

Noise valuation in ex-ante evaluations of major road and railroad projects

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In many European countries, the impact of new road and railroad infrastructure is assessed by performing a cost-benefit analysis, monetising as many relevant effects as possible. Considering that noise is a major external effect of traffic, this paper will systematically review the guidelines for monetising noise in different European countries. The study shows, firstly, that there are guidelines for monetising noise in most western and northern European countries and secondly, that not all noise effects are dealt with. Usually only annoyance in a residential context is included. Thirdly, the different prices being attached to noise in various countries are mainly due to different unit values applied to the same impacts. Fourthly, a gap has been shown to exist between the theoretical guidelines and their application in practice.

Keywords: cost-benefit analysis; infrastructure; noise

1. Introduction

Noise is a major environmental effect of traffic. About 20% of the European Union's population, or close to 80 million people, have been estimated to suffer from noise levels considered by scientists and health experts to be unacceptable, that is levels where most people become annoyed and sleep is disturbed, and where adverse health effects are to be feared. An additional 170 million citizens are living in so-called 'grey areas' where the noise levels cause serious annoyance during the daytime (European Commission, 1996). A wide variety of studies have examined the question of the external costs of transport noise to society. The estimates range from 0.2% to 2% of GDP (European Commission, 1996). The European Commission (1995) used the lower estimate of 0.2% of GDP which represents an annual cost to society in the EU-15 of over 12 billion euros. A more recent study, commissioned by the European Commission Enterprise and Industry Directorate General estimates the annual benefits of reduction of road traffic noise for the EU-27 to be at least 5.8 billion euros per dB, close to 0.05% of GDP per dB (FEHRL, 2006).

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Noise is therefore economically important and it stands to reason that noise should be part of any ex-ante evaluation of major infrastructural projects. An ex-ante evaluation is often carried out in the form of a cost-benefit analysis (CBA). In a CBA, as many as possible relevant economic, ecological and social impacts are assessed and monetised (Hayashi and Morisugi, 2000). During the last few decades, much research has been done to develop monetisation methods for environmental effects as there is a consensus that environmental effects should be included in the appraisal, but no consensus as to how (Bristow and Nellthorp, 2000).

Considering that noise is a major external effect of traffic, in section 2 we will review the national guidelines for monetising road and railroad noise in different European countries. What is the price of noise in various European countries? Are differences in price (partly) due to artefacts, like differences in the noise impacts considered or the monetisation methods used? To the authors' knowledge, no such systematic review of noise assessment practices has been carried out.

Considering that the application of environmental valuation methods and guidelines falls short of expectations (Dusseldorp et al., 2001), section 3 focuses on the possible gap between the theoretical approaches of the previous section and the practical application of those approaches. The Dutch situation is taken as an example. This section is based on both literature review and interviews with Dutch stakeholders.

Discussion, conclusions and recommendations follow in sections 4 and 5.

2. Theoretical approaches to noise valuation in different European countries

Scientific evaluation of transport projects has a long history, dating back to mid-19th century France (Nakamura, 2000). At that time, only direct effects (e.g. travel time) formed part of the evaluation. Indirect effects (e.g. on labour and housing markets) and external effects did not enter into the evaluation. External effects exist when the utility (or production) function of an actor (the receptor) contains a real variable of which the actual value depends on the behaviour of another actor (the supplier), who in turn does not take this effect of his behaviour into account in his decision making process (Maddison et al., 1996). Environmental effects are typically external and typically unpriced, since there are no property rights and, consequently, no markets for these effects. This makes monetisation of these effects difficult.

In the remainder of this section, we will answer two questions related to noise valuation: 1) which European countries are monetising noise effects and which price do they attach to noise? 2) are differences in price (partly) due to artefacts, like different noise impacts considered or different monetisation methods used?

2.1 Which countries monetise noise impacts?

Figure 1 shows European countries that value noise in monetary terms. There is a clear regional tendency in the treatment of noise. Most countries in the northern part of Europe and about half of them in the eastern part include costs due to noise in their ex-ante evaluation. All of the southern and some of the eastern countries do not consider noise effects in monetary terms. They only do qualitative assessments, or do not assess noise impacts at all.

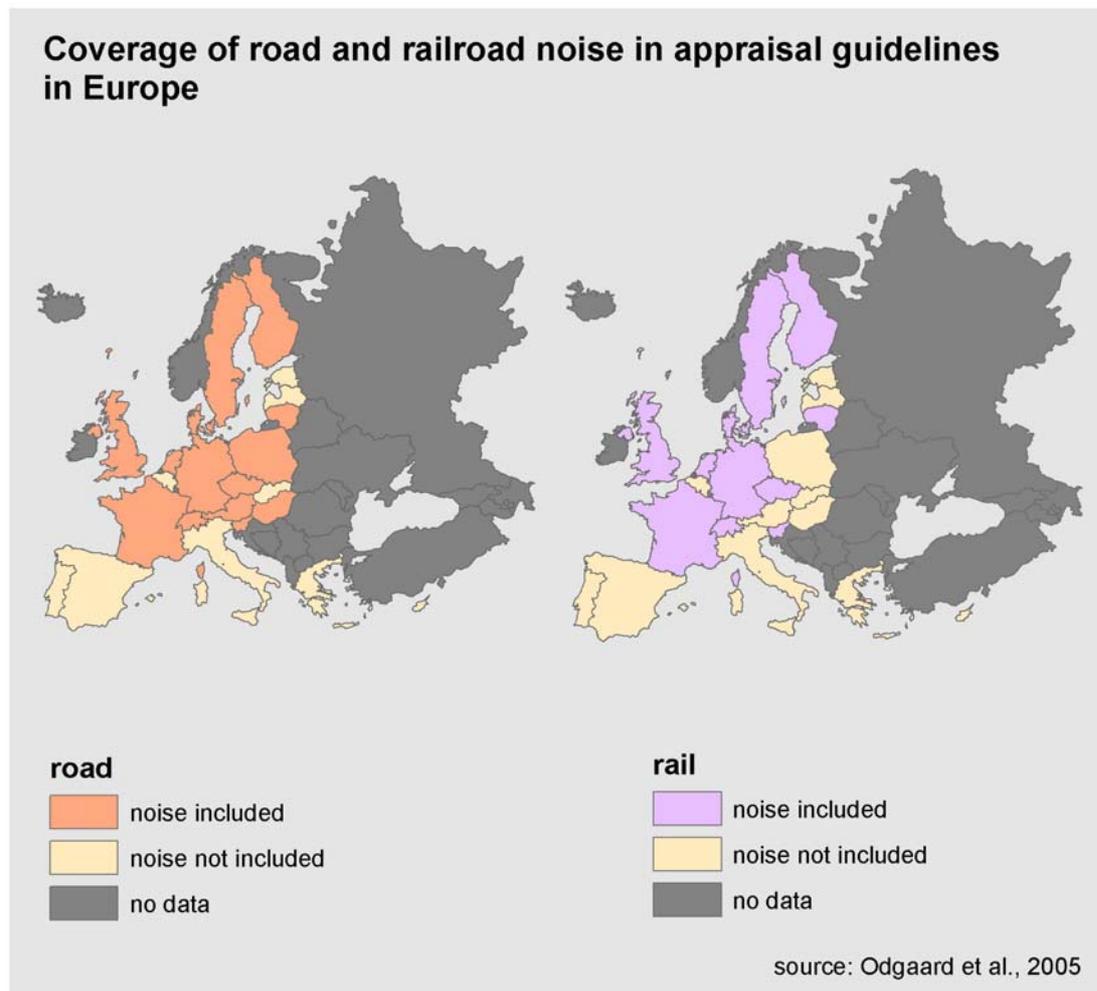


Figure 1. Coverage of road and railroad noise in appraisal guidelines in Europe
Source: Odgaard et al., 2005; DEFRA, 2007

Figure 1 also shows monetary valuation of road traffic noise to be more common than this valuation of railroad noise. Most countries that monetise noise impacts for railroad traffic apply lower values to railroad traffic than to road traffic at equal noise levels. This is consistent with much research showing that at equal noise levels annoyance due to road traffic will be higher than annoyance due to railroad traffic (for example Miedema et al., 2001). However very few studies do valuations on rail noise. The Eliasson et al. study (2002) is one of the few that values both road and railroad noise. It values road noise higher, as might be expected. The UK values road and railroad noise equally, in the absence of a broad scientific basis to do otherwise.

The threshold to start considering monetary impacts is usually 50 dB for road traffic noise and 55 dB for rail road noise. The UK starts valuing noise at 45 dB (Department for Transport, 2006), whereas France and the Netherlands only value noise at levels above 55 dB (Odgaard et al., 2005).

Figure 2 shows the value (per household per year) that some European countries put on different levels of road noise. The figure shows that up to about 70 dB, the UK attaches the highest value to noise. Above 70 dB, it is Sweden that attaches (considerable) higher values to noise. Whether this reflects a Scandinavian preference for a quiet lifestyle is speculative. Contrary to the recommendation of the European Union fifth framework programme UNITE (<http://www.its.leeds.ac.uk/projects/unite/>) that values should grow over time with real incomes, only in France and the UK are they linked to the GDP.

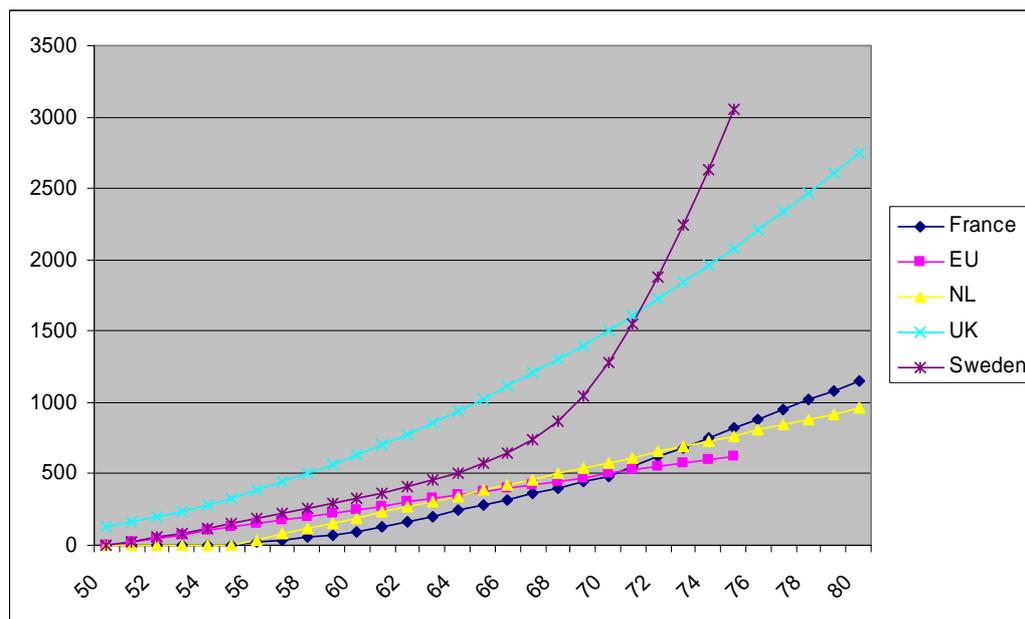


Figure 2. Value (in euros) per noise level per household per year in different European countries and the average EU values for road traffic noise

Sources: Lambert et al., 2003; WGHSEA, 2003; Odgaard et al., 2005; Department of Transport, 2006

The differences between European countries in values attached to noise levels may reflect a real difference in preferences. It may on the other hand also be an artefact as a result of differences in the kind of impacts considered and the valuation methods used. In sections 2.2 and 2.3 we will therefore examine which effects are considered in valuating noise and which valuation methods are used.

2.2 Which noise effects are monetised?

Noise has many different effects (see Figure 3). It may affect human health (see e.g. Dutch Health Council, 1994, Berglund et al., 1999) and it may have an effect on fauna (see Reijnen et al., 1995). It may also lead to a loss of potential residential areas due to exceedance of noise limits at construction sites in urban areas, where space is scarce and expensive (Jabben, 2007).

In CBAs only health effects in residential context are taken into account. In most countries the only health effect included in the monetisation is annoyance (Odgaard et al., 2005). Other health effects like cardio-vascular diseases, effects on cognitive performance at school or sleep disturbance (Dutch Health Council, 1994, Berglund et al., 1999) are usually disregarded. Only France and Denmark take other health effects of noise into account by adding additional health costs to the cost of noise annoyance. In France, the cost of noise levels above 70 dB is increased by 30% (Lambert and Lamboki, 2003). In Denmark, it is pragmatically assumed that annoyance costs comprises two third of the total health costs due to noise (Odgaard et al., 2005).

Noise valuation in ex-ante evaluations of major road and railroad projects

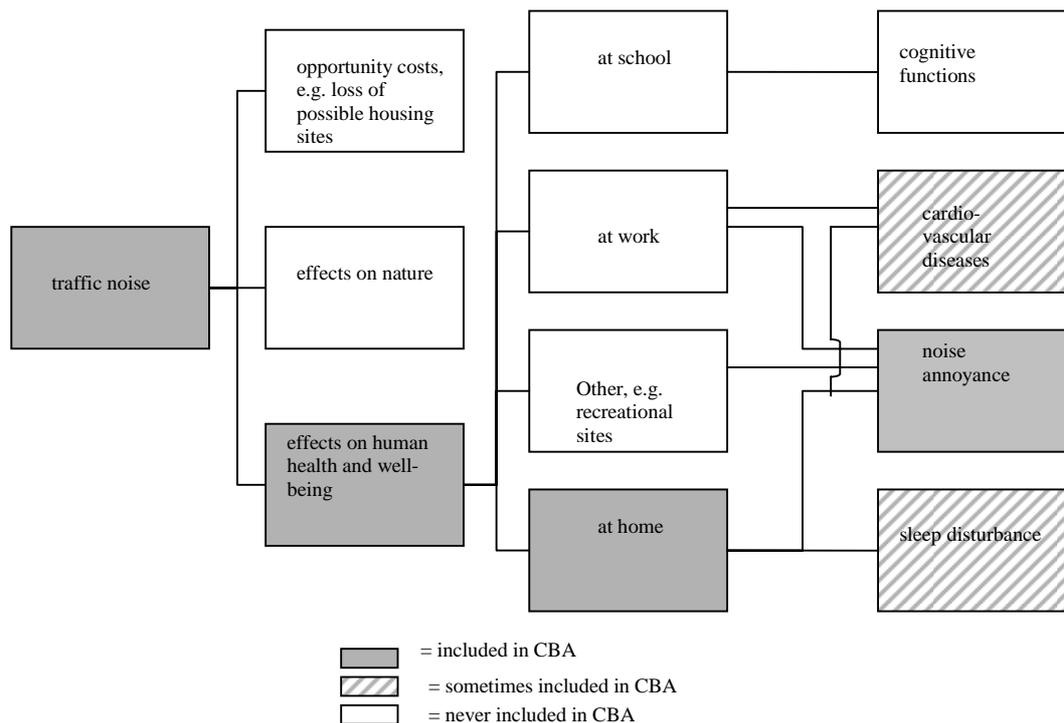


Figure 3. Conceptual model of transport noise valuation

There may be two reasons for including no health effects, other than annoyance in residential context:

- Noise impact assessment deals with noise loads before and after construction of a (rail)road. Noise exposure before and after is calculated and noise effects are estimated on the basis of dose-effect relationships. These dose-effect relationships are only available for annoyance (Miedema et al., 2001) and sleep disturbance (Miedema et al., 2007, van Kempen et al., in press), both in residential context only.
- Monetisation of noise in the CBAs takes people's behaviour as a starting point. As noise has no price tag, monetisation of noise is often done by estimating implicit prices for noise on parallel markets, like the housing market. The higher price of dwellings in a quieter neighborhood is, *ceteris paribus*, the price people are willing to pay to avoid negative impacts of noise. As most people are not aware of other noise effect than annoyance (and possibly sleep disturbance), they will not include other health impacts in their market preferences. Consequently, only annoyance (and possibly sleep disturbance) is implicitly monetised. Furthermore, as the method (called hedonic pricing) focuses on houses, its range is limited to the residential context.

Although in a CBA as many as possible relevant economic, ecological and social impacts are assessed and monetised (Hayashi and Morisugi, 2000), our review showed that noise effects are valued only partially, both in terms of possible effects as in terms of spatial contexts considered. Those countries that monetise noise impacts usually monetise annoyance in a residential context. Only France and Denmark consider other health impacts as well, but this does not lead to a higher price attached to noise.

2.3 *How are noise effects monetised?*

Hedonic pricing is the most widely used valuation method for noise (Navrud, 2004). It is suitable for attaching a price tag to annoyance and sleep disturbance in a residential context (see previous section). Houses in a noisy neighbourhood are cheaper than similar houses in a quiet neighborhood. The difference is the implicit price attached to noise. The main advantage of hedonic pricing is that it is based on actual behaviour. Main disadvantages are the enormous need for data and the limited applicability (a lot of data are needed per dwelling to distinguish the influence of noise from other factors; hedonic pricing is limited to marginal changes in the residential context). Maddison et al. (1996) and Navrud (2004) give an extensive overview of the pros and cons of different noise valuation methods.

In hedonic pricing studies, the unit used to measure the economic value of differences in noise levels is the Noise Depreciation Sensitivity Index (NSDI), defined as the average percentage change in property prices per decibel. NSDI-values differ widely in the various international studies. Bateman et al. (2000) found NSDIs for road traffic noise ranging from 0.08%-2.22% and conclude that an 'average' value will be found somewhere in the lower part of this range. For railroad noise only a few valuation studies can be found (Holsman and Paparoulas, 1982; Strand and Vågnes, 2001; Eliasson et al., 2002). The first two studies are based on hedonic pricing only, whereas Eliasson et al. use both hedonic pricing and contingent valuation.

To value other impacts than annoyance and sleep disturbance in the residential context, valuation methods other than hedonic pricing are called for. Stated Preferences (SP) methods, such as contingent valuation or choice experiments, would theoretically be suitable to value these other impacts. The basic idea behind SP-methods is to ask for people's preferences. The main advantage is the wide applicability of the method. The main disadvantage is the chance of biases due to, for example, strategic responses. In SP-studies, the unit used to measure the economic value of differences in noise levels is the willingness to pay (WTP) per decibel per person/household or the WTP per (highly) annoyed person/household (Navrud, 2004). WTP-values found in literature range from 2 (Navrud, 1997, Barreiro et al., 2000) to 112 (Pommerehne, 1988) euros per decibel per household per year for road traffic (consumer price index 2007). The Working Group on Health and Socio-Economic Aspects of the European Commission (WG HSEA 2003) advises EU Members States, in the absence of local values for noise, to use an interim value of 25 euro per decibel per household per year, regardless of the source of noise and the level (as long as the level is between 50-55 dB and 70-75 dB).

In most countries monetary values are based on hedonic pricing (using housing prices). Finland, Germany and Austria use contingent valuation. Denmark applies its own methodology (Odgaard et al., 2005). Germany also uses an additional third approach called avoidance cost.

Avoidance cost uses the price of noise abatement measures necessary to comply with local standards as a proxy for the total noise costs. This is less suitable to use for noise valuation for two reasons: firstly, avoidance cost shows no relationship between costs and effects. For example, the cost of one kilometre of noise barrier is the same for a densely built-up area as for a scarcely built-up one, but the impact of that barrier will differ considerably. Secondly, avoidance cost usually deals with reducing noise levels to noise standards. Below these standards, noise still affects health, but effects are not taken into account in the avoidance-cost method (as they should in any CBA).

This section showed that most countries use either hedonic pricing or contingent valuation as their valuation method. Differences between countries are therefore not caused by using different methodologies, but mainly caused by (widely) different unit values. The rationale for these different unit values is unclear and needs further research.

3. The gap between theory and practice: the case of the Netherlands

As described in the previous sections, noise valuation methodologies (and unit values) differ among various European countries. This section deals with the question as to what extent the practice of noise valuation differs from the theoretical methodologies and guidelines from the previous section. This issue will be further examined in the context of noise valuation practices in the Netherlands, taken as a case.

The traditional use of CBAs in infrastructural planning in the Netherlands dates back to 1953, when Nobel-prize winner Jan Tinbergen carried out a CBA on the Dutch Delta works (Smits et al., 2006). He already indicated the importance of the non-monetised effects (human lives and ecological values). Since then, CBAs were carried out to estimate the impacts of infrastructural projects using various methodologies. In 1998, the Dutch Ministry of Transport, Public Works and Water Management commissioned a research programme (called OEI) to devise uniform guidelines on the evaluation of economic effects of infrastructure. Since 2000, carrying out a CBA according to the so-called OEI-guidelines (Eijgenraam et al., 2000), is obligatory in the ex-ante evaluation of big infrastructural projects (Tweede Kamer, 2000). The national OEI -guidelines prefer hedonic pricing as the methodology for noise valuation because of its 'reliability and broad scientific basis' (Rouwendal et al., 2000).

Since 2000 eight major national infrastructural road or railroad projects have been evaluated with CBAs using the OEI methodology (Annema et al., 2007). Seven CBAs represent appraisals of railroad projects, and one concerns a new road.

Table 1 gives more details from these CBAs and shows which valuation methodologies, if any, have been used to value noise impacts.

Table 1. Noise valuation in CBAs for roads and railroads, carried out in the Netherlands since 2000

Name	Type	Year	Noise valuation	Methodology	Author
Rotterdam-Antwerp	Freight rail	2001	yes	Avoidance cost	NEI (a)
Antwerp Germany	Freight rail	2001	no		NEA UFSIA
Hanzelijn	Railroad	2001	no		NEI (b)
HSL-Oost	Railroad	2000	no		Dijkman et al.
Rondje Randstad	Railroad	2001	yes	Indicators based on contingent valuation	NEI (c)
Zuiderzeelijn	Railroad	2000	no		NEI
Zuiderzeelijn	Railroad	2006	yes	hedonic pricing	Ecorys
A6-A9	Road	2006	yes	Indicators based on contingent valuation	Decisio

Source: Annema et al., 2007

The table shows that in 4 out of 8 cases, noise impacts were not monetised at all. It also shows that hedonic pricing, the preferred national valuation method, was used only once. In the method most often used, general indicators are applied. This is a quick, but rather insecure method. The indicators are based on national averages: the total national cost of noise in the living environment (based on contingent valuation) divided by the total national sum of kilometres driven inside and outside built-up areas yields the cost per kilometre. Unfortunately, noise

impacts and traffic intensity are not at all related linearly.³ Furthermore, in this approach the connection between the (rail)road and its surroundings is almost completely absent. Thus, the approach is hardly adequate for assessment on a national scale and definitely inadequate for infrastructural projects with local impacts. Local circumstances, which may differ from the average circumstances, are important for such local impacts. Nevertheless the method based on general indicators is used often. Based on interviews with policy makers and consultants involved in carrying out the CBAs, three reasons emerge for using these indicators.

Firstly, CBAs are often carried out by consultancy firms that lack the time to do an extensive research. In such a case, indicators offer a quick solution. Secondly, the national guidelines do not oblige to apply certain methods, which makes it tempting to choose the easiest and quickest method available. And thirdly, noise is often a relatively small item compared to, for example, travel time gains or investment costs. Attention for noise is then not warranted.

4. Conclusions and discussion

There are four main conclusions. First, guidelines for monetisation of traffic noise exist predominantly in the central and north-western part of Europe. In the southern part of Europe, ex-ante evaluation often takes place in the form of a multi-criteria analysis. Noise is one of the environmental aspects considered in these analyses, although unmonetised. Monetisation of road traffic noise is more common than monetisation of railroad noise.

Secondly, not all noise effects are dealt with. Most countries monetise only noise annoyance in the residential context. Inclusion of other noise effects in different contexts would surely lead to a higher price being attached to noise.

Thirdly, the different prices attached to noise in various countries are neither caused by different noise impacts considered, nor by different valuation methods, but are mainly due to different unit values applied to the same impacts. There is obviously room for further research on the rationality behind this.

Fourthly, the experience in the Netherlands shows that, in spite of the existence of monetisation guidelines, noise is often not monetised at all. It also shows that if monetisation is done, it is usually not carried out according to the method preferred in the guidelines. Thus, for noise the application of these guidelines falls short. There is a gap between theory and practice, at least in the Netherlands. The research of Annema et al. (2007) suggests that noise is not the only external effect often omitted in Dutch CBAs. Nature, landscape, spatial quality and external safety are often 'forgotten' as well, whereas carbon dioxide and the emission of nitrous oxides are usually included. Furthermore, from personal contacts with key figures responsible for the information on noise valuation in the different European countries for the EU-funded project on developing Harmonised European Approaches for Transport Costing and project assessment (HEATCO), it appears that the situation in the Netherlands on valuating noise in CBAs is not unique within Europe. In some countries (e.g. Hungary, Lithuania) where (theoretically) noise valuation guidelines exists (according to the HEATCO documentation at <http://heatco.ier.uni-stuttgart.de/>), the application of those national guidelines is virtually non-existent.

³ It goes beyond the scope of this paper to dwell extensively on the relationship between traffic intensity and noise impact. But to illustrate its non-linearity: traffic intensity has a logarithmic relationship with the sound level. The dose-effect relationship between sound level and impact is non-linear as well.

5. Recommendations

Based on the review, we have four recommendations. First, at the same noise levels, road traffic noise has a higher impact than railroad noise. Since this is not always reflected in the (proposed) unit values for impact, research is advised, in line with recommendations of Nellthorp et al. (2007), on the differentiation between the monetary impact of road and railroad noise. Secondly, further research is advised to include all noise impacts (in different contexts) in the price tag attached to noise. Thirdly, further research on the rationality behind the use of widely different unit values for the same impacts is advised. Fourthly, we recommend a stricter application of already existing national guidelines on monetisation. How this should be achieved will depend largely on the country-specific context.

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