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EXTERNALITIES IN TRANSPORT PROJECTS – IDENTIFICATION AND VALUATION

Transport projects are extremely time and capital consuming. Hence, valuing their effects on the economy has to be regarded as an issue of significant importance. However, impacts of transport projects are often perceived as difficult or even impossible to identify and appraise. In the paper, the author identifies the impacts of transport projects, and presents methods and techniques of their valuation within cost-benefit analysis.

Keywords: transport projects, cost-benefit analysis, external costs

INTRODUCTION

The main goal of the paper is the description of external effects in transport projects and methods of their valuation. In the first section, transport projects and approaches to their analysis are synthetically presented. Subsequently, the idea of externalities and methods of putting money on them are described. Next, transport externalities and their valuation are accommodated. Finally, the current state of analyzing externalities of road projects in Poland is addressed.

The comprehension and importance of externalities in transport projects has undergone significant changes. Externalities become subject of interests of economists as long ago as in the 1950s, when the main importance was attached to so-called "pecuniary externalities" (transferred through the market mechanism). Between 1960s and 1980s, interests in the issue of external effects has decreased, in the wake of difficulties in measuring them, which was correlated with views that, in most cases, their influence on projects' social profitability is negligible. Subsequently, from the 1980s until now, the importance of real externalities has grown. Nowadays, most important are environmental effects. As the consciousness of sustainable development has grown, economists, answering to current problems, have developed many sophisticated methods of valuating environmental externalities. Accordingly, many effects which used to be regarded as

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impossible to evaluate have become quantifiable. However, still not all effects are really measurable. In such cases cost effectiveness or multi-criteria analysis should be conducted.

1. TRANSPORT PROJECTS AND THEIR VALUATION

Transport projects can be divided into those which provide transport services (usually on a commercial basis, i.e. people are charged for projects' outputs), and infrastructure projects (in most cases delivered free of charge). The latter constitutes a crucial and is the most costly component of any transport system (Potts 2002, p. 181).

Transport projects are intended to improve the economic and social welfare of people. Their main objective is the development of the transport system, and consequently a reduction of the time and energy spent on – and thus the cost of – travel and the transport of goods. In other words, transport projects lead to improvement of people's access to resources, other people, goods, opportunities, markets and services. Thus, an efficient and effective transport system is regarded as a precondition of economic growth (Seddon 2002, p. 1).

However, next to their direct positive effects, transport projects cause negative consequences to the users, as well as non-users. New infrastructure projects can induce, for instance, development in regions lagging behind, but on the other hand, the same project can impinge on people's health and harm the natural environment in the region.

Before embarking on implementing specific transport project(s), surveys and analysis should be conducted. First, a national survey, whereby the overall country's transportation needs are established. Second, a detailed survey of the existing transport systems and policies, in order to identify existing shortcomings and the desired set of complementing projects. Eventually, an analysis of a specific single project or a few closely interrelated projects, to determine the most effective projects alternatives (Adler 1987, p. 6, 7).

There are three comprehensive methods of evaluating transport projects (Shiftan, De Jong, Simmonds, Hakkert, Ben-Akiva 2001, p. 3):

- Cost-benefit analysis (CBA) – project's costs and benefits are expressed in monetary terms to establish which project alternative is most profitable from an investor's (financial CBA) or society's (economic CBA) point of view;
- Cost effectiveness analysis (CEA) – the costs of the project are valued in money, while benefits are stated in their natural measures; consequently,

the project alternatives that minimize costs guaranteeing the same benefits, or maximizing the effect generating the same costs are chosen.

- Multicriteria analysis (MCA) – costs and benefits are expressed in various dimensions, next, weights to these dimensions are assigned, and the alternative which gets the highest weighted mark is chosen.

Further discussions apply to a cost-benefit analysis, whereby all the projects' costs and benefits are to be established and expressed in monetary terms. The identification and valuation of transport projects is a tricky task. Many transport project outputs are regarded as public goods, which are characterized by two main features: non-rivalry in consumption and non-excludability in consumption (Perkins 1994, p. 272). Transport effects are also described as various, dispersed among a great number of different people, scattered across a large area and stretched in time. Moreover, as it is virtually impossible to exclude people from using public goods, it is difficult to charge for their utilization. Hence, there are no markets and consequently no market prices for many effects, generated by transport projects. Last but not least, owing to spatial and time dispersion, it is difficult to distinguish between the primary and external effects of the transport project. All this characteristics make it extremely difficult to precisely identify and quantify the external effects of transport.

2. EXTERNALITIES DEFINED

In many cases, an investment project affects not only those who directly acquire its outputs or supply its inputs. The influence of projects often spreads over various economic agents, causing positive or negative effects to them, which is not accompanied by proper charges or compensations, respectively. These indirect (secondary, external, spillover, neighborhood) effects are called externalities and are taken into account while analyzing project profitability from society's point of view.

Various definitions of externalities have been perceived. This may cause some confusion as it comes to understanding and consequently identification of externalities. Therefore, a set of definitions is presented below.

The issue of externalities was addressed by welfare economists as long ago as in the beginning of the twentieth century. Pigou, for instance, defines externalities as a "difference between marginal private and social net product", explaining that "the source of the general divergences between values of marginal social and marginal private net product [...] is the fact

that in some occupations, a part of the product of unit resources consists of something, which instead of being sold by the investor, is transferred, without gain or loss to him, for the benefit or damage to people." (Pigou 1929, p. 176).

According to Meade, external economies (diseconomies) exist where "what is done in one industry reacts upon the conditions of production in the other industry in some way other than through the possible effect upon prices of the products or of the factors in that other industry" (Meade 1952).

(1) $x_1 = F_1(l_1,c_1; l_2,c_2,x_2)$
(2) $x_2 = F_2(l_2,c_2; l_1,c_1,x_1)$

where:
F_1,F_2 – production functions of firms operating in industries 1 and 2, respectively
x_1,x_2 – outputs of industries 1, 2, respectively
l_1,l_2,c_1,c_2 – production factors in both industries

The above definitions place an emphasis on the divergence between the marketed and nonmarketed effects of the project. The latter are regarded as externalities. To put it another way, those resources used (produced) by a project, for which an investor does not pay (appropriates benefits) stand for externalities. This point of view is based on static by its nature equilibrium theory, according to which every economic influence of an agent (agents) on other agent's (agents') welfare is realized through market mechanism. However, if next to the market mechanism, there is direct, non-market interdependence among economic agents, the latter causes a divergence between social and private benefits, and consequently, is called an externality.

A broader concept of externalities has emerged on the basis of the theory of industrialization in underdeveloped countries, and the problem of allocating scarce resources among investment opportunities. This approach does not confine externalities to direct non-market interdependencies, but complete it with interdependencies occurring among economic agents within a market mechanism. These effects are reflected by price/demand changes imposed by the implemented investment project. In other words, a large scale project (in relation to market size) causes a price increase of its inputs and/or decrease of its output, creating effects called supplier's and customer's surplus, respectively.

Such a broad approach is reflected by Sitovsky, according to whom „external economies are invoked whenever the profits of one producer are affected by the actions of the other producers" (Sitovsky 1954).

(3) $P_1=G(x_1,l_1,c_1; x_2,l_2,c_2)$,
(4) $P_1=G(x_2,l_2,c_2; x_1,l_1,c_1)$,

where:
P_1,P_2 – profits of firms 1 and 2, respectively
x_1,l_1,c_1; x_2,l_2,c_2 – outputs and production factors of firms 1 and 2

Next to the presented mainstream definitions, some other perspectives of perceiving externalities have been proposed. These definitions, although rather narrow, put an emphasis on different aspects of externalities, facilitating a better understanding of the term.

Long proposes the following definitions of secondary effects (Long 1968, p. 3):

1. "primary benefit is the value of the immediate product or service resulting from the project, while indirect benefits are values added by incurring secondary costs in activities stemming from or induced by the project;
2. those intangible non-marketed, and non-quantifiable benefits of a social, political or military character;
3. those which accrue to other than users of the project."

In the first definition, direct effects are those that lead to the main objective achievement, i.e. production or national income generation. All outputs that do not add to this goal should be regarded as externalities. Put more generally, externalities are effects that do not contribute to the main goal of a project. The second definition presents the characteristics of externalities. According to it, the secondary effects are non-marketed social, political or military goods, that are non-quantifiable, i.e. impossible to be measured directly in monetary terms. In the third definition external effects are perceived as effects that accrue not to the users of the project but to other people or institutions.

Contemporarily, the comprehensive concept of externalities prevails. For example, according to Steward and Ghani, "externalities exist where the utility function of consumers or the production function of producers are affected not only by their market activities but also by the activities of other economic agents" (Steward, Ghani 1991, p. 569).

(5) $u_i = f(x_1,x_2,\ldots,x_n,e_1,e_2,\ldots,e_n)$,
(6) $p_i = f(y_1,y_2,\ldots,y_n,e_1,e_2,\ldots,e_n)$,

where:
u_i – utility function of i^{th} consumer
p_i – utility function of i^{th} producer
$x_1,x_2,\ldots,x_n$ – purchases of goods and services by the costumer
$y_1,y_2,\ldots,y_n$ – purchases of inputs by the producer
$e_1,e_2,\ldots e_n$ – externalities, that take the form of nonmarket effects or of effects mediated through the market, affecting consumption, production conditions as it comes to prices, availability and quantities.

On the basis of the listed definitions it can be assumed that a project creates externalities if it affects economic agents, positively or negatively, and these effects are not reflected as project's direct costs or benefits, respectively. Consequently, the incremental effects of the project from the private (investor's) point of view differ from the incremental economic effects, i.e. from society's point of view. There are two main types of such influence. First, project generates cost and benefits to economic agents (customers or other agents), but these gains and losses are not transferred through the market mechanism but through non-market relations between the project and its economic environment. Hence, these relations are not reflected in money transfers (gains or losses due to project itself). Second, the project influences trade conditions of other economic agents, that are reflected by price and demand changes. In other words, effects occur within the market mechanism although they are not (fully) reflected in the project's direct costs and benefits. The second group of external effects is especially plausible in case of a relatively large scale project, which usually affects:

- competitors, increasing competition and taking over a part of demand;
- suppliers, increasing demand and consequently prices for project's inputs – supplier's surplus;
- customers, increasing supply and simultaneously decreasing prices for project's outputs – customer's surplus.

Moreover, considering the fact that there are complementary goods and substitutes for virtually all goods, a large scale project may affect trade conditions of other agents, not necessarily its direct suppliers, customers and producers.

It should be emphasized that externalities spreading through a market mechanism and affecting the project's direct suppliers and customers are often described as backward and forward linkages, respectively. Linkage

effects are regarded to be important especially in the area of agro-industrial sectors. However, linkage effects are often regarded as a source of competitive advantage in various industrial as well as service sectors, which is reflected in new concepts of management, e.g. strategic alliances, supply chain management, or network organizations.

To assist identifying externalities, it is useful to break them down into various categories. Externalities fall into different types according to Steward, Ghani 1991; Buchanan, Stubbleine 1962, Cook, Mosley, Perkins 1994, p. 241-142:

1. nature of influence – as noted above, external effects can spread over other agents via non-market interrelations or throughout the price mechanism. In the former case, they are recognized as real or technical externalities and in the latter instance, financial or pecuniary externalities. Technical externalities can be further divided into two categories: static and dynamic. The former are not related to economic growth, and they mainly include environmental secondary effects. Dynamic externalities are related to economic growth, i.e. they influence the attitudes or the knowledge available to a subsequent generation of producers.

2. location of agents – both spatial and industrial locations. Externalities can affect nation, region, urban or rural areas; moreover, they can be scattered within a single industry, cluster of well defined industries, or among industries.

3. the nature of interacting agents – externalities can go in four main ways: between consumers, between producers, from producers to consumers and eventually, from consumers to producers;

4. the number of interacting agents – a single agent may affect another single agent, a small group of agents or even many agents. By analogy, an agent (agents) may be affected by one agent, a small group of agents or many agents.

5. possibility of negotiating – closely related to the number and location of agents – if the influenced agents and size of externalities are known, externalities can be negotiated, hence considered by investor (internalized). The larger area and longer time of externalities dispersion, the greater the likelihood that they will not be negotiated, and consequently taken into consideration by an investor;

6. the significance – if an externality is obvious and importantly affects other agents (their production or consumption functions) it is plausible that it will be negotiated and hence considered by an investor. In other cases a secondary effect will be regarded as negligible and accordingly ignored;

7. stage of product's processing – indirect effects can be created during the production, distribution or consumption process;

8. status of affected group – it is generally believed that externalities that affect the rich are higher valued than those affecting the poor.

Table 1

Examples of different types of externalities

Classification	Type of externality	Example
Nature of influence	Static (technical)	Air polluted by exhaust fumes produced by cars
	Dynamic (technical)	Diffusion of knowledge between company A and B due to movement of skilled worker from technologically advanced firm A to firm B lagging behind it
	Pecuniary	New large scale infrastructure project increases significantly demand for tarmac and consequently its price, what positively affects suppliers of tarmac
Location of agents	Defined location	Noise caused by motorway
	Broad, undefined location	Greenhouse effects caused by exhaust fumes
Nature of agents	Producer to customer	Factory smoke affecting people living in vicinity
	Customer to customer	Person smoking cigarette affecting non-smoker
	Producer to producer	Technology transfer, know-how transfer from company A to company B
Number of agents	One to one	Person smoking cigarette affecting non-smoker
	One to many	Radiation effects of nuclear power stations
	Many to many	Car pollution
Possibility of negotiating	Negotiated	Building a new road that improves access to a distant region depends on the industrial and/or agricultural investments in that region
	Non-negotiated	Car pollution
Significance	Unimportant	Effects of smoking cigarettes on others in the past – regarded as a negligible
	Important	Effects on smoking cigarettes nowadays – conceived as serious; accordingly, smoking in public areas is usually banned
Stage of product processing	Production	Road build within a dam project used by farmers
	Distribution	Road surface deterioration caused by heavy trucks transporting goods from a new mine
	Consumption	Scenic view available during train journey
Status of affected group	The rich	High value of scenic view deterioration due to the motorway located next to the area occupied by the rich
	The poor	Low value of scenic view deterioration due to the motorway located next to the area occupied by the poor

Source: author's own

It has been underlined in one of the presented above definitions that the external effects of investment projects are intangible non-marketed, and non-quantifiable. Accordingly, one of the most sound features of externalities is that they are hard to be measured and valued. Nonetheless, various methods of valuation, especially environmental effects, have been developed. It is useful to divide them into two broad categories: supply side approach and demand side approach. (Cambel, Brown 2003, p. 268-269; Perkins 1994, p. 245-257). The former approach is based on investigating the impact of externality on productivity or costs of economic agent(s). It is also perceived as a direct valuation method, since externalities are measured by means of observable market prices. In the latter approach, the value of externality is inferred from demand functions either from surrogate goods markets (observed customer preferences) or from hypothetical externalities markets (stated customer preferences). Hence, the second group of methods is also called indirect valuation methods.

Following supply side approach there are four methods:

a. productivity change approach – estimates productivity changes of other producers affected by the project, be it positive or negative (road installed for a dam project can have positive effect on local farmers' sales possibilities – the revenue increase is in that case the value of effect);

b. human capital approach – derivative of the above method; values the impact the project has on human health; it is assumed that the changes in human health affect his/her productivity and consequently, influence incomes he/she can get in the future (incomes lost due to hospitalization and rehabilitation after a road accident are regarded as costs incurred by the casualty).

In the case of environmental goods the above approaches are called dose/response method, and investigate the way and value the natural resource (change of its quality or availability) affects economic agents' productivity.

$$(7)\ X = f(C,L,I, Q_1,Q_2)$$

where:
X – output
C – capital
L – labour
I – other inputs
Q_1,Q_2 – natural resources

c. Opportunity cost approach – estimates costs of mitigating or even omitting negative externality by changing project design or not implementing it (the cost of bypass while constructing a new road, to preserve a natural resource adjacent to the project);

d. Preventive or replacement expenditure approach – values the costs that people afflicted by a project incur to mitigate or replace damage caused by that project (costs of installing double-glazing to avoid noise caused by a new motorway);

The demand side methods are as follows:

a. Observed customer preference (surrogate goods markets)

- hedonic pricing – comparing prices of goods (e.g. land) for which externality in question is the attribute (e.g. scenic view). The difference between prices of surrogate goods, caused by externality is regarded as a value of the latter.

$$(8)\ Z^{A}=(z_1^{A}, z_2^{A}, z_3^{A},..., z_{n-1}^{A}, z_n^{A})$$

$$(9)\ Z^{B}=(z_1^{B}, z_2^{B}, z_3^{B},..., z_{n-1}^{B}, z_n^{B})$$

$$(10)\ P^{A}=f(Z^{A}) \neq P^{B}=f(Z^{B})$$

where:
Z^{A} – vector of land A attributes
Z^{B} – vector of land B attributes
P^{A}, P^{B} – price of land A and land B, respectively
$f(Z^{A})$ – equilibrium price of land A, the function of land A attributes
$f(Z^{B})$ – equilibrium price of land B, the function of land B attributes

- travel cost method – uses as a measure of non-marketed good travel costs that people are willing to incur to get to that good (e.g. recreational fishing, scenic view); these costs include mainly: vehicle operating cost, fees and time.
- random utility method – modified travel cost method; assumption that demand is conscious is relaxed here, it is presumed that each time an individual makes a decision about consuming a certain kind of non-marketed good, he/she chooses from a bulk of available substitutes, hence, the probability that the person will choose a specific good is lower than one;

b. stated customer preference – the contingent valuation method – consists in asking people directly what value they put on certain non-marketed goods.

3. COST AND BENEFITS OF TRANSPORT PROJECTS

One can raise the question whether identifying and valuating externalities is worth doing. There are ambiguities with defining externalities, moreover,

they are often, as one of the presented definitions suggests, non-marketed goods. Accordingly, it is a complex and costly task to include them in project analysis. Dasgupta, Sen and Marglin suggest that in many instances analysts tend to exaggerate the magnitude of indirect benefits. They explain that the present value of many externalities is quite low. Hence, more significant errors are likely to arise as a result of inaccurate forecasts of outputs, inputs or their prices than omitting externalities. Moreover, in many cases it is very difficult or even impossible to quantify many externalities, which limit their inclusion in cost-benefit analysis (UNIDO – Dasgupta, Sen and Marglin 1972, p. 66). However, the quoted authors admit that one cannot generalize. There are some cases where externalities play a very important role.

In many cases transport projects seem to have powerful externalities that should not be omitted while analyzing their social profitability. Unfortunately, it is difficult to distinguish between primary and secondary effects of those projects. Potts, for example, states that the benefits from road construction tend to be pure externalities (Potts 2002, p. 181). This view is in line with Pigou's definition, according to which a positive external effect exists if a part of the project's output instead of being sold by the investor, is transferred to people, without gain to the former. On the other hand, Little and Mirrlees argue that „ordinary purpose of a transport project is transport and the analyst is not going to omit such effects as time savings or operating costs reduction" (Little, Mirrlees 1988, p. 348). In other words, the cited authors suggest that main effects of the road project should be regarded as primary benefits. This view is based on one definition provided by Long, who describes externalities as effects that do not contribute to the main goal of the project (Long 1968, p. 3).

It seems that the dividing line between primary and secondary effects in transport project is not clear-cut. However, this is important from a theoretic rather than pragmatic angle. What really matters is that all the costs and benefits of transport projects should be well recognized. Some effects are regarded as pure direct effects, other are perceived as pure external effects. Finally, there is a group of effects that do not fall neatly into either of these two categories. Nonetheless, to facilitate further discussion, costs and benefits of transport projects have to be enumerated. They are as follows (Button 1982, p. 74-130; Snell 1997, p. 113-114; Adler 1987, p. 27-44):

1. Transport projects benefits:

a. Transport services – delivered by transport companies both public and private alike, these services can be categorized mainly according to the object that is being transported (cargo and passenger transport) and the mode by which services are realized (road, rail, water, air transport or intermodal

transport that constitutes a combination of the main modes); transport services are in most cases priced and in some cases subsidized.

b. Infrastructure user benefits – perceived and enjoyed by people who use transport infrastructure; in most cases transport infrastructure is public, i.e. people are not directly charged for using it; infrastructure improvement benefits are usually as follows:

- reduced vehicle (or other means of transport) operating costs
- time savings
- reduced accidents – include destroyed property and transport infrastructure, personal injuries and fatalities...

c. infrastructure non-user benefits – enjoyed by the rest of the nation or relevant population; they are:

- reduced transport (operating) costs – transport infrastructure users share their savings with other society members, e.g. customers, producers; savings sharing is imposed by competition or government;
- stimulation of economic activity – usually these benefits are due to a bulk of investment project, not only transport infrastructure; any transport improvement is believed to stimulate economic activities if new economic activities would not have been taken without transport improvement and resources utilized by these activities which would otherwise have remained idle.

2. Transport projects costs

a. infrastructure building costs – construction cost;

b. means of transport costs (vehicles, rolling stock, ships, aircrafts);

c. infrastructure maintenance costs;

d. operating costs of providing transport services – mainly labour, fuel, and rolling stock maintenance;

e. congestion – it is a direct derivative of limited capacity of infrastructure;

f. environment costs – generally, transport is perceived to afflict the natural environment, but some transport projects are actually introduced to ease the negative effects of others; the environmental effects of transport are multi-facet including: air pollution, noise, vibrations and visual intrusion.

These listed above effects are regarded as traditional costs and benefits of transport projects. However, the author believes that there is another important group of effects, created by innovative transport companies (logistics operators) and transferred to various industries. These effects are accommodated in the last section.

Moreover, it should be stressed that the distinction between transport costs and benefits is often blurred. Many of the positive effects of transport projects stem from cost reductions, on the other hand, some of the negative

effects can become benefits in specific cases. Therefore, they are usually called impacts. In the table below, the transport project effects were divided into three categories: direct effects, indirect effects as well as cost and benefits that do not fall neatly into both categories, which accordingly may be regarded as primary or secondary effects.

Table 2

Categorization of main transport projects effects

Primary effects	Secondary effects
Transport services Information building costs Means of transport costs Infrastructure maintenance costs Operating costs of transport service providers	Infrastructure non -user effects Congestion Environment effects
Infrastructure user effects	

Source: author's own

In the case of impacts that fall into primary effects, there is a direct market connection between those who undertake an action and those affected by it. Consequently, the private and social value is equal. Moreover, these impacts accrue to transport users and directly contribute to the main goal of transport projects. Costs and benefits that constitute secondary effects affect not only transport users but also other agents. Additionally, they are not regarded as private (investor's) effects, hence, there are no direct charges and compensations connected to them. Consequently, the value of private costs within this group differs from the social value. The infrastructure user benefits contribute to the main goal of transport development project but beneficiaries do not pay for them (except for vehicle operating costs), hence they cause a divergence between private and social profitability of transport project.

Finally, it should be underlined that transport secondary effects are diverse. They are both technical and pecuniary, local, regional but also global. The agents affected by transport are both private people and companies. What is more, transport externalities can be produced by a single agent and affect a single one. However, in many cases they are produced by, and diffused among, many agents. In the latter instances, the possibility of negotiating and consequently internalizing externalities is rather low. Also the significance of transport secondary effect is diverse, although today the main emphasis is put on reducing transport environmental costs.

4. VALUATION OF TRANSPORT EXTERNALITIES

In the following section the issue of putting monetary value on transport externalities is addressed. However, it should be underlined that the procedure of valuating transport external effects is preceded by the following stages:

1. examination of current and predicted nature of the transport market;
2. identification of project's impact;
3. measurement of physical impact.

Figure 1 presents the procedure of valuating one of the most important transport environmental externality – nitrogen oxide (NOx) emissions.

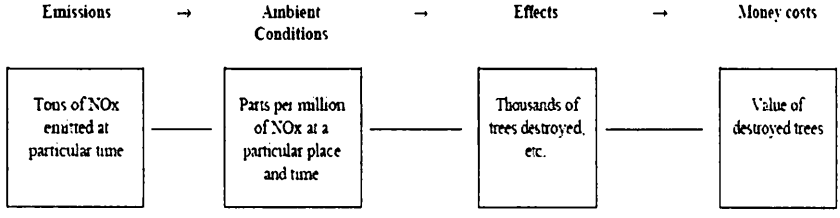

Figure 1 The chain of calculations to arrive at environmental evaluations

Source: Button 1993, p. 49

The basic effect of a transport project, appreciated by transport users, are time savings. Virtually every transport project aims at decreasing the time, people or goods moved. Before embarking on describing estimating methods the classification of travels has to be introduced. According to the aim of the travel there are: work and non-work travels. The former can be broken down into passenger and freight transport. Non-work travels are usually divided into commuting and leisure travel. It is relatively straightforward to establish the value of time saved for work travel for which the supply side methods are implemented. In the case of freight transport the analyst uses the productivity change approach. The increase in revenue that is derivative of shrinking working capital locked-up in inventories, stands for saved time value. The value of time for worker travel is based on the employer's costs of hiring that worker when it comes to business travel of entrepreneurs (self employed) the value of time is inferred from the revenues of that business person.

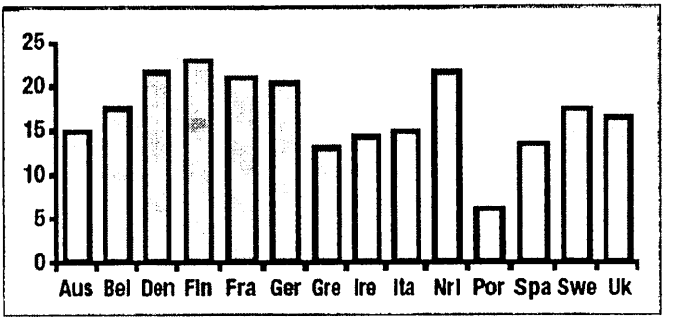

Fig. 2. Value of an hour of working time per person (1995)
Source: Florio ed. 2002, p. 77

Valuing the time saved during non-work travel seems to be a much more complex task. In general, demand side approach is utilized for this category of travel. Up to the 1980s the observed customer preference technique prevailed. In general it consists in comparing costs and times of traveling from point A to point B using various available options of transport (e.g. different modes). The difference in the costs is weighted by the difference in travel time and consequently, the value of unit of time is established. However, the above approach has an important drawback. It assumes that different costs that people are willing to incur choosing different options of travel are direct derivatives of time. Yet it has been proved that not only time but other aspects are taken into consideration, e.g. size of time savings, comfort of traveling, risks connected with specific mode of transport. Therefore, the observed customer approach (hedonic pricing) has often been replaced by stated customer preferences. The analyst designs a special questionnaire that takes into consideration various attributes, i.e. size of time saving, journey purpose, income journey length, mode, socio-economic status, sex, age. On the basis of collected data that are subsequently analysed by means of econometric techniques, the value of time for different categories are established (table 3).

Table 3
Value of non-work time by income and distance in the UK in 2000 (£ per hour)

Distance / Income	< 5 miles		5-25 miles		>25 miles	
< £17,500	Commuting	1.88	Commuting	3.30	Commuting	7.17
	Other	2.31	Other	3.67	Other	7.12
£17,500 < £35,000	Commuting	2.57	Commuting	4.75	Commuting	10.13
	Other	2.75	Other	4.37	Other	8.71
< £35,000	Commuting	3.32	Commuting	6.25	Commuting	13.23
	Other	3.79	Other	4.93	Other	9.85

Source: Mackie, Wardman, Fowkes, Whelen, Nellhoup 2003, p. 75

The third group of users' benefits constitute savings in costs of accidents. These costs are usually divided into the following categories:

- Casualty related costs: fatalities, medical treatment, losses of incomes, suffering, negative psychological effects;
- Accident related: damage to the car and other property, congestion and environmental changes, insurance and administration costs.

To calculate the value of the cost of fatalities and losses of income, the human capital approach is implemented. In case of goods transport lost output should be calculated using productivity change technique. Additionally, human life is often calculated by means of life insurance data. However, there has been conducted a considerable dispute whether human life can be valued. Hence, in many cases fatalities are excluded from cost benefit analysis and are accommodated in cost-effectiveness or multi-criteria analysis. Costs of pain and psychological effects are not calculated. Medical costs, damage, insurance and administration costs are valued directly, based on statistical data. Yet a vast amount of transport statistics is needed. Putting value on the costs of congestion and environment effects is described below.

Table 4

UK Casualty and Accidents Value 2000

Accident type	Cost per casualty (£)		Cost per accident (£)	
	Lost income	Medical costs	Property	Insurance
Fatal	393 580	670	7 780	210
Serious injury	15 150	9 190	3 750	130
Slight injury	1600	680	2 100	80
Damage only	-	-	1320	40

Source: Goodbody. Economic Consultants, 2004, p. 6

The transport projects aim at reducing congestion, accordingly, they decrease time and other costs of travel. However, in come cases, especially during the infrastructure construction period, the project can cause congestion, hence, a deterioration of transport service and infrastructure quality. This negative effect of transport projects accrues mainly to the transport users, although it can also fall on non users: pedestrians and people living near to the road or other congested object of transport infrastructure.

When it comes to users' negative effects, they are mainly reflected by the increased vehicle operating costs and lengthened journey time (Sharp 1966). These effects are exactly opposite to those described above, therefore, the same methods of valuation should be used, i.e. productivity change

approach, observed or stated customer preference for time costs, and replacement expenditure approach for operating vehicle costs. Non-user congestion costs include mainly noise and increase level of air pollution. The valuation of these effects is presented above.

The effect regarded as a non-user one is the transport project's influence on the economic activity of the region. In most cases the new access road (or other mode transport, e.g. port) is perceived as an incentive to undertake economic activity or to enlarge the scale of existing businesses. However, it should be noted that a new transport project my cause a deterioration of regional businesses competitive position, if they are less effective than their counterparts from other regions. To valuate this externality, productivity change technique is used. To put it another way, if the transport project does lead to increased/decreased output, the net value of this output is the measure of economic benefit (Adler 1987, p. 34).

The natural and socioeconomic environment is affected by transport projects in various ways. The impact differs according to elements of the environment that are affected as well as permanence and geographical level of influence (figure 3). Moreover, environmental impact is categorized as (Treatment... 1998, p. 7):

- direct – caused by transport investment itself, e.g. land consumption;
- indirect – linked closely with the project, but may have more profound consequences than direct impact, e.g. degradation of surface water quality;
- cumulative – as a result of the process of cumulative environmental change, caused by various sources, e.g. global warming.

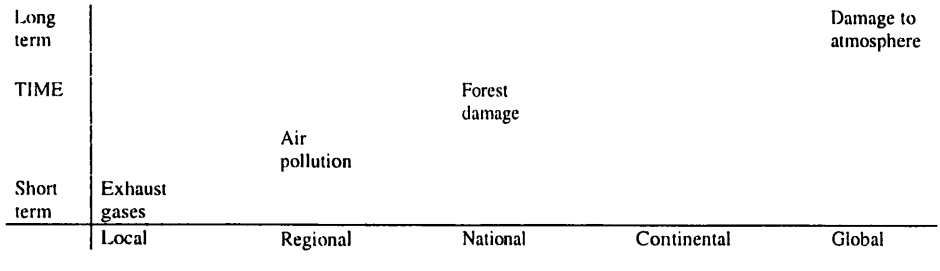

Fig. 3 The time and areal coverage of exhaust gases

Source: Button 1993, p. 31

Due to its broad aspect, the environmental impact of transport project is difficult to investigate, measure and value. Therefore, only the main environmental externalities are presented below.

One of the most important external effects of transport is noise, defined as unwanted sound. It is especially a nuisance in urban areas that suffers from bad traffic, and in areas located along major trunk arteries and around transport terminals, e.g. airports, logistics centers (Button 1993, p. 27). Hence, noise should be regarded as a local externality.

Noise causes temporal or irreversible effects on people. Most obvious are discomfort, annoyance, fatigue or reduction of hearing ability. However, next to direct there are also the following indirect effects of noise: production of stress hormones, headaches, nervousness, aggressiveness, blood pressure and heart rate increases, and reduced capacity for concentration (Valuation... 1997, p. 56-57). The following methods can be used to evaluate this externality:

- hedonic pricing – divergence in prices of land plots or rent levels between residential areas affected and non-affected by noise;
- preventive expenses – costs of double-glazing or installing barricades along the arteries;
- human capital approach – if direct link between effect of noise exposure and productivity is possible to investigate;
- contingent valuation – by questioning people how much they are willing to pay to avoid noise exposure.

Next to noise, transport produces many harmful gases that cause air pollution. This externality is ubiquitous, has various forms and is very difficult to measure. Although air pollution is caused by all modes, road transport is perceived as the main pollutant. There are four main categories of air pollution:

- photo-chemical smog – local and regional scale, afflicts health, materials and vegetation;
- acid depletion – acid rains; regional, national and even continental scale, mainly impinges vegetation;
- stratospheric ozone depletion – global scale; affects human health and vegetation;
- global warming – global scale; various effects.

It is regarded that air pollution afflicts human (discomfort, eye irritation, headache, heart and respiratory system diseases), vegetation and ecosystems (decreased yields, forest damage), materials and buildings (decomposition of polymers, dirt) and climate (depletion of ozone layer and global warming).

The time span of externality in question also varies, from short-term effects like feeling discomfort through smog, to long time effects like climate change. The latter problem is so complex that detailed analysis of future effects is virtually impossible, accordingly, its valuation is approximate.

As air pollution is a tricky problem, the methods used to measure and value them are various and usually sophisticated. The main approach is the dose-response technique. In general, this boils down to establishing a dose-response function between a level of certain emission (set of emissions) and health or other damages. However, to construct such a function vast statistical information is indispensable. The second possible approach is contingent valuation, i.e. asking people about their willingness to pay or willingness to accept air pollution decrease or increase respectively. The main shortcoming of this approach is that people are not fully aware of the effects caused by transport emissions. The third approach is human capital, whereby relations between change in human productivity and health deterioration caused by air pollution are established. Other possible methods are productivity change approach, especially in the case of the agriculture sector, and replacement expenditure approach, which should be utilized to calculate the negative effects on materials and buildings.

Table 6

Characteristics of the major transport emissions

Pollutant	People	Vegetation	Climate	Materials /buildings	Scale
Carbon monoxide (CO)	Heart and central nervous system		Ozone		Local, global
Hydrocarbons	Heart, respiratory system	Build-up in soil and food crops	Summer smog, greenhouse		Local, regional, global
Particulates	Heart, respiratory system	Reduced assimilation	Winter smog	Dirty buildings	Local, regional
Carbon dioxide			Greenhouse		Global
Nitrogen dioxide	Respiratory system	Acidification of soil	Greenhouse	Weathering erosion	Local, regional, global

Source: Shiftan, De-Jong, Simmonds, Hakkert, M. Ben-Akiva 2001, p. 30

Other environmental effects of transport projects are as follows (Valuation...1997, p. 93-104; Button 1993, p. 35-38):

1. water pollution

a. ground water – afflicted by surface transport; changes in drainage patterns (infrastructure); pollution caused by exhaust fumes (vehicles), de-ice road chemicals and weed-killers;

b. sea waters and costal land – contaminated by oil spills and tank cleanings; mainly local effects.

Water pollution is valued mainly by means of the dose-response approach. However, the contingent valuation of Exxon Valdez oil spill (1989) is the best recognized valuation of transport externality (Carson, Mitchel, Hanemman, Kopp, Presser, Rund 2003, p. 257-286).

2. vibration – caused by large vehicles airplanes and ships; afflicts transport infrastructure, buildings, humans (disruption to sleep and its consequences), banks and shores (erosion) and marine animals (communication interference); valued mainly by means of dose-response approach;

3. consumption of land – land usage by infrastructure projects; valued by opportunity cost of land;

4. visual intrusion: aesthetic impact – reduced visibility through smog and disruption of scenic views; however, there are positive effects like scenic views available to train passengers; valued by means of contingent valuation;

5. barrier effects for humans (animals) – caused by physical existence of infrastructure or extended use of infrastructure – usually valued as wasted time or by means of the contingent valuation approach.

In table 7 the costs of the main environmental externalities as well as accidents by different means of transport in the UE are presented.

Table 7

Estimates of transport environmental externalities and accidents in the EU-15 (1995)

Passenger (Euro/1000 pkm)					
	Car	**Motorcycle**	**Bus**	**Rail**	**Aviation**
Accidents	36.0	250.0	3.1	0.9	0.6
Noise	5.7	17.0	1.3	3..9	3.6
Air pollution	17.3	7.9	19.6	4.9	1.6
Climate change	15.9	13.8	8.9	5..3	35.2
Freight (Euro/1000 tonkm)					
	LVD*	**HDV****	**Rail**	**Aviation**	**Waterborne**
Accidents	100.0	6.8	11.5		
Noise	35.7	5.1	3..5	19.3	
Air pollution	131.0	32.4	4.0	2.6	9.7
Climate change	134.0	15.1	4.7	153.0	4.2

Source: Florio, ed. 2002, p. 78

Next to the above described environmental externalities, there is another group of real external effects of transport projects, which is hardly recognized, but its role seems to be more significant currently, namely the dynamic externalities of transport services.

One of the most important features of today's economic growth is shift from stable, well-established technologies and markets to technological and market changes. Under such circumstances those who gain competitive advantage are innovators, i.e. economic agents that develop and implement new technologies and are responsive to new and ever changing needs of customers. In contemporary economics, where manufacturing has given way to services, where markets are becoming global, transport services are becoming a crucial competence to many companies. The significance of transport services is reflected in the growing sector of logistics operators, who introduce new and sophisticated transport technologies and material flow management techniques. These operators are called third party logisticians (3PLs) responsible for managing the flow of goods within supply chains (from suppliers to final customers). What is more, fourth party logisticians (4PL's) have been emerging, being responsible for orchestrating all flows within supply chains. They offer world class management of material but also information flows, equipping supply chains with sophisticated IT technologies.

These transport innovations are delivered to other sectors. If the transfer stems from non-market transactions it constitutes dynamic inter-industry externality, which has not been yet analyzed. However, the idea of best-practices diffusion is well recognized in management and is called benchmarking. The non-market transfer of transport know-how and technologies from transport services providers to other industries have the following sources:

- human capital formulation – realized through informal learning on the job: employees of production or service companies which cooperate with logistics operators get specific knowledge from the latter, which is then implemented in their companies, increasing the effectiveness and efficiency of transport operations;
- technology transfer – the process of diffusion of innovative methods and technologies from logistics operators to other companies undergoes through the movement of labour (e.g. from 3PLs to service companies), or trade journals and conferences.

Although these effects seem to be of increasing significance it is difficult to distinguish them, since in most cases the know-how and technologies are transferred through market transactions. Therefore, it is indispensable to find a clear cut between market transactions and non-market relations and to value the latter. Presumably the human capital and change in productivity techniques are the appropriate approaches to value these dynamic externalities of transport externalities.

5. TRANSPORT EXTERNALITIES IN POLAND – CASE OF ROAD INFRASTRUCTURE

Road infrastructure development projects in Poland, regardless of funding sources, are usually appraised according to "Instruction for measuring economic efficiency of roads and bridges projects – revised according to EU recommendation". The Instruction has been developed by the Road and Bridge Research Institute, a subsidiary of the Ministry of Infrastructure. The document should be regarded as a universal methodology of appraising road projects, hence valuating road effects. The rationale for a common application of such guidelines is the ability to conduct direct comparison of various infrastructure project, rank them and eventually choose the most efficient ones, relative to the transport development strategy goals.

The instruction consists of three integrated parts. The first addresses the methodological issues of road project appraisal. Two other parts include standard indexes, concerning road statistics, which are essential for the CBA. Only the implementation of these indexes, along with universal methodology create the basis for project comparisons.

According to the Instruction, there are two broad categories of road infrastructure effects (Road and Bridge Research Institute, 2005, part I, p. 11):

- construction and maintenance cost of roads and bridges;
- users and environment costs/benefits that include: vehicle operating costs/savings, time savings, road accidents and air pollution.

Although not identified explicitly, time savings, road accidents and air pollution are externalities positions that should be included in road projects. Their value calculations are based on the supply side approach. Each externality is described in turn.

Travel times are divided into passenger, driver and freight groups. Time savings value is estimated as average gross wages (in the production sector), increased by insurance costs and cost of money frozen in transported goods. Road accidents consist of two groups: injuries and fatalities. The cost of the former includes lose of income, medical treatment as well as rehabilitation expenditure. The latter is calculated as loses in income plus average costs of funeral and compensation. Environmental impact includes only exhaust gases that afflicts the vicinity of the road. Exhaust cost comprises the function of speed, terrain shape, and road surface condition. The chosen externalities indexes for Poland are presented in tables 8 and 9.

Table 8

Travel and accident costs in Poland (2006-2010)

Years	Travel costs (PLN/vehicle)		Accident costs (PLN/accident)	
	Passenger cars	Buses	Build up road	Non-build up road
2006	21.59	172.74	537 492	282 573
2007	22.08	176.48	545 792	286 020
2008	22.51	180.06	554 074	289 454
2009	22.97	183.72	563 536	293 389
2010	23.57	193.32	573 634	297 382

Source: Road and Bridge Research Institute, part III, p. 21, 23

Table 9

Exhaust fumes cost in Poland

Speed km/h	Road category (PLN/1000 vehicles/km)			
	A	B	C	D
50	5.4	5.6	5.9	6.1
60	4.8	5.05	5.3	4.5
90	3.7	3.9	4.1	4.2

Source: Road and Bridge Research Institute, part III, p. 29

External effects constitute important impacts of transport development projects. Traditionally time savings and accident risk reduction have been regarded as the main external effects of transport. Today, increasing emphasis is put on the multidimensional environmental impact of infrastructure and traffic. Therefore, it is essential to identify and value secondary effects, while appraising the efficiency and feasibility of transport investments. Various methods have been developed to put a money value on externalities that usually influence the welfare of economic agents beyond the market mechanism. In general, these methods should be divided into two groups: supply and demand side approaches.

In Poland, time savings, risk of accidents and air pollution in roads vicinity have been identified as the basic secondary effects of road investments. According to existing recommendations, they are valued by means of supply side methods, i.e. their impact on costs or productivity of economic agents is calculated. Presumably, the increasing consciousness of sustainable economic development will lead to the broadening of the scope of identified and measured environmental effects in Poland. Also demand side approaches, like hedonic pricing or contingent valuation, should be employed in transport projects analysis.

REFERENCES

Adler H.A., *Economic Appraisal of Transport Projects. A Manual with Case Studies*, The John Hopkins University Press, London, 1987.

Archondo-Callao R.S., Taiz A., *Estimating Vehicle Operating Costs*, "World Bank Technical Papers" No 234, www.worldbank.org/transport/publicat/wbtp-234.pdf, 1994.

Buchanan J., C. Stubbleine C., *Externalities*, "Economica", Vol. 29, No. 116, 1962.

Button K.J., *Transport Economics*, Heinemann, London, 1982.

Button K. J., *Transport, The Environment and Economic Policy*, Edward Egar, Vermont, 1993.

Cambel H., Brown R., *Benefit-Cost Analysis. Financial and Economic Appraisal Using Spreadsheets*, Cambridge University Press, Melbourne, 2003.

Carson R.T, Mitchel R.C., Hanemman H., Kopp R.J., Presser S., Rund P.A., *Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill*, "Environmental and Resource Economics", No 25, 2003.

Cook P., Mosley P., *On the valuation of external effects in project appraisal*, "Project Appraisal", September, 1989.

Economic Assessment of Road Schemes. The COBA Manual, www.dft.gov.uk/stellent/groups/dft_econappr/documents/page/dft_econappr_504873.pdf

Department of Transport Valuation of Environmental Externalities. Full Report, HMSO, London, 1996.

Florio M., ed. Guide to cost-benefit analysis of investment project, http://europa.eu.int/comm/europeaid/qsm/ecofin/documents_en.htm, 2002.

Goodbody. Economic Consultants, Cost Benefit Parameters and Application Rules for Transport Project Appraisal, www.transport.ie/upload/general/5830-1.pdf, 2004.

Infras/IWW, 2000, External Costs of Transport 2002, http://themeseea.eu.int/Sectors_and_activities/ transport/indicators/cost/TERM25%2C2002, 2002.

Institute for Transport Studies, Treatment of Environmental Impact, http://www.its.leeds.ac.uk/projects/WBToolkit/Note12.htm#_World_Bank_(1998)_1

Little I.M.D., Mirrlees J.A., *Project appraisal and planning for developing countries*, Gower, Aldershot, 1988.

Long B., *Concepts and Theoretical Basis for Evaluation of Secondary Impacts*, U.S. Department of Agriculture, Special Paper, Washington, D.C 1968.

Mackie P.J., Wardman M., Fowkes A.S., Whelen G., Nellhoup J., *Value of Travel Time Savings in The UK – June 2003*, p. 75, www.its.leeds.ac.uk, 2003.

Meade J.E., *External Economies and Diseconomies in a Competitive Situation*, "The Economic Journal", Vol. 62, No 245, 1952.

Perkins F., *Practical Cost Benefit Analysis. Basic Concepts and Applications*, Macmillan, Melbourne, 1994.

Pigou A.C., *The Economics of Welfare*, Macmillan, London, 1929.

Potts D.J., *Project Planning and Analysis for Development*, Lynne Rienner Publishers, 2002.

Road and Bridge Research Institute, *Instrukcja oceny efektywności ekonomicznej przedsięwzięć drogowych i mostowych – weryfikacja metody badań zgodnie z zaleceniami UE {Instruction for measuring economic efficiency of roads and bridges projects – revised according to EU recommendation}*, Warsaw, 2005.

Seddon D., *Social aspect of transport*, www.transport-links.org/transport_links/filearea/documentstore/322_David%20Seddon%20Paper%201.pdf, 2002.

Sharp C., *Congestion and Welfare – An Examination of the Case for a Congestion Tax*, "The Economic Journal", Vol. 76, No 34, 1966.

Shiftan Y., De Jong G., Simmonds D.,Hakkert S., Ben-Akiva M., *Externalities' Evaluation in Transport Projects*, www.stellaproject.org/focusgroup4/helsinki/Presentaties/YoramShiftan.ppt, 2001.

Sitovsky T., *Two Concepts of External Economies*, "The Journal of Political Economy", Vol. 62, No 2, 1954.

Snell H., *Cost-benefit analysis for engineers and planners*, Thomas Telford, Falmouth, 1997.

Steward F., Ghani E., *How Significant Are Externalities for Development?*, "World Development", June, No. 3, 1991.

UNIDO, *Guidelines for Project Evaluation*, UNIDO, New York, 1972.

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