"External Costs of Transport: valuation of travel time and traffic noise".
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State-of-the-art in Valuation of Transportation Noise

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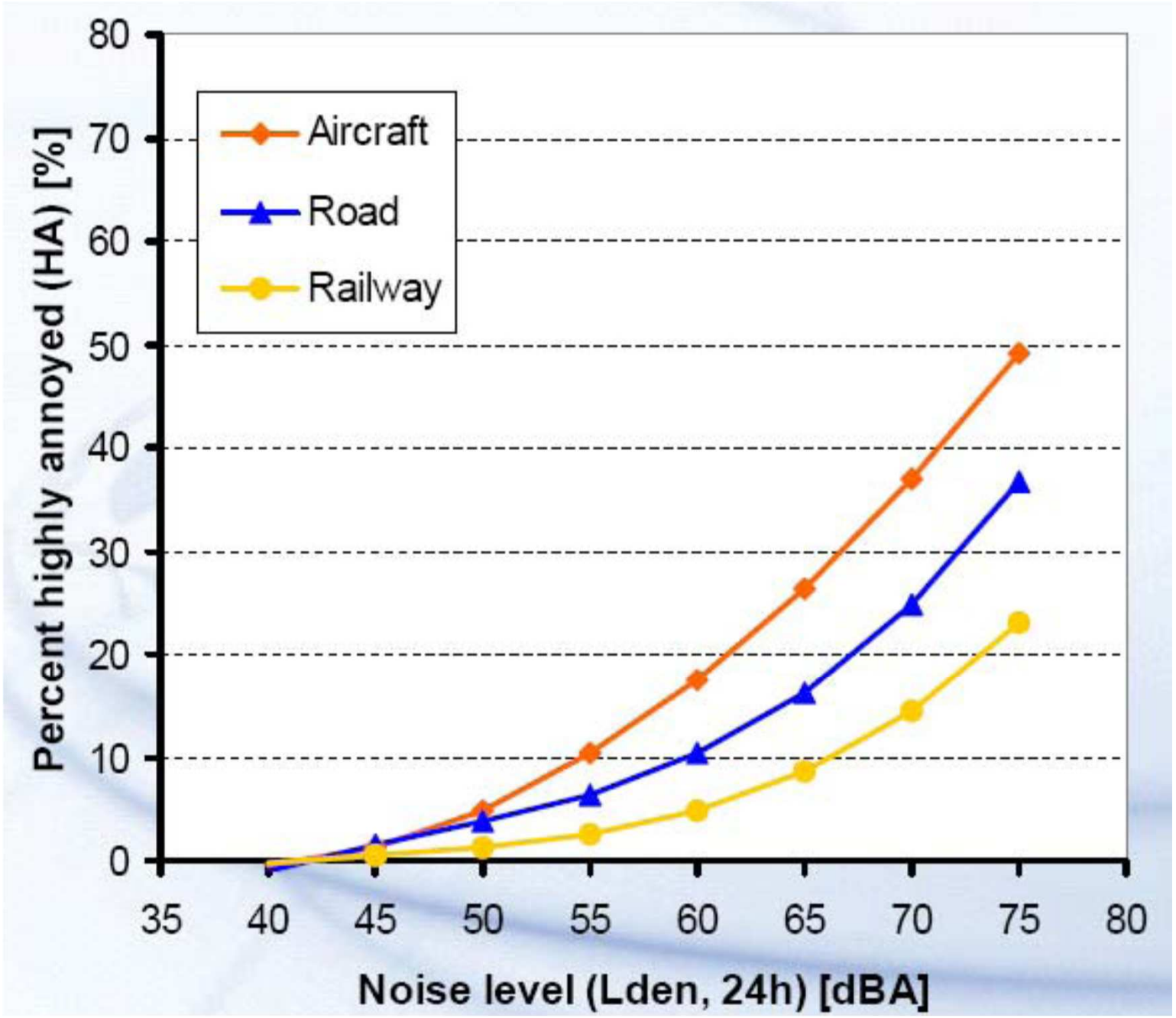

Aircraft
Road
Railway
Percent highly annoyed (HA) [%]
0
10
20
30
40
50
60
70
80
35
40
45
50
55
60
65
70
75
80
Noise level (Lden, 24h) [dBA]

Damage Function Approach

1. Identify the change **in noise emissions** due to transportation project, described in terms of change in time, location, frequency, level, and source of noise (and composition/contribution of noise sources if there are multiple sources)
2. **Noise dispersion models** are used to estimate the ***changed exposures to noise*** at different geographical locations; measured in dB(A) and noise indicators (L*den* and L*night*) (presented in noise maps)
3. **Exposure-Response Functions (ERFs),** between decibel levels (measured by noise indicators like L*den*) and response endpoints like levels of noise annoyance, ischaemic heart disease, subjective sleep quality and other impacts of noise. For noise annoyance the endpoint of the ERF could be "percentage of exposed persons per year that are "highly annoyed" (HA)"
4. ERFs and information about the number of cases of each endpoint, e.g. the change in the total number of persons HA by noise per year, are used to calculate the **overall change in noise impact.** Calculating the change in total number of person HA requires information about e.g. the number of dwellings, household size, and averting behaviour/existing noise mitigating measures (e.g. special insulation against noise and noise screens).
5. **Environmental Valuation techniques** are used to find an economic value for a "unit" of each endpoint of the ERFs , e.g. "euro per person HA by noise per year" . Two different valuation approaches can be used:
    1. Conduct a new, primary study using environmental valuation techniques; mainly Stated Preferences (SP) methods; or
    2. Transfer estimates from existing valuation studies (using benefit transfer techniques and literature review/databases on noise valuation studies).
6. **Economic costs/benefits** of increas/reduction in noise annoyance are calculated multiplying the economic value of each unit of the endpoint (e.g. "euro per person HA per year ", from step 5) with the calculated, corresponding impact (e.g. "change in number of persons HA per year"; from step 4); and aggregate over all endpoints from ERFs (but avoid double-counting).

Noise Annoyance Scale

When you are here at your home, how much does noise from the road traffic bother, disturb or annoy you?

- Extremely annoyed
- Very annoyed
- Moderately annoyed
- Slightly annoyed
- Not Annoyed

ISO Standard; ISO/TS 15666:2003; changed from 4-step to this 5-step scale.
Often assume: Highly annoyed (HA) ~ Extremely and Very Annoyed

Economic costs of noise

(i) *Resource costs* i.e. medical costs paid by the health service in a given country or covered by insurance, and any other personal out-of-pocket expenses made by the individual (or family).

(ii) *Opportunity costs* i.e. the cost in terms of lost productivity (work time loss (or performing at less than full capacity)) and the opportunity cost of leisure (leisure time loss) including non-paid work.

(iii) *Dis-utility* i.e. other social and economic costs including any restrictions on or reduced enjoyment of desired leisure activities, discomfort or inconvenience (pain or suffering), anxiety about the future, and concern and inconvenience to familymembers and others.

i) and ii) = "Cost-of-Illness" (COI) measure of welfare

iii) = Dis-utility of sleep disturbance, illnesses, noise annoyance etc

Environmental Valuation methods

- **Revealed Preference methods**
  - Hedonic Price (HP; Property Price method)
  - Averting Costs
- **Stated Preference Methods**
  - Contingent Valuation (CV)
  - Choice Experiment (CE)

Hedonic price studies – road raffic noise

- **Percentage change in house prices with respect to a 1 dB(A) change in road traffic noise levels (Noise Sensitivity Depreciation Index)**

Reference	Location	Threshold (dB(A))	Percentage change (NSDI)
Wilhelmsson (2000)	Stockholm	56 (implicit)	0.60
Lake et al. (1998, 2000)	Glasgow	54	0.20
		68	1.07
Rich and Nielsen (2004)	Copenhagen:	50	
	houses		0.54
	apartments		0.47
Bjørner et al. (2003)	Copenhagen	55	0.47
Bateman et al. (2004)	Birmingham	55	0.21–0.53

Source: Nellthorp et al. (2007)

Lessons HP road noise (I)

- Bateman et al. (2004) review HP studies

  - NSDI range 0.08–2.22, with a mean value of 0.55.

- Andersson et al (2010), Sweden

  - NSDI = 1.15-1.17 (≥ 50 dB); 1.68-1.69 (≥ 55dB)

- Navrud & Strand (2011); Norway (≥ 55dB)

  - NSDI= 0.87 in urban areas, and 0.34 in rural areas (*lower* when including distance to road and level of shielding; *higher* for expensive homes 0.97)

  - Noise is an *indicator* of multiple external costs of roads; can be used to determine compensation payments for the *overall* disutility of new roads

Lessons HP road noise (II)

- Bateman et al. (2004) derived demand curve for „peace a quiet“ related to road transport – WTP for 1 dB(A) reduction is between GBP 88.76 (at 80 dB level) and 31.49 (at 56 dB level)
  - broadly comparable with SP studies on WTP for noise annoyance reduction
- Bjørner et al. (2003) found that omission of air pollution may bias the noise value upwards

Hedonic price studies – aircraft noise

- Meta-analysis of 33 estimates of airport noise and hedonic property values from 20 HP studies in US and Canada (Nelson, 2004)
  - Fixed effects and random effects models
  - Mean NSDI is 0.58 % per dB (0.50 - 0.64%)
  - country and model specification have some effect on the measured noise discount (higher NSDI in Canada)
  - need to control for accessiblity benefit
  - effect of time on the NDI not observed (studies over 30 y)

Rail noise

- Rather limited attention, few studies
- HP studies; NSDI

  - Day et al (2007); UK NSDI = 0.69

  - Andersson et al (2010), Sweden

    NSDI = 0.34-0.36 (≥ 50 dB); 0.70-0.72 (≥ 55dB)
- CE study: Nunes and Travisi (2007) in Italy
    - WTP for abatement program – not just noise reduction but also visual intrusion
    - noise abatement benefits ranges from € 33 to € 230 per household, but decrease with the height of noise screen

Example: Contingent Valuation

- HEATCO = Developing **H**armonised **E**uropean **A**pproaches for **T**ransport **Co**sting and Project Assessment (EC FP6)
- Same Contingent Valuation survey of road and rail noise conducted in 5 countries – Germany, Hungary, Norway, Spain, UK (reproduced in SE (road) and CR)
- Norway: Sample Size N= 627 (400 above 65 dBA; they had lower income, higher age, lower education, less sensitive to noise than the overall population)

Contingent Valuation

- Describe change in environmental quality
  - scientifically correct, understandable to people,
- Program to acheive change
  - realistic, fair distribution of costs, trust institution that will implement program
- Payment vehicle
  - realistic, fair, minimize protest behaviour (e.g. Increased tax),
- Willingness-to-pay (WTP) per person per year
- Reminder about budget restriction

There are people currently bothered, disturbed or annoyed by noise from road traffic. The authorities are considering implementing a **package of measures** to reduce noise from road traffic. These measures include noise-absorbing road cover in roads and streets that absorb noise from tires, and add-on engine noise dampening boxes for buses, heavy goods vehicles, private cars, scooters and motorbikes. These measures have proven to be effective in reducing noise in other countries, and people are satisfied with them.

This package of measures **will reduce the level of noise here at your home to a level which is *not annoying*** to people who are currently bothered, disturbed or annoyed by noise from road traffic. Other conditions such as traffic safety, exhaust fumes, and dust from road traffic will stay the same, and will be addressed by another package of measures. The measures described here **reduce road traffic noise only**.

This package of measures costs money. The current budget of the road authorities will cover part of these costs, such as the maintenance of the new road cover. However, given their limited budget, those causing noise, such as road users and car manufacturers, and those that benefit from this package of measures, such as residents, will also have to share the costs.

Think about how bothered, disturbed or annoyed you are by noise from road traffic at home now, and how much it is worth to you personally to avoid this. What is the most you personally are **willing to pay per year for the next five years to a special public fund, earmarked for this purpose** – in order to remove *your* road traffic noise annoyance when you are at home? Remember that the money used to avoid noise annoyance must either come from your savings or from what you would have spent on other things.

Start at the top. Tick the amounts you <u>almost certainly are willing to pay annually</u> to remove your noise annoyance from road traffic here at home. Stop when you are uncertain, and report the *highest amount you are almost certain you will pay. If you are uncertain about the lowest amount, tick "I am not willing to pay anything".*	
AMOUNT PER YEAR	
€ 5	
€ 10	
€ 30	
€ 50	
€ 80	
€ 100	
€ 200	
€ 400	

€ 3000	

Table 1. Reasons for stating zero willingness-to-pay (WTP). N=425

Reason	**Reply option no.**	**Percentage (%)**
I am not that bothered, disturbed or annoyed by the road traffic noise that I would pay.	1	24
I cannot afford to pay	2	10
It is more important to reduce other nuisances from road traffic …….	3	3
The noise reducing measures cannot remove my annoyance from road traffic noise	4	2
If you live in a city there will be road traffic noise ….	5	3
I am going to move soon	6	2
I already pay enough charges and taxes	7	39
Government should pay	8	45
Those that cause the noise should pay for it.	9	10
I do not want more roadwork in the street	10	1
The question about paying is too difficult to answer	11	2
Other reasons	12	-

Mean WTP/person/year (2005-PPP €) to eliminate noise annoyance from road traffic in Norway

- Sample size (protest zeros deleted): 416

Noise annoyance level	**WTP**	**Obs**
Not Annoyed	12	88
Slightly annoyed	93	147
Moderately annoyed	316	83
Very annoyed	214	75
Extremely annoyed	143	22

Mean WTP/person/år (2005-PPP €) to eliminate noise annoyance from railways in Norway

- Sample size (protest zeros deleted): 304

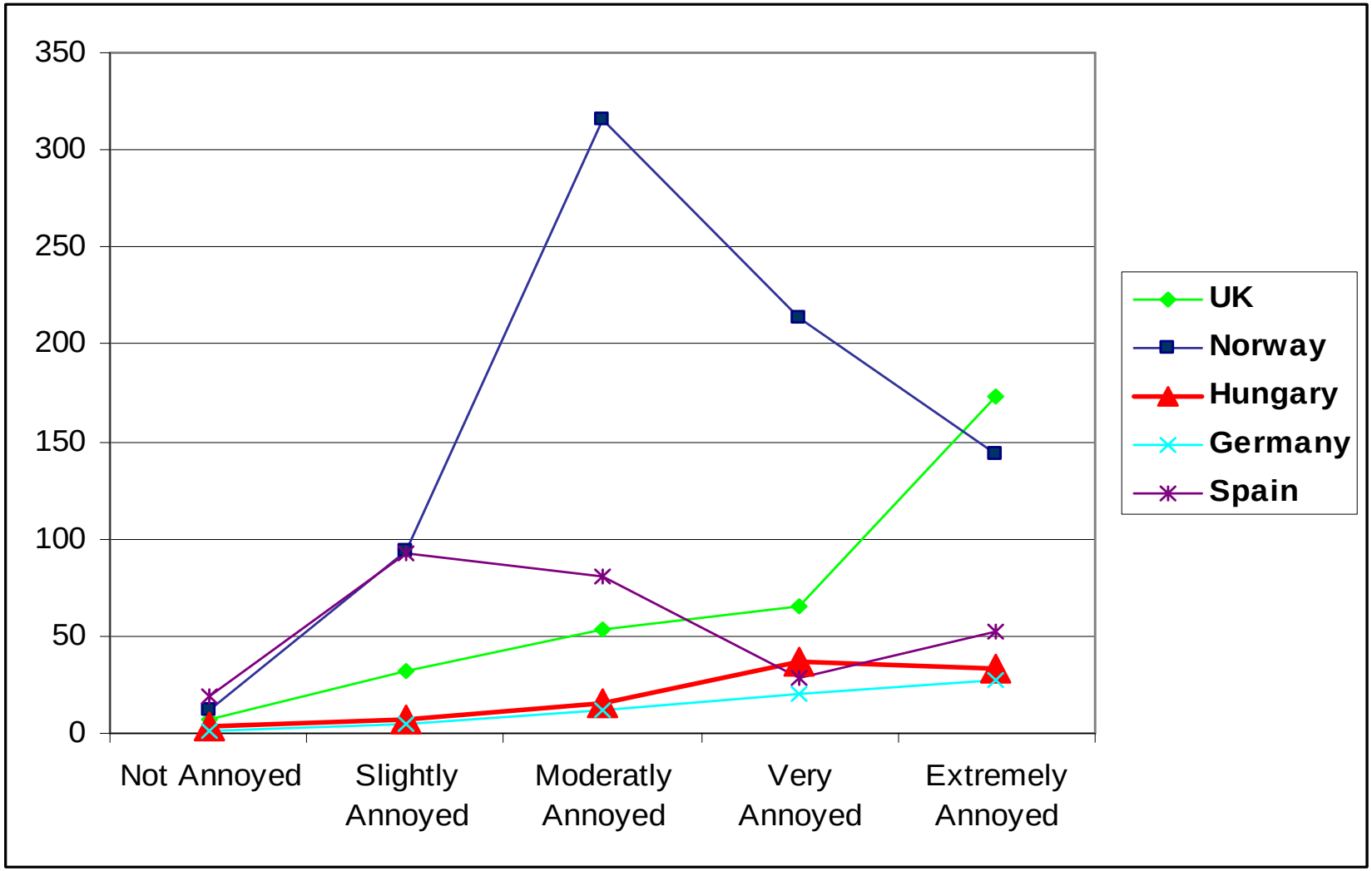
Noise annoyance level	**WTP**	**Obs**
Not Annoyed	15	105
Slightly annoyed	51	146
Moderately annoyed	100	28
Very annoyed	69	19
Extremely annoyed	484	6

Results

- Significant difference in WTP *only* between two broad groups of annoyance; not/slightly and extremely/very/ moderately annoyed
- **Mean WTP** per person is about 2500 2005-NOK per year (mean of the two ways of defining true zeros; 2900 and 2100 NOK).
- Divide by the reduction in noise level of 8.1 dBA; from 63.1 dBA to 55dBA (assuming that all noise annoyance would be eliminated at 55 dBA). Adjusting these 2005-NOK values to 2009-NOK using the consumer price index (9.2 % from 2005 to 2009) gives a mean WTP per person per year **per dBA** of 335 2009-NOK (**37 €**)

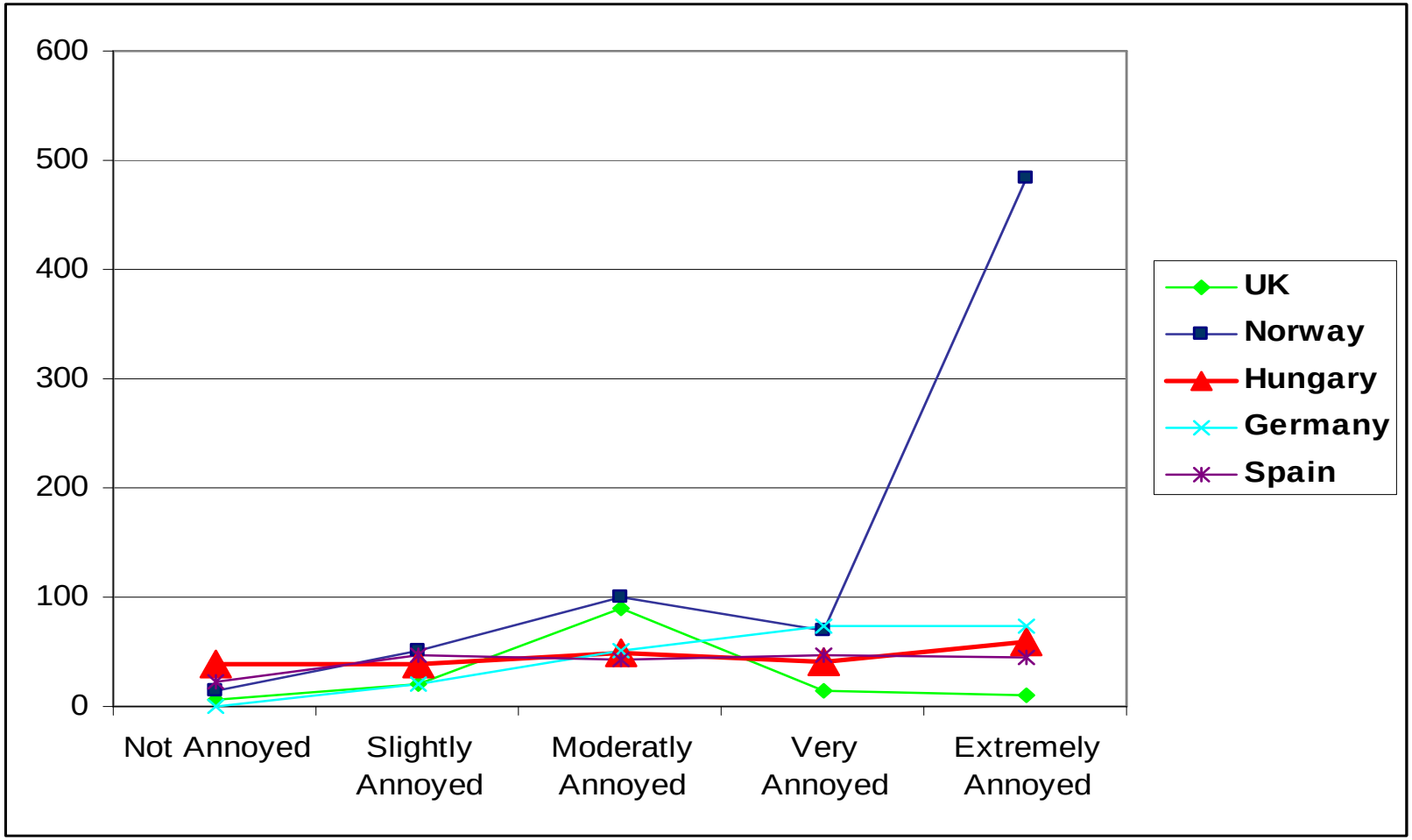
HEATCO

WTP for eliminating of noise annoyance caused by road transportation (in 2005-PPP €)



HEATCO

WTP for eliminating of noise annoyance caused by rail transportation (in 2005-PPP €)



Stated preference studies

Road traffic noise:

Willingness-to-pay per dB(A) per household per year, € 2001

Reference	Method	Location, study year, scenario	€
Pommerehne (1988)	CVM	Basle, Switzerland, 1988, percentage change	99
Soguel (1994)	CVM	Neuchâtel, Switzerland, 1993, percentage change	60–71
Sælinsminde (1999)*	SP	Oslo and Akershus, Norway, 1993, percentage change	48–96
Vainio (1995, 2001)	CVM	Helsinki, Finland, 1993, elimination of annoyance	6–9
Thune-Larsen (1995)	CVM	Oslo and Ullensaker, Norway, 1994, percentage change	19
Wibe (1997)	CVM	Sweden (national study), elimination of annoyance	28
Wardman and Bristow (2004)*	SP	Edinburgh, UK, 1996, percentage change	37–55
Navrud (1997)	CVM	Norway (national study), 1996, elimination of annoyance	2
Navrud (2000)	CVM	Oslo, Norway, 1999, elimination of annoyance	23–32
Barreiro et al. (2000)	CVM	Pamplona, Spain, 1999, elimination of annoyance	2–3
Lambert et al. (2001)	CVM	Rhônes-Alpes Region, France, 1999, elimination of annoyance	7
Arsenio et al. (2006)*	SP	Lisbon, Portugal, 2001, change to level in a known location	55

Source: Nellthorp et al. (2007), Navrud (2002)

Recommended values

Recommendations from ECs Working Group of Health and Socio Economic Aspects in 2005:

1. For road transport, the (interim) use of the median value change in noise perceived by households of **25 € per dB (Lden), per household per year.** The validity range of this interim value is between 50/55 Lden and 70/75 Lden and it should be adjusted as new research on the value of noise becomes available.
2. The estimate of the change should apply at all initial noise levels, and regardless of the size of any change brought about;
3. In the absence at present of conclusive evidence on how the value might vary on different modes, it is advised to leave open the possibility of an adaptation of this roads-based value for use on other noise sources like rail and air using adjustment factors. Specific research should be carried out to resolve this issue.
4. This value should be corrected using Purchase Power Parity (PPP) indices for use in accession candidate countries if necessary; and
5. For other impacts, it is recommended that, in the interim, qualitative and qualitative assessments are used to complement the value of the perceived changes and that research is initiated on this issue.

Conclusions

- **Increased demand for economic values for noise** for:
  i) Cost-Benefit Analysis (CBA) for transportation projects
  ii) Compensation payments for disutility from new roads
  iii) Calculating transportation charges based on marginal external costs in order to internalize external effects

- Stated Preference (SP) studies are able to isolate and value noise annoyance, but continue to improve methodology
- More SP studies needed, especially for rail and aircraft noise
- In Hedonic Price studies implicit costs of noise is often an aggregate measure of multiple external effects of transportation; but based on actual behaviour
- Collect data on dB(A), noise annoyance, illnesses, and WTP at the same time in order to improve certainty of ERFs and WTP estimates for value transfer in a Damage Function Approach