WHAT IS IT WORTH? SAFETY VALUATION APPLICATIONS AND RESEARCH REQUIREMENTS

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ABSTRACT

Accidents cause damage, loss of property and life and have other cost-implicit consequences. The public regard accidents as worthy of preventative action, and support expenditures to minimise the losses incurred. There are many problems inherent in applying the various forms of safety valuation, due to the conflicting views of the goals of such expenditures and the inconsistent inclusion of different second and third round 'costs' of an accident. Recent changes in academic and administrative attitudes towards the practical use of 'willingness to pay' valuation bases have occurred in several countries, and provide valuable experience in bringing this type of approach to bear in Australia. This paper treats the issue from the top down: from the expenditure of resources to turn a small risk into a smaller one, and the methodological consequences that follow from this approach. Specific projects are proposed to be undertaken as a result. Inter alia; it is proposed that a range of projects be examined to find out where the valuations applied to safety have had a major technical influence, and how much larger (or smaller) they would have to be to have changed the technical decisions made.

INTRODUCTION

The views expressed in this paper are a natural progression from those reported at the 1982 ARRB conference (Atkins, 1981; Wigan 1982*a*), and the results were put into effect through a workshop held prior to this conference (Wigan 1982*b*). ARRB has periodically re-examined the values of the safety parameters required for project appraisal and costing, and progressively reassessed the basis of the methods employed. This paper is one further step towards better safety valuation and accident costing, and should be seen in that context. For many years ARRB has been publishing a set of 'standard' valuations for NAASRA, based on a consistent methodology open to considerable misinterpretation, and now overdue for improvement.

The basis for accident costing in 1982 (as distinct from the valuation of safety expenditures), was largely based on the ex-post accounting form of methodology due to Dawson (1967) and subsequently employed by Troy and Butlin (1971). The age of Troy and Butlin's work, based on 1969 data, forced many bodies to apply a range of updating procedures, leading to increasingly wide variations between the accident costing used by different organisations. The general result of the review and assessments recorded in the above references was to cause a general agreement amongst a number of parties to shift their bases for ex-post valuation

Net value of forgone earnings, as advocated by Dawson (1967), was originally the standard approach in Australia. No value was then attributed to the lost lifetime experience and production of those expected to die of an accident in a given period. This lost production was added back into the costs of accident in 1982, in accord with Dawsons'(1971) revised position, and led to a slight increase in the levels of cost attributed to a life, and the analytic work of Atkins (1981) was turned to as a new basic start line to which almost all organisations then adjusted their base line.

A range of awkward methodological differences and problems had been raised in the reviews referred to. Few if any of these were addressed by Atkins, who addressed the problem of improving the ex-post calculation of the measurable costs invoked by an accident which he then set for accident cost values in Australia. However, as result of his work there has been a comparable set of base valuations available for use in Australia for some time. As these have subsequently had to be updated and revised by various parties, new ad-hoc adjustments and new variations in interpretation have crept in, until today there is once again a clear need to set a new agreed baseline for project assessments on a national basis The need to develop some experience with willingness to pay (ex-ante) forms of valuation had been floated as an alternative to the ex-post accounting procedures then in vogue, but met with little support when raised in the early 1980's. The general view was that such issues should be addressed some time in the future, perhaps five years or so: i e. in 1987, as the meeting was held in 1982

A national workshop was convened in February 1988 to reconsider the current "state of play" as seen by a wide range of authorities. It was clear that the need for fresh work has increased considerably (Andreassen, Thoresen, and Wigan 1988). The present paper was a contribution to this cooperative process. It concentrates on the new information required and the reasons for proceeding in the specified direction of greater use of willingness-to-pay criteria, in accord with official and academic activities in other countries.

VALUATION OF SAFETY

Investigation and remedial work on safety is necessary both to reduce the overall direct and indirect costs to the community, and to meet the expectations of that community, even where these values do not appear to match the costs that can be worked out on accounting terms.

Consequently there are major differences between :

1. The **costs** of accidents, where accounting investigations can yield figures only *after* the accidents have happened, and -

2. The **valuation** of safety measures and effects, which reflect the levels of resources and funds that are (or 'should' be) allocated *before* accidents occur.

This difference is crucial, and the lack of general agreement on the fact that there is a difference leads to many distortions and confusions in the use of available accident costs, valuations of life, and cost benefit evaluations of projects where safety factors play a significant part.

There are severe problems with both approaches, the first - costing - is generally assumed to be well understood by most parties - yet the values in use are applied in a manner that belies this. The second - valuation - is only slowly becoming part of the working knowledge of analysts and engineers in transport. The close links with decision analysis and support, multicriteria evaluation, risk assessment and stated preference measurement have contributed to this slow penetration into operational evaluation.

This must be corrected, as there is mounting evidence that the public feels that insufficient weight is currently being given to safety - a view which can be responded to consistently only by the valuation type of approach. A dual approach to this subject is advocated, where willingness to pay valuations are to be sought by stated preference interview techniques (now field tested with a good measure of success in both the US and the UK) or constrained simulation resource allocation methods, with the other prong aimed at providing a different way of approaching the development of the actual numbers of dollars to be used to represent the importance of the safety valuation component in projects and programs, and the manner in which they should be used.

A third and complementary requirement is to improve the interpretation and use of existing 'costing' figures (Andreassen 1988). This would involve both better detailed accounting costs and better ways of explaining how to use them properly and appropriately. None of these three directions are dispensable, as they address different stages in the continuing evaluation, implementation, monitoring and prioritisation process.

An essential startpoint is that expenditures on safety by public (and indeed private) bodies is intended to reduce what is normally a low probability of an event occurring to an even lower level. This may be seen by considering the likelihood of accidents recurring at a particular location. In these types of cases a very small risk is reduced to an even smaller one, for a particular driver or vehicle (depending on the analysis standpoint adopted in this particular case), and the same applies location as well. Once broader measures, designed to affect behavior over a wide area are considered then the expenditure of effort, publicity or money is exactly as specified: money spent to reduce a low level risk to an even lower level risk

Even a few accidents at a specific location provides a substantial suggestion that remedial action would be desirable at that exact location. If money is then spent on improvements at that particular site then the very small accident-involved proportion of the stream of person movements at that point is reduced from one small figure to another - as far as a single person or vehicle is concerned.

As far as the *location* is concerned, a statistical confirmation that the measure has had some effect could be expected in these circumstances, and as far as the official roads bodies were

concerned this would provide an appropriate justification for the preventative expenditure. A few studies have analysed accident data in a form suitable for such a probabalistic outcome analysis. These include a study of collisions with poles carried out at Melbourne University (Fox, Good and Joubert 1979, Good, Fox and Joubert 1987). The probability distributions of outcomes, given prior information of varying types, was combined with some cost figures to give an expected value of any remedial measures that could be taken. This is perhaps one of the best-informed and clearly focused examples available, and many others require action before the event, on the grounds that the prior probability of an event occurring at that particular site is assumed to have been established by the evidence from other sites with similar features. These are aspects of risk assessment and prevention that have become very much more widely known in the last five years, and the work of Tversky, Slovic and others (see Slovic, Fischhoff and Lichtenstein 1984 as an example) has become the foundation of a broadly based field of 'risk assessment'

Risk assessment and decision analysis approaches are closer to current safety measure choices than might at first be supposed. When treatments at particular sites are considered, it is the probability of success that is in question, and this is usually deduced from other broadly similar sites or situations. One example (Slovic et al) which reveals the same structure is risk assessment for dam structures. The failure probability is designed to be low, but the weight applied to the consequences by the community are high. The risk assessment analysis follows both the hydrological tradition (for the risk levels as far as they can be estimated), and the attitudinal, to ensure that the alternatives are treated consistently. This combination of forecasting and valuation of alternative outcomes is one that has much to offer road project assessment, and provides a more usable method for marshalling the information needed for multi-criteria assessment, in a consistent and problem oriented manner

When willingness to pay valuations are to be applied, the basis for them is the balancing of one level of risk against another, and both against financial expenditures. The size of the accident reduction expected and the cost of necessary measures are both needed for a standard cost/benefit evaluation, and is matched from a willingness to pay standpoint by the expected reduction in risk level (i.e. improvement in safety) and the price that we are (as individuals or as society) prepared to pay to obtain such a level of risk reduction. The latter is a more relaible means of allocating resources than ex-post costings of the consequences of possible accidents, but a compromise is still needed for a better basis for valuation as a whole. Dalvi (1988) revised the options underlying the recent moves of the UK towards a revealed preference basis for accident valuation, albeit solely for fatal accidents at this stage

The two processes are remarkably similar, but the numbers are arrived at quite differently. The willingness to pay valuation is far better matched to the actual decision framework, as both are based on valuing changes in risk level given a degree of confidence in the expectation of the level of reduction that can be obtained. The current Australian procedure is to attribute a cost to the accident (or category of accidents) by tracing the resource and lost output costs resulting from similar accidents. This method permits the use of 'standard' values, as long as the appropriate categories for this costing and categorisation are agreed and understood

There is an alternative: by assessing peoples' actual behavior in situations of greater or lesser risk, the implied valuation of risk can be assessed directly. This corresponds very closely to a budgetary official determining that a safety budget of $\$x$ was allocated to 'safety' in a particular manner, given the alternative uses competing for these funds. Just as individuals must explicitly or implicitly weigh up the costs and benefits of undertaking various levels of road risks (however imperfectly they may perceive them), officials must weigh up different budget headings, each with their own balance of safety and other goals. This means that the

range of people whose perceived willingness to pay must be measured (directly or indirectly) must be wider than the groups at risk themselves.

This short discussion has raised a few questions and issues which should now be listed explicitly:

1 Who exactly weighs up the 'risk'?

2 On what type of information (or lack of it) are their weightings based?

3 What effect does greater knowledge of (or experience with) the risk have on the willingness to pay for preventative measures- or to take action?

4 In what forms do the issues arise that require such weightings to be used?

5 What are the valuations that would follow from costing the results of safety-directed works?

6 Do the cost consequences of identified accidents match the forecast cost reductions made on a comparable basis before the accidents occurred?

7 How much do the actual values obtained matter? in what cases?

8 What are the problems inherent in ex-ante methods?

9 What are the specific assumptions required to obtain comparable and useful ex-post costings?

10 How best should the valuations and costings be combined with each other and with other economic and social measures, and be applied in specific cases?

11 Given that a major task of safety planners is to allocate funds to reduce a small probability of an accident occurring to a still smaller one, how well do the valuations derived from surveys of the stated preferences on willingness to pay for safety improvements line up with this (very similar) task?

12 Within the major task of safety planners, *viz.* to reduce overall accident numbers or their severity, then internal allocations become important in terms of the proper weight between fatal, casualty, minor injury and property damage only incidents.

Most of these questions are concerned with the use of costs or valuations, and - not surprisingly - appear to take an *ex-ante* view It is still necessary to make effective use of historical data, and there is a real place for *ex-post* costing.

The wide range of varied assumptions, cost components and treatments of these components apparent in the literature and in practice attests to the alarming ease with which one can become enmired in the ex-post costing *process*. After the more obvious costing components have been extracted from the accident records, quasi-valuations from lost production, unquantifiable distress, and other issues which are considerably less soundly based in a accounting sense - and which have a real element of willingness to pay buried in them - must still be addressed.

Even the simple valuation of lost production from loss of life rarely addresses the issue that non-working people demonstrate at least the same value of time as their working partners in many cases, yet their cost of lost 'production' cannot sensibly be set to zero if societal expectations are to be matched even approximately. In most of the more defensible ex-post costings since Dawson (1971), a real value is attributed to lost production by those not then (or perhaps never) in the workforce.

This is but one of the many traps in the costing process. As one example of the underlying inconsistencies and variations, the omission or inclusion in the notional 'lost production' factor for loss of life or serious injury should be done prospectively, with a productivity correction factor to counterbalance the social discount rate for the future benefit stream (Wigan 1982): this is not universally adopted, and can distort ex-post values (and the relativities) substantially.

Unfortunately these are but the tip of a very substantial and clouded iceberg, and the finer details of costing the results of accidents can be shown in virtually every case to have some less than defensible assumptions added to the initially clean ex-post costing basis. Even when a fair measure of agreement can be reached on the components and valuations of non-quantifiable factors (travel time being included here for this purpose), then the compatibility of these valuations with the bases used for the remainder of the econometric valuation procedures is far from assured - and even more rarely questioned.

There is a fundamental difference between working out the results of an actual accident once it has occurred, and deciding how much one is willing to pay in the hope of reducing the chance of others of the same category arising in future.

This divergence of viewpoints is not often recognised, and the historical' costs deduced from the results of particular accidents are used without due care and interpretation when the question is how much to spend (and on what) to improve safety in the future. The strains that arise in particular cases when attempting to reconcile these two standpoints in a particular case with all the special features of the location and accident types involved provide ample further room for confusion, double counting and error.

It is unfortunate that this is even then not the startpoint. There are many ways in which accidents, personal injuries and property damage can be recorded and subsequently used. The evidence is that the recording, interpretation and use of these apparently neutral figures varies widely across Australia, and even the introduction of more consistent recording would require the addition of well specified unit costs before any greater degree of consistent application could be expected to arise.

There is therefore a good case for starting from the Beginning: i e. expenditure decisions aimed at improving safety. This means careful re-examination of the basis of the costs of accidents, injuries and fatalities, and probably more attention should also be paid to the public perception of the costs of safety.

VALUATIONS OF SAFETY IN CONTEXT

The first step is to ask why a valuation of safety factors is required at all. This is not a trivial question, as the answer depends on who is asking it and in what context. There is no commonly accepted basis for valuing *safety*. In many cases it is not the cost of accidents forgone that is in question, but the level of risk of an event of any kind. Dam failures and airliner crashes are examples of this type.

The most commonly adopted approach is to react to accidents as patterns emerge, work out the costs to individuals and others of the particular accident, and take steps to reduce this accounting cost. Justifications for expenditures are then based on the resource cost reductions to be expected from a reduction in the frequency or severity of these particular types of accidents in future

Such methods rarely go further than examining the historical costs, and it is unusual to find the question posed in terms of relative risk levels for one type of treatment against another very different social and behavioural administrative safety measure. The ex-post 'costs' of the accidents involved in the past, and the application of these costs to the predicted accidents in future are the common language of the evaluation and the assessment and indeed of many of the known pitfalls The application of economic theory to the question (Jones-Lee 1982) shows that the appropriate valuations of safety must include an element attributable to the risk that the individual feels and is prepared to pay to alter, a smaller component for the amount that he is prepared to spend to minimise the risks to others and a resource component covering both accounting costs and lost output figures.

The crucial question then becomes: how much of the resource costs are encompassed by the revealed willingness to pay values? Experimental results suggest that less than a fifth of the resource costs are taken up (Jones-Lee, Hammerton and Abbott 1987), and so willingness to pay valuations are almost entirely an additional component to be added to the current resource-cost based valuations in common use. The work in decision analysis has led to consistent findings that the basic cost/benefit and risk/benefit bases for evaluation are not satisfactory, and other factors must be taken into account.

The overall effects of reconsidering the basis for valuing safety expenditures using either *ex ante* or stated preference valuations in place of some or all of the current accounting-based values are:

1 The overall values would rise significantly

2 Distributional questions then arise, depending on the incomes of the population concerned. This could be those involved in the accidents, the population at risk, or the overall population.

3 The detailed resource costing figures would certainly require revision and re-examination.

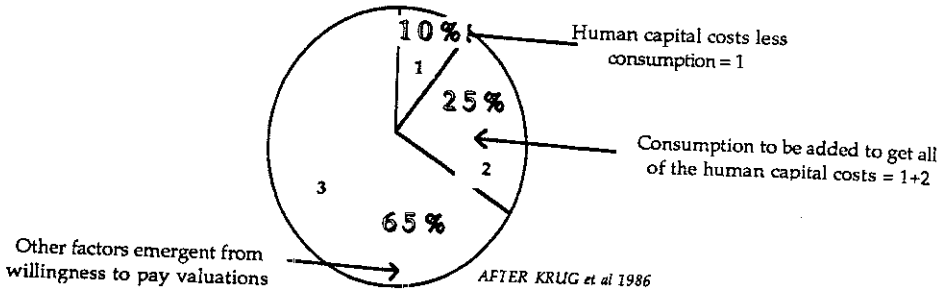
However, it is much more important to obtain some first round willingness to pay valuations to avoid any overall distortions in resource allocation that may already be happening

SOME RECENT RESULTS

At the time that Wigan (1982) and Atkins (1981) were written, the major need was for a new commonly-held baseline set of figures for safety costs. The major practical issue in Australia (if not elsewhere) was the inclusion or the exclusion of consumption forgone by injured parties. The shortfalls in the overall costing system, highlighted by discussion of the early willingness to pay studies, did not attract much attention from the practicioners involved.More recent work in both the US and the UK has caused official shifts towards more of a willingness to pay-based valuation of life. The authors of some of the relevant US work have summarised the differences between the three rather different stances noted in Fig. I.

Pure resource cost losses take up the smallest part of the willingness to pay valuation now adopted in the US, and the lost production aspects (included by NHTSA and indeed Australia) take up a rather larger slice: however, the willingness to pay valuation dwarfs both. It is clearly not possible to ignore the impact that such a large change would have in many roading areas if applied consistently throughout

FIG. I: HUMAN CAPITAL AND WILLINGNESS TO PAY COMPONENTS



US RESULTS FOR WILLINGNESS TO PAY EFFECTS ON OVERALL ACCIDENT COSTINGS OF HUMAN CAPITAL

The trend for governments to raise the valuations used for fatal accidents or a person killed above the values obtained from ex post accounting computations is not restricted to the US. The UK has done the same. There are also indications from the political process in Australia that the relative weight placed on safety *vis a vis* other costs and benefits is also seen to be too low. From these events and the committee hearings and reports leading up to them, the establishment of valuation figures in adequate accord with public expectations has clearly not been achieved by current ex post estimation methods, which means that *ex ante* and revealed preference methods are now essential to bring these expectations and the values used in assessment into line

There are a number of approaches to establishing revealed preference valuations. These include analysis of projects with safety components, hedonic price indices for cars (Uri 1988) (where safety has an implied price effect), and behavioral studies where the perception of risk levels and the responses must be related to the objective values. Some comparisons between different public sector expenditure headings have already been published by Hartunian, Smart and Thompson (1981). The figures that emerge from these comparisons between traffic and health expenditures and outcomes also indicate a much higher level of valuation than the ex-post accounting cost values currently employed in Australia.

The demonstrated importance in Fig. I of the differences in interpretation of cost and 'valuation' are explored further by Jones-Lee (1976), who suggests that the value of avoiding one statistical accident of a particular type (*excluding* output or real output effects) can be expressed as the population average of the individual marginal rates of substitution of wealth for 'own' risk, plus the population average of the aggregate of each individuals marginal rates of substitution of wealth for other peoples risk. This is the basis for the values ranging roughly from 1 to 2 million UK pounds obtained in Jones-Lee's (1987) national survey in the UK.

The results of the field surveys on willingness-to-pay in various situations have produced a strongly skewed set of results, strongly reminiscent of the skewed accident cost distributions

found in accidents of different types As a result, the choice between the overall mean, the outlier-trimmed mean and the median values is not straightforward The close relationship between the marginal utility to pay for risk reductions and the income level of the household are amplified by the elasticities involved. Although these elasticities are small (they range from 0.4 to 0.7), these values can lead to substantial changes in the total life valuation figure for small changes in household income level This makes it hard to avoid including some distributional component in the application of life valuation figures.

APPLICATION OF VALUATIONS WHEN DETERMINED

The next steps to address the issues raised are:

1. Production of a report summarising the present state of the art in the two major areas of valuing safety investments, and in costing the consequences of safety failures.

This will provide a sound basis for interchange with users of these materials, and an opportunity to clarify some of the misconceptions that have crept in over the last decade.

2. Production of a report which goes through the appropriate use of valuation and costing figures (once available), and shows how they should be selected, applied and interpreted for evaluation. This might best be done using a spreadsheet format, so that the interactions between application, assumptions and results can better be understood - and used by others without delay.

The need for this document became apparent at a working meeting on costing and valuing accident and safety factors, held at the ARRB (Andreassen, Thoresen and Wigan 1988). The wider use of unit costs, of consistent corrections for property damage, the effects of projects targeted at the highest cost types of accidents all require worked examples and explanations.

3. The selection of a range of actual projects undertaken in roading to determine the size of the safety valuation weighting required to alter the *technical* decision made.

This will make clear the range of revealed preference values that have effectively been used, and will be a valuable complement to the figures used for the safety components at the planning stages.

4. Design and test stated preference survey instruments for risk evaluation, and test using constrained budget priority evaluator methods.

The methods and instruments used to date have not proved to be entirely effective. Stated preference methods in other areas of transport assessment have been improved substantially, and before surveys are done, it is necessary to do some small scale work to design and test better methods for this particular application. As safety is one of a number of competing areas for resources in roads and transport, a complementary simulation method using a constrained budget allocation technique should also be set up and tested.

5. Undertake willingness-to-pay valuation surveys to provide a sounder basis for safety assessments in the future.

Once the tools described in the last heading have been developed and tested, a fairly wide ranging survey will be needed to make best use of the ability to determine *ex ante* values for safety expenditures.

A start has been made on the first task, but the second has more implications than are immediately apparent, and bear on the actual uses made of the valuation figures once they are available. It is fairly clear that even the (debatable) values currently used are not always correctly applied in a significant number of current assessments, and so the 'technical' decisions and recommendations remain open to technical reappraisal. However, the results of such debates and decisions are now on the ground in considerable numbers, and provide two different forms of valuation base:

1. The political willingness to pay implied by the divergence from (or even agreement with) the technical cost/valuation based project rankings or allocations

2 The assessable valuation of the decision from the consequential accident record

Needless to say, the combined uncertainties in the prediction of the accident numbers and the choice and implementation of the treatment selected on the ground make this a trifle hazardous as a procedure. The development of such forward probabilistic estimation procedures has a number of side benefits. The probability distributions of outcomes, and the probability distributions of likely accident outcomes (and costs) can be handled consistently. The construction of a decision support tool (some might call it a low level expert system) for remedial investments would become fairly easy to build if the results warranted it.

A few previous efforts have been made to deduce governmental willingness to pay from the subsequent accident record at sites where projects have been done (Byer, Bacchus and Melcher 1980). This revealed preference approach should give us some better insights into the overall priority for safety, when measured in terms of the opportunity costs incurred to address it. This work gave statistical life values in the range from $4 to $16 million Canadian Dollars (at 1979 values) by calculating the cost of the accidents that followed from the decision to install railroad crossings, suggesting that either the weight given to safety is too low or that the predictions of the likely accident reductions were overestimated - this being a good example of the joint uncertainty in the economics of safety.

A number of different items are required for an effective evaluation. The predicted accident pattern, the matched set of expected costs of the altered pattern of accidents resulting from the proposed measures, the weight to be given to the probability of achieving the expected level of safety improvement, and the final outcomes. *All* need to be combined to produce the dollar results required for such a review of the prior economic analysis. In view of the dilution of the forecasting reliability that occurs when all these factors are considered, it is not surprising that there is a wide spread in the implied valuations of safety produced.It is also worth noting than in several of the cases treated by Byers et al. there was no safety effect, as the projects were apparently well justified by benefits other than safety in these cases.

This is an approach that appears to be problematical in application, yet which produces valuations not completely out of scale with the more recent systematic willingness-to-pay survey and assessment work in US and UK. It certainly brings a sense of balance and reality to the relative importance of different factors concerned when an economic analysis of safety measures is to be carried out in advance.

The range of revealed preference values that could be determined by a wider application of this style of analysis of what people have actually done should give a distribution of values, but could reasonably be expected to yield values rather higher than those now in common use in Australia.Table I summarises some of the better willingness to pay and tradeoff valuations of life that have been reported to date. The general range of values is far above the human capital (ex-post) costings that are currently used in Australia, and the most recent work

(Jones-Lee) also provides sober defusing of many of the assumptions made about the unreliability of this style of approach

Specification	*Country*	*Valuation*	*Date*	*Basis*	*Source*	*Year*
Males	USA	$0.2 m	1967	Excess deaths in 37 riskiest jobs	Thaler et al.	1976
Fatals/10^8 man-hrs	USA	$1.5 m	1969	Inter-industry	Viscusi	1978
Fatals/10^8 man-hrs	USA	$1.5m	1973	White males in manufacturing	Smith	1976
Male manual	UK	£0.6m	1975	Excess deaths	Marin et al.	1982
Non-manual	UK	£6.6m	1975	per 1000 workers	Marin et al	1982
Costs *after* building new crossings	Canada	$4-16m	1979	Rail crossing accident records	Byer et al	1980
Risk tradeoff	UK	£1-2 m	1982	Total population	Jones-Lee	1987
Tradeoff analysis by sector	USA	$1.3m	1986	Cancer *v* heart *v* traffic accidents	Hartunian Re-est by Kragh	1981 1986
For comparative purposes						
Ex post: Standard	Australia	$0.4 m	1985	Adjusted Atkins	Steadman et al	1988
Ex post: +ex ante	'	$1.1m	1985	Lendefeld adjusted	Steadman et al	1988

TABLE 1: VALUATION OF A STATISTICAL LIFE

There are substantial problems with the willingness to pay evaluation by survey (as indeed was fully acknowledged by Jones Lee) but there is wide agreement that the method in fundamentally sounder than the rather messy architecture of a delicate scaffolding of interdependent (and largely unsophisticated) figures essential for the 'conventional' ex post evaluation procedures. It is clear that the design of the instrument to be used must be carefully refined to ensure that consistent results may be obtained for using the very small probabilities of accident involvement that are inevitably involved.

The various labor market studies are substantially superseded by the work of Marin and Psacharapolous (1982), who used a wider range of social occupations than the previous workers. The US figures were deduced from a major study of different types of public health problems and the costs associated with each: car accidents were one of these. At first sight these values seem to be in reasonable agreement: this impression is quickly destroyed when the wide range of dates and currencies is noted. The only common thread is that the values reported are all substantially higher than those generally adopted in Australia on the basis of ex post accounting calculations

It must be emphasised that these figures in turn are far from being value-free and generally include a number of elements to account for some of the willingness-to-pay factors that otherwise would be neglected in the figures completely: see Steadman and Bryan (1988) for a detailed discussion. When the additional factors (as estimated by Steadman and Bryan) are added, the ex post costs rise substantially to more than twice the ex post values Steadman

and Bryan also point out that even these values (which are the most recent for Australia) are really a holding action until ex ante valuations can be put on a sounder and more widely acceptable footing. As they conclude, this needs field research work to be done.

However, the use made of any numerate valuations of accidents, life loss or other safety aspects in the economic assessments of the original projects are still vulnerable at the decision stage to any errors in interpretation of the values employed, and to any inaccuracies in their application. Common confusions between the cost to an individual in an accident and the number of individuals involved in the accident are far from rare. Any move to make greater use of willingness-to-pay assessments for life, accident and property damage would also have the dual effect of reinforcing the importance of more careful and consistent use of the values determined upon for the task in hand.

Greater use of the risk assessment and perception methods will be needed (typified by Kahneman and Tversky (1979) and Slovic, Fischhoff and Lichtenstein (1981)). The modification of perception, and through this, behavior, to improve safety is an important tool in the armory of the safety policy maker and the practitioner. This will not always lead to reductions in usage by 'dangerous' modes, but will lead to a better match between resources and their usage. A good example is given by Barnard (1988), where the perceived level of bicycle commuting in Adelaide was found to be considerably higher than it actually was, thereby suggesting that an increase in such travel would arise from a better balance between perception and reality. It might be argued that on safety grounds such distorted perceptions could even be regarded as laudable, in their effect in reducing the usage of a 'dangerous' mode. It is difficult to find arguments to support this position, but it is one that can severely complicate the move towards willingness-to pay-valuations (or valuation supplements), and their effective and judicious usage.

For most practical cases, money is spent to make what is generally already a small risk of an accident ocurring at a given location even smaller. Measures are taken on the basis of the available evidence of incidents, accidents and other ocurrences (such as conflict analyses). These pieces of prior information can be - and are - used to help to select locations where the probability of introducing a change is the largest. As an aside, it is often assumed that this will mean a reduction in the overall accident costs, but this need not be the case as measures to reduce fatalities may increase the number surviving with serious injuries, and measures to reduce injury accidents may increase property damage only costs. The overall result is not always taken into account.

The treatment of safety and safety valuation from the standpoint of reducing a small probability of an accident event to a yet smaller one has not received much attention since Schelling (1968) pointed out that this was the case. The methods required to evaluate this type of risk reduction must rely heavily on stated and revealed preferences on the choice of how much to pay for what levels of risk reduction. Only Jones-Lee, Hammerton and Abbott (1987) provide even comparatively solid results on which this approach can be tested.

An Australian-specific survey is necessary to be able to catch up with the current state of practise in the UK. The findings would be of general application, and would be of equal importance in medical and industrial areas, where significant cost/benefit problems also arise in terms of life and accident valuation. The perceptions of risk to the customers and to the community, have been frequently shown to be dependent on factors over and above the cost/benefit and risk/benefit tradeoffs alone. There are other dimensions which keep on reappearing, dimensions that the public require to have taken into account.

The risk perception and assessment work by Slovic and others (Slovic, Fischhoff and Lictenstein 1981, 1984, 1985; MacGregor and Slovic 1986; Slovic, Macgregor and Kraus 1987), provide a growing consensus basis for these values to be picked out. Slovic et al (1987) included a study of the perception of safety defects in vehicles (a study which could reasonably be repeated for road and road design characteristics), the degree of 'manufacturer prior knowledge' and 'uncontrollable impact' reappeared once again.

These factors correspond closely to those considered by Bodily (1980), who identifed the degree of responsibility or control over a risk and its possible outcome as a major factor in the amount that individuals (and society) was prepared to pay to reduce it: Bodily also identified the willingness of society to pay to prevent major disasters even where the expected cost (the product of the probability of their ocurrence and the costs of their possible outcomes) would not appear to justify it. The need to accommodate these recent findings from related fields of risk assessment cannot be ignored, and the analogies to road investments and other safety measures are clear.

It is also apparent that the two different forms of accident costing and safety valuation (historical costing of accidents once they have ocurred, and dollar valuations of expected future risks) are perceived as being simply different ways of calculating the 'same' figure. It is necessary to alter this view, and ensure that the appropriate valuation methods are used when considering various forms of project. The errors due to using inappropriate basic valuation methodologies in particular cases is only half the story. The even more common variations in the manner in which a given set of 'accident costs' have been (and continue to be) applied in the field demonstrate the need for clarification at a detailed level.

CONCLUSIONS

The general move towards more economic cost benefit analysis across different technical fields in the public sector requires a reassessment of the overall valuation applied to safety within the roading sector. The pressure is on for the best allocation of resources within that sector. This demands as good a set of evaluation and cost benefit tools as possible. The greater attention being paid to such efficiency and economic assessment processes also has the side effect of magnifying any resource misallocations that could arise from inappropriate detailed costing figures or their incorrect application in particular cases.

Willingness-to-pay as a basis for safety valuation has become a usable tool in the last five years, but the necessary work to apply it in Australia has not been done using either revealed or stated preference techniques. Some effort can be saved by careful examination of the methods and results of those who have tried to do this in other countries. However this will not obviate the need to assess the values in Australia *for* Australia. Attitudes are not necessarily portable between countries and societies, and this is what is involved.

Some survey work needs to be done. It is not clear if this should be modelled on a modified version of the forms used by Jones-Lee (which are acknowledged to be less than ideal) or a different type of stated preference or constrained tradeoff framework. It is clear that, at the very least, experiments to design and validate suitable instruments are well overdue. Examination of the findings of stated preference and tradeoff surveys suggests very strongly that the questions and tradeoffs need to be considerably improved, and a better instrument for such constrained, tradeoff and stated preference data gathering be designed and tested before any surveys are done. Table II is a summary of some of the tools available.

We should pay most attention to areas where varying safety valuations has an effect. In the evaluation of major roadworks, safety factors are unlikely to be dominant in either size or

sensitivity for major project decisions For very small projects the safety returns are essentially all the benefit , although travel delays and other disbenefits may be involved It is in the middle ground, once the broad level of safety as whole *vis a vis* other factors such as fuels costs and time savings have been reassessed, that attention should then be placed. Specific examination of existing and proposed projects to see how the decisions would vary with different levels of the weightings applied to safety as a factor are where there is a lot to be learned.

Approach	*Technique*	*Methododology*
Revealed preference	Hedonic price analysis of car prices and safety features	**Econometric**
	Wage premiums for different occupations and activities	**Econometric**
	Analysis of various project projections, outcomes & values	**Accounting**
Stated preference	Risk tradeoff preference ratings	**Survey**
	Constrained simulation for priority evaluations	**Interactive**

TABLE II: RELEVANT METHODS FOR IMPROVING VALUATIONS

Neither of these two steps are enough in themselves, as property damage, the application of the values obtained, and the whole question of reconciling the ex-post 'costs' in common use with the questions now raised will still have to be addressed. Better detailed costings will still be needed to discriminate between different safety treatments at the detailed level

RECOMMENDATIONS

There are two major recommendations. The most important is that probabalistic safety valuations must now be developed to improve the allocation of resources to safety goals. this means that work on both risk assessment methods (a la Slovic et al) and economic revealed preference (willingness to pay) valuations should be initiated.

In addition, a systematic reassessment of the **uses** made of safety valuations is now required. A generally accessible document covering examples of a range of uses of safety valuations and accident costs in some detail Inconsistent (and in some cases simply incorrect) application of these values is already a problem, and better values will not help if they are not used properly.

Unless a better general understanding can be achieved for the appropriate methods for using the results of safety valuation and costing work, then the treatment of safety in evaluation stages of programs will remain as inconsistent and inappropriate as it has been in the past, and the results will continue to miss the expectations of the public in terms of the weight given to safety.

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