TRANSPORT INVESTMENT AND THE ZERO SUM SOCIETY

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ABSTRACT: *Transport investment analysis has traditionally been conducted within the framework of conventional microeconomic theory. In particular, it has utilised the concepts of cost-benefit analysis to determine the relative efficiency of alternative courses of action. This paper questions the validity of such analytical techniques, given the current economic conditions with which we are faced. In situations where the factors of production are not fully employed, it is suggested that far greater attention be paid to the true opportunity costs of resources used in transport projects. The concept of the Zero Sum Society is employed to highlight some of the problems associated with economic evaluations under prevailing economic conditions. The paper illustrates the arguments raised by reference to recent research on the value of reductions in traffic accidents.*

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INTRODUCTION

The role which public sector investment plays in discussions of national economic well-being, especially from a Keynesian viewpoint, is well known and generally acknowledged. Increases in public spending will boost the aggregate demand schedule in relation to the aggregate supply schedule and hence result in a higher equilibrium net domestic product. In times of high unemployment, most of this increase will be in terms of real NDP increases rather than money NDP increases.

Whilst such effects are generally recognised in macroeconomic discussions, it appears that transport economists, and others involved in the detailed evaluation of transport, and other public sector, investments pay little attention to these effects. The economic evaluation of transport projects is still firmly rooted in the microeconomic concepts of cost-benefit analysis. However since a large proportion of total Government capital expenditure is devoted to transport (approx. 20% at both State and Federal levels), and since a large proportion of private income is allocated to transport (approx. 15% of private income is spent on transport services), it is clear that transport investment and expenditure will have significant impacts on the nation's economic performance. It is therefore necessary to examine transport investment from a macroeconomic viewpoint, as well as a microeconomic viewpoint, in order to obtain a complete picture of the full effects. It is, in fact, necessary to perform both evaluations in order to avoid the "fallacy of composition", as described by Jackson and McConnell (1980, p. 15), whereby microeconomic conclusions are falsely aggregated to yield spurious macroeconomic conclusions, and vice versa.

This paper examines the methods used in conventional economic analysis of transport projects; in particular, it concentrates on the methods used in the assessment of road safety proposals. Deficiencies in this approach are highlighted and an alternative procedure, which places more emphasis on national economic and social goals is then outlined.

THE ROLE OF PUBLIC SECTOR INVESTMENT

Before beginning to outline the methodology currently employed in most transport project evaluations, perhaps it is useful to review briefly the theory underpinning the role which public sector investment plays in the national economy. In developing this theory, it is necessary to account for relationships between aggregate supply schedules, the role of private consumption and the role of private investment.

According to Keynesian theory, the level of output generated by a nation (i.e. the net domestic product, NDP) is dependent on the aggregate level of spending in the community. In fact, the NDP is identical to the total level of spending since producers will not be willing to produce more than they can sell, nor will they produce less than they could possibly sell (see Jackson and McConnell, 1980, p. 227). The aggregate supply curve can therefore be represented as shown in Figure 1. Any point along this line is a possible state of production (with the restriction that NDP must be less than the maximum production dictated by the production possibilities frontier curve).

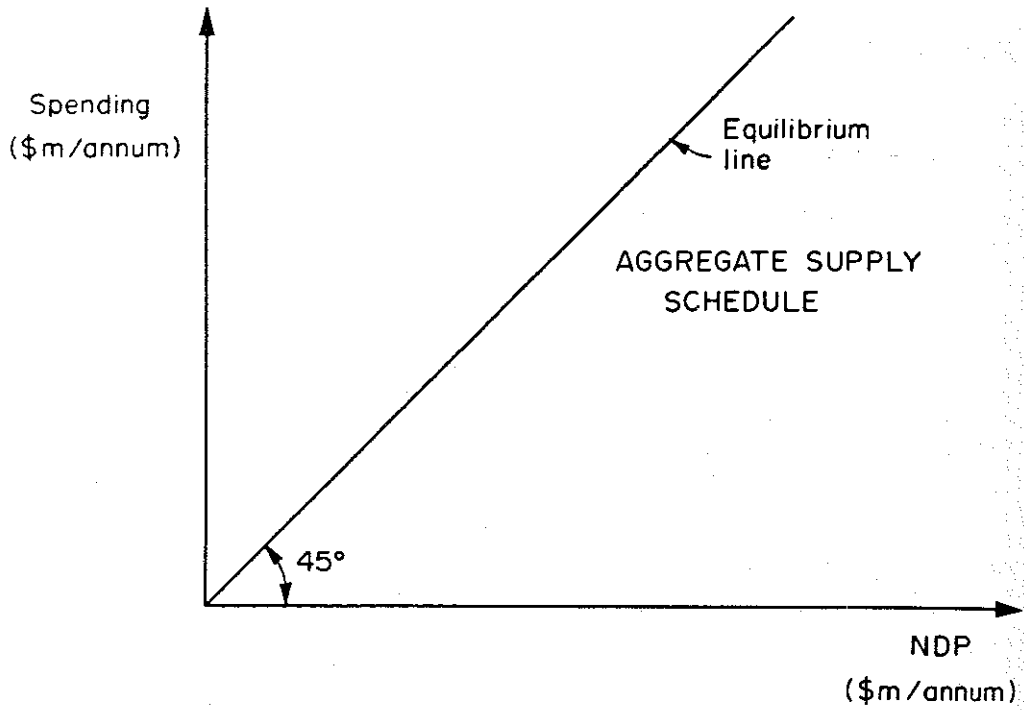

Fig. 1. Aggregate Supply Schedule.

To determine the point on this line which will actually exist, one needs to consider the aggregate demand schedule which is composed of two elements: consumption and investment. The consumption curve will depend on the relative propensity of the community to spend and to save the income which it earns. By allowing for the tendency of lower income households to consume in excess of their current incomes and for the proportion of income saved to rise as income rises, a consumption schedule as shown in Figure 2 can be derived. The slope of the consumption schedule is given by the marginal propensity to consume.

To determine the aggregate demand schedule, one must add the (private sector) investment schedule to the consumption schedule. If it is assumed that private investment is not a function of income, then the aggregate demand schedule will be as shown in Figure 3. The aggregate demand schedule will be uniformly higher than the consumption schedule by an amount equal to the total private investment.

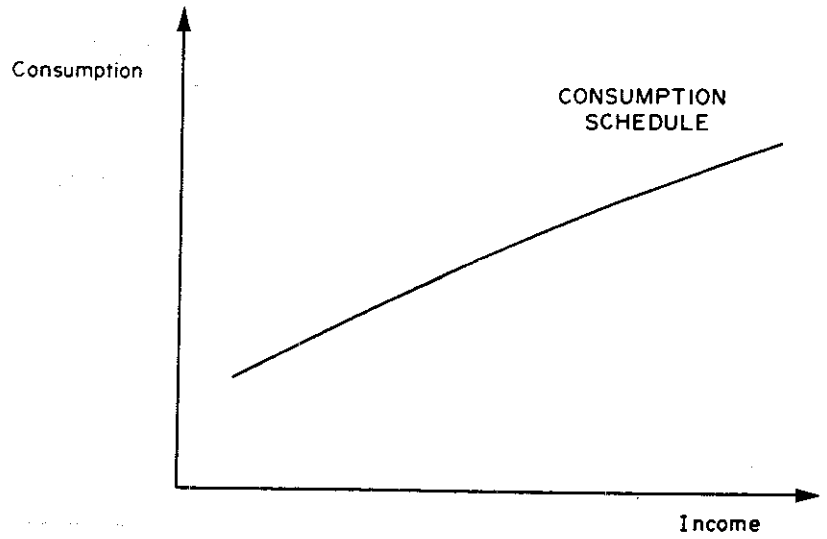

Fig. 2. Consumption Schedule.

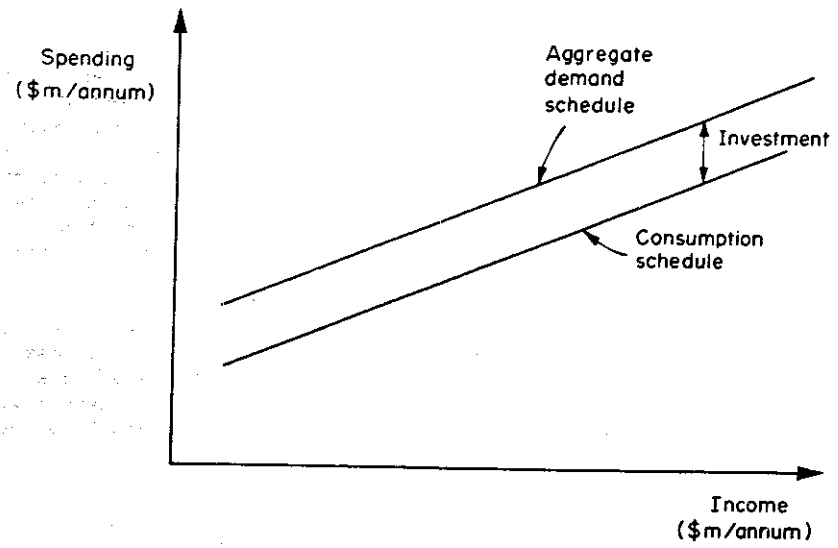

Fig. 3. Aggregate Demand Schedule

Since income and NDP are really just different measures of the same quantity (see Jackson and McConnell, 1980, p. 162), it is possible to overlay the aggregate demand schedule of Figure 3 on the aggregate supply schedule of Figure 1 to obtain equilibrium measures of NDP and spending as shown in Figure 4. The equilibrium point denotes the situation where consumers are willing to demand all of the nation's output and producers are willing to produce all of the nation's demand.

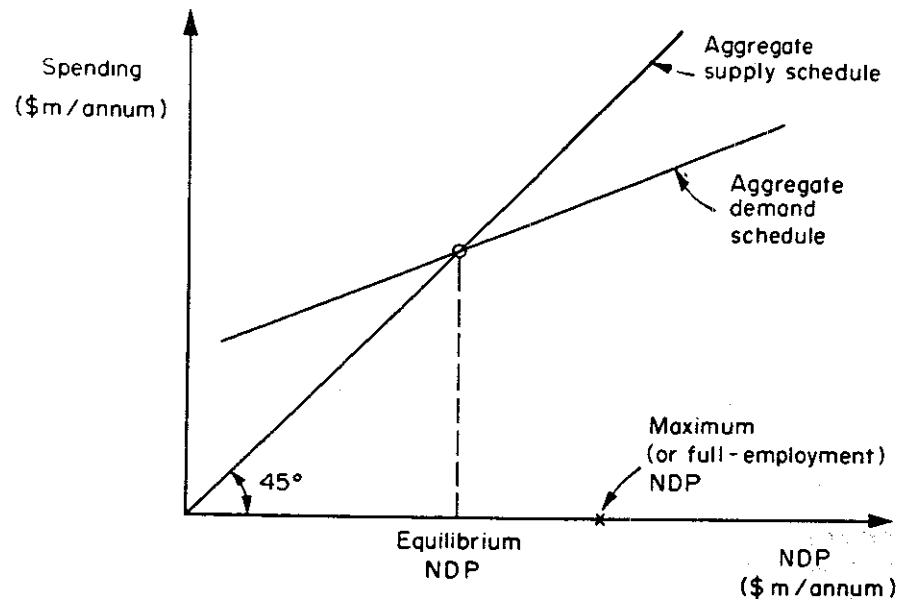

Fig. 4. Estimation of Equilibrium NDP

However, contrary to Say's Law, which assumes that supply creates its own demand, the equilibrium NDP is not necessarily equal to the maximum NDP. If Say's Law were valid, producers could produce the maximum NDP and consumers would unhesitatingly demand all of it. Because Say's Law does not hold, there will normally be a gap between the equilibrium NDP and the maximum (or full employment) NDP as shown in Figure 4. Another way to think of this is by means of a production possibilities frontier (PPF) curve as shown in Figure 5. Rather than lying on the curve, the less-than-full employment condition lies somewhere within the curve. The task of macroeconomic management is to move this production/employment condition closer to the PPF curve by means of appropriate fiscal policy. As shown in Figure 3, the aggregate demand curve can be raised by increasing the level of investment. Therefore, by increasing public sector investment the curve can be raised even further as shown in Figure 6. This results in a new (higher) equilibrium NDP which is closer to the full employment NDP. If government investment were increased even further, the full employment NDP would be theoretically reached. However, further increases in government investment would result in an inflationary gap which would result in an increase in money NDP, but not real NDP (i.e. inflationary pressures would exist).

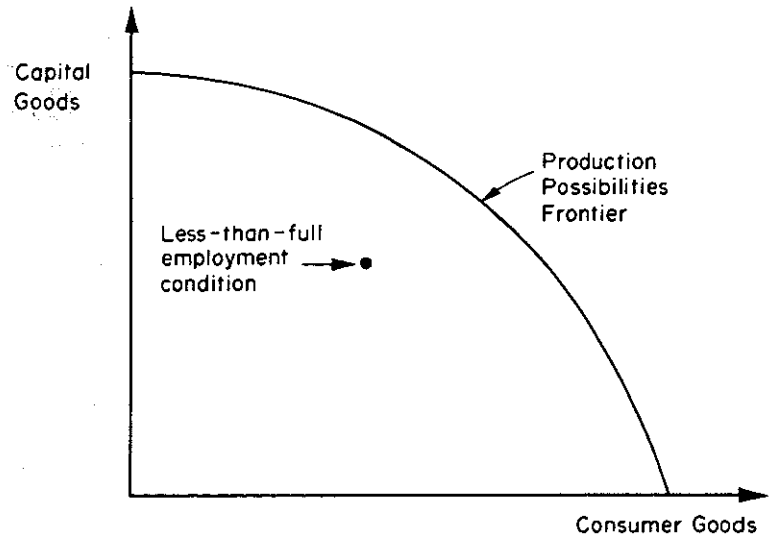

Fig. 5. Production Possibilities Frontier

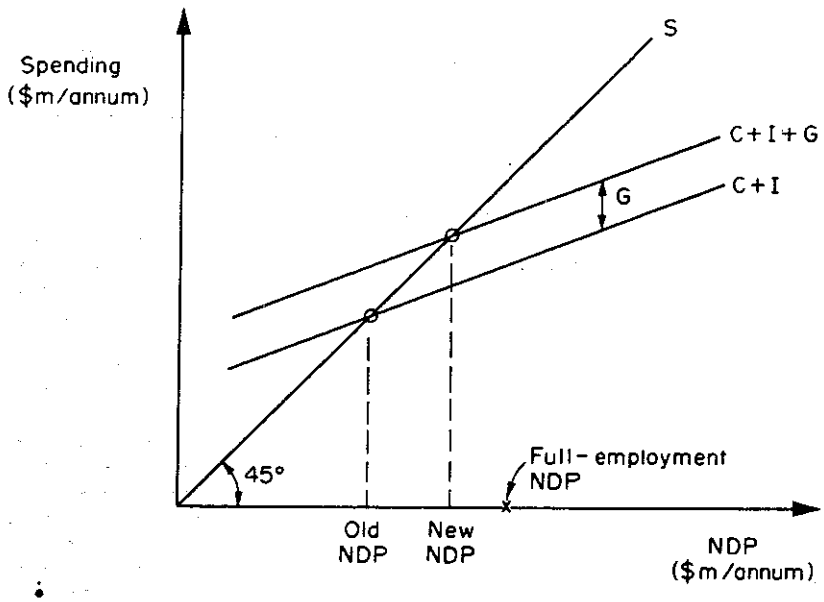

Fig. 6. The Effect of Government Investment (G) on Equilibrium NDP.

From the above discussion it can be seen that judicious use of government investment during periods of recession can help to increase real NDP and reduce unemployment. One might therefore expect that large public sector investment areas might be examined for their effect on such factors. Such an expectation is not, however, realised in practice. The following section of the paper will describe the method of economic evaluation employed in transport project evaluation. In particular, it will concentrate on the evaluation of road safety projects since several aspects of this type of evaluation have direct macroeconomic implications.

CONVENTIONAL METHODS OF TRANSPORT EVALUATION

The conventional method of economic evaluation of transport accident countermeasures is firmly based on cost-benefit analysis employing the Hicks-Kaldor criterion. As such, it follows several relatively well-defined steps as follows:

(a) Identification of Costs and Benefits
(b) Measurement of Costs and Benefits
(c) Valuation of Costs and Benefits
(d) Conversion to Present Values
(e) Comparison of Costs and Benefits
(f) Selection of Project(s)

Identification of Costs and Benefits

The first step in the economic evaluation, or cost-benefit analysis, of accident countermeasures is to identify the costs associated with the countermeasure and the benefits resulting from the countermeasure. Another way of thinking of this is by using the idea of inputs to and outputs from an accident countermeasure project. The inputs are invariably costs, whilst the outputs may either be benefits or costs (negative benefits). The inputs generally fall into three categories; capital costs, operating costs (such as enforcement costs), and maintenance costs (of safety equipment). The benefits are generally the reductions in accidents resulting from the project. It should be realised, however, that some types of accidents may be increased, while there may be other negative benefits arising from the project (such as increased travel time).

Measurement of Costs and Benefits

The measurement of costs and, more particularly, benefits of safety projects has been the subject of many papers in the literature. Measuring the changes in accident occurrence which occur as a result of the introduction of a particular countermeasure is the focus of attention of many safety studies, particularly by means of before-and-after studies. As noted elsewhere (e.g. Gipps, 1983), careful statistical design and analysis is necessary to ensure that statistically significant changes in accident occurrence are being observed. Whilst such studies can show whether *statistically* significant changes have occurred, it is the objective of economic analysis to show whether *economically* significant and desirable changes have occurred.

Valuation of Costs and Benefits

The valuation of the costs and, more particularly, the benefits of accident countermeasures is the most contentious of the steps involved in the evaluation process. Because there is no market for accident reductions, the value of reductions in accident occurrence should be determined by means of shadow prices inferred from the willingness-to-pay concept. This is often referred to as *ex-ante* valuation, wherein estimates are made of the value which people would assign to a reduction in the probability of a particular type of accident.

In practice, however, nearly all past accident countermeasure evaluations have relied on *ex-post* costing of accidents, wherein the consequential costs of accidents have been used as a measure of the value of eliminating those accidents. In listing the costs associated with particular types of accidents, a framework proposed by Reynolds (1956) is often used:

(a) Direct Costs

- Damage to vehicles, goods and property;
- Costs associated with loss of use of vehicles;
- Cost of medical treatment for accident victims;
- Administrative costs associated with the accident e.g. police attendance at scene, insurance company costs, legal costs;
- Level of service costs imposed on other users of the facility in terms of delay etc.

(b) Indirect Costs

- The loss of productive output by persons killed or injured;
- The loss of consumption by those persons killed;
- The transfer of income from those killed to other members of society.

(c) Intangible Costs

- The pain and suffering incurred by the accident victim;
- The pain and suffering incurrd by relatives and friends of the accident victim;
- The fear and anxiety suffered by the general community because of the risk of being involved in an accident.

All major Australian studies of accident costs have used *ex-post* costing techniques. These include the studies of Troy and Butlin (1971), Paterson (1972) and, more recently, Atkins (1981). In each of these studies, the intangible costs are not quantified due to measurement difficulties but it is generally argued that "the use of *ex-post* accident cost procedures provides only an irreducible minimum value" of the social consequences of accidents (Wigan 1980). The use of *ex-post* unit costs is therefore argued to provide a minimum value of the benefits of accident reductions. A typical breakup of the components of *ex-post* unit costs, as given by Atkins (1981), is shown in Table 1. The unit costs derived by Atkins (1981) are fairly representative of unit costs used by other transport authorities in Australia as shown in Table 2.

TABLE 1 COMPONENTS IN ACCIDENT UNIT COSTS

COST COMPONENT	TYPE OF ACCIDENT			
	FATAL	INJURY	PROPERTY DAMAGE	AVERAGE ACCIDENT
Forgone Income	128,690	950	-	870
Losses to Family, Community	38,600	290	-	260
Medical, Hospital	2,020	2,010	-	260
Vehicle Damage	3,400	2,110	670	860
Other (including traffic delay, insurance admin., legal costs)	5,380	1,060	510	610
TOTAL	178,090	6,420	1,180	2,860

SOURCE: ATKINS (1981)

TABLE 2 ACCIDENT COSTS USED IN AUSTRALIA

TYPE OF ACCIDENT	BTE 1976	NCDC 1976	MRD (WA) 1976	TARU (NSW) 1976	ATKINS 1981
FATAL	115,000	122,000	131,000	156,000	178,090
INJURY	5,200	6,400	2,900	-	6,420
PROPERTY-DAMAGE	900	1,250	-	1,100	1,180

Note: BTE: Bureau of Transport Economics.
NCDC: National Capital Development Commission
MRD(WA): Main Roads Department of Western Australia.
TARU(NSW): Traffic Accident Research Unit of N.S.W.

Whilst there are debates over numerous details in the calculation of *ex-post* costs (see e.g. Atkins, 1981), the major controversy has been with respect to the indirect economic costs of an accident. In particular, the decision as to whether to use *gross* future earnings as a measure of contribution to productivity, or *net* future earnings (i.e. minus future consumption) has raised considerable debate. Before entering this debate, however, it is as well to explain why future earnings of the individual involved in the accident are used at all in the evaluation. The argument is

that if an individual is (say) killed in an accident, then there is an economic contribution which is lost to society. This contribution, or productivity, is best measured by an amalgamation of the individual's future earnings. This procedure relies, however, on several key assumptions:

(i) The future earning potential of an individual can be estimated;
(ii) Earnings are a good indication of an individual's economic contribution to society; and
(iii) An individual cannot be replaced (economically) by anyone else.

The validity of these assumptions will be examined in more detail later in this paper.

Some (e.g. Dawson, 1967) have argued that future productivity is not an adequate measure of an individual's economic impact on society. They argue that net future earnings (i.e. earnings minus consumption) is a more appropriate measure, since when an individual is killed, society benefits by not having to provide for his consumption as well as being penalised by the reduction in his production. It has been counterargued, however, that the use of net future earnings is inappropriate since it implies negative economic values of net present worth for both elderly people and very young children (see, for example, Wigan (1980) and Figure 7). Elderly people have negative

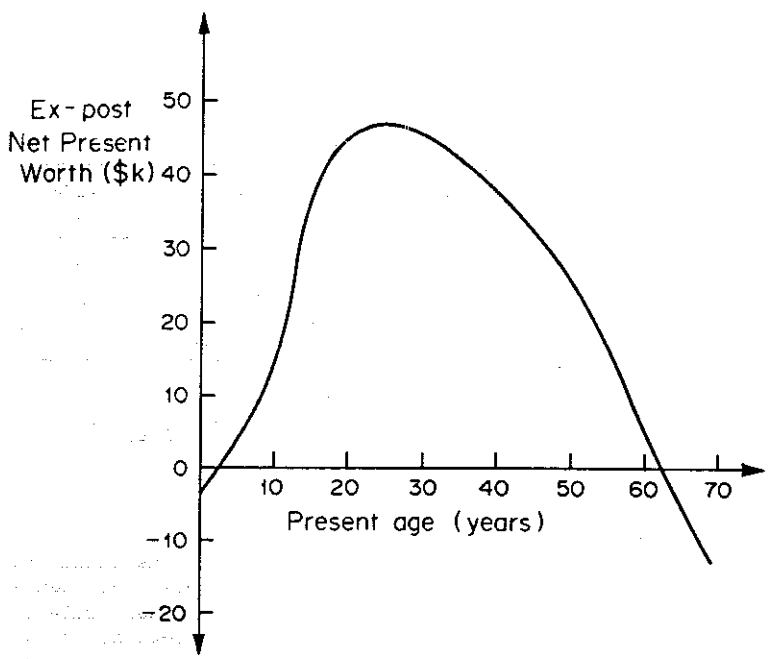

Fig. 7. Ex-Post Net Present Worth.

economic values because while they will continue to consume, they will produce little, if anything, of economic value. Very young children, on the other hand, have lifetimes of both production and consumption ahead of them. However, their productive lives will not commence for approximately twenty years whilst their consumption starts immediately. Therefore, using any reasonable discount rate on future costs and benefits, the net present worth of young children's lives will be negative. The current concensus then is that *gross* future earnings should be used as the measure of an individual's economic contribution to society.

Whilst a considerable body of literature has been amassed on the subject of accident unit costs (especially using *ex-post* methods), it is the contention of this paper that much of the debate contained therein has been irrelevant to the topic of the value of accident reduction under current economic conditions. This claim will be expanded upon later in this paper; for the moment, however, consider that appropriate unit costs can be derived for the different types of accidents so that this section of the paper on cost-benefit analysis can be completed.

Conversion to Present Values

Given that the costs incurred in provision of the countermeasure and the benefits accruing therefrom will occur at different points in time, it will be necessary to convert all future costs and benefits back to present day values. This conversion is performed using the standard discounting formula:

$$PV_o = \frac{FV_n}{(1 + i)^n} \qquad (1)$$

where PV_o = present value at time zero

FV_n = future value at time n

i = discount rate per time period

The critical factor in this conversion to present values is the choice of an appropriate discount rate. Underlying the selection of a discount rate are the concepts of a Social Opportunity Cost Rate (which measures the opportunity cost for inputs to the project which are not used for something else) and a Social Time Preference Rate (which measures the preference by the community for consumption of benefits now, rather than at some time in the future). Heggie (1972) provides a good description of these two concepts. The actual selection of a discount rate will normally be based on maintaining compatibility with other evaluations, although the choice of discount rate should be subject to sensitivity tests (see Treasury Department, 1978).

Comparison of Costs and Benefits

The comparison of present values of costs and benefits serves two distinct functions; firstly to determine the economic viability of the project and secondly, to assist in the selection of projects where multiple alternatives exist. Both tasks generally rely on the use of *economic evaluation indices* which attempt to summarise the results of the comparison into a single index of economic worth. The three indices which have been used most often in

project evaluation are the net present worth, the benefit cost ratio, and the internal rate of return. For various reasons the net present worth (which is defined as the difference between the present value of all benefits minus the present value of all costs) is generally favoured. A project is deemed to be viable if the net present worth (NPW) is greater than zero.

Selection of Project(s)

It should be noted that obtaining a positive net present worth for a project does not mean that the project should necessarily be implemented; it simply means that *if* the project was to be implemented then the benefits would exceed the costs. To determine whether it should be implemented requires that it be compared with other acceptable projects (i.e. other projects with NPW > 0). In performing this comparison, account should be taken of budgetary constraints (over either one time period or a series of time periods), mutually exclusive projects, and dependent projects.

A RE-APPRAISAL OF ACCIDENT EVALUATION PROCEDURES

It was stated in the previous section of this paper that much of the work on the valuation of accident reductions was currently irrelevant to the economic evaluation of road safety proposals. This section of the paper attempts to explain why this may be so. In particular, it will show that while *ex-post* unit costs may be of some use in road safety project evaluations, they are presently being misused and yielding spurious results.

The Systems Planning Process

A fundamental problem with current methods of accident evaluation is that they are not developed and used within an overall systems planning framework. Because of this, many elements within this framework are ignored in current road safety evaluation studies. One representation of this planning framework (Richardson and Graham 1980) is shown in Figure 8.

Whilst all elements in this process are important in ensuring a comprehensive evaluation of road safety proposals, it is evident that each of these elements has received a different amount of attention in previous studies. In particular, the goals and objectives of road safety evalution studies have rarely been clearly defined, whilst the definition of system boundaries has, almost universally, been neglected. These two elements of the planning process are closely related and discussion of each requires consideration of the other. Consider, first, the definition of system boundaries.

Definition of system boundaries

The system boundaries specify the limits of the system to be considered in the evaluation. These boundaries should be specified in at least three dimensions as shown in Figure 9. These dimensions cover the spatial, social and temporal boundaries to the system. For road safety evaluation studies, the spatial boundary defines whether the evaluation is to consider effects only at the site at which the countermeasure is implemented, whether it is to consider possible effects upstream and downstream of that

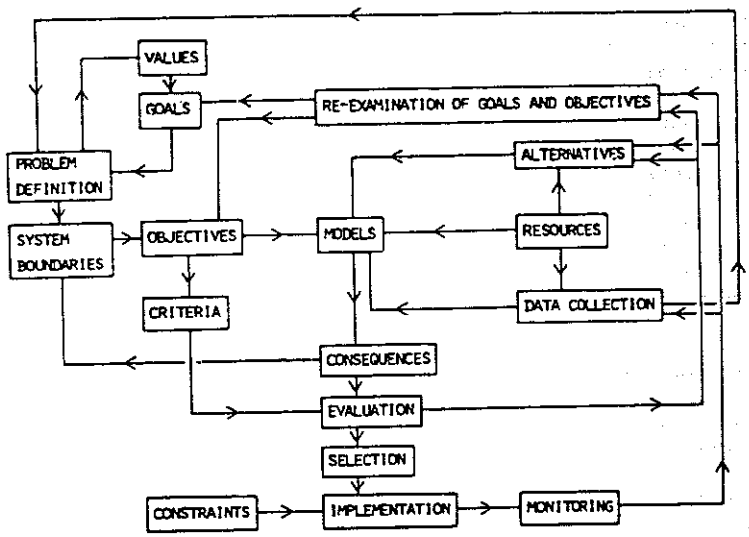

Fig. 8. The Transport Systems Planning Process.

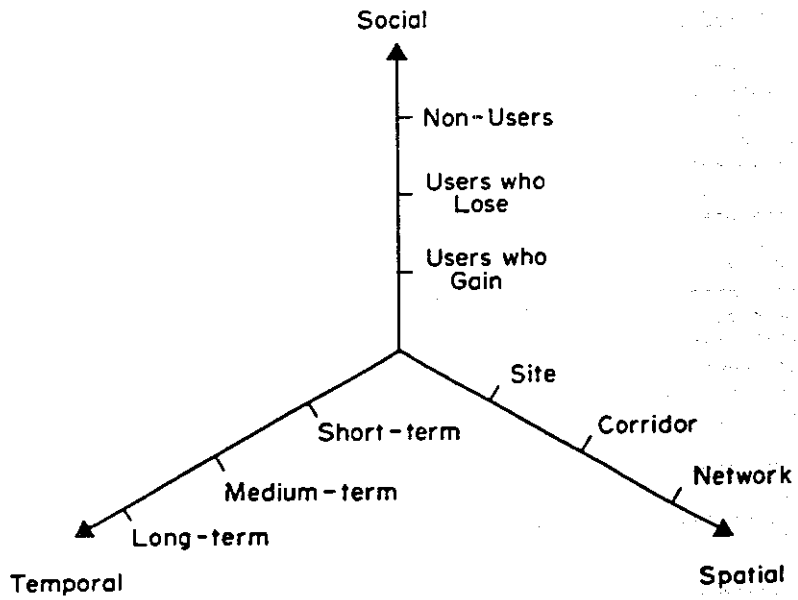

Fig. 9. System Boundaries for Evaluation Studies.

site within a corridor, or whether it is to consider effects outside of that corridor in a wider network perhaps because of the diversion of traffic away from the site at which the countermeasure was implemented.

The social dimension of system boundaries describes who is to be included in the evaluation. For transport project evaluation, the social categories consist of users of the transport system who gain from implementation of the proposal, users who lose as a result of implementation, and non-users who are in some way affected by the proposal. In road safety project evaluations, it is usually the case that the first two groups are reasonably accounted for (at least with respect to changes in accidents). However, as will be seen later, non-users are most often neglected.

The temporal dimension accounts for the fact that some transport proposals take some time before their effects are fully realised. Alternatively, the effects of some proposals may diminish over time after an initially large impact. For example, the impact of random breath-testing may have a large initial impact as drivers initially overestimate the probability of being selected for roadside testing. However, with experience, drivers may well learn that the probability of being apprehended is not as large as was initially perceived. Similar changes over time may also occur with other media campaigns which attempt to change drivers attitudes towards road safety. Obviously, the selection of a temporal boundary for an evaluation could have a large effect on the overall results of an evaluation of such countermeasures.

Definition of goals and objectives

The definition of specific goals and objectives is essential to all good management and planning practice. In some projects these objectives may appear to be relatively straightforward, whilst in others they may be quite obscure. In all cases, however, the definition of objectives is essential to the later selection of criteria against which the success, or otherwise, of a project will be evaluated. This is especially the case for public sector evaluations where there are often numerous conflicting objectives.

Whilst the definition of objectives is important, it is the norm in transport project evaluations, including road safety evaluations, to neglect to define explicit objectives for the evaluation study. For example, what is the explicit objective of road safety programs: *why* do we wish to reduce the number and severity of road accidents? Only if this question can be answered fairly precisely can we be confident that road safety projects are directed at achieving their objectives.

In attempting the definition of appropriate objectives for road safety proposals, consider some given by Heggie (1972) in the context of national public sector evaluation. Among others, he sees four such objectives as being:

(a) Maximise National Income

(b) Increase Average Consumption per Capita (i.e. raise standard of living or quality of life)

(c) Increase (or decrease) employment

(d) Redistribute Consumption (or Income)

Given these general objectives, and the conflicts inherent therein, it is clear that the objectives of road safety evaluations need to be clearly defined if one is to know when success has been achieved in obtaining them. Whilst explicit road safety objectives have rarely been stated, it is possible to infer implicit objectives from previous evaluation studies. It is clear that improving the quality of life is a major objective. Most studies mention that the alleviation of pain, suffering and anxiety caused by traffic accidents is a major benefit of road safety proposals. Certainly, public and political concern with road safety appears to be centred on quality of life considerations. Unfortunately, however, because such quality of life improvements are difficult to measure and value, it is precisely these effects which are invariably omitted from comprehensive treatment in most evaluation studies.

In the majority of road safety studies, where economic analysis is attempted, it appears that the concern is with efficiency and, implicitly, national income considerations. Thus most studies conclude that if the costs of an accident countermeasure are less than the *ex-post* costs of the accidents which would be prevented, then investment in that countermeasure is economically efficient in that either it increases the national income or else it increases the nation's standard of living (purely on the basis of the *ex-post* economic costs and not considering the *intangible* quality of life improvements). It is considered, however, that the use of *ex-post* costs in this way is misleading because of inadequate attention being paid to the system boundaries for the evaluation, and to the macroeconomic implications of the third and fourth objectives noted by Heggie (1972). To explain the reasoning behind this assertion, consider the concept of the Zero-Sum Society recently formalised by Thurow (1980).

ROAD SAFETY AND THE ZERO-SUM SOCIETY

The concept underlying the main argument presented in this paper is that of the Zero-Sum Society (Thurow 1980). In essence, this concept states that many economic systems (i.e. societies) have a substantial "zero-sum-game" element in them. A zero-sum-game is any situation where the losses exactly equal the winnings. All competitive sporting events are zero-sum-games. For every winner there is a loser, and winners can only exist if losers exist. In a national economy, the Zero-Sum element can only be overcome if there is a substantial excess of exports over imports. In this case, winners can be winners on the basis of profits made on the exports, whilst there need not necessarily be any losers within the nation; the losers in this case are residents of other nations.

The concept of the Zero-Sum Society is really just a more graphic description of the conflicts inherent in the objectives described by Heggie (1972). As such it is intimately associated with the definition of system boundaries, as shown in Figure 10. Consider the system boundary depicted by the small circle (system 1) in Figure 10. A transfer of benefits from individual A to individual B will have no effect on the income of system 1; there will simply be a redistribution of income (or benefits) within system 1. Thus while it may be a contribution toward the achievement of the fourth of Heggie's objectives (i.e. the redistribution of consumption), it has no effect on the first objective (i.e. the maximisation of national income). A transfer of benefits from individual A to individual C, however, will represent a loss

of income to system 1. However, if we consider the larger system 2, the transfer from A to C no longer represents a loss of income to the system but merely a redistribution within the system. Clearly as the system boundaries are widened, more of the economic transactions are internalised within the system and it becomes more like the Zero-Sum Society described by Thurow (1980).

The transaction between A and B is an example of a zero-sum-game. Individual A loses a certain amount of benefits but individual B gains an equal amount of benefits. To system 1, the net result is a zero-sum*. In most real transactions the transfer of benefits is not entirely one-way; although A may give B a certain amount of money, B may also give A benefits in the form of services rendered. The transfer shown in Figure 10 is merely the net effect of the transaction. The only way in which the transaction between A and B could be detrimental to System 1 is if B, instead of providing services to A, could be usefully employed in earning income outside of System 1. The difference between the value of services provided to A and the value of income which could be earned outside of System 1 is the opportunity cost of the services provided by B.

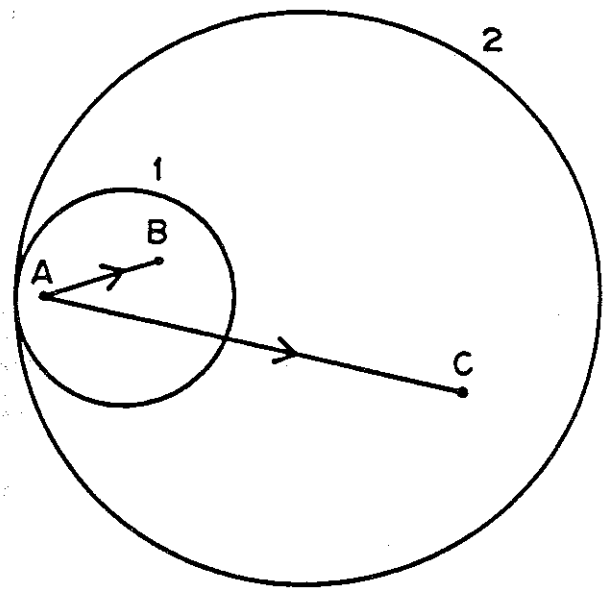

Fig. 10. The Effects of System Boundary Changes on System Income.

* (We assume here that, as in most transport evaluations, equal monetary benefits have equal subjective utility to individuals A and B).

Let us then apply these principles to the evaluation of road safety proposals. Consider firstly an average property damage accident as described in Table 1. The total *ex-post* cost of this accident is $1180. Conventional accident evaluation practice would assume that if this accident could be prevented by an outlay by the community of less than $1180 (say $1000), then it would be economically justified because the benefits (a savings of $1180) are greater than the costs ($1000). An amount of $180 would either be added to the national income or else would constitute an increase in the national standard of living equivalent to $180. Such a conclusion however can only be justified under fairly strict conditions.

To demonstrate this, consider the chain of transactions which follows either the expenditure of $1180 as a result of the accident or the expenditure of $1000 as a result of implementing the countermeasure. Of the $1180, $670 is attributable to the repair of vehicle damage. Of this amount, a certain (large) proportion will consist of wages paid to panel-beaters, materials suppliers and others employed in the vehicle repair industry. Another (small) proportion will be paid for raw materials used in the repair industry (e.g. paints, metal parts, etc.). If both the labour and the materials are obtained from within Australia (assuming that road safety is a national problem which requires the use of Australia as the system) then the transactions following the expenditure of $670 on repairs will constitute a zero-sum-game provided that the following conditions apply:

(a) The labour employed in vehicle repair has no opportunity cost. In times of low unemployment this condition may not be met. However in current conditions of high unemployment it is more than likely that this condition is true. If panel-beaters etc. cannot be usefully employed in some other activity which is capable of earning export income then the opportunity cost of such labour in economic evaluations is zero (Anderson and Settle, 1977).

(b) The opportunity cost of the raw materials is zero. As with labour, if the materials used cannot be used in alternative manners to earn export income then their opportunity cost to the nation is zero. This condition is perhaps less likely to be upheld, although in a world economy where there is a resources glut (e.g. of minerals, oil, coal) this may be the case for some materials. The materials needed in vehicle repair would need to be the subject of special investigation.

If the labour or the materials used in vehicle repair are obtained from outside Australia then this results in a resource cost to the nation for vehicle repairs. It is unlikely, however, that any vehicle repairs are performed by overseas labour (although replacement vehicles may well be obtained from overseas sources) whilst the source of raw materials used in vehicle repairs would need to be determined.

To the extent that the labour and materials used in vehicle repair do not have zero opportunity cost, then the resource cost of vehicle repair will be non-zero. Under current economic conditions, however, it is probable that the resource cost of vehicle repairs (to the Nation) will be considerably less than the *ex-post* cost (of $670) currently used in accident evaluations.

The above argument applies equally to the other components of the property damage accident *ex-post* cost, and also to the cost of the accident countermeasure. Thus the cost of the countermeasure will be composed of wages paid to traffic safety authority personnel involved in the design, implementation and evaluation of the countermeasure, and of money paid to the suppliers of road safety countermeasure equipment (e.g. street lighting, traffic signals, etc.). Once again, the resource cost of the countermeasure to the community (the nation) will only consist of the opportunity costs associated with the countermeasure. For similar reasons as given above, it is likely to be substantially less than the $1000 mentioned earlier in this section.

Consideration of zero-sum-games, system boundaries and opportunity costs leaves us with a situation where the economic resource costs to the community of the accident and its countermeasure are both substantially less than the *ex-post* costs used in previous evalutions. Not only are they lower than the *ex-post* costs, but the ordering of the magnitudes of the *ex-post* costs may also be reversed. On the basis of resource costs to the community, the cost of the accident in the above example may be lower than the cost of the countermeasure if, for example, the countermeasure required considerable expenditure on equipment purchased from overseas. In the case where both the accident and the countermeasure have zero opportunity cost, a perfect zero-sum-game exists with respect to each. Irrespective of whether there exists a perfect or a partial zero-sum-game, the computation of *ex-post* costs is irrelevant to any decision based on Heggie's first objective concerning national income unless one chooses to measure national income in the artificial manner critiqued by Jones (1982). What are required are the resource costs of accident and countermeasure, not the *ex-post* costs.

The use of *ex-post* costs to measure qualify-of-life improvements is also invalid for much the same reasons. Whilst certain individuals may enjoy quality-of-life improvements by the prevention of accidents, the nation as a whole will not benefit to the same extent. For example, it has been argued that if a motorist did not have to spend money on vehicle repair (assuming for the moment that it is the motorist who meets these costs) then he would be able to spend that money on some other purchase, such as a video-cassette recorder, which would give him greater pleasure (i.e. improve his quality of life) than would spending the money on vehicle repair. From the point of view of the motorist (a very small subsystem within the national system), the above argument is obviously correct and is not at all at variance with the thrust of this paper. What this paper states is that if the motorist must spend his money on car repairs, then it is now the panel-beater who is able to buy the video-cassette recorder and thereby improve *his* quality-of-life. The quality of life of the nation is improved by the same amount (i.e. one video-cassette recorder's worth); it is just a case of whose quality-of-life is improved.

One must also consider in this argument whether the expenditure patterns of the motorist and the panel-beater are the same. If the motorist would spend the money on a video-cassette recorder, which is imported from overseas, while the panel beater would spend it on more basic commodities such as food, which is grown in Australia, then as well as having a transfer of quality-of-life improvements there may also be different effects on the national income.

What comes out of the above arguments is that while *ex-post* costs are generally useless in assessing the worth of accident countermeasures with respect to the first and second of Heggie's objectives, they are quite useful in assessing the impacts with respect to the third and, especially, the fourth of his objectives (i.e. the redistribution of consumption). Tracing the flows associated with *ex-post* expenditures on accidents and countermeasures enables the distributions of costs and benefits to be established. One then needs to decide whether the distribution of consumption associated with the accident or the countermeasure is to be preferred. The use of *ex-post* costs to assess distributional effects, rather than efficiency effects, is quite contrary to conventional practice but is more in line with the realities of the current economic situation.

Similar arguments can be applied to the evaluation of fatal accidents. Consider the average fatal accident shown in Table 1. Of the total cost of $178,090, the majority is attributed to the forgone income of the individual killed in the accident. Remember that this forgone income represents the economic opportunity cost of that individual to society. However, in a period of recession and high unemployment, this amount is an obvious overestimate of the opportunity cost of that individual. When that individual is killed, his economic contribution to society is not totally lost. Someone else will fill his job (and so on) with the total productive labour force staying constant before and after the accident. Only in times of full employment will that individual be economically irreplaceable. Therefore, in times of high unemployment the economic opportunity cost of most individuals (except those with unique skills) will be zero. The same conclusion can be reached by means of the Zero-Sum Society argument. The loss (of a job) experienced by the individual who is killed is exactly balanced by the gain (of a job) to someone else who was previously unemployed. Similarly the losses to family and community identified in Table 1 are balanced by the gains to someone else's family (who now have a breadwinner).

The use of conventional *ex-post* costs for fatal accidents is therefore currently inappropriate. This conclusion is not particularly new; it was recognised by Troy and Butlin (1971) who stated that *ex-post* costs could only be used when "all the factors of production were fully employed", i.e. when we are on, not inside, the production possibilities frontier shown in Figure 5. However, others who have either used or updated Troy and Butlin's figures have not taken account of this restriction, with the result that the use of *ex-post* valuations, and the concepts embodied in them, have been perpetuated blindly.

A RE-APPRAISAL OF THE VALUE OF INTANGIBLE EFFECTS

The above discussion may sound highly clinical in that it recommends the evaluation of accident countermeasures based on whether they increase the national income and after consideration of who benefits from the occurrence of accidents. It should be realised however that the above argument is based solely on the quantifiable economic costs which are observable in financial transactions. No account has been taken of the community's emotional desire to reduce accidents on the basis of pain, suffering and anxiety caused to accident victims and the rest of the community. Remember though that in conventional accident evaluations, these intangible costs are also neglected on the grounds that they are too difficult to measure. The usual rule-of-thumb has been to assume that the true cost of an accident is greater than the calculated *ex-post* amount by some unspecified amount to account for the intangible costs.

In the light of the arguments in the previous section, however, where it was shown that the resource costs to the nation are substantially less than the *ex-post* cost (and perhaps equal to zero), the above rule-of-thumb can no longer be applied. After decreasing the *ex-post* cost to obtain the resource cost and then increasing it by some amount to account for intangible costs, where do we finish up; above or below the original *ex-post* cost?

If accident countermeasures are to be evaluated on the basis of their contribution to an increase in the economic and emotional quality of life of the nation then there is no alternative but to devote greater attention to measuring the value of accident reductions with respect to the intangible qualities of pain, suffering and anxiety. Such greater attention, whilst being essential, theoretically, may also be more in line with community and political response to traffic accidents.

One important consequence of this redirection of effort would be that greater efforts would be made to reduce fatal and injury accidents rather than property damage accidents, because whilst there are emotional costs associated with property damage accidents, it is to be expected that these costs would be higher for injury and fatal accidents. This redirection of effort to reducing fatal and injury accidents is perhaps contrary to current trends in accident evaluation studies which attempt to show the high incidence and high total costs associated with property damage accidents (Searles 1980; Wigan 1980; James 1983). This redirection of effort must, however, consider that while property damage accidents may have relatively little emotional cost, and little effect on the national income they may provide a more desirable redistribution of income than either fatal or injury accidents. Therefore research on property damage accident costs is not entirely wasted.

Research on the emotional costs associated with accidents has already begun, although in a minor way compared to the attention devoted to *ex-post* costing. The assessment of *ex-ante* "willingness to pay" values of accidents has been studied by Jones-Lee (1969, 1976), Bodily (1980) and others, and these studies are discussed by Wigan (1980) and Atkins (1981). The general conclusions re *ex-ante* values are that measurement techniques are not yet well-developed and that, as a consequence, the reliability of estimated *ex-ante* values is not high compared to *ex-post* values. One should however note the difference between reliability and applicability of such values. This may best be summarized by a quote from Tukey (1962) in which he advises "Far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise". *Ex-post* values are not better than *ex-ante* values simply because different researchers can obtain the same results for *ex-post* values; reliability is a desirable but not sufficient property of such estimates.

Given that *ex-ante* valuation studies appear to be more appropriate for measuring the intangible value of accident reductions, it is still important that such studies observe the conditions governing objectives and system boundaries described earlier. For example, it is important that *ex-ante* valuations of accident reduction be obtained from a representative selection of the entire community, not just from those who are potential accident victims. Alternatively it would be necessary to ensure that people gave a value only for the emotional costs associated with accidents and not for the financial costs which they will incur if they are involved in an accident.

This distinction is necessary to ensure that the emotional costs (to which Zero-Sum does not presumably apply) are separable from the financial costs (to which Zero-Sum does apply). It may however, be very difficult, if not impossible, for humans to make this distinction. Therefore one should ensure that people who stand to gain financially from accidents are included in the sample to balance those who stand to lose financially. In this way, the net result will approach an *ex-ante* valuation of emotional costs only.

CONCLUSIONS

This paper has described the conventional approach to the economic evaluation of traffic accident countermeasure proposals, and has then proceeded to show that serious deficiencies exist in conventional practice because of its lack of adherance to an adequate systems planning process and its non-consideration of current macroeconomic conditions. In particular, it has argued that conventional analyses are deficient in the definition of specific objectives for the evaluation, and in the definition of system boundaries. As a result of this, the paper reaches several specific conclusions:

(a) The conventional method of calculating the net present worth of a proposal using the *ex-post* cost of accidents and the cost of countermeasures is an inappropriate way of obtaining the economic efficiency of the proposal;

(b) Efficiency, or national productivity, effects can only be calculated by determining the opportunity costs to the nation of labour and materials used either as a consequence of the accident or in prevention of the accident;

(c) The total social cost of accidents is not necessarily higher than the *ex-post* costs as presently calculated;

(d) *Ex-post* costs as presently calculated are primarily of use in examining the distributional effects of accident occurrence and prevention;

(e) Greater emphasis needs to be placed on the intangible emotional costs of accidents and their impact on the nation's quality-of-life;

(f) *Ex-ante* willingness-to-pay methods, which account for appropriate system boundaries, need to be developed to estimate the emotional costs of accidents;

(g) System boundaries need explicit definition in traffic accident evaluation studies, especially along the social dimension.

Whilst this paper has cast doubts on current methods of placing economic values on accident reductions, it does not question the need to obtain such values. Decision-makers are still faced with the problem of allocating funds to competing road safety projects and to other transport projects. To do so they need to know how much they should spend on each project. What this paper suggests is that we look again at the basic

assumptions underlying previous work in the area of transport safety evaluation and, by implication, other areas of transport and public sector investment evaluation.

REFERENCES

ANDERSON, L.G. and SETTLE, R.F. (1977) Benefit-Cost Analysis: A Practical Guide, (Lexington Books, Massachusetts).

ATKINS, A.S. (1981). The Economic and Social Costs of Road Accidents in Australia: with preliminary cost estimates for Australia 1978. Office of Road Safety, Report CR21.

BODILY, S.E. (1980). Life Risk Analysis. Operations Research, 28(1), pp. 156-175.

DAWSON, R.F.F. (1967). Cost of Road Accidents in Great Britain. Road Research Lab. (U.K.), RRL Lab. Rep. LR79.

GIPPS, P.G. (1983). "Statistical Considerations", in D.C. Andreassend and P.G. Gipps (Eds.) Traffic Accident Evaluation, Monash University.

HEGGIE, I.G. (1972). Transport Engineering Economics. (McGraw-Hill, London).

JACKSON, J. and McCONNELL, C.R. (1980). Economics: Australian Edition, (McGraw-Hill, Sydney).

JAMES, G.H.H. (1983). A Study of Accident Costs and Accident Type. ESSO-Monash Workshop on Traffic Accident Evaluation, Monash University.

JONES, B. (1982). Sleepers, Wake! Technology and the future of work. (Oxford University Press, Melbourne).

JONES-LEE, M.W. (1969). Valuation of Reduction in Probability of Death by Road Accident. Journal of Transport Economics and Policy, 3(1), pp. 37-47.

JONES-LEE, M.W. (1976). The Value of Life: An Economic Analysis. (Martin Robertson, London).

PATERSON, J. (1972). Review of the Cost of Road Accidents in Relation to Road Safety. Commonwealth Dept. of Shipping and Transport, Canberra.

REYNOLDS, D.J. (1956). The Cost of Road Accidents. Journal of the Royal Statistical Society, 119(4), pp. 393-408.

RICHARDSON, A.J. and GRAHAM, N.R. (1980). Objectives and Performance Measures in Urban Traffic Systems. Seminar on Fuel Consumption, Vehicle Emissions and Vehicle Design, SAE-A/ARRB, Melbourne.

SEARLES, B. (1978). A Study of Uncoded Accidents in Sydney. M. Eng. Sc. Thesis (unpublished), Univ. of New South Wales.

THUROW, L.C. (1980). The Zero-Sum Society: Distribution and the Possibilities for Economic Change. (Basic Books, New York).

TREASURY DEPARTMENT (1978). Discounting in Australian Public Sector Project Analysis. Draft Paper, Canberra.

TROY, P.N. and BUTLIN, N.G. (1971). The Cost of Collisions. (Cheshire, Melbourne).

TUKEY, J.W. (1962). The Future of Data Analysis. Annals of Mathematical Statistics, 33, pp. 1-67.

WIGAN, M.R. (1980). Safety Evaluation - Some Explicit and Implicit Considerations. Proc. ARRB Seminar on Measuring Social Behaviour in Road Research, pp. 215-228.