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Vibrations as the main element of transport external costs in terms of economic and human impact

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Abstract. Transport negatively effects borne not only the environment, but they also have a negative impact on society and contribute to economic efficiency decrease and economic losses. The purpose of this article is to present economic and social approach to vibrations as the external cost of transportation.

Keywords: transport external costs, transport vibrations, transport externalities, health.

1. Introduction

Transportation dealing with the movement of people and goods is a particularly important component of the economy in the contemporary world. Efficient and effective transport system is one of the essential factors of growth and socio-economic development at the regional, national, international and global scale. It generates a lot of positive but unfortunately also some negative externalities in economic and social spheres. Progressing over the years, economic development in technology and communications have a significant impact on transport technologies. A particularly important role in the service as a whole fulfills road transport. It is particularly important while growing supply of transport services bring their degradation impact on the environment. These trends are specifically noticeable:

– growing ecological awareness of participants of transport processes,

– development of new methods of measuring environmental damage by transport activity,

– the evolution of methodologies to assess the economic impact of transport on the environment (human being also), thus allowing for a more precise determination of the negative effects of its cost.

Contemporary trends of transport development, based largely on road transport of passengers and goods, leading to growing levels of sector external costs. Their negative effects borne not only the environment, but they also have a negative impact on society and contribute to economic efficiency decrease and economic losses [1].

The purpose of this article is to present economic and social approach to vibrations as the external cost of transportation.

2. Vibrations among transport external costs – economic approach

Literature studies and observation of economic practice suggests that transport processes in addition to the specific economic benefits have negative externalities in terms of environmental and social area. Responsibility for part of the negative effects remains fuzzy and as unpaid injuries to third parties impacts occur in the form of external costs. The primary cause of the imperfections of transport external costs estimated results is the lack of adequate empirical data and practical observations. Often, the transport external costs do not affect in a decisive way to shape the structure of the transport sector and are not an essential element of decision-making for individual transport users.

There are different categories of external costs of transport activities shown in Table 1, as described in a report of the project Pricing European Transport Systems [2]. Externalities are all changes of welfare which are caused by economic activities without being reflected in market prices [3]. The main categories of external costs are: congestion, accidents, pollution of surface water, groundwater and soil, noise, vibration, climate change, and using land for the construction

of transport infrastructure. These costs impact directly or indirectly on the deterioration of the natural life quality, health and human life, contributing to reduce the level of social welfare.

There are many authors discussing in details procedures of economic valuation, which are mainly based on quantifying individual "willingness to pay" (WTP) for environmental benefit or "willingness to accept" (WTA) payment in lieu of environmental harm.

Alternative techniques have been developed for valuation of non-market goods, such as: human health, ecological systems, based on hedonic pricing, travel costs methods and contingent valuation [3].

Hedonic pricing is to quantify the worth of one good through variation in the price of another good. The best example probably is the economic estimation of people's aversion to vibration by reference to variation house prices between environments close or far to the source of vibrations (e.g. train or tram rails).

Travel costs approaches quantify the worth of the things that may attract visitors (landscapes, ecosystems, nature reserves, historic buildings etc.) by considering money and time spent on visits. Contingent valuation involves setting up hypothetical market, usually with questionnaires to elicit the preferences of the interviewed. Unfortunately, all of those techniques involve uncertainties, though they have been considerably refined over the years [3].

The negative impact of transport on the environment is currently estimated at costing the general transport (internal and external). In Poland, the cost of the negative impact of transport on the environment represent approximately 29 % of external costs, including the costs of air pollution (11 %), the cost of climate change (5 %), the cost of noise (11 %), other environmental costs (2 %). The remaining 71% of external costs are the effects of human and material transport accidents. In total, it is estimated that the external costs are equivalent to 6 % of Polish GDP and are not included in the accounting [4].

Uncertainty in externality estimates arises from a number of sources, including:
– the variability inherent in any set of data;
– extrapolation of data from the laboratory to the field;
– extrapolation of exposure-response data from one geographical location to another;
– assumptions regarding threshold conditions;
– lack of detailed information with respect to human behaviour and tastes;
– political and ethical issues, such as the selection of discount rate;
– the need to assume some scenario of the future for any long term impacts;
– the fact that some types of damage cannot be quantified at all [3].

3. Human impact approach

Vibration and noise associated with it are an essential item affecting the level of the external cost of transport in the category of environmental costs. Transport vehicles emit a lot of sounds that can be unpleasant and aggravating seriously the human body [5] (Table 2). The human ear receives sound in a wide range of intensities (adopted range from 0 to 120 decibels). On the other hand, our ear is able to receive this sounds like the roar of cannons, the roar of a rocket taking off or jet. Special security to protect the sensitive ear mechanism from damage in almost all situations, in addition to the most intense noise [6]. In addition, exposure to vibration and associated noise increases the risk of heart and circulatory diseases, reduces subjective sleep quality. The vibrations and unpleasant sounds have a lot of sources, which include the usual: motor noise, vibrations of individual elements, rolling tires, air flow and cooling fan noise. Annoyance and harm to health and other adverse effects depend mainly on the volume, frequency vibration, the vibration exposure time for the man, but also on the individual characteristics of human sensitivity [7-10]. The fact that the receiving votes and vibration can also be a subjective feeling is the fact that for some people the sound of "roaring" engine is enjoyable and exciting, for others repulsive.

The publication of the World Health Organization (WHO) and the Joint Research Centre of the Commission [11] was shown that due to the noise associated with traffic followed by a major

loss of health in Western Europe.

Noise is also accompanied by other types of mechanical vibration waves. Acoustic waves which are also called noise [12] may adversely affect the human being. Infrasound – low-frequency vibrations (0-16 Hz), inaudible or difficult to hear, but strongly affecting internal organs. Ultrasound – waves of very high frequency (above 20 000 Hz), almost inaudible, but acting in man and the vibrations – vibrations propagating in solids that affect them in contact with the person. Too high levels of vibration affect the entire body, causing systemic disorders and ailments in the individual human systems (Fig. 1). The influence can be measured both in physiological and psychological parameters [13].

Table 1. Transport externalities

Social costs types		Internal costs		External costs
		To individuals	To the sector	
Environmental costs	Fauna and flora energy noise air, water, land landscape effects vibrations	Own disbenefits (individual)	Own disbenefits (sector)	Uncovered environmental costs
Congestion costs		Time lost by the user (and the increase of other direct costs)	Time lost by the user (and the increase of other direct costs)	Costs provoked on others outside the transport sector
Accidents		Own accident costs covered by insurances	Costs covered by insurances	Uncovered accident costs
Infrastructure costs		Tolls, vehicle and fuel taxes	Unperfected allocation of costs	Uncovered infrastructure costs
Transport expenditure		Fuel/vehicle costs or tickets and fares	Unperfected of costs	Costs covered by others

Table 2. Negative impact of noise generated by transport on human

Sound intensity [dB]	Impact on human
Less than 35	Noise intensity harmless to health, may be annoying or disturb in work that requires concentration
35–70	Noise intensity affect the tiredness of human nervous system, seriously impede speech intelligibility, sleep and rest;
70-85	Noise intensity affect a significant reduction in labor productivity can be harmful to health and cause hearing loss;
85–130	Noise intensity may cause numerous diseases of the human body, prevent speech intelligibility, even from a distance of 50 cm;
Over 130	Noise intensity cause permanent hearing damage, induce vibration stimulation to the human internal organs causing their disease

These types of defects typically occur under the influence of heavy vibrations and noise, the degree of damage to organ [14, 15] depends on the intensity and the activity of the waves on the human body.

Due to the negative impact of infrasound noise on the human body, created appropriate procedures for frequency measurement at workplaces [16-18] so that they are consistent with the principles of safety and health at work.

4. Negative impact of noise and vibration on drivers of vehicles

In terms of the negative impact of noise and coming out of it acoustic waves or vibrations EU Council created Directive [19] on the approximation of the laws of the Member States Relating to the permissible sound level and the exhaust system of motor vehicles. On the basis of standardization activities undertaken in each country and started to lead experiments into the effects of low frequency noise upon human behavior [20, 21].

Studies show how versatile they are wheeled machines negative actions on the human body [22]. Even in the agriculture environment [23] the exposure levels of noise it can make a small risk of potential adversely effects on hearing during tasks performed inside the closed cab of tractor [24, 25] causing discomfort [26]. The research was also carried out among bus drivers [27], truck drivers [28] and other groups of the driver in agriculture or urban areas.

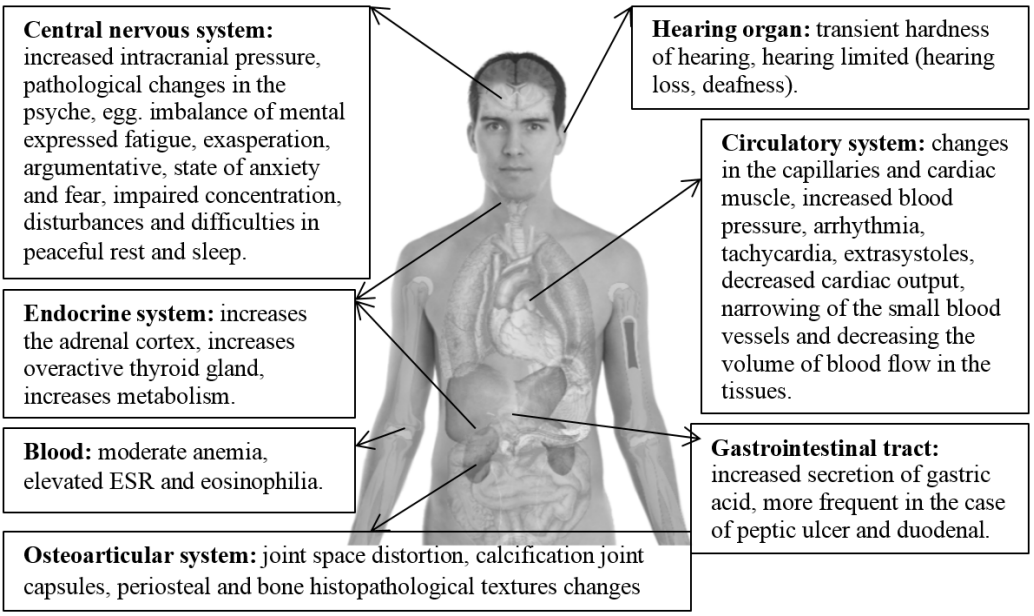

Fig. 1. Physiological and psychological impact of vibration and infrasonic noise on human body. Source: own elaboration, image from http://www.clker.com

5. Protection from vibration

Reducing the level of transport externalities can be done by reducing emissions from the source itself, e.g. using new technology or new technology. In the case of traffic noise effort is aimed at silencing the vehicle by reducing operating noise of the engine and the entire drivetrain and the development of adequate tire tread surface. In the case of vibration leveling, the relevant damping systems are designed for vehicles and driver's seat. Also research on the respective properties of the surface layers of roads, which will reduce noise and vibration that arises when the car is on the road surface are conducted.

6. Conclusions

Europe, including Poland, are threatened by increasing levels of vibration and noise first of all communication, resulting from increased pressure on the automotive industry. The negative effects of noise and vibration on the health and condition of man is well known and undisputed by environmental specialists in the medical and acousticians and numerous organizations (e.g. WHO). Many studies and observations point to a progressive decline in health, in particular ear of the population. At the same time it draws attention to the losses incurred by the state due to the withdrawal of people with hearing loss or deafness or other diseases resulting from the negative impact of vibrations from work, but also an active life in society, which causes additional costs to the state.

The awareness of noise pollution in societies is rather low, primarily for two reasons: lack of knowledge about the effects of exposure of the body to excessive and prolonged noise and

vibrations and the absence of direct and visible effects of vibration on the human (years may develop in secret).

Given the state of health hazards, it seems reasonable proposal to introduce universal, publicly available research people who are particularly vulnerable to increased negative vibrations. They can make a significant contribution to improving the health of the population, reduce the cost of treatment and increase awareness about the dangers of health damage, and thus conscious of its protection.

Because the problem is universal and transnational, it is important to introduce a common transport policy aimed at reducing the harm impact of transport on the environment, carried out in three dimensions:

– transfer of passengers and freight from road transport to more environmentally friendly branches (forming rational structure modal balance),

– introducing the principle of "polluter pays" principle, which is making perpetrators orders to pay for the external costs of damage,

– elimination of pollution and noise at the source, i.e. the introduction of instruments affecting the technical modernization of vehicles, fuels and infrastructure.

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