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TRAFFIC DISTRIBUTION INTO TRANSPORT NETWORK FOR DEFINED SCENARIOS OF TRANSPORT SYSTEM DEVELOPMENT IN ASPECT OF ENVIRONMENTAL PROTECTION

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Abstract

The article is a result of research work carried out under the project EMITRANSYS for shaping ecological transport system. The paper presents selected aspects of multi-variant distribution of traffic into transport network for defined scenarios of transport system development. Distribution of traffic on the network is made due to the global criterion function. Partial criteria for distribution of traffic are: external costs, marginal costs and average costs of the transport services expressed in monetary units and in emission units. An important aspect of the development of transport network is to include the external costs of transport activity to economical counting.

The harmful components of exhaust gases, external costs for each mode of transport, list of selected external costs for each mode of transport [eurocents/vehicle-km], structure of communication between Warsaw – Gdansk, characteristics of connections in the communication network between Warsaw and Gdansk, distribution of passengers stream in relation Warsaw – Gdansk, the distribution of the passengers stream in relation Warsaw – Gdansk for the second scenario according to criterion of average and marginal costs are presented in the paper

Keywords: *distribution of traffic on the network, external costs of transport, development of transport system*

1. Introduction

One of the main factors spurring the development of techniques and technology in all fields of the industry is the necessity to reduce its negative impact on the environment. Especially road transport has, as an important part of economy has huge negative influence on environment.

Development of transport network stems from one hand from forecasts of transport needs, and on the other from the possibility of adaptation of network infrastructure to the standards and requirements of the European Union. The European Commission pays particular attention to the need of sustainable and environmentally friendly transport development. Unbalanced transport consumes huge amounts of energy, pollutes the environment. Increasing investment does not improve the level of service (in particular, does not improve the situation of specific groups of economic subjects). Transport generates lot of costs, wherein the users and the other concern the whole society pay the percentage, because these costs are associated with negative impact on the environment. An important issue in this area is the organization or distribution of traffic on the transport network. The problem of searching for variants of distribution of traffic into network must be solved in a way ensuring optimization of sub-objectives like maximization of the profit of suppliers and the benefits of buyers of transport services whilst minimizing the impact of transport operations on the environment. This problem is multi-criteria optimization task [6].

The distribution of traffic on the transport network is a subject of long-term research. One of the problems of traffic organization on the transport network, or differently distribution of the traffic on the network, is the realization of transportation needs at the lowest possible costs [6]. At the same time, the costs can be considered in the commercial or economic category – respectively from the points of view of buyer and supplier of transport services, as well as the ecological category – taking into account the impact of transport on the environment.

Within 30 years, starting from 1976, about four thousand articles were prepared about distribution of the traffic on the transport network [14]. Studies touching distribution of traffic in terms of environmental protection ae conducted from 2004 and consisted of the unfolding traffic on the network according to minimal external costs [11]. In 2013, the influence of distribution of traffic into transport network for CO_2 emission was investigated [1]. The article presents selected aspects of impact of traffic distribution on the environment by summing emissions from individual means of transport. The influence of different modes and types of means of transport on the environment is an important element in assessing the distribution of the traffic.

Emissions originating from the transport can be more harmful to humans then those resulting from industrial pollution, because impurities are spread by vehicles in close proximity to humans and at high concentrations at low altitudes. Air pollution [5] depends on many factors. These include: fuel composition, engine characteristics and the standard of maintenance, type and basic characteristics of vehicle, deployment of infrastructure, speed of formation of congestion, etc. During the combustion of fuel in the engines of motor vehicles many different products and mechanical volatile particles appear. Recently conducted research on the analysis of emissions under real conditions, present levels of harmful gaseous compounds [5, 8, 12] and solid particles [12, 13] (Tab. 1).

Tab. 1. The harmful components of exhaust gases

Harmful to living organisms	Governed by the EURO exhaust emission standards	CO	carbon monoxide
		THC	hydrocarbons, total
		NO_x	nitrogen oxides
		PM	Particles
		NO_2	nitrogen dioxide
		SO_2	sulphur oxide
		NMHC	non-methane HC
Harmful to the environment		**CO_2**	carbon dioxide
		CO_2E	CO_2 equivalent
		NH_3	Ammonia
		N_2O	Nitrous oxide
		CH_4	Methane

EU directives focus only on those particles that significantly contribute to the destruction of environment, health and global climate change. The paper discusses distribution of traffic in terms of emission of nitrogen oxide (NO_x), particulate matter (PM), sulphur dioxide (SO_2) and carbon dioxide (CO_2).

European Union takes coordinated actions to reduce the harmful impacts of transport through the integration of transport policy with environmental policy. Speaking of sustainable transport, it should be noted that all elements forming it shall be environmentally friendly and as little as possible affected on it. Sustainable development of transport systems is a concept of integrating social, environmental and economic objectives considered from the point of view of transport policies of individual countries and the whole European Union. One of the indicators determining the impact of transport on the environment is the parameters related to air pollution [2].

2. The structure and characteristics of the transport network

The elements of transport system constituting infrastructural objects like roads, railways, seaports, aviation links, etc., define the relations between the points of origin, processing and receiving goods thus define the structure of the transport system [1, 4, 5, 10].
Formally, the structure of the system has been noted by a graph [5]:

$$\boldsymbol{GE} = \langle \boldsymbol{WE}, \boldsymbol{LE} \rangle, \tag{1}$$

where:

WE – set of nodes representing origin and destination points together with middle nodes for goods and passenger flows (bus stops, stations, reloading points etc.), $\boldsymbol{WE} = \{1, ..., a, \ldots, i, ..., i', ..., b, \ldots, \mathrm{WE}\}$,

LE – set of transport connections in actual transport network between distinguished transport nodes ***WE***, where: $\boldsymbol{L} = \{(i,i'): i,i' \in \boldsymbol{WE} \times \boldsymbol{WE}, \quad i \neq i'\}$.

Set ***WE*** is decomposed into three subsets: set of sources of material and passenger flows $\boldsymbol{N}=\{i\equiv n_{pn}\text{: } pn=1, \ldots, PN\}$, set of destinations of material and passenger flows $\boldsymbol{O}=\{i\equiv o_{op}\text{: } op=1, \ldots, OP\}$, and set of intermediate nodes $\boldsymbol{P}=\{i\equiv p_{ol}\text{: } ol=1, \ldots, OL\}$. Symbol ***WE*** describes the set of numbers of elements of system; sources, destinations and middle nodes which are involved in the movement of goods and passengers. $\boldsymbol{WE}=\boldsymbol{N}\cup\boldsymbol{P}\cup\boldsymbol{O}$ and sets ***N***, ***P***, ***O*** are pairs disjointed. For the unambiguity and clarity of further considerations it was assumed that nodes belonging to the set ***N*** are marked with symbol a, i.e. $i\equiv n_{pn}\equiv a$ while nodes belonging to ***O*** are marked with symbol b, i.e. namely $i\equiv o_{op}\equiv b$.

For the purposes of modelling transport, system it was assumed that there are exploited the direct transport links between the various transport nodes of the network [9].

One of the characteristics of roads or their sections is the possibility of the occurrence of congestion affecting exhaust emissions. The possibility of minimizing congestion by making proper operational decisions locating vehicles streams on particular roads in the transport network is extremely valuable in terms of pro-environmental transport. It is assumed that for each pair of nodes $(a, b) \in \boldsymbol{E}$, where a is the source, b is destination, while the symbol ***E*** defined set of relations of transport, there is a set of paths marked with symbol $\boldsymbol{P}^{ab}$ binding the beginning of the relation with its end. A single path in a given relation (a, b) will be numbered with index p, wherein $p\in \boldsymbol{P}^{ab}$ and

$$\forall (a,b) \in \boldsymbol{E} \quad \exists p \in \boldsymbol{P}^{ab}. \tag{2}$$

The demand for transport $x(a,b,m)$ in the different transport relations $(a,b) \in \boldsymbol{E}$ is given for different modes of transport. The limits described by functions assumed on the nodes of a graph $\boldsymbol{F_{WE}}$ and (or) edges $\boldsymbol{F_{LE}}$ constrain traffic distribution. The basic constrains of transport network are: nonnegative traffic volume **NP**, traffic additivity **AP**, traffic leakage prevention **ZP,** and constraints resulting from the network parameters and limitation of possible emissivity (EURO standards). Moreover, following sets are defined:

- ***RSP***= { *rsp:* *rsp*=1,2,…,RSP} – numbers of types of engines (according to type of fuel and characteristics),
- ***NEU***= { *neu:* *neu* =0,1,2,3,4,5,6} EURO – standards of emission,
- $\boldsymbol{ST} = \{st: st = 1, ..., ST\}$ – numbers of types of vehicles.

Due to the pro-ecological aspect of the transport system, the decision variable would be the number of vehicles moved in the transport network. The decision variable marked as $x(st,rsp,neu,i,i',m)$ is understood as a number of vehicles of a given type moving on particular elements of transport infrastructure.

3. The criteria for the models of distribution of the traffic on the network

3.1. External costs

Transport generates high costs paid by users, and charged to all taxpayers. It means that external costs are not pay only by generating entities. The internalization (empowerment) of external costs is intended to prompt the user for their covering. The criterion of external costs allows analysing traffic distribution when some transportation technologies having smaller harmful impact on the environment are preferred. Over the harmful impacts of transport should be understood factors such as noise, air pollution, transport accidents or uncovered infrastructure costs that adversely affect the environment.

Destructive impact of transport on the environment pulls together significant costs, both indirect (designing, manufacturing, use and destruction of means of transport and infrastructure) and direct (accidents, noise, vibration). The effect of that impact is difficult to quantify what is shown by studies like [7].

National transport system is large, heterogeneous, multimodal system. Each mode of transport has different technical, technological and organizational characteristics. In the case of the external costs, the impact of heterogeneity is clearly noticeable. Tab. 2 presents a list of external costs for each mode of transport.

Tab. 2. External costs for each mode of transport

Mode of transport	The sum of external costs	
	Min	Max
road – in the city	2.1 [eurocents/vehicle km]	1.92 [euro/ vehicle km]
road – outside the city	1.0 [eurocents/ vehicle km]	1.09 [euro/ vehicle km]
rail – in the city	48.3 [eurocents/train km]	10.77 [euro/ train km]
rail – outside the city	26.7 [eurocents/ train km]	9.2 [euro/ train km]
air	1605 [euro/lot]	
inland waterways	105 [eurocents/ship km]	14.82 [euro/ ship km]

Source: own work based on [10].

The data in Tab. 2 illustrate differences in external costs generated by different modes of transport. Disparities between minimum and maximum values are large, what is associated with differences in the test vehicle (passenger, freight), and the conditions in which the studies were performed (type of terrain, time of day, rush hour, drive type).

Table 3 presents the values of selected components of external costs for selected sectors. As the data in table show, the various modes of transport interact in different ways with environment. Some modes have greater negative effects (higher value of external costs), others less.

Tab. 3. List of selected external costs for each mode of transport [eurocents/vehicle-km]

Mode of transport	Exhaust emissions		Noise emission	
	min	max	min	max
Road transport	0.1	0.3	0.8	3.4
Rail transport	16	42	1.7	5.2
Air transport	119	631	150	1200

Source: own work based on [4].

The total external costs of emissions by the transport system must be lowered. One of the activities for that may be moving traffic from transport modes characterized by higher external costs onto modes characterized by lower external costs. Analysis of traffic distribution according to external costs allows assessing the sustainability of transport network. The criterion of external costs for alternative distribution of the *st*-this type traffic $x(st,rsp,neu,i,i',m)$ with *rsp*-this type of engine, of *m*-th type of transport that meets *neu*-th standard emission moving in (i,i') link, can be expressed in the form:

$$z^{pab}\left(x\left(st,rsp,neu,i,i',m\right)\right)=z^{p'ab}\left(x\left(st,rsp,neu,i,i',m\right)\right)\ \wedge\ \min\ z^{pab}\left(x\left(st,rsp,neu,i,i',m\right)\right), \quad (3)$$

reaching minimum value for each transport relation $(a, b)\in\boldsymbol{E}$ and for different paths in relation $p'\in\boldsymbol{P}^{ab}$.

3.2. Average costs

Average cost criterion used in assessing distribution of traffic into multi-modal transport corridor can be treated as an assessment of the cost of transport done from the point of view of transport services buyer. Usually many decision makers decide about of vehicles movement and then traffic. Selection of paths in a given relation is made by each participant of the stream (decision maker) in accordance with the criterion of maximum benefit, i.e. the minimum time of movement.

Relation $(a,b)\in\boldsymbol{E}$ is composed of paths connecting the node *a* with the node *b*. The selection of roads by each participant is a result of many decisions. The distribution of the traffic onto paths through network is done until none of decision makers can increase his benefits by changing the chosen road to another. The distribution of traffic established in that way is the equilibrium-distribution. The distribution of *st*-th of vehicles (type of traffic) $x(st,rsp,neu,i,i',m)$ with *rsp*-this type of engine, of *m*-th type of transport that meets *neu*-th standard emission moving in (i,i') link, we write in the following form:

$$c^{pab}\left(x\left(st,rsp,neu,i,i',m\right)\right)=c^{p'ab}\left(x\left(st,rsp,neu,i,i',m\right)\right)\ \wedge\ \min\ c^{pab}\left(x\left(st,rsp,neu,i,i',m\right)\right), \quad (4)$$

reaching minimum value for each transport relation $(a, b)\in\boldsymbol{E}$ and for different paths in relation $p'\in\boldsymbol{P}^{ab}$.

The equilibrium conditions result in equal average cost of moving through each road in relation. It is equal to a constant value characteristic for the transport network and the size of the demand for transport $[x(a,b,m)]$, while this is the minimum value of the average cost. The distribution of traffic according above properties is optimal from the point of view of all decision makers because none of them can reduce costs associated with the carriage or increase own benefits by choosing another way in the relation.

Modelling traffic distribution according to accounts of average costs allows for prediction of the behaviour of buyers of transport services. The results of such instruments allow selecting preferences – restrictions aimed at providers of transport services. It is desirable from the point of view of transport policy because the distribution of demand between modes of transport and paths in relations (indirectly between transport service providers operating in the system) is visible.

3.3. Marginal costs

The marginal costs account is used to determine optimal volume of traffic, for which the total costs are smallest. Therefore, it is assumed that transport system has one active element whose aim is using system equipment in a way ensuring minimal total cost of transport services. Such action is undertaken by a single scheduler for the whole system. This means that other users are forced to take a decision in accordance with the decision highlighted by main decision-maker. Hence, the result of his action is nothing more than a plan of traffic in transport network, which describes the organization of movement for a fixed structure of system and fixed equipment structure elements.

Such analysis of the distribution of traffic onto transport network allows assessing the sustainability of the transport network, which is correlated to distribution of traffic on paths, whereby the marginal cost of each path is equal and minimal at the same time. The criterion of marginal costs for alternative distribution of the *st*-this type traffic $x(st,rsp,neu,i,i',m)$ with *rsp*-this type of engine, of *m*-th type of transport that meets *neu*-th standard emission moving in (i,i') link, is written in the form of the following expression:

$$m^{pab}\left(x\left(st,rsp,neu,i,i',m\right)\right)=m^{p'ab}\left(x\left(st,rsp,neu,i,i',m\right)\right) \;\wedge\; \min\; m^{pab}\left(x\left(st,rsp,neu,i,i',m\right)\right), \quad (5)$$

reaching minimum value for each transport relation $(a,\ b)\in \boldsymbol{E}$ and for different paths in the relation $p'\in \boldsymbol{P}^{ab}$.

According to above expression equilibrium with minimal cost for each transport relation, the marginal cost of movement on all paths used in the same relation is the same. It is equal to a constant value characteristic for the transport network and the demand for transport [$x\ (a,b,m)$]. Traffic distribution according to marginal cost is an estimation of the distribution of the traffic from the perspective of the service provider. Modelling traffic distribution, according to this criterion, allows primarily for assessment of degree od infrastructural investment by the providers transport services and to identify overinvested or undercapitalized elements of transport network. Obtained results allow the determination of instrumental preferences – restrictions aimed at providers of transport services resulting in desirable distribution of traffic between transport technologies with minimal involvement of suppliers and budget resources.

4. The distribution of traffic between Warsaw and Gdansk for two scenarios of transport system development

4.1. General assumptions

Modelling the distribution of traffic with taking into account harmful exhaust emissions has been carried out for a fragment of the transport network taken from the model of environmentally friendly transport system of Poland (**MEST**) in relation Warsaw - Gdansk. The existing rail and road networks (individual and public communication) are mapped. The structure of connections in the analysed network is shown at figure 1. Edges marked with dotted line are the road connections, while solid line edges are rail connections. Each connections is characterized by parameters such as length, driving time and average price per ride (in the case of rail it is assumed that trip will be held in the carriage of Class 2 - see Tab. 4).

Two scenarios of traffic distribution were assumed, $\boldsymbol{S} = \{s\colon\ s=1,\ 2\}$. In the first one the network of connections is escribed by characteristics interpreted as the average cost of movement expressed in PLN per passenger. In the second one characteristic are interpreted as the volume of emission of harmful exhaust compounds by given mean of transport expressed in grams per vehicle.

Estimating the average emissions of harmful exhaust gases by means of rail transport was carried out on the basis of the formula provided in [3]. The amount of energy needed to drive a specific type train from Warsaw to Gdansk was calculated, and then, on the basis of available data [15], the volume of carbon dioxide, sulphur and nitrogen oxides and particulate matter PM emission was estimated. In the case of cars and coaches, it was assumed that they comply with EURO 5 standards and emissions by these vehicles are equivalent to the upper normal limit.

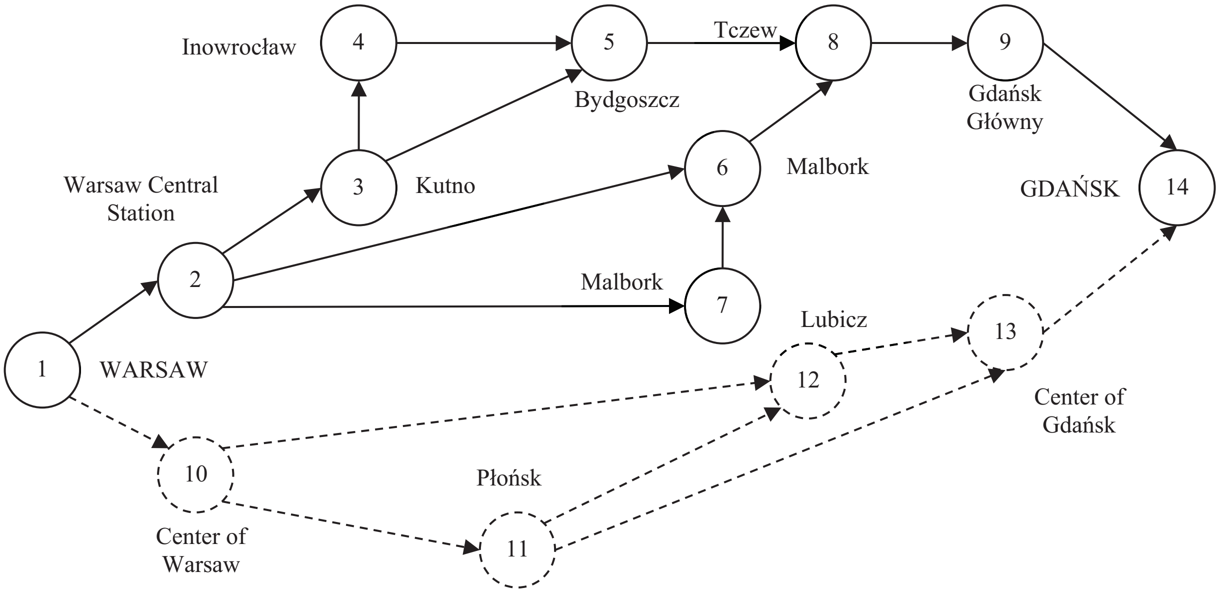

Fig. 1. The structure of communication between Warsaw– Gdansk

Tab. 4. Characteristics of connections in the communication network between Warsaw and Gdansk

No.	Type of connection	Relation	Length of connection [km]	Travel time [hours]	Average price of regular ticket [PLN]
1	*2*	*3*	*4*	*5*	*6*
1	rail	Warsaw – Kutno – Inowrocław – Bydgoszcz – Tczew – Gdansk	461	4:34	75.00
2	rail	Warsaw – Kutno – Włocławek – Bydgoszcz – Tczew – Gdansk	446	5:48	67.00
3	rail	Warsaw – Działdowo – Malbork – Tczew – Gdansk	328	4:52	62.00
4	rail	Warsaw – Białystok – Ełk – Olsztyn – Malbork – Tczew – Gdansk	631	10:53	73.00
5	car / bus	Warsaw – Płońsk – Ostróda – Gdansk	342 / 337	4:00 / 4:55	110.00 / 39.00
6	car / bus	Warsaw – Płońsk – Lubicz – Gdansk	364 / 360	4:30 / 5:30	132.00 / 50.00
7	car	Warsaw – Stryków – Lubicz – Gdansk	401	4:02	164.00

For each scenario, traffic distribution was made in three variants, $\boldsymbol{V}(s) = \{v(s): v(s)=1,\ldots, V(s)\}$. **Variant 1** distributes passenger streams on existing paths in analysed fragment of transport network, like rail and bus connections and roads for cars. In **variant 2,** the distribution has been carried out only on the rail network. **Variant 3** considers only road network.

The criteria for assessing the quality of organization of performance of the transport system in each s-this variant of scenario, $v(s)$, $v(s) \in \boldsymbol{V}(s)$ are:

- $f_1(\mathbf{X}(v(s)))$ – the average cost of traffic movement in analysed fragment of transport network,
- $f_2(\mathbf{X}(v(s)))$ – the marginal cost of traffic movement in analysed fragment of transport network.

Therefore, the global criterion function $F(\mathbf{X}(v(s)))$ consists of two sub-criteria, which will be evaluated for any variant $\mathbf{X}(v(s))$ of the distribution of traffic on analysed fragment of transport network, namely:

$$F\left(\mathbf{X}\left(v\left(s\right)\right)\right)=\left\langle f_1\left(\mathbf{X}\left(v\left(s\right)\right)\right), f_2\left(\mathbf{X}\left(v\left(s\right)\right)\right)\right\rangle \quad \longrightarrow \quad \min_{\mathbf{X}\left(v\left(s\right)\right)} . \tag{6}$$

It was assumed that stream of travelers loading analysed communication relation is of 8800 passengers per day. Assuming that not all journeys are carried out daily, the annual stream for analysed relations is 2 640 thousand passengers.

4.2. Traffic distribution on the transport network for defined development scenarios

For defined transport network, communicating Warsaw with Gdansk the distribution of passenger's streams according to established criteria was simulated. For the first scenario, distribution was made by the criterion of equal average costs and equal marginal costs (Tab. 5). The lowest cost per passenger was obtained for the first variant. The greater cost was for busses - road connections in variant 3, both at the criterion of equal average costs and marginal costs.

In the first variant with equal average costs, the railway network load was about 63%, bus connections about 34% and car transport took only 3% of the total volume of the passenger stream. In the second variant, the distribution of traffic was made only on the rail network. In the third variant, traffic distribution was made only on the road network, where 65% of the passengers burdened bus connections, while 35% took individual cars.

In the second scenario, transport links were characterized by indicator of medium-sized emissions of harmful exhaust gases. As criteria for evaluating the quality of organization in the transport system the cost of traffic movement expressed as the emissions of harmful exhaust gases was adopted.

The distribution of the passengers stream up to above assumptions and due to the average and marginal costs are shown in Tab. 6.

Tab. 5. Distribution of passengers stream [thousand passengers / year] in relation Warsaw - Gdansk for the first scenario according to the criterion of average costs and marginal costs

No.	Type of connection	Relation	VARIANT 1		VARIANT 2		VARIANT 3	
			f_1	f_2	f_1	f_2	f_1	f_2
1	*2*	*3*	*4*	*5*	*6*	*7*	*6*	*7*
1	rail	Warsaw – Kutno – Inowrocław – Bydgoszcz – Tczew – Gdansk	345	352	584	609		
2	rail	Warsaw – Kutno – Włocławek – Bydgoszcz – Tczew – Gdansk	417	394	664	659		
3	rail	Warsaw – Działdowo – Malbork – Tczew – Gdansk	618	561	954	922		
4	rail	Warsaw – Białystok – Ełk – Olsztyn – Malbork – Tczew – Gdansk	263	262	437	450		
5	car / bus	Warsaw – Płońsk – Ostróda – Gdansk	75 / 510	186 / 405			476 / 917	515 / 740
6	car / bus	Warsaw – Płońsk – Lubicz – Gdansk	0 / 414	112 / 348			323 / 796	422 / 661
7	car	Warsaw – Stryków – Lubicz – Gdansk	0	20			129	301
VALUE OF ASSESSMENT RATIO [PLN / pas.]			122,38	171,66	155,27	242,25	171,66	281,16

The lowest values of the indicator of the solutions quality were obtained for both variants (1 and 2 – distributions of traffic are the same). The highest cost of transport of one passenger was obtained for variant 3 – a difference from the first and second variant is huge.

Tab. 6. The distribution of the passengers stream [thousand passengers / year] in relation Warsaw - Gdansk for the second scenario according to criterion of average and marginal costs

No.	Type of connection	Relation	VARIANT 1		VARIANT 2		VARIANT 3	
			f_1	f_2	f_1	f_2	f_1	f_2
1	*2*	*3*	*4*	*5*	*6*	*7*	*6*	*7*
1	rail	Warsaw – Kutno – Inowrocław – Bydgoszcz – Tczew – Gdansk	541	541	541	541		
2	rail	Warsaw – Kutno – Włocławek – Bydgoszcz – Tczew – Gdansk	713	713	713	713		
3	rail	Warsaw – Działdowo – Malbork – Tczew – Gdansk	1222	1222	1222	1222		
4	rail	Warsaw – Białystok – Ełk – Olsztyn – Malbork – Tczew – Gdansk	164	164	164	164		
5	car / bus	Warsaw – Płońsk – Ostróda – Gdansk	0 / 0	0 / 0			523 / 597	523 / 597
6	car / bus	Warsaw – Płońsk – Lubicz – Gdansk	0 / 0	0 / 0			492 / 559	492 / 559
7	car	Warsaw – Stryków – Lubicz – Gdansk	0	0			470	470
VALUE OF RATIO OF SOLUTIONS QUALITY ASSESSMENT [mg]			5372,34	10744,68	5372,34	10744,68	$1{,}94\cdot10^{11}$	$3{,}88\cdot10^{11}$

5. Conclusions

Analysing simulations performed for defined scenarios of development showed that when traffic distribution is done up to the harmful emissions, the rail connections are more burdened from the perspective of a buyer of services and suppliers. Probably this is caused by the fact that rail transport is environmentally friendly and emits far less harmful exhaust than road mode.

Cost-effective transformation of transport system makes slowly in Poland. In particular, this applies to infrastructure projects influencing organization of transport and distribution of traffic. A number of different issues related to infrastructural projects, such as lack of concentration of capital for the implementation of large projects, insufficient rate of return (compared with other investments) and too much economic and political risk of these investments must be overmastered. In the case of large organizational projects, an important role is played by implement suboptimal (sometimes) patterns from developed countries (e.g. the balance between individual and collective passenger transport).

Shaping the sustainable transport system should integrate the objectives of social, environmental and economic benefits that are considered from both the point of view of transport policy of individual countries and the European Union.

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