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Incorporating Principles of Sustainable Development within the Design and Delivery of Major Projects: An international study with particular reference to Mega Urban Transport Projects for the Institution of Civil Engineers and the Actuarial Profession

Working Paper 1

The Perspective of the Economist

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An Economic Perspective

Roger Vickerman

Transport is one of the major contributors of environmental damage. All forms of transport use fossil fuels, all forms of transport produce harmful emissions, all forms of transport lead to noise, to vibration, to visual intrusion in the landscape or cityscape and to damage to biodiversity. On the other hand transport is a major contributor to wealth and economic growth. Transport facilitates the specialisation and trade which is the key to economic growth. Transport provides the links between markets which enables that trade to take place, but it also enables the concentration of economic activity into regions and cities which benefit from the resulting agglomeration economies. Achieving an appropriate balance between these negative and positive impacts of transport is a key element in achieving sustainable economic development.

The key to understanding this balance is a consistent approach to the economic appraisal of the impacts of transport. To measure such an array of different types of impact necessitates the use of a common medium of exchange which enables one factor to be weighed against another. First, therefore, we must establish what this medium is and how we can translate a variety of physical measures into this medium. Secondly, we have to recognise that some of the impacts are immediate and can be assessed against the values of the current residents of an area, but some are less readily obvious and involve an implicit transfer across both space and time of factors, the impacts of which may not be fully understood. Thirdly, we review critically the way these factors are considered in the appraisal system used in the UK, with some comparison of differing practices in other EU countries.

There has been much written about both the principles and practice of the evaluation of environmental and other social impacts of transport projects. The information in this paper is based very heavily on the findings of a major EU funded study into Harmonised European Approaches for Transport Costing and Project Assessment (HEATCO) (http://heatco.ier.uni-stuttgart.de/) supplemented by information available on the UK Department of Transport's WEBTAG website (http://www.dft.gov.uk/webtag/) and papers prepared as part of the DfT's NATA Refresh (http://www.dft.gov.uk/consultations/archive/2008/consulnatarefresh/).

1. Valuing impacts: the monetising paradigm

The economic appraisal of major transport projects is usually carried out with some form of cost-benefit analysis which aims to assess whether a project is worthwhile by comparing the costs of the initial investment with the stream of benefits over time (see Layard and Glaister, 1999 for a full background to CBA). In most cost-benefit analysis this stream of benefits has been taken to be the benefits to users of the project as in the Department for Transport's COBA analytical tool (Department for Transport, 2006). These arise mainly from the time savings which the improvement

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generates and also from improved safety in terms of reduced accidents. As well as the benefits which accrue to existing users, there will also be benefits to traffic which diverts to the new or improved route and to newly generated traffic. This is traffic which previously found that the implied costs of a journey was too great to justify making it but because of the perceived reduced cost after the improvement now becomes worthwhile.

Increasingly, however, it has been recognised that there are both benefits and costs which accrue to non-users or to users which they do not perceive sufficiently accurately. In the latter category are such factors as the costs of congestion, but in the former are a wide range of economic, environmental and societal effects which a project may have and which are not captured in any of the user benefits. The wider economic impacts relate to changes in the sectors which use transport which are induced by the change in transport provision, but are not adequately reflected in user benefits when these transport using sectors (including labour) operate in conditions of imperfect competition (Vickerman, 2006). These include changes in productivity which arise out of potential agglomeration effects and also to changes in the competitive structure of industries. Such wider impacts can be either positive or negative. A full analysis of these impacts is beyond this paper (see SACTRA, 1999). Here we shall concentrate on the environmental and societal effects which can be incorporated in a full cost-benefit analysis, but which frequently are not and thus are used only outside the formal economic analysis. The presumption here is that most of these can be included, although there is often resistance to making this step.

The common medium of exchange used in economic appraisal is that of money. It is neutral both to the units used to measure impacts and to the direction and size of these impacts. Essentially the factor is given a price. The price of something is a measure of both the resources used up in its supply and the value of it to the user. In equilibrium the price will be that level which ensures that exactly the right quantity of resources are used to satisfy the needs of the user. It will be determined by the value of their use in the next best alternative – the so-called opportunity cost.

The usual way to measure prices is through the operation of a market. A well functioning market adjusts the prices faced by buyers and sellers to reach this equilibrium. However, to be well-functioning there needs to be perfect information available to all agents in the market. Any asymmetries in this information and the prices can be distorted by the agents with the better information. But most of the factors affecting the environmental impact of transport do not have well-functioning markets. This does not mean that we cannot define the implicit price, just that we cannot use an existing market to do the job for us. Thus the first task is to establish an appropriate price without a market.

The usual objection to this approach is that we are attempting to measure the value of things which, because they are not traded, have no market price. But the argument is usually taken further than this to suggest that it is wrong to place a money value on things which are in a sense beyond value. However, not placing an explicit money value, or more strictly a money price, does not get us out of this because everything will have a relative price. If we decide not to do something because the price is deemed too high for environmental reasons, then we have placed on that the price associated with the lost activity – the opportunity cost. On

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this basis there are no factors which cannot be included in a monetised CBA since choices are being exercised with respect to everything relevant to both environmental and social interests. This does not mean however that there are not factors for which it might prove more difficult to obtain robust values. As we shall see later judicious use of qualitative information can help to place orders of magnitude on these.

The standard theory of externalities identifies the importance of defining an optimal level of externality which may be very different from a zero level (for a full discussion see Quinet and Vickerman, 2004; Small and Verhoef, 2007). For example, as illustrated in Figure 1, suppose that an external effect, e.g. particulate emissions, rises with traffic levels. This is shown by the msc line in Figure 1. The demand for mobility is assumed to fall as price rises, as given by the usual downward sloping demand curve. In this diagram it is assumed that the marginal private cost has been netted out of the demand so that the line wtp represents the net willingness to pay. Ignoring the external effects would lead to a traffic level of T*. The optimal level of traffic allowing for the externality is, however, given by the intersection of the two lines wtp and msc. Note that this is at a traffic level T_1 higher than a level which would involve no emissions T_0, but that as any value attached to the emissions increased (to msc') this optimal level of traffic would fall (to T_2).

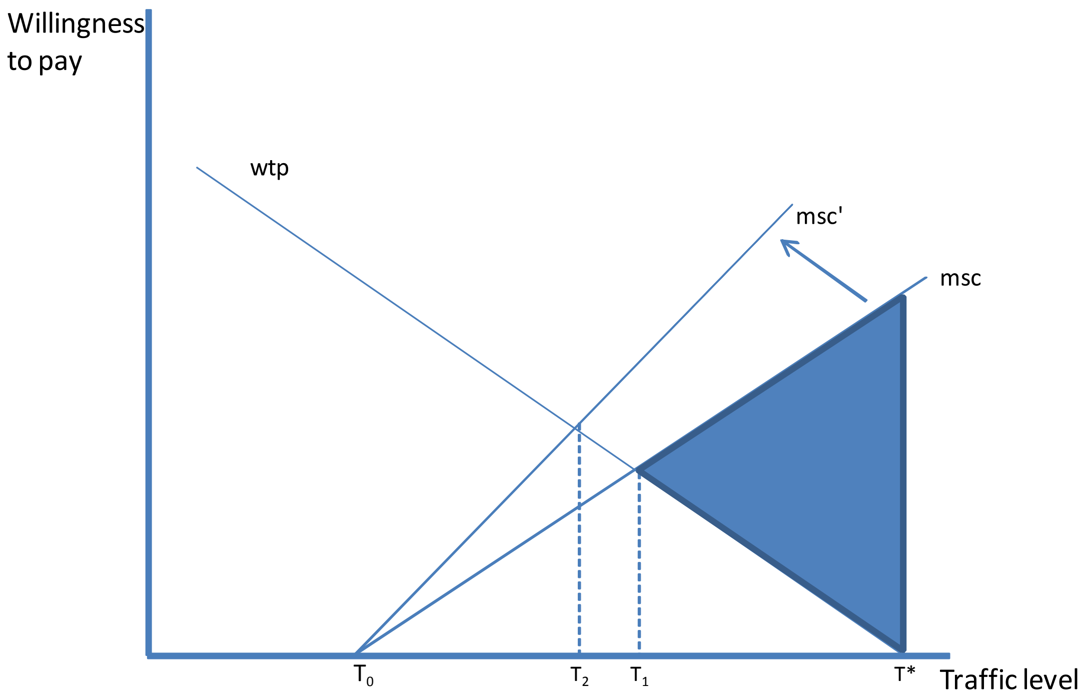

Figure 1

If we took no note of the external effects and traffic was at level T* there would be a total deadweight loss as given by the shaded triangle in Figure 1 reflecting the traffic levels for which the external costs is greater than any willingness to pay for the activity itself. If the price attached to the externality were higher, as at msc', then this deadweight loss would be even greater.

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For simplicity we have shown the external cost as a linear relationship, but it is clear that many external effects may be cumulative so that the msc curve becomes steeper as the intensity of the external effect increases as shown in Figure 2.

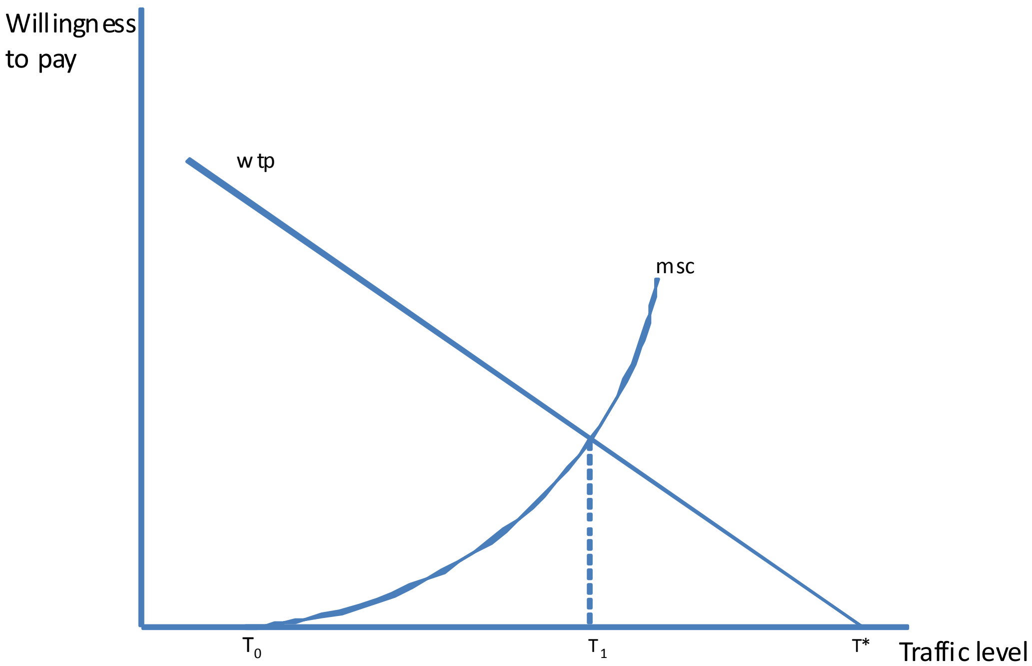

Figure 2

This suggests that the critical step is, given the correct identification of the external impact in physical terms, to provide a correct valuation by identifying appropriate prices. There are three basic ways in which non-marketed impacts can be monetised: through surrogate markets; through revealed behaviour and through stated preferences or contingent valuation.

Surrogate markets
The use of surrogate markets is perhaps one of the best established routes to the valuation of environmental impacts. The idea is to use a market in which trading takes place of something which embodies the environmental characteristics in question.

The simplest example of this is the use of property prices. For example, properties close to a noisy environment such as an airport runway are likely to have lower prices than equivalent properties in a quieter environment. The relationship of price to noise levels gives an estimate of the value of the noise itself. Getting a situation in which otherwise identical houses can be compared simply on the basis of noise levels is unlikely. However, it is possible to isolate all the likely impacts on house prices through the use of hedonic pricing techniques Nellthorp et al, 2005).

An alternative approach is via the costs of preventing the impact, for example the willingness to pay for double-glazing or other forms of noise insulation identifies the

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nuisance value of the noise. Such an approach can be used more widely to sue the costs of prevention as a measure of the implicit value of the nuisance. The problem here is the move from the individual's valuation to a collective valuation of, for example, local air pollution or climate change. Nevertheless, it may be possible to look at the costs of obtaining a cleaner environment: particulate filters on cars, eliminating the use of fossil fuels in power generation reducing the use of non-sustainable timber, as a measure of the benefits to be obtained (Infras-IWW, 2000).

A third use of surrogate markets is via the insurance market. The willingness to pay to insure against some external impact, whether by the individual or society, provides a useful measure of the assumed value of the impact. The difficulty with insurance values is the potential incidence of moral hazard – where the individual can influence the likely outcome of an event it is not possible to get a true market insurance value. The fully insured individual may not take sufficient precautions to prevent an event occurring if they believe they will suffer no financial loss. Hence insurance premiums may be higher than otherwise necessary to reflect the true value (Layard and Glaister, 1999).

At a societal level this is often referred to as the precautionary motive. Given uncertainty about the future, society may over-value the implied impact in order to cover itself (or rather future generations) against excessive losses. This is the problem encountered with climate change, and to some extent with local air pollution impacts on health. Since we do not know for certain what will happen, we may take excessively cautious decisions now to cover ourselves (Infras-IWW, 2000).

Revealed behaviour

The revealed behaviour of individuals provides a significant amount of information about values of external impacts. The most obvious ones are in the way individuals are prepared to pay higher prices to save time, obtain greater comfort etc. This is a direct measure of the value of these non-marketed elements.

As with surrogate markets there are difficulties of ensuring that there is no extraneous information affecting the decisions and the number of elements where individuals can exercise such decisions is limited. However, numerous studies have shown that the revealed behaviour of individuals is consistent with normal market expectations and robust values can be obtained. The value of time savings is one of the major sources of benefit in all transport investments and standard values have been derived for a range of activities, whether people are travelling in course of work, commuting, travelling for business or pleasure, and whether as a driver or passenger (Mackie et al, 2003). Time can also be divided into access time, in-vehicle time and waiting time, including the inconvenience of having to change vehicles or modes as revealed behaviour suggests that waiting time for example ,may be valued much more highly than time spent actually travelling. A further variant is the value attached to the time penalties which are imposed by inconvenient timetables or potential delays which require people either to plan to arrive earlier or to suffer the possible costs associated with a late arrival at their destination.

The potential importance of correct valuation of time savings has occasioned the large amount of work which has gone into improving valuations, but this has resulted in a identifying a lot of consistency in the estimates. The more important

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environmental and other external effects become the more effort is going similarly into improving the behavioural response of individuals. The difference, however, is that time savings benefits accrue to the individuals themselves, environmental benefits accrue to society as a whole, and for this revealed behaviour is less likely to be an effective tool

Stated preferences – contingent valuation
If individuals' revealed behaviour displays consistency, can we obtain reliable information from asking people about their intentions in hypothetical situations? There is a long established tradition of devising such stated-preference situations in which individuals are asked in effect to allocate budgets between alternative scenarios with different characteristics (Hensher, 1994). These have been used widely for estimating values of time savings, but also for more general environmental impacts in which individuals rank alternative scenarios with differing characteristics.

The problem with these contingent valuations is how to get consistency between different states. For example, if individuals are asked to estimate how much they would be prepared to pay to prevent the environmental degradation of a particular location the implied value is likely to be very different (typically lower) than if individuals are asked to estimate the compensation they would need to restore them to a situation where they were equally as well off as if the degradation were not to take place. Whilst the differences may not be great in situations where individuals have a degree of control over the outcome, for example over the choice of transport modes with different characteristics, there may be substantial differences emerging in cases where the individual cannot hope to influence the final outcome by the choice they exercise. For example, individuals may feel relatively powerless in assessing their willingness to pay an airport to reduce noise, but perceive this as an opportunity to have their opposition bought off for a substantial amount of compensation. Typically, therefore, individuals will over-estimate the compensation they require and under-estimate their willingness to pay to avoid the nuisance.

Contingent valuation does, however, give us a better basis for societal evaluation as individuals do not have to engage in actual trades. The usual problems are, however, those associated with the subjects of any study having sufficient and reliable information on which to make informed choices. Contingent valuations are also affected by so-called option values. Individuals may not have direct first hand knowledge of the options they value but maintain a high valuation of, for example, landscapes as they want to retain the option of enjoying them. This is similarly found in the way people who never use public transport believe strongly that it should be provided just in case they might need it in the future. Option values thus raise the question of when a valuation applies and requires us to think more carefully about valuations through time.

Market prices or factor costs
A potentially difficult decision is whether values used should be based on market prices or factor costs (Sugden, 1999). UK guidance has generally used market prices whereas HEATCO bases its values on factor costs. There is, however, no consensus in the national approaches used across the EU. The key difference here is that market price valuations will include the difference between indirect taxes and subsidies which are not included in factor cost estimates. Market prices thus value

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impacts in terms of the implied prices faced by consumers – thus reflecting willingness to pay; factor costs relate more to the impacts on output - thus relating more to costs. Willingness to pay is a better measure of individuals' welfare, factor cost gives a better estimate of impacts on output and productivity. Each may be more appropriate in a particular situation given the objective of the evaluation.

Resisting monetisation
Given objections to full monetisation through the introduction of 'prices' for all elements of the appraisal, some countries have adopted a hybrid approach in which those elements with more robust and objective prices are fully monetised, but other elements are introduced using more qualitative measures. A typical way of bringing these together in a common framework is through multi-criteria analysis (MCA) (Keeney and Raiffa,1976; Von Winterfeldt and Edwards,1986; NERA, no date). However, a full MCA implies a set of weights which enable the various criteria to be traded-off by the decision maker. These weights are in effect surrogate prices applied to each criteria and thus the determination of the weights becomes a major exercise. In the UK the New Approach to Appraisal (NATA) introduced some 10 years ago, sets out such criteria in a format which looks like a MCA, the Appraisal Summary Table (AST), but which avoids formal weights and leaves these to the discretion of the decision-maker (Vickerman, 2000; Department for Transport, 2008).

2. Valuation through time

The problem with any investment is that capital costs are incurred in the present but the impacts of the project arise through time – in the case of major transport investments with a typical life of 50 years or more, the cost of getting the decision wrong can be significant. Normal investment appraisal caters for this by applying the concept of net present value in which all values are reduced to a single time period by discounting future value at an appropriate discount rate. For financial appraisal this is straightforward as the appropriate discount rate is typically, given functioning capital markets, the market interest rate. For a wider societal appraisal however the market interest rate may not fully reflect society's time preference (HM Treasury, 2003).

Time preference refers to the general preference of individuals for certain consumption today rather than less certain consumption tomorrow. To overcome this preference individuals need to be offered compensation in the form of interest payments; hence any future benefits will have a lower value when compared with consumption today (Layard and Glaister, 1999). Environmental issues raise some problems with this approach, particularly if the expectation is that any impact is cumulative. Putting off environmental protection until tomorrow thus costs much more than acting today even if the apparent benefits tomorrow seem both smaller (when viewed from today) and uncertain.

This raises two issues: society's intergenerational preferences and the cost of delay (or the precautionary motive). Intergenerational preferences are an extreme form of time preference. Whilst individuals may be able to express preferences for their own consumption in different time periods over relatively short periods of time (say up to ten years since beyond that at most normal interest rates the value of any

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discounted costs and benefits becomes negligible), they are much less able to do this over generations (say periods of 50 years or more). A strict economic interpretation suggests that sacrifice now for potentially small and uncertain benefits in the future is an irrational response – if it were not markets would place a much higher value on such benefits. Moreover this argument would claim that sacrificing economic growth at the present might actually cause more damage by removing the prospect of the sort of innovation which would deal with any future problems. This would contrast with an extreme environmentalist view which might claim that it is the economic growth which lies at the source of the problem and only by curtailing this can the planet be saved.

Between these extremes is the idea of sustainable development. This promotes the idea that nothing should be done which would prevent both the economy and the environment being able to sustain themselves; damaging either has a cost. This gets closer to a stewardship view of the world which would argue that each generation has the duty to pass on their inheritance to future generations in at least as good a state as they inherited it. But this brings us back to the fundamental question as to how we assess each generation's evaluation of the benefits to future generations under uncertainty.

The precautionary motive implies that because of our lack of certain knowledge we have to exercise caution in how we evaluate our current actions against their future consequences. Whilst it is difficult to assess the benefits which people will derive from a cleaner environment, as we have already suggested, it may be possible to estimate the costs of reducing factors which harm the environment. This does not mean that these can be taken as the clear benefits but they provide a basis for assessing what level of benefits would have to be achieved from the environmentally harmful activity in order to justify incurring such costs.

There is one further element which needs to be considered here, the marginal cost of public funds (Layard and Glaister; Small and Verhoef, 2007). Since most major transport projects involve public funds, either directly or through some form of guarantee to a public-private partnership we have to be careful not to assume that the cost of such funding is zero. Typically the public sector can obtain funds, either by taxation or borrowing, more cheaply than the private sector. This is usually because the public sector as borrow is seen as more secure. Thus the implicit rate of interest appears lower when public money is involved. However, the market interest rate may not be the appropriate discount rate to use if the use of public money for a particular project also impacts on its ability to undertake other projects. There are two aspects to this.

One is the simple opportunity cost argument that use of funds for one project implies other projects cannot be undertaken as the overall capacity of the public sector to fund investments is finite. Hence transport projects compete with say education and health care for a similar pot of money and the potential benefits from these projects must be taken into account.

The second, is the so-called 'crowding out' argument: because the availability of funds in the economy is limited then the public sector's ability to raise funding must reduce the private sector's access to those funds and at the same time makes the

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interest rate payable by the private sector higher than it would be otherwise. Thus excessive public expenditure could result in reduced private sector investment and hence reduced private sector productivity damaging the economy's long-term growth potential. Of course, to the extent that the investment raises the productivity of the private sector by reducing transport costs, enlarging labour market potential, the initial crowding out may be less of a problem than is sometimes argued.

In either case, however, the assumption that the marginal cost of public funds is zero would be wrong and an appropriate adjustment to the market rates faced by the public sector needs to be made to ensure that a project is correctly valued.

3. Valuation across people

As well as the problem of valuation through time a second major problem for large projects is how to deal with distributional effects (Layard and Glaister, 1999). Since standard monetary valuations are frequently income related, for example, the values of time savings, accident costs etc are directly dependent on income. This tends to favour projects which benefit richer groups in the population – a classic question is whether this would always favour rail projects against other forms of public transport or automatically bias the answer in favour of an urban expressway built through a low income area. In both of these the value of the time savings to the project users would dominate the implied values of the environmental and social costs on the non users.

What this implies is the need for explicit distributional weights in any CBA. Distributional weights, like inter-temporal preferences, depend on being able to determine society's preferences. Considerable work has been done on this problem, most recently in terms of the claimed problems of introducing congestion charging (Goodwin, 1989). Here the problem has been seen as to confer most benefits on those who are more able to afford to pay. Detailed studies of consumer preferences suggest that acceptability often depends on how the revenues would be spent – thus congestion charging revenues can be spent on enhancing public transport in a way which can effect a redistribution of the benefits towards those otherwise being worse off (Verhoef et al, 1997).

A further issue is how to deal with a situation in which different groups of people affected by a similar project place different values on the same impact. This has caused problems in EU studies which have tried to find standardised values for use in EU-funded projects (Nellthorp et al. 2001; Grant-Muller et al, 2001; Mackie and Kelly, 2007), and in particular to find consistent estimates of carbon emissions (Infras-IWW, 2000). In theory there is no problem that different groups in different situations place different values on environmental impacts if we place emphasis on willingness to pay as the key determinant, since this simply reflects different preferences. For example, we might expect different values placed on noise nuisance or visual intrusion to reflect different preferences.

Where it does become a problem is where the environmental impacts are not retained within a relatively homogeneous community where either the preferences are consistent or there are clear distributional weights. This will be the case where a project links areas with very different preferences, or where there are spillovers, such

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as arise in the case of greenhouse gas emissions. In such cases there could be difficulties if widely different values are imposed. The development of international carbon trading can serve as a way to develop consistent values.

4. Environmental valuation in practice

The UK Department for Transport has developed one of the most comprehensive transport investment appraisal systems in Europe. This was originally used exclusively for highway appraisal but has evolved into a multi-modal framework under the New Approach to Appraisal (NATA). Because of the uncertainties involved in placing monetary values on many of the wider environmental and economic impacts these have not all been fully incorporated into a formal cost-benefit analysis but are often left as physical or indicative values in an appraisal summary table (AST). The AST is similar to the multi-criteria analysis approach which is used by a number of other countries, but refrains from placing formal weights on each indicator and leaves final decisions to the judgement of the decision maker. NATA has recently been under review and a new draft set of guidelines is currently being proposed. Here we just consider the elements relating to environmental guidance in NATA and not to those relating to economic, accessibility or integrated transport elements. This is separate from the statutory duty to provide a Strategic Environmental Assessment for most large schemes.

Currently environmental guidance covers ten areas as follows:

- Noise
- Local air quality
- Greenhouse gases
- Landscape
- Townscape
- Biodiversity
- Heritage of historic resources
- Water environment
- Physical fitness
- Journey ambience

Noise

Noise is one of the simpler environmental impacts to account for since it is perceived and responded to by individuals (Nellthorp et al, 2005). The formal assessment of noise involves two stages. First, is the measurement of noise in terms of the recognised physical measures, how these are perceived by people and the population affected at different noise levels. Noise levels relate to both loudness and duration. Thus dB(A) measures of the loudness can be combined with the length of exposure to give an equivalent noise level over a specific period, $L_{Aeq,\ 18hr}$, which measures the percentage of the population annoyed as a function of the noise level. Secondly, a value can be applied to this using the impact on house prices as a measure of willingness to pay to avoid noise. Of course different people may respond differently to the same level of noise nuisance and hence individual values may appear to differ greatly and subjectively. However, average responses across

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the community are remarkably stable suggesting that there are reliable values which can be used.

Noise also differs between different modes of transport, road, rail and air all create different intensities and durations of noise. Again there is a degree of stability in the differences in response between different modes such that, although the impact of a given level of noise may differ between modes, it does so in a consistent and stable way.

Up to around 45 dB $L_{Aeq,\ 18hr}$ the perceived value of an additional dB of noise is zero, but above that it rises to £34.80 per household at 55 db(A) and £98 per household at 80 db(A), based on 2002 values. HEATCO based its values on individual rather than household exposure using stated preference methods. This produces similar values at lower noise levels, but suggests a more rapidly rising value at higher noise levels implying a greater perception of extreme noise nuisance.

Note that noise values are based on individual perceptions of the nuisance value, there may be additional effects which are not captured by this measure such as the longer term health issues arising from prolonged exposure to noise.

Local air quality

Local air quality is thought by many to be a more serious environmental problem than the emission of greenhouse gases which affect overall climate change. This is in part because they are more immediate in impact and have direct and measurable impacts on individuals. Local air quality effects of transport consist of oxides of nitrogen (NO_x), particulate matter such as PM_{10}, carbon monoxide (CO) and volatile organic compounds (VOC) such as benzene.

Factors such as PM_{10} and NO_2 have clear air quality strategy objectives which impose maximum levels to be achieved by certain dates. These objectives are set in terms of annual mean levels and maximum levels not to be exceeded on more than a given number of occasions per year.

Setting the physical levels is a thus a clear and unambiguous task. The second step is to measure exposure, for example in terms of numbers of properties exposed to increases or decreases in levels of each pollutant. This is usually done in bands of 50 metres up to 200 metres from the line of route. What is not yet done is any attempt to provide a monetary value to these calculations and the impact remains essentially a qualitative measure, albeit based on a physical measure of numbers affected and how intensely.

Imposing a monetary value would imply a number of stages. First, we need to identify what the costs of exposure are – in the main these will be health related and thus we could measure the costs of additional health care occasioned by exposure and the loss of output associated with such ill-health. Secondly, however, there is the problem that the susceptibility of an individual to health problems occasioned by exposure may depend on the type of person (e.g. children or the elderly may be more susceptible to health problems brought on by exposure to local air pollution) and their own state of overall health.

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HEATCO did provide estimates based on monetary values used in a number of EU countries for local air pollution. These differ significantly by country and also by mode of transport. The typical approach used to estimate these was the impact- response or impact-pathway method (Friedrich and Bickel, 2002) reproduced in Figure 3. This looks first at emissions, then the dispersion across the population, the human response to this dispersion and then a monetary valuation of this based on changes in welfare. The claimed strength of this approach is that the costs derive from the actual costs of, for example, increased hospital admissions, rather than trying to estimate willingness to pay for reduced emissions. This approach can also be used for estimating the impact and costs of noise pollution.

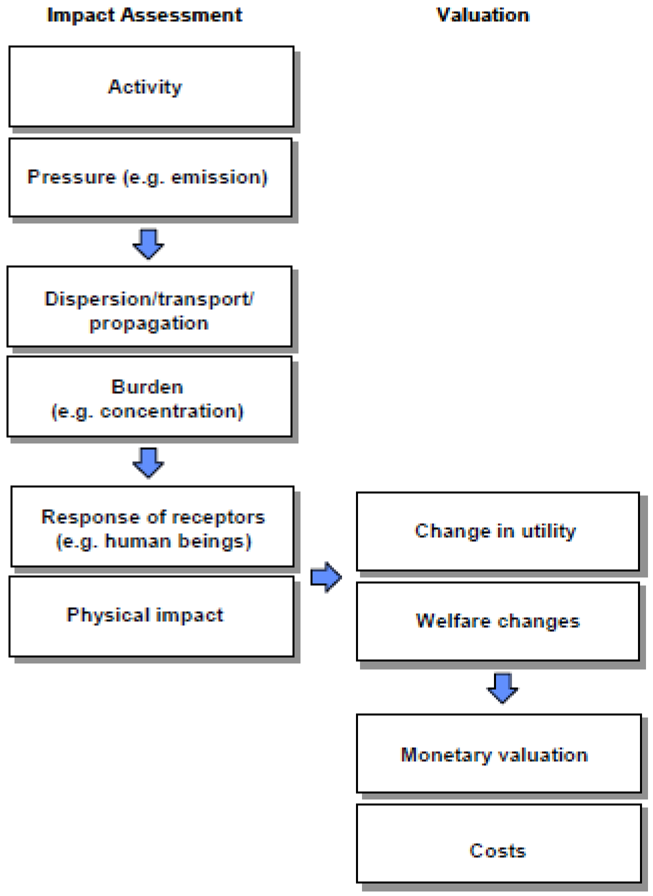

Figure 3. Impact Pathway Approach (from HEATCO D5)

Greenhouse gases

The difference between local air pollution and greenhouse gas emissions is that the former is confined to fairly narrow area (up to 200 metres of a transport route) whereas the latter has a more widespread effect not specifically identifiable in particular location or at a particular time. The key greenhouse gas is carbon dioxide (CO_2), but nitrous oxide (N_2O) and methane (CH_4) are also important. As with local pollution the key variable is the level of emissions, although here this can be translated into equivalent tonnes of carbon released into the atmosphere, which can be used to give a monetary value.

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The big question, however, is the appropriate value of this carbon. This has been investigated in depth most recently by the Stern Report (2007) which assembled a large quantity of scientific evidence on the impacts of this carbon equivalence on climate change and then applied a range of economic techniques to provide a valuation of this. Such a value has to take into account time and the potential costs of doing nothing, too little, or too much. Stern has been heavily criticised for giving too high a weight to higher estimates of damage and placing a price on carbon which is based on a strong precautionary approach. Stern's view was that the potential costs of doing nothing were too great and that using a higher value of such emissions now imposed a lower overall cost on the economy relative to GDP than might be the case if there was a delay.

Based on this a central figure of £25.50 per tonne of CO_2 at 2007 prices is suggested. This figure is assumed to rise by 2% per year in real terms. Given the uncertainties involved a range of values is suggested for transport projects from 10% below to 25% above the central estimate. The central estimate is assumed to be appropriate for most projects, but a range could be used in the case of large projects or if there was believed to be a disproportionately large impact on carbon emissions. Note again that the emphasis is on encompassing high values by using a larger up-side error in costs, reflecting the use of the precautionary motive. However, in practice the value is only applied to the difference in carbon emissions between 'with scheme' and 'without scheme' scenarios. This is appropriate for measuring the impact of a particular scheme, but means that the continuing potential impact on climate change from doing nothing is effectively ignored.

The use of this monetised value of carbon emissions is, however, limited in the appraisal process. Transport appraisal guidance simply places this figure as one element in the AST. Hence, although it is a monetised value which could be incorporated in an overall cost-benefit analysis, it is actually used just like the more qualitative local air pollution measure as one independent element which the decision-maker has to compare with other factors. The potential power of using a common metric is therefore lost. It should also be noted that the future values of carbon emissions are not discounted like other costs and benefits, in fact the assumed 2% growth in real terms in the cost of carbon emissions gives a distinct bias towards emphasising this aspect in favour of projects which make more significant long-term savings in greenhouse gas emissions. Such an approach may be thought appropriate, but it has to be recognised that this implies a different approach to the time preference associated with these costs or benefits than to all others discounted in the normal way.

Most other EU countries which incorporate some estimate of climate change effects use an avoidance cost approach to reach certain (but differing) targets (Infras-IWW, 2000; Bristow and Nellthorp, 2000). At 2002 prices such values ranged from under €50/tonne to nearly €200/tonne depending on the severity of the reduction required and the time period involved. Some countries such as Germany have placed much more demanding reduction targets in place and this gives correspondingly much higher values than the UK figure which is based on an estimate of damage costs. These targets are based on similar scientific evidence, but typically with the assumption of a much larger precautionary motive.

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Cutting across this environmental cost based approach to climate change is the introduction of markets in carbon-trading which can provide a parallel set of prices for use in appraisal. Currently these markets are fairly embryonic and unlikely to meet the normal criteria of perfect or at least symmetric information. However as they develop they are likely to provide useful additional information and have the advantage that, to the extent that they are international markets, they will provide a less value-driven evaluation.

Landscape
Impact on the landscape is one of the major public concerns voiced over new transport infrastructure projects, but economic evaluation of landscape is a difficult concept and thus there is a tendency to rely heavily on qualitative measures based on physical characteristics. The problem with an economic evaluation is that it is not always clear what is the measureable economic benefit from high quality landscape, or cost from its destruction, in terms of impacts on output or economic well-being. Having said this, it is, however, also clear that individuals and society as a whole do place a value on high quality landscape in terms of being prepared to contribute to its upkeep or incur additional costs to prevent its destruction. This is a classic case of individuals being prepared to exert an option value over a natural resource. The problem is that this option value is often set extremely high on the basis that in many cases a natural landscape cannot be harmed a bit such that there is a trade-off between willingness to pay for the activity and willingness to pay for the resource – if its is harmed it is thought likely to be destroyed completely. In such circumstances it may be difficult, if not impossible, to provide a genuine economic basis for evaluation.

What is landscape is a huge topic in its own right, but in simple terms it encompasses both the natural physical features and the cultural features which reflect previous human impacts on the landscape. The methods used for evaluating the impacts of a project on this landscape involve first describing and assessing the existing landscape and then evaluating qualitatively how the project will affect this assessment. That assessment involves not just the physical measure but also an assessment of the so-called environmental capital which attempts to place a simple objective measure in their overall context. The impact is then measured on a subjective seven point scale with respect to whether the project will have a large, moderate or slight beneficial or adverse impact or be neutral. The overall impact assessment is however backed up by a detailed textual description of all the individual landscape characteristics.

The problem for overall appraisal is that the qualitative score is then one item in the AST which sits alongside the detailed cost-benefit assessment of user impacts such as time savings and the quantitative estimate of the cost of carbon emissions.

Townscape
Townscape is conceptually rather like landscape except relating more to buildings and their setting. This again involves both a physical measure and the social context giving an implied measure of environmental capital. The approach is thus essentially the same resulting in a qualitative indicator or a seven point scale.

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Heritage
The impacts on heritage are in effect a subset of landscape and townscape impacts but in the context of individual buildings or historic resources. The approach is identical resulting i a further seven point qualitative assessment.

Biodiversity
Impacts on biodiversity are frequently seen as a major aspect of the environmental effects of transport. Biodiversity has the potential for a more objective assessment using scientific indicators, but also carries the risk as with landscape or heritage that marginal changes are not possible in that any introduction of instability in an ecosystem can lead to its destruction. If that destruction is irreversible in that the system cannot be recreated then there is a potentially infinite cost associated with it. However, that cost needs to be balanced against other costs and benefits and the problem is that we do not have a clear basis for doing this.

In practice biodiversity is assessed very much like the three impacts above with a description of characteristics leading to a measure of environmental capital, the impacts of the project on which are then assessed on a seven-point scale. The descriptors are however influenced by prior designations such as Ramsar Sites, World Heritage Sites, Sites of Special Scientific Interest or Local Nature Reserves; the more important the site the greater the overall effect of any given impact.

Water
Water is a further subset of specific environmental impacts. Water impacts include biodiversity impacts such as those on fisheries and other living organisms; waterways as sources of potable water, flood defences etc; and the potential use of water for recreation as well as part of cultural heritage. There is clearly a measureable economic aspect to some of this. The commercial use of water, whether rivers, canals or coastal environments for fisheries, recreation or indeed transport has a measurable impact. However, for consistency with other natural environmental impacts the qualitative seven point scale is used.

Physical fitness
The impacts of transport on health have been an under-represented issue in transport appraisal. The negative aspects through for example local air pollution or noise have been researched and incorporated, but the positive benefits through improving access to various services as well as recreation have not been incorporated in such detail, except as part of general improvements in accessibility. What is not incorporated elsewhere is any direct impact on physical activity such as walking or cycling which a scheme may have. There is a potential problem here that transport improvements which have a strong measurable economic impact e.g. through contributing time savings, may have a significantly negative impact on health if they discourage walking and cycling. Conversely projects which encourage walking and cycling may extend journey times and appear to have negative economic impacts.

Measuring the economic impact of any change in physical activity could sue known values from health care research to provide a monetised measure, but there is the risk of some double counting with direct user benefits. Thus for appraisal only a

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general measure of changes in the numbers of people engaged in walking or cycling for more than 30 minutes a day is counted.

Journey ambience

There may finally be environmental aspects of the journey itself which could have a bearing on the value of any improvement in transport. Journey time and reliability is generally taken into account as part of the direct user benefits, but the quality of vehicles, ride, seating etc is relevant as is the quality of interaction with other passengers. Three aspects are recognised, care, vies and stress. Care involves the provision of facilities which provide for travellers. Views involve consideration of the interaction with the external environment to the mode of travel. Stress includes factors relating to fear and frustration, likelihood of accidents, uncertainty about route or connections. Given the subjectivity of much of this a three-point scale is used to assess simply whether these actors are made better, worse or neutral by any change. Again there is also a need for subjective aggregation across a number of potentially conflicting characteristics.

Conclusion on environmental evaluation

Three factors stand out from this review of current practice:

- There is a diversity of approaches which include both objective quantitative analysis (with and without monetary evaluation) and more subjective qualitative measures;
- Where monetary evaluation is included, it is normally kept separate from any cost-benefit analysis of direct user benefits so there is little effort applied to gaining a comprehensive economic evaluation;
- There is a strong emphasis on the precautionary motive in both the quantitative and qualitative indicators

5. Conclusions and recommendations

The purpose of this paper has been to review the evidence on how to provide an economic evaluation of environmental factors in major transport projects. The assumption has been made that the primary task of such an approach is to provide evidence for such impacts on a basis which can be compared with all the other impacts of the project from its costs to the direct user benefits and wider economic impacts. This implies monetary evaluation, but such evaluation involves a number of problems.

First, the absence of a well-functioning market in environmental impacts requires an alternative approach. The simplest approach is via a direct surrogate market which demonstrates the way people respond to environmental effects – the most obvious is the use of house prices to infer preferences about noise and local air pollution. More complex approaches involve for example the impact-pathway approach which aims to trace the physical impact of, say pollution, through to its possible costs in terms of additional health care. The main issue here is the difference between an assessment of individual preferences affecting willingness to pay and the costs to society based on for example current treatment costs which may reflect factors other than social preferences.

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Of greater potential significance and certainly greater controversy are those factors where individuals find it difficult if not impossible to express informed preferences such as landscape or climate change. On these the scientific measurement is problematic and valuation involves difficult inter-generational problems. The danger is that evaluation goes for an extreme. This extreme is either the extreme pessimistic precautionary motive, because of uncertainty we must do nothing which has the potential to compromise the future. Or it can involve an excessively optimistic approach, because the future is uncertain we should not do anything which compromises our ability to increase economic welfare in the present, because this will also compromise our ability to deal with change in the future through invention and innovation. Public policy has to steer a difficult course between these two extremes recognising that each carries enormous risks of being wrong, risks which themselves have to be adequately evaluated.

Different European countries have adopted different degrees of emphasis on the various elements of environmental appraisal of transport projects. Sometimes these reflect different social preferences, for example, French evidence suggests rather higher values placed on noise nuisance than in other countries, German evidence on higher values on climate change effects. Sometimes they reflect different ways of combining information. The UK has so far resisted the idea of combining all the information into an overall rate of return on a project but prefers this to be left open in the AST for the decision-maker to weigh up the relative impacts of projects. Thus projects with very high benefit-cost ratios (BCR) in terms of the direct user benefits may get a lower overall valuation because of some concern with another element in the AST whereas rather poorly performing projects on the basis of the BCR get priority because they are seen as less risky on environmental grounds. Germany has gone further in incorporating more elements in a formal CBA approach, the Netherlands uses an MCA approach placing consistent weights on similar elements to those in the UK's AST.

What the HEATCO project has shown is that there is no consistency in either approach or values used. Whilst it would seem appropriate, not least for evaluating cross-border projects in Europe, to use a similar basis for large projects, it can still be argued that differences reflect different national priorities and references. They may also reflect different starting positions. Most appraisal compares a with-project to a do-nothing or business-as-usual situation and measures the changes implied. For major projects there may also be a need to include the total implied costs of a do-nothing situation and not just the changes from it. This recognises the cumulative impacts of many environmental factors and hence the fact that do-nothing is rarely exactly that when it comes to the environment.

What this discussion highlights however is that the better the science becomes, the greater the certainty that can be applied to an economic evaluation. Such evaluation needs to take into account both willingness to pay approaches to measure consumer preferences and impact-pathway approaches to identify the implied costs. However, there will always be uncertainty and the degree of uncertainty may well govern the extremity of the precautionary approach we take. For these reasons, whether or not we can move to an overall BCR approach, there will always be a benefit in having the transparency of something like the AST which sets out clearly the impact of each element, hopefully with an increasing number of these carrying reliable monetised

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economic values. Ultimately, however good the economic evaluation, unless it carries social acceptability it is of little value in decision making. Major decisions on major projects often involve very detailed and complex modelling of both the transport impacts and the wider economic and environmental impacts, but if these are left in a 'black-box' there will be little trust in the decisions made.

6. Key questions

In this section we draw out some key questions which emerge from above discussion:

1. How useful is the guidance given in official documentation as to how to include estimates of environmental and social effects on a consistent basis?
2. How comfortable is the conclusion that all effects can be monetised?
3. How easy is it to convey the basis of such estimates to all stakeholders in a project?
4. Is there a danger that the emphasis placed on greenhouse gas emissions leads to relatively more effort being placed on getting this value right to the exclusion of more local impacts which might actually have greater potential cost?
5. Does official guidance on discount rates and distributional weights enable adequate assessments to be made of projects which affect a wide variety of different neighbourhoods, especially when these are in different jurisdictions?
6. What areas of external impact cause the most difficulty in terms of obtaining reliable supporting evidence and do these lead to increased problems of optimism bias in appraisal?

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Further Reading

The most valuable resources for further reading are included in the references above, in particular reference to the findings of the HEATCO project and the valuable information on the Department for Transport's WebTAG site.

The standard textbook analysis of the key issues in CBA is Layard and Glaister (1999) A good analysis of the definition of a full CBA for transport is given in SACTRA (1999), but all the issues are handled in the standard transport textbooks such as Quinet and Vickerman (2004) or Small and Verhoef (2007). The Stern Report (Stern 92007) remains a valuable guide to the greenhouse gas emission problem, but earlier reports such as Infras-IWW (2000) still contain useful discussion on approaches even if the precise estimates may be out of date. The Impact Pathway approach is well documented in Friedrich and Bickel (2002).

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