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# INCLUDING THE ENVIRONMENTAL IMPACTS OF ROADS IN PROJECT EVALUATION AND DECISION-MAKING

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**TITLE:** Including the Environmental Impacts of Roads in Project Evaluation and Decision-Making

**ABSTRACT:** The environmental impacts of roads are of increasing community concern. There is growing recognition that the environmental impacts of road projects should be better included in project decision-making and project evaluation. As well as measuring environmental impacts, there is a need to better incorporate them into decision-making. Continued improvements in the technical methods of measuring and quantifying environmental impacts will be invaluable. However measurement is only part of the issue: impacts must also be compared with other project costs and benefits.

Assessment of impacts is discussed including non-monetary assessment of impacts and monetary valuation. It is argued that monetary valuation of environmental impacts would improve decision-making, as it would allow for more impacts to be quantified in a common unit, improve consistency and make trade-offs more explicit. There are a number of techniques available for monetary valuation. Methods which rely on hypothetical markets (contingent valuation and stated preference methods) offer great promise and have yet to be fully utilised in this context. As an indication of the costs of environmental impacts, some "real numbers" from several studies are presented.

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## INTRODUCTION

The environmental impacts of roads are of increasing community concern. There is growing recognition that the environmental impacts of road projects should be better included in project decision-making and project evaluation. As well as measuring environmental impacts, there is a need to be able to incorporate them into decision-making. The paper briefly discusses measurement of impacts. However measurement is only part of the issue. Assessment of impacts is then discussed including non-monetary assessment of impacts and monetary valuation. It is argued that monetary valuation of environmental impacts would improve decision-making. Finally, some "real numbers" on the costs of environmental impacts are presented.

## WHAT IMPACTS ?

Roads generally have mostly negative impacts on the environment. While new roads may allow higher speeds, reduced travel times and fewer vehicle stops/starts, this may be negated by the effects of induced demand. Roads can have direct environmental impacts on the physical environment and also impacts on humans resulting from changes in the environment. Thus a broad view of "environment impacts" includes concern about environmental impacts for their own sake, and for the consequential impact of environmental change on humans. The paper primarily refers to impacts arising from existence and use of roads, although lifecycle effects are briefly discussed. Some impacts occur regardless of the level of use of the infrastructure, while other impacts increase with use. The environmental impacts of roads and road use in general may be described as follows:

- *Air pollution*
  Air pollution impacts include the global scale impacts of greenhouse gas emissions (principally $CO_2$) which may be contributing to global warming through the enhanced greenhouse effect, as well as regional scale impacts such as smog in large urban areas, and local impacts such as ozone, lead, benzene and other toxic emissions. Health impacts include respiratory damage and cancer. Apart from human health, pollutants can cause material damage to buildings and damage to agriculture.

- *Noise pollution*
  Road transport is a major source of noise in urban areas. The effect of noise on human health is perhaps more difficult to determine: although people are unlikely to die from excess noise, noise can affect health indirectly through stress, annoyance, frustration, and impacts on sleep.

- *Physical systems*
  Impacts on natural systems may include changes in geomorphology, the physical structure and shape of the earth, including changes in slope and surface material. These changes may affect runoff and hydrologic patterns, contributing to flooding.

- *Living systems*
  As well as changes in physical structures, road works may cause loss of habitats and ecosystems, resulting in loss of flora and fauna, loss of biodiversity, and interference with ecological processes.

- *Water pollution*
  Apart from direct changes to water channels, there may be impacts on distant waterways from pollution of stormwater by contaminants such as oils, metals, and tyre residue deposited on roads.

- *Green space impacts*
  Roads may require the resumption of bushland, parks and recreation space, resulting in the loss of "green space", which has increasing importance in urban areas.

- *Visual/aesthetic impacts*
  The visual and aesthetic impacts of a number of current and proposed road projects in Sydney have been subject to debate including the Glebe Island Bridge, Woronora River medium level bridge, and the Cahill expressway.

A related impact which has a strong social component is community severance arising from the physical structure. Other impacts may include the physical structure blocking sunlight, views and impinging on privacy.

### Lifecycle impacts

The impacts described above relate to the existence and use of road infrastructure. However, there are also "life-cycle" impacts of road projects (also called cradle to grave impacts) including "upstream" and "downstream" impacts. The Victorian Transport Externalities Study (VTES) (EPA 1994) identified "upstream" externalities as those associated with the provision of infrastructure (such as quarrying for road construction materials) and the production of vehicles and fuel, while "downstream" externalities include those associated with the disposal of scrapped vehicles, used oil, batteries and tyres. There may also be impacts during the construction phase.

### Distribution of impacts

Some road projects may redistribute impacts from one area to another. For instance, rural bypasses remove noise from the town centre, and transfer it elsewhere, where it arguably has less impact on humans. A bypass may have a positive impact on one local environment and a negative impact on another in terms of noise, but overall there would be little difference in total emissions area-wide.

Another aspect to the distribution of impacts is whether, for any road project, the communities who bear the (environmental) costs, also gain the benefits. In many inner urban road projects, the local environment has suffered for the benefit of better access to and from the city for middle and outer suburb residents. These *intra-generational* impacts must also be recognised. The distribution of impacts over time also has important implications for *inter-generational* equity.

## MEASURING IMPACTS

The process of measuring environmental impacts includes establishing the existing level of environmental quality or amenity, determining the level after construction of the road project; and assessing the significance of the change, if any. Environmental Impact Assessment (EIA), and the production of an Environmental Impact Statement (EIS), is usually required for projects with large potential impacts on the environment. In an EIS, the impacts on different aspects of the environment are estimated, through prediction and environmental modelling.

For air and noise pollution there are standards that impacts are compared against. For instance, NSW Environment Protection Authority air quality standards for carbon monoxide are a one hour maximum of 31 milligrams per cubic metre, and for ozone, a one hour maximum of 12 parts per hundred million (Manidis Roberts 1994). Mathematical models (such as the Caline 4 dispersion model used for the M5 East EIS) can be used to estimate the total volume of emissions, and to model how the emissions will be dispersed, given climatic and topographic conditions.

Noise levels are usually expressed in terms of an index: common indices include $L_{eq}$ (time period) which is a measure of the average noise level in decibels over the time period of interest, and $L_{10}$ (time period), which is the noise level in decibels which is exceeded for 10% of the time over the period of interest. Although technically easy to measure, the relationship between these indices and the impact of noise on people is not always clear. As for air quality, there are standards or guidelines for desirable noise levels.

There are generally no standards for other categories of impacts. Impacts on natural systems are usually evaluated by experts in disciplines such as ecosystems, ecology, botany and zoology, and also physical environment experts in geology, geomorphology and hydrology. The experts present changes in units appropriate to the impact such as hectares/square metres of bushland to be destroyed, number of species which are likely to decline, increase in runoff in cubic metres, increased risk of flooding, or changes in stream channel width and depth.

Experts such as landscape architects are used to assess visual impacts. The visual impacts of projects can be indicated through the use of artists impressions such as photos or sketches showing the proposed project in its environment. The impacts are usually described qualitatively, using terms such as “substantial”, “significant”, or “negligible”.

## Uncertainty of impacts

It is important to note that there is often much uncertainty about environmental impacts. For instance, while levels of greenhouse gas emissions may be able to be measured, the contribution of those emissions to changes in global climate is harder to determine. The relationship between emissions and human health can also be uncertain and difficult to determine. Regarding air quality and health, the Victorian Transport Externalities Study (VTES) (EPA 1994) has outlined the many complex steps in the causal chain as follows:

traffic volumes —> total emissions/primary pollutants —> secondary pollutants —> air quality —> human exposure —> dose received —> health effects —> costs

As the VTES notes, the final estimates of costs at the end of the chain are clearly “influenced by the accuracy of information available for each of the preceding steps”, and any results are usually indicative, rather than definitive.

### Scale of impacts

Environmental impacts of transport (or just roads) can be looked at from a global perspective, from an urban wide perspective, or from a project level perspective. Different approaches for measuring, and assessing, impacts are called for, depending on the scale. Examples of the different scales of impacts include: what is the contribution of road transport in Australia to greenhouse gas emissions? vs what is the impact of noise from road traffic in Sydney? vs how will a particular project affect the habitat of a local endangered species? Attempts to cost environmental impacts or transport externalities have expressed the costs at different scales: at the national level in terms of proportion of GDP; city-wide estimates; or as costs per passenger km, as discussed later.

## INCLUDING IMPACTS IN DECISION-MAKING: NON-MONETARY METHODS

It is easy to get "weighed down" in the technical detail of measurement or prediction of impacts, but that is only part of the process of considering environmental impacts. There is also a need to address the significance of the impact, and a need for some means of weighing these impacts up against other costs and benefits of proposed road transport projects. There are non-monetary methods of assessment of environmental impacts, and monetary methods of assessment. Different approaches to non-monetary assessment of environmental impacts and inclusion in the decision-making and project evaluation process are discussed first, including limitations and problems.

### Simple scales

Several simple techniques for assessment include:

- qualitative scales, in which impacts may be classified, for instance, as substantially negative/positive, noticeably negative/positive, slight, or none; or
- scaled checklists, on which impacts are rated on a scale from say +5 to -5, or 0 to 10.

Using qualitative scales, the impacts may be described or ranked in terms of significance: for instance, the impact on vegetation may be "significant", while the impact on some other aspect of the environment, say water quality, may be described as "negligible". However the difficulty lies in comparing one "significant" impact with another "significant" impact. And are two "significant" impacts jointly more important than one "very significant" impact? If environmental impacts only are assessed using non-monetary methods such as these, it is difficult to compare the assessments with other traditional project costs and benefits: how to compare a "significant" impact on vegetation against travel time savings of say $2 million? Even if *all* project impacts are described using the scales, it is difficult to compare a "significant" impact on vehicle operating costs with a "significant" impact on green space. Other problems with these simple scales include determining the scale to be used and the relative numeric values to apply to different impacts.

### Rating and weighting

There are a number of non-monetary approaches which rely on giving different objectives, criteria or impacts weights reflecting their importance. Impacts are assessed by combining a rating on that criteria with the importance or "weight" of that criteria. The planning balance sheet utilises this approach. Multi-criteria analysis is another approach which overcome some of the problems with the very simple quantification and measurement methods by weighting different criteria. Multi-criteria analysis involves an evaluation or effectiveness matrix (showing what the project will achieve) and a priority matrix (showing how important different objectives are) which are mathematically combined to produce an appraisal matrix. However, different mathematical techniques for combining the matrices to produce an appraisal matrix can produce different assessments on the ranking of project options. An issue with all the weighting methods is the derivation of the weights. They are usually determined by experts. Even with community consultation, different community groups will have different ratings and weights for impacts.

### Decision rules and standards

Sometimes simple decision rules or standards may be used. A simplified decision rule could require that if a project or policy is not consistent with a particular objective, say, ecologically sustainable development, it be excluded from further consideration (EPA 1994), in effect a pass/fail criteria. Similarly, policies and projects can be considered according to whether they are compatible with the maintenance of scientific standards which may be set for instance to protect the health of the community (EPA 1994)). However, determining scientific standards may also be difficult: in setting a standard for biodiversity, what level of species loss can be tolerated in a particular area?

### Environmental impact assessment

While environmental impact statements can be a useful documentation of the existing environment in an area, the main focus of environmental impact assessment in practice is the measurement or quantification of the physical impacts on the environment, rather than any attempt to assess the environmental impacts in relationship to other project costs and benefits. The environmental impacts are in different units from other costs and benefits which makes comparison and weighing up difficult. There is little monetary valuation of environmental impacts conducted and reported as part of EIA.

In general, the non-monetary methods of including the environment in project evaluation tend to examine the environmental impacts in isolation from the traditional project costs and benefits. It is difficult to integrate the results of the non-monetary evaluation methods into other evaluation and assessment procedures, particularly cost-benefit analysis. Non-monetary methods may be appropriate in some cases, for some impacts, but not all impacts. An element of subjectivity exists, regardless of the technique chosen (EPA 1994: 20).

## INCLUDING IMPACTS IN DECISION-MAKING: MONETARY VALUATION

### Cost-benefit analysis

The most common method for project evaluation in current use is cost-benefit analysis, in which the stream of benefits to be derived from the project over time is weighed up against the project costs which will be incurred over the life of the project. The traditional benefits from road projects usually include travel time savings, vehicle operating cost savings, and accident reductions. These benefits are valued in dollars and included in the cost-benefit analysis (although there is controversy over valuation of travel time and the value of human life and injury to be used in valuing accident reductions). Project costs usually include land acquisition, construction and maintenance. If the ratio of benefits to costs is above a certain level, the project is considered favourable, and economically justified.

The cost-benefit method of project evaluation means that unless a monetary value can be placed on goods, those goods tend to be ignored in the evaluation procedure. As Bishop, Heberlein and Kealy (1983) note, “things with unknown economic values tend to be assigned zero or very low economic values in public decision processes”. Environmental impacts, generally being non-market goods, are difficult to value. Thus adverse impacts on the environment are not usually valued in dollar terms and summed up with other costs, rather they are identified and described separately from the other costs and benefits. The process by which environmental impacts are weighed up against the cost-benefit ratio, particularly when there are several options under consideration, is not clear to the community. Trade-offs are not systematically addressed. It is cynically suggested that if the environmental impacts of roads were usually benefits, more effort would have been made to value them.

There is a need for a better system to include environmental impacts in project evaluation. As noted in VTES (EPA 1994): “unless a formal mechanism is introduced for incorporating uncosted impacts in the decision process, they are likely to be ignored and decisions made on the basis of perhaps accurate but partial, cost information”. Putting a dollar value of environmental impacts is one way of allowing environmental impacts to be included in assessment. In cost-benefit analysis, price acts as a weight, allowing costs and benefits to be summed up.

## Benefits of valuation

On a project level scale, monetary valuation of environmental impacts would allow more impacts to be quantified in a common unit of $, thus improving comparison of costs and benefits; trade-offs would also be more explicit; consistency would be improved; and valuation would also assist in determination of project mitigation budgets.

### *Common unit*

Ideally, all costs and benefits should be expressed in terms of a common unit to enable different impacts to be compared. In a review of valuation methods, the Resource Assessment Commission (1992) noted that “the task of decision making is made easier as more and more of the consequences of actions become measurable in a common unit: comparisons between alternatives are then facilitated”. From a theoretical perspective, an ideal unit of measurement and comparison would be “utilities” or “satisfaction units”, in which all costs and benefits would be converted to “utilities”, measuring people’s degree of satisfaction, happiness or welfare. However, in reality this is very difficult, and the best practical common unit appears to be the dollar. Other commonly measured impacts of projects are quantified in terms of dollars and the dollar is easily understood, as people are used to expressing their preferences for many goods in dollar units and making decisions based on a good’s dollar value.

### *Explicit trade-offs*

Valuation allows any trade-offs which are made between different environmental impacts, and between environmental impacts and other impacts, to be more explicitly stated. The recently released M5 East EIS (Manidis Roberts 1994) contains several examples of implicit environmental values. For instance, an option to extend the Wolli Creek tunnel a further 1 km through Arncliffe at a cost of $82 million is “not considered justified”, without any attempt to value the benefits of reduced community severance and reduced visual impact.

### *Mitigation*

It is difficult to evaluate the appropriateness of project mitigation budgets without some valuation of the environmental impacts. In regard to the M5 East, it was decided that raising noise barriers from 4 to 5 metres to further reduce noise levels was “not economic". Similarly, there is no evidence with which to evaluate the appropriateness of the project's landscaping budget of $2 million.

### *Consistency*

To ensure that externalities are treated consistently with other costs and benefits in project evaluation, it is useful where practicable, for externalities to be assigned a monetary value. If the value of human life and health is included in cost-benefit analysis through valuing accident reductions, for the sake of consistency, the analysis should also include the value of any adverse impacts on human health arising from a project. Greater monetary valuation would also assist comparisons between projects.

Monetary valuation would also be beneficial on a wider scale.

### *Scale*

Monetary valuation of transport externalities is important as an indication of the scale of the problem and can assist in the formulation of policies to address externalities as estimates of the costs of externalities can be compared with the costs of measures that might be introduced to control or reduce the damage from externalities.

### *Pricing and subsidy*

On a wider scale, valuation can assist in debates about pricing and subsidy. The introduction of full-cost pricing of transport modes requires information about the environmental impacts of different modes and also the costs of different modes. The Ecologically Sustainable Development Transport Working Group noted that "the prices that individuals face for transport services when making their transport decisions do not reflect the full environmental costs imposed on society by those decisions" (EPA 1994:1). Thus the level of transport activity (and thus environmental impacts) are likely to be higher than is justified by the benefits that transport provides (EPA 1994). The question of subsidies in transport — who is subsidising whom in transport — could also be addressed by valuation. Do road users pay enough to cover the full costs of road use? Are the environmental benefits of public transport greater than the government subsidy to public transport?

## Criticisms of valuation

### *"Too important to be valued"*

A criticism of monetary valuation is that some things are simply too important to be valued. However, as demonstrated in the M5 East EIS, there are implicit environmental values in decisions that are currently being made without the aid of valuation.

### *Strategic issues*

Another criticism of monetary valuation is that it is limited by the extent to which it can take into account the larger strategic issues. For instance, Whitelegg (1993a:128) argues that even if peace and quiet achieved by a proposed bypass is "worth more" than the decrease in landscape attractiveness, monetary valuation does not take into account encouragement of the use of roads, and increased emissions, global warming, car dependence and discrimination against cyclists and pedestrians. However, there is no reason these wider impacts could not also be valued using the range of valuation techniques currently used to value the more localised impacts.

### *Substitute or aid to decision-making?*

It is feared by some that monetary valuation will result in decisions being based solely on ability to pay, rather than what is morally or ethically desirable. Sagoff (1988) is critical of the use of cost-benefit analysis (CBA), with its valuation of benefits and costs, for project evaluation, because CBA does not judge opinions and beliefs on their merits but asks instead how much might be paid for them. Sagoff (1988:41) is also wary of monetary valuation because "those willing to pay the most, have the right view; theirs is the better judgement, the deeper insight, and the more informed opinion". "The soundness of an ethical argument does not depend on willingness to pay, although economic information may be relevant" (Sagoff 1988:37).

Valuation should be viewed as an aid to decision-making. If the benefits are greater than the costs in a cost-benefit analysis, a project is considered "good", regardless of who gets the benefits and who suffers the costs. Monetary valuation can determine the value of benefits and losses to different groups, but the decision-makers must still decide the equity and distributional issues. Monetary valuation of environmental costs will not overcome that distributional problem. The decision-makers, as representatives of the community, have to make decisions on the distributional and equity issues of who benefits and who loses. Monetary valuation will never be a substitute for political decision-making. Rather, cost-benefit analysis, and monetary valuation, should be seen as inputs to decision-making, an aid to the decision process. It is useful to have better information on environmental costs.

## METHODS OF MONETARY VALUATION

There are a number of different methods available to put monetary values on the environmental impacts of transport, including roads. These methods may be classified or grouped in many different ways. The following classification is used: direct costs; related market methods; and hypothetical market methods.

### Direct costs

The direct costing method is based on actual expenditures incurred or revenues lost as a result of an external impact. Costs and benefits are based on observed monetary values such as prices. As the method uses prices from real markets, its values are firmly grounded in observed market prices. However it is generally applicable to only some components of total external cost. Examples of direct costing applications include the medical expenses associated with the adverse impact of vehicle emissions on health, and the damage caused to crops by air pollution.

### Revealed market methods

Revealed preference methods for determining monetary values for the environment derive values from people's observed behaviour in the marketplace, that is their revealed preference. These methods may also be called "indirect methods" because values for *non-market* goods are derived indirectly from *market* goods. The methods rely on the general concept of weak complementarity where changes in environmental quality are valued by making use of the complementarity of environmental quality with a purchased good. The price of a market good which is a complement for some aspect of environmental quality is used to determine the environmental good's value.

### *Mitigating and averting costs*

Mitigating costs are used to measure the value of changes in the collective environment by examining costs incurred to make the personal environment different from the collective environment. For instance, people's preference for low levels of noise is revealed by their decision to buy normal market goods such as double glazing for windows facing a busy street, wall insulation, or building high fences and garden mounds. Preference for clean air is revealed by expenditure on air filters. However, it is often difficult to determine what proportion of the expenditure on a market good is related to the effects of the non-market environmental good.

### *Hedonic pricing*

A commonly used revealed market method is hedonic pricing. People's preference for levels of environmental amenity is revealed in house prices: people pay more for a house in a clean, quiet neighbourhood than an identical property in a polluted, noisy area. By analysing data on many houses including the sale price, internal characteristics and neighbourhood characteristics, the effect of each characteristic, such as noise and pollution, on the price can be derived statistically. Transport applications of the hedonic method using house prices include valuing accessibility to freeways or public transport routes and the impact of road noise and aircraft noise on property values (eg Nelson 1979, 1982). For instance, over many studies, it has been found that an increase in one dB(A) of traffic noise decreases residential property value by 0.5% to 1%. Reynolds (1992) has demonstrated evaluation of different noise attenuation measures using hedonically derived values to value noise reductions.

### *Value of time*

Another related revealed preference approach is using the value of time and contributions to community lobbying efforts as a measure of the value of environmental amenity. For instance, Carson and Martin (1991) have suggested that lobbying efforts for the Alaskan Wilderness Bill could be used to value the wilderness. In the urban context, perhaps the time and effort devoted by community and residents action groups for and against freeways, airports and noise attenuation measures (eg re-surfacing of roads, noise barriers, landscaping) could be used as an indicator of the value of urban environmental amenity. However, there have been few, if any, reported examples of applications of this method for urban environmental valuation.

## Hypothetical markets

Hypothetical market methods of valuation ask people directly for their values, usually with the aid of hypothetical markets, rather than inferring values from observations of their behaviour in existing markets. The hypothetical market methods are thus sometimes called direct methods of valuation, but this term may be confused with "direct costing methods" which in contrast rely on existing markets. Two hypothetical market methods include contingent valuation (CV) and stated preference (SP) or conjoint methods: CV asks respondents to state values directly, while SP asks respondents to state their preferences, from which values are derived. Both methods require experimental designs.

### *Contingent valuation*

Contingent valuation (CV) is a technique for eliciting values for goods which are not or cannot be bought and sold in a normal market. People are asked for their value of a good, *contingent* on a market existing for that good. A hypothetical market is created and described to the respondent, who is then asked to make a market (purchase) decision. Contingent markets define the good or amenity of interest, the existing level of provision, possible increments or decrements, the institutional structure under which the good is to be provided, and the method of payment. Mitchell and Carson (1989) provide a comprehensive explanation of the theoretical foundations of the technique, methodological issues and practical application. Respondents are asked for their willingness to pay for an improvement in environmental quality, or their willingness to accept compensation for a decline in environmental amenity.

Since its early applications in visibility studies in the early 1970s, the technique has been used extensively, particularly in America, to value a wide range of non-market goods. Aspects of natural resources and the environment which have been valued include: visibility, air quality and aesthetic damage; water quality and water based recreation; hunting and fishing permits; conservation and wilderness; and species preservation. Apart from valuation of safety features in automobiles, transport applications include valuation of the non-use benefits of local public transport (Bonsall, Wardman, Nash and Hopkinson 1992). Hopkinson, Nash and Sheehy (1992) do not mention the phrase “contingent valuation” in their study, but asked respondents for their willingness to pay to secure the benefits of preferred road schemes in their local village area.

### *Stated preference methods*

In stated preference or conjoint experiments, as they are known in the marketing literature, respondents are presented with descriptions or “profiles” of products with different levels of characteristics and asked to rate, rank or choose which “profile” they prefer, after weighing up the trade-offs between characteristics and price implicit in each profile. Each profile includes a price in $, so that based on the evaluation of the profiles (either a ranking, rating or choice), individual valuations for attributes can be determined.

Nash, Preston and Hopkinson (1991) discuss transport applications of stated preference analysis. However, Nash (1990:9) notes that “stated preference, although widely used in the UK [and Australia] for demand forecasting and valuing travel time savings, has been little used in the area of environmental valuation”. To value changes associated with transport projects, profiles of different transport solutions to a particular problem could be developed, each with different environmental impacts, transport benefits, and price tags (representing construction costs), perhaps expressed as a levy on petrol (if a road project) or fare increases. Nash (1990) believes there remains considerable unexploited potential for the use of stated preference techniques in the monetary valuation of environmental impacts.

The key criticism made of contingent valuation and stated preference methods is their hypothetical nature and the incentive for strategic behaviour by respondents to influence outcomes. However the evidence from many studies appears to be that people do give carefully considered, rational responses to valuation questions, despite their hypothetical nature, and do not behave strategically. As methods which rely on experimental designs, they may also be subject to normal survey design problems. Other possible sources of bias in contingent valuation have been detailed by Mitchell and Carson (1989) and in stated preference by Nash, Preston and Hopkinson (1991).

### Comparison of valuation methods

The market based approaches which rely on observed behaviour can only be used to value environmental levels which are currently experienced in the market. They cannot value changes which are beyond people's current experience. However, because the direct questioning methods use hypothetical markets, they can obtain values about future projects and changes in goods, especially those beyond the range of existing experience. The hypothetical techniques provide richer data than is obtainable through other methods as they enable a number of scenarios to be presented to one person and values obtained for different levels of a resource, perhaps reflecting the different options available for a proposed project. Stated preference experiments have an inherent dynamism which is not present in revealed preference which relies on past behaviour.

Because the direct questioning methods are hypothetical, they are applicable to a wide range of environmental resources and can be used where other techniques are not appropriate or feasible. They have great flexibility and can be applied to many different scenarios.

In addition, the direct questioning methods can obtain non-use values, that component of value arising not from actual use of an environmental resource, but from knowing it exists (existence value), that it is there for others to use, for future generations (bequest value), or the possibility of use in the future (option value).

Hypothetical methods are appropriate to use where there is uncertainty over a project's impact on the environment. Different impact scenarios can be presented to respondents to value, and the degree of uncertainty can be presented and explained in the description of the contingent market.

Different methods are useful in different contexts and applications. Revealed preference methods may be appropriate for some environmental costs, whereas contingent valuation or stated preference may be necessary to derive individual values for major environmental changes, particularly for projects with an element of "user pays". Methods may also be combined. For instance, Nash, Preston and Hopkinson (1991:65) propose a stated preference application which has elements of the hedonic approach: "an approach based on hypothetical choices between alternative houses in locations known and described by the interviewee would be a fruitful way forward on this issue [environmental disamenity caused by transport]". However overall, the hypothetical, direct methods have more strengths and offer greater promise than the revealed preference methods for valuation of currently unvalued environmental goods.

## INDICATIVE COSTS: SOME "REAL" NUMBERS

As an indication of the potential importance of valuation of environmental impacts, some indicative studies are reported below. It is important to note that each study has used different methods and measured different impacts to derive the monetary estimates.

## National costs - percent of GDP

The Victorian Transport Externalities Study included a table of indicative transport externality costs as a percent of GDP, from selected countries, which is partially reproduced below as Table 1. As noted in VTES, the costs are presented as the only indication available of the scale of the problem and as a very rough indication of the relative magnitudes of these externalities.

Table 1: Indicative transport externality costs: percent of GDP

| Country | Noise | Emissions |
|---|---|---|
| France | 0.24 | 0.15 |
| Germany | 0.2 | 0.2-0.34 |
| Netherlands | 0.23 | 0.14-0.23 |
| United Kingdom | 0.5 | 0.05-0.12 |
| United States | 0.06-0.2 | 0.1-0.2 |
| Australia | 0.1 | 0.2 |

*Source: EPA (1994: 8).*

## Urban-wide costs

The Victorian Transport Externality Study "is a landmark study in Australia in that it represents the first serious attempt in this country to assess transport externalities in a systematic manner using local data" (EPA 1994: iii). The study estimated costs of externalities in Melbourne. Selected results are shown in Table 2.

Table 2: Externality costs in Melbourne

| Externality | Cost in $1992 |
|---|---|
| Noise | $43 - $86 million |
| Ozone | $0.01 - $0.1 million in 1991-92 |
| | $0.8 - $10.9 million in 1988-89 |
| Toxic emissions | $26 - $45 million in 1990 |

*Source: EPA (Volume 4, 1994: 12).*

The noise estimate was the cost of noise on arterial roads in Melbourne over 63 dB(A), based on the depreciation effect of noise on (residential) properties adjacent to arterial roads. A noise depreciation factor of 0.5% of value per decibel was used for the low estimate and 1% for the high estimate. Note that obviously not all the impacts of noise are reflected in property values.

The cost of ozone was estimated as the costs of human health effects based on willingness to pay estimates. Low, central and high estimates were calculated. The results vary considerably from year to year, due to climatic conditions. Health effects were calculated only for days on which the highest hourly ozone reading exceeded 0.08 ppm.

The costs of air toxic emissions from motor vehicles was based on the estimated annual number of new cancer cases due to air toxic emissions from motor vehicles. An average cancer 5 year survival rate of 51% was assumed.

### Costs per km

The costs of motor vehicles have also been expressed as costs per km of travel. Table 3 shows indicative costs in Australian cities: the cost in cents per passenger km in $1991 for any additional passenger kms of travel added to the Australian urban transport system, as cited by Newman (1994).

Table 3: Externality costs: comparison of modes (cents per km in $1991)

| Cost | Rail | Bus | Car |
|---|---|---|---|
| Air pollution | 0.00 | 0.25 | 0.43 |
| Noise pollution | 0.00 | 0.20 | 0.08 |

*Source: Newman (1994: 88).*

Newman notes that the air pollution and noise costs are based primarily on health impacts and are likely to be underestimated due to inadequate data in these areas; and that there is also the wider, and as yet mostly unquantified damage, from air and noise pollution (such as materials and crop damage from air pollution, psychological /social impacts of noise and reduced real estate values due to traffic intrusion).

### Lifecycle costs

Whitelegg (1993b) reports on a German study which has calculated the environmental impacts of a medium sized car from “cradle to grave”. While there are no monetary costs, the volumes involved indicate the importance of lifecycle effects. Extracting the raw material to produce one car is estimated to cause 26.5 tonnes of waste and 922 million cubic metres of polluted air, while over its 10 year life the car strews the roadside with 18 kgs of worn bits of road surface and tyre and brake debris, and disposal of the vehicle produces a further 102 million cubic metres of polluted air and quantities of PCBs and hydrocarbons.

## CONCLUSION

There is a clear need for better procedures for including the environmental impacts of transport infrastructure projects, including road projects, in project evaluation and decision-making. Continued improvements in the technical methods of measuring and quantifying environmental impacts and their impacts on humans, particularly human health, will be invaluable. However, impacts must be compared with other costs and benefits. Non-monetary methods have been used in the past to incorporate the environment (and other “non-economic” aspects) into decision-making. However, there are a number of problems such as relying on subjective evaluations of importance, and the difficulty in comparing and weighing up impacts with other project costs and benefits. Monetary valuation of environmental impacts would allow for more impacts to be quantified in a common unit, improve consistency and make trade-offs more explicit. There are a number of techniques available for monetary valuation. Methods which rely on hypothetical markets offer great promise and have yet to be fully utilised in this context.

## NOTE

Sections of this paper are based on a paper presented at the 19th Australasian Transport Research Forum, Lorne Victoria, 28-30 September 1994, and published in the conference proceedings as:
Daniels, R. (1994) Monetary valuation of the environmental impacts of transport, *Papers of the Australasian Transport Research Forum*, 19, 365-382.

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"Clearly, an inability to assign monetary values to certain impacts of transport systems must not be used as an excuse for ignoring those impacts" (VTES 1994).

Similarly, Brookshire, Ives and Schulze (1976) note aesthetic damages are usually described as "intangibles" in benefit-cost studies, and "their consideration by decision-makers has been on a strictly judgmental or political basis".

[It is important to note that putting dollar values on environmental impacts and including them in cost-benefit analysis will not necessarily correct market failures and produce socially desirable urban environments.]

"As peace and quiet, clean air and short commuting times become increasingly scarce, it might be expected that society's valuation of them will rise" (VTES 1994).

"We don't give the public any genuine choices in our transport investments. We don't have good means of knowing what the public thinks on these issues or even how they would weigh the various criteria (env. quality, accessibility, economic efficiency). I am not sure that the EIS process is the way to do it.

## Greenhouse gas emissions

"There is considerable scientific uncertainty regarding the scale of global warming and the regional impacts that the greenhouse effect is likely to bring about" (VTES 1994 p. 17). Carbon dioxide contributed over 90% of greenhouse gas emissions by land based passenger transport

A project by project approach to measuring and assessing environmental impacts can overlook the cumulative impacts of many projects in an area. Each individual project may not have much impact, but taken as a whole, over time and space, (the aggregated) impacts may in fact be significant.

Note: "(VTES 1994). Most attempts to estimate the costs of the health impacts of motor vehicle emissions focus on ozone and particulates (and their respiratory and carcinogenic consequences) - the impacts of lead have not always been included.

[[ delete ??A related valuation method is the control costs technique which uses the costs of controlling an external impact as a proxy for the damage caused by the impact. Typically, the engineering based costs of eliminating or reducing an external impact at its source are calculated. However, as Dess et al. (1992) note, there is unlikely to be much relationship between the costs of controlling an externality and the damage caused by the externality. Thus control costs should not be used as a proxy for damage costs, but may be useful when the interest is in control costs for their own sake. ]]

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