The Costing and Costs of Transport Externalities

Mark Dess
Greenhouse Unit
Office of the Environment, Vic

Godfrey Lubulwa
Project Leader
Bureau of Transport and Communications Economics

Trisha Dermody
Research Officer
Bureau of Transport and Communications Economics

Magda Waszczeniuk
Research Officer
Bureau of Transport and Communications Economics

Abstract:

This paper identifies the externalities associated with the provision of transport services. The techniques available for assigning monetary values to externalities are discussed.

The paper then reviews the literature related to estimates of the costs of a sub-set of negative transport externalities (accidents, vehicle emissions, noise and congestion). Reasons for variations between cost estimates are considered.

The last section of the paper discusses issues which need to be considered when estimating external costs, and in developing policies to address externalities.

The views expressed in this paper are those of the authors, and do not necessarily represent those of the Bureau of Transport and Communications Economics or the Office of the Environment.

Contact Author:

Dr Godfrey Lubulwa
Bureau of Transport and Communications Economics
GPO Box 501
CANBERRA ACT 2601

Telephone: (06) 274 6628 Fax: (06) 274 6816

Introduction[1]

Externalities are the effects of the activities of individuals/groups which confer costs or benefits on a third party, but which are not reflected in prices. As a consequence of this 'market failure', transport markets do not produce a level, or mix, of transport services which is optimal from the point of view of society. As stated in the final report of the Ecologically Sustainable Development (ESD) Transport Working Group (1991):

> "The major economic impediment that inhibits a move towards more ecologically sustainable transport is the fact 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... (The) adjustment of transport prices in all modes towards levels that account for the full economic, social and environmental costs of providing transport services is likely to be an important component of a strategy towards attaining a transport sector consistent with the principles of ESD".

The Inter-State Commission (1990) suggests that taking into account these environmental and social costs may increase road transport costs by between 12 and 100 per cent, depending on the assumptions made and the factors selected.

The range of externalities associated with the delivery of transport services is presented in Figure 1. Given resource constraints however, the Externalities Policy Development Project, and hence this paper, focus on a sub-set of the negative externalities (ie. those giving rise to external costs) associated with land-based transport[2]. These are:

- accidents
- vehicle emissions
- noise
- congestion.

The impacts associated with these externalities are presented in Table 1.

[1] The information presented in this paper is based on preliminary work undertaken for the *Externalities Policy Development Project - Transport Sector Study*. This major study, which focuses on transport externalities in the Victorian context, is being prepared by the Bureau of Transport and Communications Economics and the Victorian Office of the Environment with assistance from the Victorian Environment Protection Authority; Vic Roads; the Commonwealth Department of the Arts, Sport, the Environment and Territories; and a group of consultants comprising R.J. Nairn and Partners, Leonie Segal and Dr. Harry Watson.

[2] Given this focus, the term 'externalities' henceforth should be interpreted to refer to negative externalities unless otherwise stated.

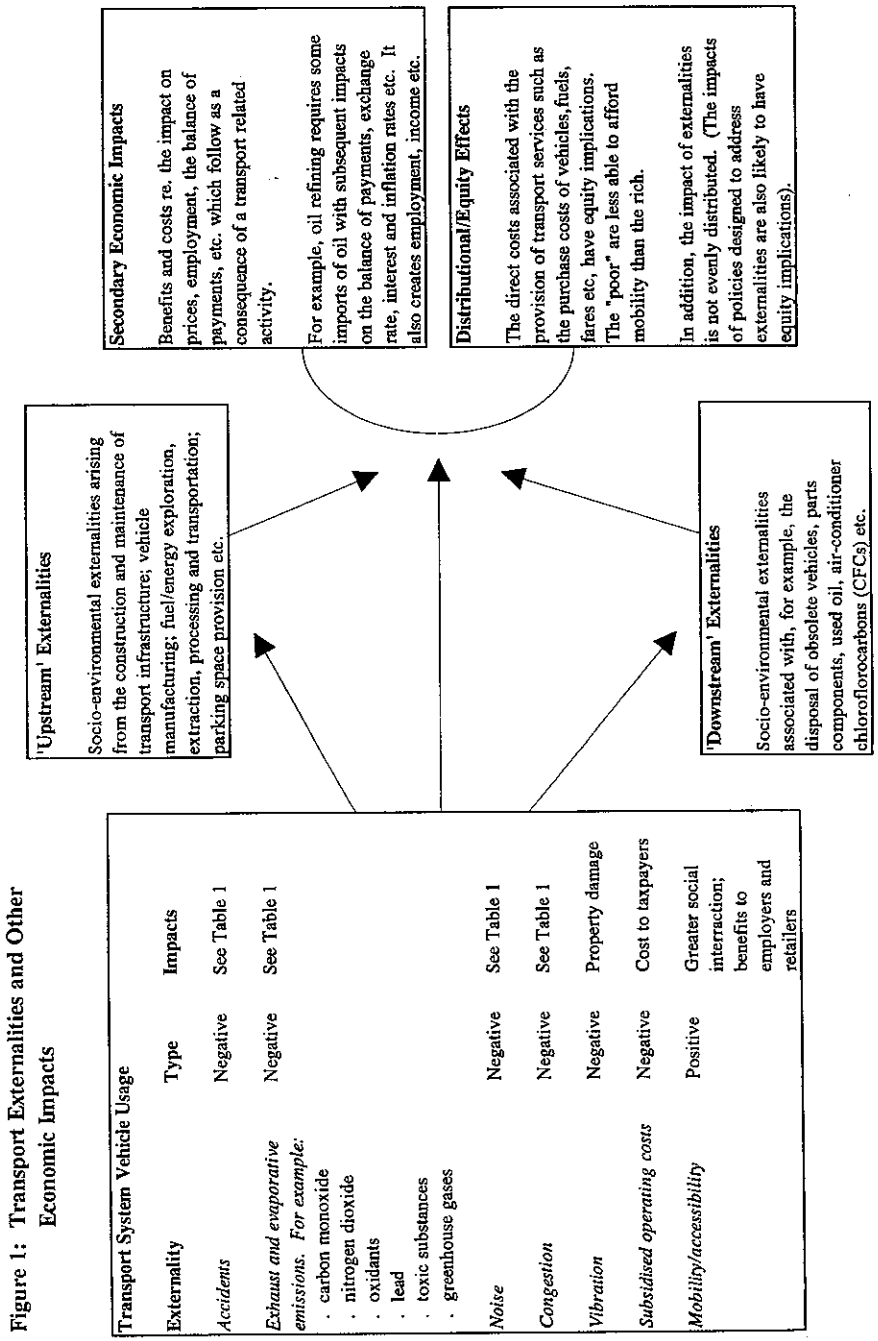

Figure 1: Transport Externalities and Other Economic Impacts

Table 1: Transport Externality Impacts

Externality	Impacts *
Accidents	Death and injury Physical pain and suffering of victims Psychological pain and suffering of victims and relatives/friends Damage to property Cost of providing police and other emergency services, and legal and medical services Traffic congestion Costs of accident prevention measures
Emissions	Adverse impacts on human health (mortality, morbidity, physical discomfort and psychological suffering on the part of victims and their relatives/friends) Visual impacts (aesthetic) Damage to buildings from dirt and corrosion Adverse impacts on flora and fauna Contribution to the enhanced greenhouse effect Ozone layer depletion Impacts on waterways from 'acid rain' and road runoff. Resultant impacts on drinking water quality, fisheries, recreation etc.
Noise	Health impacts including temporary or permanent hearing loss, tension, contributions to cardiovascular and digestive disorders Annoyance and interference with sleep Interference with communication (social, employment) and reduction of enjoyment of leisure activities
Congestion	Increased travel time Lost economic production and/or higher production costs due to human and freight delays, higher labour turnover, higher delivery costs, and difficulties in implementing 'just-in-time' production systems Increased operating costs and sub-optimal utilisation of vehicles Psychological and physiological symptoms of stress, including heart disease, blood pressure etc. Increased environmental impacts from increased emission levels Increased accident risks

Note * The impacts listed are direct impacts. These impacts may also be associated with indirect effects. For example, death and injury arising from accidents result in the loss of economic production by the victim. These indirect effects often are used to estimate the cost of the direct impacts.

Assigning a monetary value to externalities

The assignment of a monetary value to externalities can assist in the conduct of project evaluations which employ cost-benefit analysis as the framework for objective decision-making. In order to ensure economic rationality and consistency in decision-making, it is important that an estimate of the economic value to society of externalities be made.

An understanding of the monetary value of externalities can assist in the determination of optimal policy settings. Economic theory indicates that the optimal level of externalities such as air pollution, noise etc. is not zero. Rather, the optimal level exists where the marginal cost of their abatement equals the marginal benefits generated by that abatement or, in other words, where net benefit is maximised. An understanding of the monetary value of externalities is therefore crucial in identifying optimal levels of control.

A number of techniques are available for estimating the economic value of externalities. The choice of technique must be considered on a case-by-case basis, and must achieve an acceptable trade-off between ease of implementation; potential accuracy of the technique; and ease of understanding both by decision-makers and those who will be affected by the decision.

The techniques applicable to estimating the monetary value of externalities are presented in Attachment 1, along with a summary of their strengths and weaknesses. It is apparent from this Attachment that, irrespective of the technique selected, due caution must be exercised in their application. Each technique relies on restrictive assumptions and has various limitations. The estimates generated therefore should be regarded as indicative rather than definitive. In addition, it is important that the results not be regarded as static. Improvements in knowledge, and changing social values, mean that as time passes, the monetary values assigned to externalities are likely to change.

Despite these qualifications, estimates of the economic value of externalities can provide a valuable input into the decision-making process. As stated by Ottinger and Ward-Willis (1991):

> "A crude approximation, made as exact as possible and changed over time to reflect new information, (is) preferable to the manifestly unjust approximation caused by ignoring these costs and thus (implicitly) valuing environmental damage at zero".

Estimates of the costs of externalities

As part of the Externalities Policy Development Project, the Bureau of Transport and Communications Economics (BTCE) and the Victorian Office of the Environment

(OOE) have conducted a literature review to ascertain existing estimates of the costs of transport externalities. Table 2 presents a representative sample of these estimates.

Table 2: Externality cost estimates (as per cent of Gross Domestic Product)

Country	Noise	Emissions	Congestion	Accidents
Australia	0.16	0.2	0.8	1.5 to 2.1
Britain	0.5	0.16	3.2	1.45 to 1.5
France	0.02 to 0.8	0.07 to 0.21	2.1	2.0 to 2.6
(Former) W. Germany	0.2 to 1.0	0.4 to 0.6	Not available	2.4 to 2.54
USA	0.06 to 0.12	0.3 to 0.35	1.3	2.0 to 3.0

Sources: Inter-State Commission (1990); BTCE (1988); Quinet (1990) and Bouladon (1991).

The information presented in Table 2 indicates that there is a wide range of estimates of transport externality costs in both overseas and Australian studies. Whilst the approach taken to derive cost estimates is not always transparent, a number of reasons can be advanced to explain this range. Estimates may vary due to the application of different costing methods in different studies. For example, Lambert [reported in Quinet (1990)] estimated the cost of traffic noise in France to be equivalent to 0.8% of Gross Domestic Product (GDP) on the basis of the impact of noise on property values. This estimate is significantly higher than other estimates of 0.02% to 0.56% of GDP reported in Quinet (1990) which were based on control costs.

Even where cost estimates are derived using a common method, there may be variation due to the use of different criteria for determining the impact of an externality. For example, in estimating the cost of noise, it can be expected that different results will be obtained if dBA L10 (18) is used rather than dBA Leq (24 hours) to measure the effects of noise[3]; or if 50 dBA rather than 55 dBA is accepted as the critical point beyond which noise commences to have deleterious effects. Finally, the adoption of data for different years may also affect the results generated.

These considerations suggest that caution needs to be exercised when attempting to make international comparisons of the costs of externalities - especially if it is proposed to adopt overseas estimates as a guide to determining the cost of externalities in another country.

[3] dBA L10 (18) represents the noise level exceeded 10% of the time over an 18 hour period, whilst dBA Leq (24 hours) represents the average noise level over a full day.

Other Issues

External Costs v Total Costs

As discussed in the introduction to this paper, external costs are those which fall on third parties but which are not reflected in the prices of transport services. Transport noise and emissions from automobiles fit this definition: it is the community at large which suffers their impact.

However, the situation is less clear in respect of transport accidents and congestion. In the case of accidents, it may be the case that a significant proportion of costs are 'internalised'. In minor traffic accidents for example, the costs may be met directly by the person causing the accident. Even in circumstances where the individual responsible for an accident does not pay directly for all damage, the costs of the accident may be met through car and other insurance.

The Inter-State Commission (1990) for example, advanced the view that road accident costs are, de facto, fully internalised via the payment of insurance premiums, direct payment by the person(s) responsible, and through sick leave award provisions. The Commission acknowledged that other accident related costs such as medical care, ambulance, policing and legal costs are significant - amounting to $727 million in 1985. However, it also noted that:

> "it must be recognised that comprehensive and third party insurance premiums exceed insurance payments. For example, in 1987/88, insurance premiums amounted to $4.4 billion and payments were $3.4 billion .... The difference between insurance premiums and (payments) of approximately $1 billion is greater than the cost of the items identified as possibly having a significant externality component. The Commission considers that the difference between insurance premiums and payments ... can be regarded as an adequate surrogate price for the externalities ... because it modifies demand" (p91).

There are a number of criticisms of the Commission's conclusions. Firstly, sick leave provisions, whilst protecting those injured in accidents, give rise to higher production costs and product prices which are met by society at large. Material damage not covered by insurance is not necessarily met by those responsible for accidents - 'hit-and-run' property damage being a case in point. There is also an unknown amount of property damage and injury which is unreported. Finally, there is debate as to the appropriateness of the value of life used in the accident cost estimates adopted by the Commission.

The question of the extent of internalisation also applies in relation to congestion costs. Some of the impacts of congestion, such as loss of economic productivity, higher production costs, increased levels of noise and noxious emissions are external, being borne by society rather than users of the transport system. However, the situation is less clear regarding impacts such as increased travel times for commuters, higher vehicle operating costs, driver stress and higher insurance costs

(reflecting increased accident risks) which, it might be argued, are borne collectively by road users.

The issue of the extent of internalisation of costs is crucial to the development of policy from two perspectives. Firstly, the higher the proportion of costs which are internalised, the less is the necessity to introduce corrective measures to reduce the impacts of an externality. In circumstances where costs are partly or fully internalised, the introduction of measures such as additional fuel taxes, congestion charges or regulatory measures etc, would effectively result in the double-counting of costs and, all else being equal, raise the price paid by transport users above the total costs (including operating, social and environmental costs) of transport service provision.

Secondly, it raises the question of whether costs which are internalised collectively (ie. by transport users as a group) provide price signals which adequately influence the behaviour of individuals within the group. In the case of accidents for example, insurance may, in part or in full, cover accident costs. However, it is unlikely that all drivers consciously link their payment of an insurance premium with the costs of accidents. Moreover, by spreading the cost of accidents across all motorists, insurance premiums are unlikely to provide sufficient incentive for individuals to recognise the potential costs associated with their actions, and to respond appropriately (ie. by driving with maximum care).

Double-Counting of Costs

Double-counting of costs, as discussed above, can cause policy settings to be distorted, and transport resource allocation to be adversely affected. Double-counting may also arise due to the interrelationships between externalities. As highlighted in Table 1, the impacts of congestion for example, are interrelated with those of vehicle emissions. The costs of vehicle emissions however, generally are assessed independently, and will include the increased emission levels generated as a consequence of congestion. In determining an appropriate policy response to transport externalities, it is therefore important that the costs of the impacts of noxious emissions not be counted twice. It is the net cost which is relevant for policy determination.

In this regard, it is also interesting to note that single focus policies, such as those directed at reducing the external costs of congestion, may have multiple effects. Continuing with our example, a policy to reduce congestion (eg. congestion pricing of roads), will reduce travel time costs etc., but may also reduce accident costs, and the costs arising from the deleterious impacts on human health associated with vehicle emissions. Failure to recognise this fact raises the danger that there may be an over-correction for the presence of transport externalities (Thoreson, 1990, p6).

Finally, double-counting may occur due to the fact that external costs may be estimated in more than one way. The costs of noise, for example, might be estimated through the impact of noise on real estate values, or through its effects on human health and well-being. However, the two estimates should not be added. An

individual can avoid health and other costs by moving, but in doing so would experience a capital loss on his/her property. Alternatively, the individual may choose to remain in the property and suffer the health and other costs, but in doing so avoid realising the capital loss from the reduction in property value.

Redistribution v Reduction of Welfare

In estimating the costs of externalities, it is important to distinguish between those impacts which actually reduce the welfare of society, and those which merely redistribute that welfare. Impacts which transfer wealth from one group in society to another, but which do not reduce total welfare, should not be included in estimates of the cost of externalities[4].

For example, a freeway development will generate increased noise levels and, all else being equal, cause property values to decline in areas bordering the development. However, in those areas from which traffic is attracted by the freeway, property values can be expected to rise. Whilst it is unlikely that the total changes in property values in the two areas will be exactly compensating, it must be recognised that the loss of property value in the former area will be offset by value gains in the latter area[5].

Data Availability and Transferability

The availability of data is a significant problem to be confronted in generating estimates of the costs of externalities. A lack of data may manifest itself in a number of ways. It may be difficult:

- to obtain data which enables the analyst to assess the scale of external impacts. For example, it may be difficult to obtain detailed data relating to the distribution of noise levels across an urban area, and more difficult still to isolate the extent to which this noise is generated by transport vis-a-vis other noise generators (eg. industry).

- to establish a clear and consistent relationship between an externality and its impacts. For example, in relation to noise, there is no level above which it is agreed that deleterious effects occur, nor is there agreement about the nature of the relationship between cause and effect beyond the 'critical level' (for example: is this relationship linear,

4 In this context, a narrow view of welfare is adopted. According to this view, no attempt is made to assess the relative merits of any given distribution of welfare.

5 Offsetting movements in property values are likely to be of consequence in the case of new transport developments, such as the development of a new road or rail link. In general however, transport noise is a pervasive problem in urban areas. It might therefore be expected generally to have a "depressive effect" on urban property values.

exponential or of some other form?). Different individuals have different tolerance levels for noise and for noxious emissions. Dose:response analyses are therefore difficult to establish with confidence.

- to obtain data for all transport modes. Research into transport externalities has tended to focus on the external costs associated with automobiles. Consequently, data relating to the externalities of public transport is limited. The lack of data for public transport external costs makes comparative assessment of transport modes on the basis of total costs (ie. including operating as well as external costs), a difficult proposition.

Confronted with data constraints, the options available to the analyst are often limited. A typical response is to adopt the findings of other (often overseas) studies, and 'massage' these to produce estimates for the area with which he/she is concerned. Factors that may mitigate against the appropriateness of translating data from one geographic setting to another include:

- the nature of externalities - for example, the emission characteristics associated with fuels used in Europe may be different to those used in Australia (eg. different levels on sulphur content etc.)
- the concentrations of a range of pollutants which may react synergistically, giving rise to different impacts in different areas
- climatic conditions
- the nature of the population as regards their tolerance levels, both physical and psychological, to an externality.

In recognition of these difficulties, the BTCE/OOE study referred to in the introduction to this paper will seek to establish estimates of the costs of externalities based on local data, rather than attempt to translate overseas estimates to provide costs for Victoria.

The Valuation of Life

Estimates of the (monetary) value of life are important for the generation of estimates of the costs of externalities. In particular, such values are of critical importance in assessing the costs of accidents and the health effects of vehicle emissions. Apart from the moral dilemma of attempting to assign a monetary value to human life, difficulties arise due to the fact that a variety of approaches can be used to estimate this monetary value. The two main approaches are:

- the human capital approach which equates the value of life with the discounted present value of the victims future earnings; and
- the willingness to pay approach which seeks to estimate the value individuals attach to a reduction in the risk of mortality. This is typically undertaken via contingency valuation, or through the use of hedonic pricing models based on wage differentials in occupations of different perceived riskiness.

The willingness to pay approach is generally accepted as the more reasonable approach. It has been adopted by the British and Swedish Governments, and by the US Secretary of Transportation; the latter more than doubling its previous estimate of the value of life based on the human capital approach (Moffet, 1991, p28).

Conclusion

This paper has analysed the concept of externalities and discussed the externalities associated with the provision of transport services; assessed the techniques available for estimating the monetary value of the impacts of externalities; and indicated the wide range of externality cost estimates in the international literature.

A range of issues to be considered in a study of transport externalities has been highlighted. It was noted that international comparison of externality cost estimates is problematic, and that extreme caution must be exercised where it is proposed to extrapolate the findings of overseas studies to another country. It was also noted that in developing policy, care must be taken to consider the extent to which costs are currently internalised, to avoid double-counting in the estimation of external costs, and to consider whether an externality merely redistributes rather than reduces welfare. Failure to consider these issues gives rise to the possibility of over-correcting for the presence of externalities.

Technique	Description	Strengths	Weaknesses	Applications
Direct Costing	Calculates the costs/benefits of an externality by reference to the expenditures incurred/saved and revenues lost/gained as a consequence of an externality. Costs and benefits are based on observed monetary values such as prices paid by individuals and budget costs of government.	Given the existence of an observable monetary value, there is no need to derive estimates of costs and benefits through indirect, and possibly subjective means.	Market prices do not reflect "willingness to pay", which is the true measure of the value of a resource. Able only to provide an estimate of the cost of the impacts of externalities for which there is a directly observable price/cost. Market prices may be affected by the presence of an externality (eg. an externality may induce a change in the volume of supply or production methods/costs). Prices are also distorted by taxes, subsidies, etc.	This technique may be applied to that sub-set of externalities for which there is a directly observed price/cost. For example: • medical expenses associated with the impacts on health of vehicle emissions, noise and accidents • damage costs to vehicles and property in accidents • increased delivery costs due to congestion • damage to crops due to air pollution
Hedonic Pricing	The hedonic pricing technique analyses prices in *related markets* to derive an estimate of the cost of the impacts of an externality.	Values, although inferred from related markets, are based on the actual decisions of individuals and therefore not subject to subjective analysis or hypothetical relationships.	The technique is data intensive. It is assumed that the 'related market' operates efficiently, that all participants have perfect knowledge and act rationally. Such assumptions never hold absolutely.	Hedonic pricing may be applied to assess the impact on property values of a range of transport externalities, including noise; air quality/emissions; aesthetic amenity; accessibility to employment, recreation and other facilities.

Technique	Description	Strengths	Weaknesses	Applications
Hedonic Pricing (cont)	Hedonic pricing typically employs multiple regression analysis and other statistical techniques to isolate the impact of an externality upon house prices or wage rates. For example, changes in house prices are analysed to provide a proxy for the cost of the impacts of traffic noise.		Results may be distorted if any variable influencing the dependent variable (eg house price) is ignored; or if the externality in question is treated as significant, but is not perceived as such by individuals in reality. Captures impacts on residents, but ignores impacts on those recreating or working in the area.	Can also be used to produce estimates of the value individuals place on risks to life (hedonic pricing of wage differentials). Such values can be used in assessing the cost of deaths and injuries from accidents etc.
Contingent Valuation	The contingent valuation method (CVM) uses surveys to seek from respondents the value they place on the quality and quantity of goods which are not sold in the market. These values are expressed in terms of the amount an individual is willing to pay (WTP) for an improvement in, or to avoid a reduction in, amenity. Alternatively, respondents may be asked the amount they would require in compensation (WTC) for a reduction in amenity.	Is the only technique/method which can be applied to provide an estimate of 'non-use values'. For example, it can provide an estimate of the value attached by society to preserving the environment for future generations, or indeed for preserving the environment as an end in itself. Does not require extensive primary data. CVM can produce both WTP and WTC measures.	As with all survey techniques, CVM is subject to a no. of biases which may affect the quality of results. CVM must assume that all respondents are familiar with, or able to comprehend, the implications of the scenarios presented to them. WTP and WTC approaches have been found to generate substantially different results. WTC measures have been found to be up to 3 times greater than WTP.	CVM may be applied to assessing the value of all the externalities associated with the delivery of transport services.

Technique	Description	Strengths	Weaknesses	Applications
Contingent Valuation (cont)	CVM does not make reference to directly observed costs/prices, nor to prices inferred from related markets.	Can be used to provide a single estimate of a complex bundle of externalities (eg. the combined cost of the impacts of transport noise, emissions, vibration etc.).	The method is not based in an actual market (either direct or related). It therefore provides subjective answers to hypothetical questions.	
Control Costs	The control cost method adopts estimates of the costs of controlling an externality as a proxy for the costs of the damage caused by that externality. The approach typically estimates the engineering-based costs of eliminating or reducing an externality at its source. In simple terms, it is assumed that the costs that society is willing to pay in order to control an externality is a reasonable measure of the benefits of that control.	Information regarding control costs is often more straightforward, clearly definable and more readily available than that required to estimate actual damage costs via the other methods outlined above. The parameters of cost estimation are clearly defined (eg. 'what are the costs of moving from current levels of an externality to a nominated target or standard?').	Other than by co-incidence, it is unlikely that there is a relationship between the costs of controlling an externality, and the damage caused by that externality. The level of control accepted by society (ie. through the political process), is a function of many other factors which are not directly related to the damage caused by an externality (eg. political power).	The control cost approach has been applied in the literature in order to provide estimates of the costs of noise, emissions, congestion. However, for the reasons outlined under 'weaknesses', it should be concluded that control costs should not be applied as a proxy for the damage costs associated with an externality.

Technique	Description	Strengths	Weaknesses	Applications
Control Costs (cont)		The technique provides estimates of the costs of externality control, which is a useful end in itself.	It is not possible to determine the optimal level of abatement of a negative externality. By assuming that the costs and benefits of abatement are equal at all levels of control, all levels of control will therefore be optimal. Control costs tend to fall over time as technology improves. It is not logical to extrapolate from this that damage costs also fall.	
Relative Potency	This approach may be described as a 'short-cut' to the estimation of total external costs, in that it takes the estimate of the costs for one externality, and extrapolates it to others on the basis of a mathematical relationship.	The method relies upon the extrapolation of the results obtained from the techniques outlined above, and as such inherits their strengths and weaknesses.	See strengths.	Application is limited to those sub-sets of externalities for which a consistent mathematical relationship can be established. It has, for example, been used in relation to the estimation of the impact of greenhouse gas emissions, with estimates of the impact of methane, nitrous oxide etc. being provided on the basis of their warming potential relative to CO_2.

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