Association of Canada, Ottawa, September 1978.

Mercer, D. (1985), Australia's Time Use in Work, Housework and Leisure: Changing Profiles, *Australia and New Zealand Journal of Sociology,* vol. 21 no. 3, November.

Mishan, E. J. (1971), Evaluation of Life and Limb, A Theoretical Approach, *The Journal of Political Economy*, vol. 79 no. 4, July-August.

Motor Accidents Board (MAB) (1978), *Statistics of Persons Killed or Injured in Road Accidents Occurring Year Ended 30th June 1978 for which Claims were Registered with the Board*, Melbourne.

__ (1985), *Statistics of Persons Killed or Injured in Road Accidents Occurring Year Ended 30th June 1985 for which Claims were Registered with the Board*, Melbourne.

__ (1986), *Statistics of Persons Killed or Injured in Road Accidents Occurring Year Ended 30th June 1986 for which Claims were Registered with the Board,* Melbourne.

National Highway Traffic Safety Administration (NHTSA) (1972), *Societal Costs of Motor Vehicle Accidents*, US Department of Transportation, National Highway Traffic Safety Administration, Washington.

National Roads and Motorists' Association (NRMA) (1987), letter to BTCE providing collision claim cost data, 14 May 1987, (unpublished).

Northern Territory Police Force (1986), *Road Accident Statistics, 1985*, Darwin.

Office of the Insurance Commissioner (1986), *Selected Statistics on the General Insurance Industry, For the Year Ended 30th June 1985*, AGPS, Canberra.

Searles, B. (1980), Unreported Traffic Crashes in Sydney, *ARRB Proceedings*, vol. 10 part 4, 1980.

Sherwin, M. A. (1977), Road Accident Costs, *The Cost of Road Accidents: Papers and Report from a Workshop on Cost of Road Accidents*, National Roads Board, Wellington.

Somerville, C. J. & McLean, A. J. (1981), *The Cost of Road Accidents*, University of Adelaide Road Accident Research Unit, sponsored by State Department of Transport, South Australia.

South Australian Department of Transport Road Safety Division (1987), Road Traffic Accidents in South Australia, letter to the BTCE, 10 March 1987, (unpublished).

Traffic Authority of NSW (1986), *Road Traffic Crashes in New South Wales, Year Ended December 31, 1985*, Sydney.

Troy, P. N. & Butlin, N. G. (1971), *The Cost of Collisions*, Cheshire, Melbourne.

Wigan (1980), *Safety Evaluation - Some Explicit and Implicit Considerations*, Paper for Seminar on Measuring Social Behaviour in Road Research held at Australian Road Research Board, April 1980.

__ (1982a), Conference Report, *Australian Road Research*, vol. 12 no. 2, June.

__ (1982b), *Accident Valuation and Indexation Options*, Australian Road Research Board Internal Report, AIR 293-1.

ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AGPS	Australian Government Publishing Service
AIS	Abbreviated Injury Scale
BTCE	Bureau of Transport and Communications Economics
CPI	Consumer Price Index
edf	effective discount factor
FORS	Federal Office of Road Safety
GDP	Gross Domestic Product
GNP	Gross National Product
ICD-9	International Classification of Diseases Ninth Revision
ISS	Injury Severity Score
MAB	Motor Accidents Board
NRMA	National Roads and Motorists' Association
NSW	New South Wales
PDO	property damage only
SMVU	Survey of Motor Vehicle Use
US	United States (of America)
WTP/HK	adjusted willingness to pay/human capital (approach)