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NOISE ANNOYANCE AND WILLINGNESS TO PAY OF INHABITANTS EXPOSED TO TRANSPORT NOISE

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Abstract

During the process of European integration the question arose how a standard could be created to assess qualitative and quantitative effects deriving from the development of transport infrastructures. The issue gets an even higher emphasis in case of valuation the development of large projects which impact several countries. The main aim of the research was to determine how much people are bothered, disturbed or annoyed by noise, and then to establish a correlation between this and their willingness to pay, and the absolute noise levels. This paper summarizes the survey and its results. Noise influences people's well being and standard of living. It is the only environmental pollution where it is not a polluting material that effects the body adversely – as it is in the case of air or water pollution –, but the danger is created by an energy overdose reaching the sensory and data processing organs. Here we talk about nervous processes and this characteristic distinguishes noise pollution from all the other contaminating factors. It has also got to be mentioned that perceiving noise is very subjective. The reaction of people is largely predetermined by how they relate to the noise source. Noise annoyance can be determined by socio-acoustical studies. The essence of these is that they do not only take into account decibel levels, but attach so called annoyance levels to the given sound pressure levels.

Keywords: noise pollution, noise annoyance, willingness to pay, cost of pollution.

1. Introduction

High quality standard of transport infrastructures is of highest importance from the point of view of social-economical development and preservation of the environment. During the process of the European integration the question arose how a standard could be created to assess qualitative and quantitative effects deriving from the development of transport infrastructures. The issue gets an even higher emphasis in case of valuation of the development of large projects which impact several countries. It is well known that different EU member states have different assessment procedures for the valuation of investments. However, these approaches can only be adopted for the assessment of projects of individual countries, and do not provide sufficient means in planning schemes that affect several states.

The European Commission has initiated to launch a research programme aimed to create a standard European approach to evaluate the TEN-T projects which

are spread in several countries. The project intends to construct an assessment method which is reliably applicable, and best matches the practices of individual member states. A part of this project was a noise annoyance study conducted at the Department of Transport Economics of BUTE. The main aim of the research was to determine how much people are bothered, disturbed or annoyed by noise, and then to establish a correlation between this and their willingness to pay, and the absolute noise levels. This paper summarizes the survey and its results.

2. Analysis and Evaluation of Noise Pollution and its Effects

Noise influences people's well being and standard of living. It is an environmental pollution the effects of which can directly be sensed only in the short term, but in the long term it leads to health problems and deteriorates the living standards. According to estimates 30% of the Hungarian population is forced to endure noise levels which are unacceptable, say experts, and which make people restless, and their sleep troubled. In the first part of this paper we sum up the effects of noise pollution on health, and then we assess the negative effects of noise. Then we turn onto the results from the survey.

3. Effects of Noise on Health

Noise is the only environmental pollution where it is not a polluting material that effects the body adversely – as it is in the case of air or water pollution –, but the danger is created by an energy overdose reaching the sensory and data processing organs. Here we talk about nervous processes and this characteristic distinguishes noise pollution from all the other contaminating factors. According to the World Health Organization the effects deriving from noise pollution can be put into the following categories:

1. hearing impairment
2. difficulties in perceiving speech
3. troubled sleeping
4. physiological reactions (e.g. Hypertension)
5. higher risk of depression and other mental illnesses, stress
6. people tolerate smaller workload
7. a change in behaviour, rage.

1. It is *hearing impairment* that can be most directly associated with noise pollution. Depending on the intensity and duration of the effect we can talk of temporary or permanent hearing impairment. Permanent is a noise effect if the threshold of hearing is not regenerated after 40 hours of rest. In case of temporary impairment hearing can return depending on the duration of the resting period.

2. *Verbal communication* and getting along in society is adversely affected by reduced hearing. To make human speech containing messages understandable (at school, while listening to talking in foreign languages, or on the phone), at least 15 dB difference is needed between the level of noise and the level of speech, and the latter should be at least of 50 dB(A).
3. *Troubled sleep* occurs already from sound pressure levels (SPLs) of 30 dB(A). 35 dB(A) extends the time period need to fall asleep, and sleeping will be more superficial. Noises of low frequency can even be disturbing at a lower SPL, and the impulses of short duration but high SPL have to be definitely avoided. The maximum SPL for impulses is 45 dB(A).
4. Noise has a further effect that deteriorates health. Noise levels of 60 dB(A) or above *irritate the autonomic and the central nervous system*. To what extent we find noise a burden depends also on whether the effect is continuous or periodic. We can tolerate periodic noise pollution less: the nervous system is in a constant state of alarm, awaiting the arrival of a new stimulus, and this creates an unpleasant feeling. This is how it can happen that some noises of exceedingly high level prove to be more annoying than those of constant level, although both sources create the same equivalent sound pressure level.

   It is more difficult to prove that noise has an effect on physiological reactions, since these vegetative problems usually occur when several effects are present. Still it has been found that noise can convey to changes in blood pressure, blood composition, heart functions and hormonal system. Heart diseases and Hypertension might occur. Those workers or inhabitants living close to airports or major roads who have to endure sound levels higher than 65-70 dB(A) in the long term can be observed to have a higher risk of Hypertension and stress.
5. – 6. Constant noise *reduces the workload* people can bear, and they are also *less able to concentrate*, and are less creative. Due to the overload on the nervous system fatigability and the rate of mistakes committed increases. *Increasing stress levels* can also contribute to further problems and depression.

7. People do not become furious from 50-55 dB(A) SPL in daytime, and at night are not annoyed by noise levels 10- 15 dB(A) lower than this. But the behaviour of inhabitants who are exposed to 80 dB(A) can be observed to change radically: they tend to become aggressive and less helpful.

It has also got to be mentioned that perceiving noise is very subjective. The reaction of people is largely predetermined by how they relate to the noise source. When they feel that the facility or phenomenon causing the noise is important and useful to them, because it contributes to social-economical welfare or because it is connected to something related to higher standards of living, then they will much easier tolerate even higher noise levels. However, if they feel the noise events are independent of their own lives, and are something they cannot influence, then they will tolerate even the lower noise levels less.

3.1. Noise Annoyance

Noise annoyance can be determined by socio-acoustical studies. The essence of these is that they do not only take into account decibel levels, but attach so called annoyance levels to the given sound pressure levels. The guideline values for different transport modes published by the European Union can be very well used [6]:

(1) Air Transport: $\%A = 8{,}588*10^{-6}(\text{Lden-}37)^3 + 1{,}777*10^{-2}(\text{Lden-}37)^2 + 1{,}221(\text{Lden-}37)$

(2) Road: $\%A = 1{,}795*10^{-4}(\text{Lden-}37)^3 + 2{,}110*10^{-2}(\text{Lden-}37)^2 + 0{,}5353(\text{Lden-}37)$

(3) Railway: $\%A = 4.538*10^{-4}(\text{Lden-}37)^3 + 9{,}482*10^{-3}(\text{Lden-}37)^2 + 0{,}2129(\text{Lden-}37)$

(4) Air Transport: $\%HA = 9{,}199*10^{-5}(\text{Lden-}42)^3 + 3{,}932*10^{-2}(\text{Lden-}42)^2 + 0{,}2939(\text{Lden-}42)$

(5) Road: $\%HA = 9{,}868*10^{-4}(\text{Lden-}42)^3 - 1{,}436*10^{-2}(\text{Lden-}42)^2 + 0{,}5118\ (\text{Lden-}42)$

(6) Railway: $\%HA = 7{,}239*10^{-4}(\text{Lden-}42)^3 - 7{,}851*10^{-3}(\text{Lden-}42)^2 + 0{,}1695(\text{Lden-}42)$

where:

%A is the percent of people annoyed, bothered or disturbed by noise;

%HA is the percent of people highly annoyed, bothered or disturbed by noise.

Lden is the unit also used in Hungarian law for the description of average noise levels. It gives a higher weight to evening and night noise levels, and is defined as follows:

$$\text{Lden} = 10 \lg \left[(12/24)*10^{LD/10} + (4/24)*10^{(LE+5)/10} + (8/24)*10^{(LN+10)/10}\right]$$

In which:

LD, LE and LN are the A-weighted sound pressure levels as defined in ISO 1996-2 (1987) for the daytime (7-19h), evening (19-23h) and night time (23-7h) period.

If noise mapping depicts the average noise level of a certain area, with the help of the methodology described above it becomes possible to give an estimate of what percent of the people are annoyed, bothered or disturbed by noise emitted by the different modes of transport, such as air, road or railway traffic.

Comparing the equations given above (see *Figs. 1.* and *2.*) it is evident that air traffic is considered much more annoying at the same noise level than road or railway traffic, that is, a much higher percent of people feel air traffic is more unbearable than the other two modes of transport. At the same time road traffic is considered more disturbing than the railways. This phenomenon can be described as follows: when we evaluate noise annoyance, it is not sufficient to consider the maximum A-weighted noise level in itself, but the frequency of changes has also to be taken into account. It is typical of air traffic noise events, that they are composed of high sound pressure levels of short duration. As it has been explained above the human ear and nervous system have difficulties in adapting to this. Whereas noise events caused by railway traffic are of lower sound pressure levels, and do not vary so frequently, meaning that they are easier to adapt to. This is one of the reasons why people evaluate noise levels of different transport modes differently.

3.1.1. Contingent Valuation (CV) as Method to Assess WTP

To evaluate the external effects and the monetary value of transport noise, we have a wide variety of methods to choose from: revealed preference methods (hedonic pricing, knowing the prices on the real market, creating a hypothetical market, method of travel costs) and the stated preference methods (choice experiment, contingent ranking and contingent valuation) can all give reasonable answers to our questions. Nevertheless, contingent valuation is the only method to assess the total economic value [3]. This was the method chosen as the basic methodology of the survey, not at least because there is sufficient knowledge available for its benefit transfer.

CV method is used to create a hypothetical market and the interview person (IP) is asked to choose a value representing the amount of money he/she would be willing to pay in order to have a more silent neighbourhood. To achieve this we need an introductory part that prepares the IP for the decision, then the description of the "more silent" neighbourhood follows. What does this exactly mean, and what techniques would be used to achieve it? The financial vehicle and its bureaucratic background has to be explained, only after these can the WTP question follow [5].

Follow-up questions need to be used to reveal why the answers were positive or dismissive, and the rate of protest zeros has to be established. At the end of the questionnaire should the questions be asked about the demographic background and the attitude of the IP.

4. Determining WTP in Relation with Noise Annoyance

In the survey a sample of 2000 people were interviewed in person by the Hungarian Gallup Institute. The interview persons (IPs) were divided in different groups depending on what source of transport noise they were bothered by (road, railway, air traffic or none) and also into subgroups depending on the extent of exposure (significantly or not significantly exposed to noise). *Table 1* contains the size of the samples and the different categories.

Constructing the survey, one of our main aims was to create a structure which would enable us to compare the results of the aircraft noise study with the results of the previous study directed at railway/road noise annoyance. At the same time we wanted to include some changes that might help reduce the extremely high rate of protest zeros experienced in the previous survey. We also intended to examine the embedding phenomenon.

The questionnaire was aimed at discovering how much in the last 12 months or so the IPs have been annoyed, bothered or disturbed by noise[1], and how much they would be willing to pay to reduce noise to a level where it would not annoy, bother, or disturb them anymore – given that the other factors (safety, air pollution, size of traffic) remain unchanged.

[1] The questions were phrased as suggested by the relevant ISO standard. See [8]

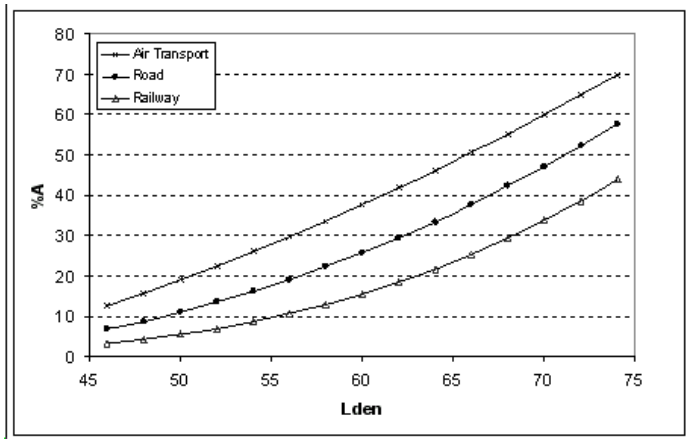


Fig. 1. What percent of the people are annoyed, bothered or disturbed by noise at a given noise level?

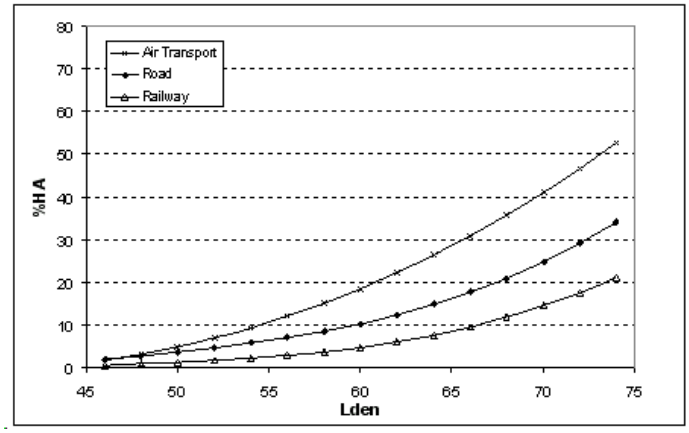


Fig. 2. What percent of the people are *highly* annoyed, bothered or disturbed by noise at a given noise level?

In order to test the differences between the preferences of rural and urban respondents, we divided the sample, and each questionnaire was tested on both groups. The surveys took place in Budapest and in the surrounding villages.

Evaluating the results we will always refer to data collected in the total sample unless indicated otherwise. First the answers to the basic annoyance question are examined and the context in which the questionnaire respondent finds him/herself. Then we move on to the analysis of the WTP.

In the survey the inhabitants exposed to noise annoyance have been put into

Table 1. Distribution of the subcategories of the sample

	%	No. of IPs
Exposed to significant road traffic noise	10	200
Road traffic noise not significant	10	200
Exposed to significant railway noise	10	200
Railway noise not significant	10	200
Significant noise exposure – random sample	5	100
No noise exposure – random sample	5	100
Exposed to significant air traffic noise	25	500
Air traffic noise not significant	25	500
Sum:	100	2000

5 categories depending on how much they are annoyed, bothered or disturbed by road, railway and air traffic noise (*Table 2*)

Table 2. Noise annoyance distribution in Hungary

	Road	Railway	Air Traffic
	%	%	%
Not at all	22	20	22
Slightly	17	18	18
Moderately	20	22	31
Very	22	25	20
Extremely	19	15	9
Number of answers (IPs)	500	500	1000

Table 3 shows the distribution of the most frequent answers given by the IPs to the question what problems they encounter because of the noise exposure.

Basically we can conclude analysing the curves (see *Fig. 3*) that if other factors are unchanged, with an increase in road traffic noise WTP to reduce noise annoyance also increases; as expected.

Analysing the relationships further it is clear that WTP in relation with railway noise is nearly constant, it varies only slightly with the changes in noise level; and for the elimination of air traffic noise annoyance people are barely willing to pay. The relatively high WTP can be explained with the nature of the product offered. In our country citizens have to pay a lot of taxes in connection with transport, for example "weight tax." That is why they might refuse to pay anything more related to transport, while previous studies showed that the percent of zero WTPs is

Table 3. Effects of noise exposure

If noise bothers, disturbs or annoys you, could you say what the consequences are for you?	Road	Railway	Air traffic
	%	%	%
Do not open windows as often as I would if there were no noise	61	55	30.2
Find it hard to sleep	36	44	33.0
Disturbing when watching TV or listening to the radio/music	47	70	63.9
Hard to concentrate and disturbing when reading or working	23	25	25.0
Disturbing when talking or talking in the telephone	29	47	45.7
Get headaches/migraine	14	10	14.8
Sleep with earplugs	4	3	2.4

not necessarily so high if the product offered is different (for example protection of caves or water quality). The result that we got is in correlation with the international

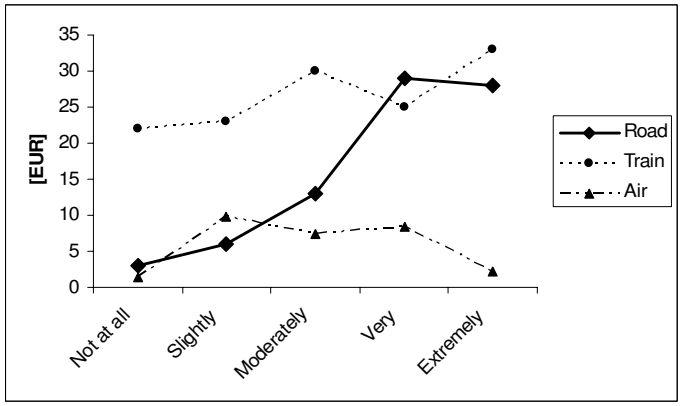
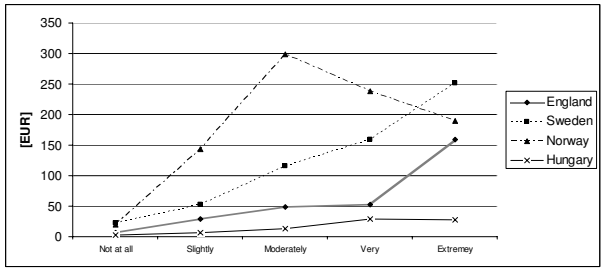


Fig. 3. Correlation between transport noise annoyance and willingness to pay

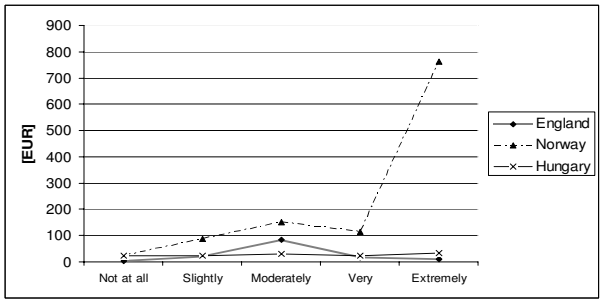
standards, despite of the special economical, social, environmental milieu of the newly associated states (see *Fig. 4*).

5. Conclusion

Noise influences people's well being and standard of living. It is an environmental pollution the effects of which can directly be sensed only in the short term, but in the long term it leads to health problems and deteriorates the living standards. The Department of Transport Economics of BUTE conducted a survey in which the



WTP of noise caused by road transportation



WTP of noise caused by rail transportation

Fig. 4. Based on the survey conducted in HEATCO

Hungarian Gallup Institute has been contracted to ask a sample of 2000 interview persons in form of face-to-face interviews based on a written questionnaire about their noise annoyance and their willingness to pay to eliminate this noise annoyance.

Those people who are not, slightly or moderately annoyed, bothered or disturbed by transport noise would rather pay for the elimination of railway noise annoyance (see *Table 4*). One of the reasons for this can be that people have to pay lot of taxes in connection with road transport in Hungary (e.g. "weight-tax"), and they are not willing to pay more because of this section of the industry. On the other hand they might feel that air transport is a privilege of a "chosen few" and thus they are not willing to pay to reduce noise annoyance deriving from aircrafts. This leaves railway transport for which their WTP is higher. It can also be explained by the fact that in the new member states in Central-Eastern-Europe the living standard is influenced by social indices, but the environment-conscious attitudes and protection of environmental values are not yet wide spread enough.

Future work in the field of WTP to eliminate transport noise annoyance in the short term is to establish the connection between social indices and WTP (e.g. how education, standard of living, and age influences WTP in case of the different transport modes), while in the long term the Hedonic Pricing (HP) method could be used to carry out a further research and enable us to compare the results of this Contingent Valuation study with the outcome of that examination, thus analysing whether the tendencies present in older EU Member States can be discovered in Hungary.

Table 4. Noise annoyance categories and average WTP

Not at all		
Road	Railway	Air
3	22	1.35
Slightly		
Road	Railway	Air
6	23	9.75
Moderately		
Road	Railway	Air
13	30	7.35
Very		
Road	Railway	Air
29	25	8.35
Extremely		
Road	Railway	Air
28	33	2.3

All values are in Euros

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