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A Novel Model for Determining Public Service Compensation in Integrated Public Transport Systems

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Abstract: In free market conditions, if public passenger transport services are commercially unprofitable, there will be no interest for transport companies to perform them. However, directly because of the citizens' interests, on the one hand, and indirectly because of the economy, passenger public transport services have become of a general public interest. The authorities must prepare appropriate legal fair market conditions, based on which public transport will be subsidized and conducted. In order to achieve that, for the mutual benefit of the public, users and transport companies, it is necessary that the right Public Service Obligation Model (PSO model or in some literature PCS—Public Service Compensation) be defined. Within this study, the optimal approach to assigning a PSC contract to transport companies for performing the PSO in integrated and regular public passenger transport systems is determined. A novel model, presented in this paper, can help national, regional and local authorities to choose and determine the way and level of PSCs for conducting the public transport of passengers and establishing a sustainable public passenger transport system.

Keywords: public transport; authorities; operators; PSO; PSC

1. Introduction

Public transport is one of the most important factors for the development of region. The goal of the EU current transport policy is to overcome the unwanted domination of road transport in the "modal split" and open a possibility for the transport system's development in the spirit of sustainable development. From the viewpoint of passenger transport, the main goal is to provide a safe, efficient and high-quality passenger transport service throughout organized fair market competition, with guarantied transparency and the Public Transport of Passengers (PTP), which are ecological and boost regional development.

Regional accessibility, especially on suburban routes, is significantly restricted by the integration of the transport offer. One of the most important characteristics of regional and suburban routes is that passengers' public transport services are provided by a greater number of operators and by different means of transportation. In such conditions, a sustainable integrated transport offer has mostly been present in the transport market for the last few years.

The PTP can be accomplished as a part of the Integrated Public Transport Systems (IPTS), when transport is conducted jointly by railway and bus operators, or when public transport is concerned—separately by bus or by a railway operator.

In fact, the Public Service Obligation (PSO) system represents a model for financing unprofitable transport services of a common interest of the country, the region or the local community (the city and the municipality). The EU has improved and developed the PSO concept in each and every modality of transport, especially in railway and road passenger public transport in the last 50 years. The last regulation adopted by the EU is Regulation No. 1370/2007. The basic idea of the above-mentioned concept is that the authorities provide public transport on the routes where the operator (the transport company) cannot do business at a profit. Thus, the ordering party "buys", or in other words negotiates the transport service on the "open" market, publicly and without discrimination. The service quality, the number of lines and transportation units, the level of compensation for providing the services, as well as the rest of their mutual rights and obligations are regulated by contractual provisions. The operator is awarded a PSC for public transport.

In order to determine the mechanism of the decision-making process of the passenger for selecting the PTP, several latent variables are defined. One of the variables refers to the economy of services expressed through travel cost of taking bus and cost rate in monthly income. Travel costs of taking a bus as well as travelers' socioeconomic characteristic monthly income indicate the importance of the existence of a PSC if it is to be improved the mode share of public transport and reduce the transition to private transport [1].

In order to guarantee the basic rate of the operator's profit, and that the ticket prices are maintained at low levels, subsidies are usually necessary for the sustainable development of the public transport system [2].

The conducted research described in the paper presents a new analytical model with empirically determined parameters which allows determining PSC elements in PTP systems according to EU directives, determining its amount and allocation of funds for the PSC. The existence of a unified and transparent model of the PSC can initiate and enhance the partnership between authorities and operators and enable authorities to manage the transport policy in order to ensure the sustainability of the PTP. To accomplish this, three goals are defined. The first is the development of a new model for determining the PSC in integrated public transport systems harmonized with the EU transport policy, enabling a possibility of its partial application (either railway or bus transport). The second objective aspires to the examination of its applicability and sustainability in practice. The third objective is the overcoming of the gap between different ways of defining the elements for the determination of the PSC and its potential unification.

Creation of a unique model for determining the PSC allows to improve the quality of the service while achieving minimal costs for the functioning of the PTP system, as from the aspect of local government as system operator as well as in the case where the private operator is the organizer of the public transport services.

The paper is organized as follows. In Section 2, elements of Regulation (EC) No. 1370/2007 are described which set guidelines for determining the PSC and defined the structure of "net contracts" and "gross contracts". In Section 3, is given a brief overview of the research and available studies that were dealt with by the PSO, or the PSC. Section 4 deals with the development of a novel model for determining the PSC which includes defining the elements of the railway operator costs, the bus operator costs, gross income and effects and PSC allocation in the IPTS. In Section 5 the model for determining the PSC and the analysis of the results is tested. The paper ends with conclusions.

2. Regulation (EC) No. 1370/2007

In the European Council Regulation (EC) No. 1370/2007, it is stated that the reimbursement for covering the expenses made by performing the PSO should be defined in such a way as to prevent an excessive reimbursement and that it should be calculated in such a manner that it must not exceed the sum corresponding to the financial efficiency that equals the addition of effects, both positive and negative. The two basic terms incorporated into the new system of public transport are: The Public Service Obligation (PSO) and the Public Service Compensation (PSC). The PSO is the request defined or set by the competent authorities in order to ensure the Public Transport of Passengers (PTP) of a common interest that the operator, if taking into account its commercial interest, would not take over, or would not take over in the same amount or under the same conditions without a reimbursement. The PSC indicates the benefits, especially financial ones, directly or indirectly granted by the competent authorities for the period of the application of the obligations in public transport [3].

There are two basic types of the financial mechanisms of the PSC, through the so-called "net" and "gross" contracts (Figure 1):

- In "net contracts", the revenue derived from ticket sales goes to the provider of the service as a part of the payment for its services by the public authorities. These forms of contracts are more commonly used in the EU because they strongly and naturally motivate the operator to increase the number of passengers, as well as customer satisfaction. These types of contracts are considered as appropriate for the distribution of responsibilities between the public authorities and the operator, leaving little room for innovation and quality improvement. This is one of the opportunities for the public authorities to engage the operator who will take the risk of changing the number of passengers.
- In "gross contracts", the revenue derived from ticket sales goes entirely to the public authorities, who then pay the operator to provide transport services. These forms of contracts are used in cases when the public authorities want to keep a full responsibility for passengers. This can go along with a certain economic incentive for the operator.

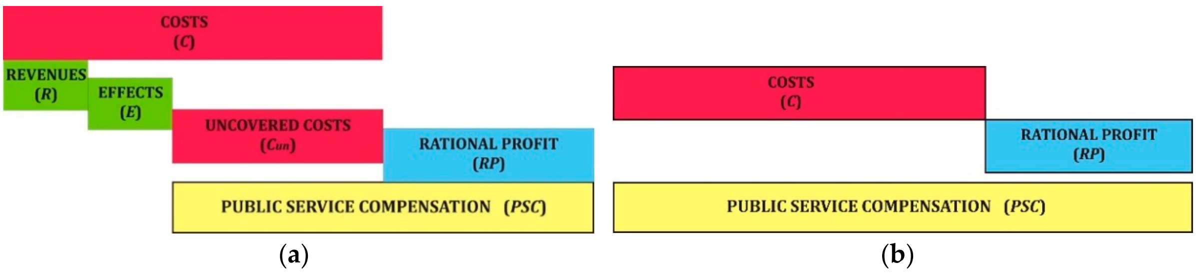


Figure 1. The structure of the Public Service Compensation (PSC): (**a**) Net contracts; (**b**) gross contracts (Source: Own research based on Regulation 1370/2007/EC).

3. Literature Review

There is no universal and generally accepted model for defining the PSO and the PSC accordingly. In the available literature, the largest number of the studies of the PSO refer to air traffic [4–6].

In a research study of public bus transport in Germany [7], the author analyzes the effect of the institutional framework and subsidies of noncommercial transport on the strengthening of commercial transport. In a study of the reforms of the public city bus transport systems in Malta [8], the details incorporated into the regulation of public transport are directly analyzed, simultaneously taking into account the agreement upon the service standard, the arranged responsibilities, as well as the clearly defined relations between the authorities and the operators.

The methodology described in the studies by Hensher and Stenli and Hensher and Houghton [9,10] estimates the future needs for transport in public bus transport in the function of changing the service price and standard (vehicle/kilometer). A group of authors [11] include in this model subjective time values and passengers' readiness to pay for a service improvement in order to determine the optimal PSO formula.

In the paper "New pricing theory of intelligent flexible transportation" has been developed a new model which makes it possible to apply marginal cost theory in the field of flexible transportation. The innovative idea behind the presented solution was the newly defined unit of marginal cost pricing in case of flexible transportation, namely the individual transport loop (instead of transported volume, e.g., passenger kilometer etc.) [12].

When railway traffic is in question, Gand [13] analyzed the internal and external factors affecting the former German federal railways that had had an impact on the negative financial trade effects and the tendencies of the reorganization of the German railways and dividing the infrastructure and transportation. The author also provided a critical review of the consequences of such a reconstruction in the case of the implementation of the essential business standard for public transport commitment. A group of authors [14] used a fuzzy logic to assess the liberalization of passenger public transport by taking Serbia as an example, the PSO being one of the criteria in the assessment model. In the research [15] committed to the determination of the manner and control of the distribution of the "state money" prior to all subsidies (the PSO, maintenance and the infrastructure development) it was concluded that it had just led to a cost reduction.

Vesković and associates state that budget size of public authorities which should be taken to assess the performance of passenger traffic operators in the PSO system is the most important criterion [16].

Some countries (the Czech Republic and Romania) finance international transport through the PSO. There is a tendency to gradually reduce the PSO to suburban and regional transport, and to convey the competence to the local authorities because they can define best the needs and take the responsibility for controlling the implementation of the contract. Market openness to competition that countries choose significantly determines PSO models. The ultimate two solutions that set the boundaries of the PSO contract model that exceptionally stand out are [17]:

- The French model, where regions are authorized to define the PSO, but they have to sign exclusive contracts with the State Transport Company (SCNF);
- The British model, where only private transport companies exist, and the authorities in charge provide contracts (franchises) mainly by an open tender.

The rest of the countries are in-between these two extremes, whereas the German experiences and improvements made in this field are the most important. In Germany, PSO-based transport is for the largest part (80%) provided by the DB (DB Regio), although there has been a gradual increase in the participation of the other domestic operators and foreign operators are also expected to enter this transport market segment.

The importance of proper ways of defining the PSC was explained by Xue and his associates. They state that due to low subsidies from the state (etc. China), or local self-government, the introduction of a private sector into a PTP can ruin, because the private operator also shares the same government subsidies as the traditional public transport company. In the same paper, it is also stated that government subsidies include fuel allowances, vehicle subsidies, trips allowances for special social groups (students, the aged, the disabled, soldiers), and other subsidies for policy-related losses [18].

Railistics GmbH [19] defined the following four scenarios: the PSO Calculation of the Current Situation, the PSO Calculation of the Current Situation, but With New Equipment, the PSO Calculation Under Consideration of New Equipment and Operational Optimization, and the Best Solution Under Consideration of the Combined Different Aspects.

In order to understand the idea underlying public transport subsidies, some researchers [20,21] especially point out the fact that cities and municipalities do not subsidize operators, but the real public transport service is offered to citizens. Taking the said into consideration, every public transport has its own pertaining cost (which usually does not cover the price of the tariff), and the timetable approved by the city or the municipality. Regardless of the corresponding traffic needs (the number of passengers) during each period of the day and on certain days of the week/year, cities and municipalities choose to subsidize public transport, which is done in order to accomplish the goals defined by the wholesale/altogether transport policy [22]. These goals are different and their base provides a possibility of transport to every social category so as to increase the mobility of all citizens. As a special advantage of these systems, some authors [23,24] point out the fact that the implementation of such a transport policy decreases the need for using personal vehicles, which offers a possibility of a better management of urban spaces and transforms the surroundings for the purpose of enabling a sustainable development of urban communities.

In an article on the subsidization of urban public transport [25], a model aimed at demonstrating the fact that user-time-consumption-based costs are not an excuse for subsidizing public transport is developed. Contrary to these claims, Basso and Jara-Díaz [26] proved that the Mohring effect is a valid argument for subsidies.

Ševrović and associates [27] stated that the determination of the optimal level of subsidies is especially important in the distributive model for a city and suburban public transport. In order to solve the problem of a fair subsidy, the distribution between the different municipalities that organize the mutual (regional) public bus transport of passengers across their territories, they developed a new improved model of subsidies in the area of Dubrovnik-Neretva District in the Republic of Croatia. In a research paper dealing with the analysis of the public transport in Germany [28], the fact that the quality, attractiveness and productivity of public transport services have been improved during the last two decades in spite of the fact that subsidies have significantly decreased is presented.

The items included in the PSO standards significantly differ from one country to another [29]. Beside the items connected to the PSO in the transport sector, which can be found in the literature, in practice, the studies have been done for the needs of the authorities in charge at the state or the local level.

The older different approaches for subsidizing public transport in European cities were presented by Reynolds-Feighan and Durkan [30]. The research showed that, in Europe, the four main groups of countries could be identified on the basis of their share in subsidizing: Low percent 0–20%, lower 20–40%, medium-high 40–60% (the most frequent), and high 60–70%.

Social-economic and transport data for public transport services in European cities have been published in the report by the European Metropolitan Transport Authorities (EMTA) [31]. According to this report, the relationship between subsidies and operative costs, as well as the relationship existent between gross income from ticket sales and the gross operative costs of the public transport services can be noticed. According to this study, income from ticket sales covers 44% on average of the gross operative cost of public transport companies.

As can exclusively be seen through the prism of market principles, public transport is not always the optimal choice for everybody. The experiences gained by developing countries show that the growth of residents' economic power decreases the number of the people who opt for public transport and public transport generally becomes the first choice of economically and socially destitute passengers. This further leads to a decreasing number of passengers on roads, especially those who pay the full price. This trend implies the need for increasing public transport subsidies so as to maintain its function or even increase the transport offer in an effort to change the modal distribution of travelling in favor of public transport.

4. The Development of a Novel Model for Determining the PSC

4.1. The PSC Level Determination

As previously explained, the level of a reimbursement for the PSC code according to the EC Regulation No. 1370/2007 is determined according to Figure 1:

$$\begin{aligned} PSC_{net} &= C - R - E + RP \quad [currency] \\ PSC_{gross} &= C + RP \quad [currency] \end{aligned} \tag{1}$$

where:

PSC_{net}—PSC at "net contracts" [*currency*];

PSC_{net}—PSC at "gross contracts" [*currency*];

C—the costs that occur as a result of performing the public service or a group of obligations according to the PSO [*currency*];

R—the revenues earned from the applied tariff and the other income generated from the performance of the PSO [*currency*];
E—all the other positive financial effects generated from the performance of the PSO [*currency*];
RP—the reasonable profit [*currency*].

The reasonable profit (RP) is determined as a fixed percentage (p_{rp}) of the sum necessary to cover the real operator cost, that is:

$$RP = \left(\frac{p_{rp}}{100}\right) \cdot C \quad [currency] \tag{2}$$

Based on Equations (1) and (2), it follows that:

$$\begin{array}{ll} PSC_{net} = C - R - E + p_{rp} \cdot C = C \cdot (1 + \frac{p_{rp}}{100}) - R - E & [currency] \\ PSC_{gross} = C + p_{rp} \cdot C = C \cdot (1 + \frac{p_{rp}}{100}) & [currency] \end{array} \tag{3}$$

The gross costs of performing PSC in IPTS comprise the railway transport operator costs (C_{op}^{rail}) and the road traffic operator costs (C_{op}^{road}), so that the following is derived from Equation (3):

$$\begin{array}{ll} PSC_{net} = \left(C_{op}^{rail} + C_{op}^{road}\right) \cdot \left(1 + \frac{p_{rp}}{100}\right) - R - E & [currency] \\ PSC_{gross} = \left(C_{op}^{rail} + C_{op}^{road}\right) \cdot \left(1 + \frac{p_{rp}}{100}\right) & [currency] \end{array} \tag{4}$$

If no PSO contract is executed for the purpose of performing operations through the integrated transportation system, then the PSC for each operation can be calculated in the following manner:

$$\begin{array}{ll} PSC_{net}^{rail} = C_{op}^{rail} \cdot \left(1 + \frac{p_{rp}}{100}\right) - R - E & [currency] \\ PSC_{net}^{road} = C_{op}^{road} \cdot \left(1 + \frac{p_{rp}}{100}\right) - R - E & [currency] \\ PSC_{gross}^{rail} = C_{op}^{rail} \cdot \left(1 + \frac{p_{rp}}{100}\right) & [currency] \\ PSC_{gross}^{road} = C_{op}^{road} \cdot \left(1 + \frac{p_{rp}}{100}\right) & [currency] \end{array} \tag{5}$$

where:

PSC_{net}^{rail}, PSC_{gross}^{rail}—PSC at "net contracts" or "gross contracts" at the railway operator;
PSC_{net}^{road}, PSC_{gross}^{road}—PSC at "net contracts" or "gross contracts" at the road operator.

4.1.1. The Railway Operator Costs

EMU/DMU—C_{im} Investment Maintenance Costs

The monthly costs of the investment maintenance of an electric multiple unit (EMU) or a diesel multiple unit (DMU) can be calculated by means of applying the following equation:

$$C_{im} = \frac{n_{EMU} \cdot C_{im}^{EMU}}{12 \cdot \sum_{i=1}^{n} N_{km_i}} \; or/and \; C_{im} = \frac{n_{DMU} \cdot C_{im}^{DMU}}{12 \cdot \sum_{i=1}^{n} N_{km_i}} \quad \left[\frac{currency}{train\ km}\right] \tag{6}$$

where:

C_{im}^{EMU} or C_{im}^{DMU}—the average costs of one investment repair in the cycle of the corresponding EMU/DMU series reduced annually [*currency*];
n_{EMU}—the number of the engaged EMU/DMU units for performing the PSO (exploitation);
$\sum_{i=1}^{n} N_{km_i}$—the gross monthly transport kilometers of the EMU/DMU [*train km*],"*i*" is the number of EMU/DMU involved in the implementation of the PSO.

The Costs of the EMU/DMU—C_{cm} Current Maintenance

The monthly costs of current maintenance:

$$C_{cm} = \frac{n_{EMU} \cdot C_{cm}^{EMU}}{12 \cdot \sum\limits_{i=1}^{n} N_{km_i}} \; or/and \; C_{cm} = \frac{n_{DMU} \cdot C_{cm}^{DMU}}{12 \cdot \sum\limits_{i=1}^{n} N_{km_i}} \left[\frac{currency}{train\ km}\right] \tag{7}$$

where C_{cm}^{EMU} is the gross annual costs of the current maintenance for one EMU/DMU [*currency*].

The Cost of Electricity for EMU—C_{el}^{EMU}, or the Cost of Fuel for DMU—C_{f}^{DMU}

Electricity is distributed by the infrastructure manager and in most situations the consumption of electricity is charged through a track access charge by the transport kilometer.

The amount of the power consumed for the traction of the EMU is affected by several parameters: The railway parameters (the ascent, the descent, the curves, etc.), the gross train mass, the power of electric engines, the specific consumption depending on the type of the EMU, the type of the traction, and so on. Several electricity-consumption calculating models used are based on the analytic and simulation models that can be found in the literature, and there is a developed piece of software for that purpose, too. Manufacturers frequently provide data on electricity consumption in their catalogues. Every EMU of a more recent date has a meter which measures the amount of the consumed electricity, which is the most reliable way to determine the amount of the consumed electricity. The fact that the EMU has a possibility of returning electricity to the electric grid while braking (recuperation) should be taken into account. The costs of the consumed electricity C_{el}^{EMU} should be charged for the amount of the consumed electricity, which the amount of the recuperated electricity is deducted from (The data can be found with the infrastructure manager). Reading the EMU's meter is suggested as the most reliable way to determine electricity consumption:

$$C_{el}^{EMU} = \frac{\left(\sum\limits_{i=1}^{m} Q_{el_i}^{tr} - \sum\limits_{j=1}^{m} Q_{el_j}^{rc}\right) \cdot c_{el}}{\sum\limits_{i=1}^{n} N_{km_i}} \qquad \left[\frac{currency}{train\ km}\right] \tag{8}$$

where:

$\sum\limits_{i=1}^{m} Q_{el_i}^{tr}$—the amount of the consumed electricity read on the meter of all of the deployed EMU [*kWh*] on a monthly basis, "*i*" is the number of EMU involved in the implementation of the PSO;

$\sum\limits_{j=1}^{m} Q_{el_j}^{rc}$—the amount of the returned (recuperated) electric energy from all of the deployed EMU received from [*kWh*] on a monthly basis, "*j*" is the number of EMUs involved in the implementation of PSOs that have recuperated the energy. c_{el}—the actual price for 1 kWh [*currency/kWh*].

The consumed amount of the diesel fuel of the DMU can be calculated based on the diesel motor shaft power and the diagram of its specific consumption. Consumption can also be calculated based on the mechanical work performed while one train is on the move. In their catalogues, the manufacturers of DMUs show the data about the time (hourly) of the consumption of the diesel fuel (*g/kW*) in the different conditions of exploitation. In that case, taking into account the speed on the railway section (of the same characteristics) and that of the fuel consumption while the DMU is standing in the station, the costs of the diesel fuel can be calculated with a satisfactory accuracy, as follows:

$$C_{f}^{DMU} = \frac{\left(\sum\limits_{i=1}^{n} N_{km_i} \cdot g_{tr} + \sum\limits_{i=1}^{n} T_{st_i}^{st} \cdot g_{st}\right) \cdot c_f}{\sum\limits_{i=1}^{n} N_{km_i}} \qquad \left[\frac{currency}{train\ km}\right] \tag{9}$$

where:

g_{tr}—the average fuel consumption for the traction of the DMU per 100 transport kilometers [*l/100 train km*];
$\sum_{i=1}^{n} T_{st_i}^{st}$—the total standing time in stations [*h*], "*i*" is the number of standing EMU/DMU; g_{st}—the average consumption of the fuel as per hour, while the DMU is standing in stations [*l/h*];
c_f—the actual price for 1*l* fuel [*currency/l*].

EMU/DMU—C_{gr} Costs of Grease Consumption

The monthly costs of grease consumption can be calculated as follows:

$$C_{gr} = \frac{\sum_{m} M_{gr_m}}{\sum_{i=1}^{n} N_{km_i}} \cdot c_{gr}^{EMU} \; or/and \; C_{gr} = \frac{\sum_{m} M_{gr_m}}{\sum_{i=1}^{n} N_{km_i}} \cdot c_{gr}^{DMU} \qquad \left[\frac{currency}{train\ km}\right] \tag{10}$$

where:

c_{gr}^{EMU}—the average price for 1 *kg* of grease for the EMU (or the DMU) [*currency/kg*];
$\sum_{i=1}^{n} M_{gr_i}$—the altogether consumption of grease for the EMU/DMU on a monthly basis [*kg*], "*i*" is the number of EMU/DMU involved in the implementation of the PSO.]

Consumption depends on the EMU/DMU usage. In accordance with that, Equation (10) can be calculated differently:

$$C_{gr} = \frac{\sum_{i=1}^{n} N_{km_i} \cdot m_{gr}}{\sum_{i=1}^{n} N_{km_i}} \cdot c_{gr}^{EMU} = m_{gr} \cdot c_{gr}^{EMU} \qquad \left[\frac{currency}{train\ km}\right] \tag{11}$$

where m_{gr} is the specific consumption of regular grease [*kg/km*].

The Costs of the Train Staff the Engine Driver and Conductors (In City-Suburban Passenger Transport in Some Cities, Conductors Are Absent and Passengers Buy and Punch Tickets on Ticket Vending Machines.) and the Transport Manager—C_{st}^{ge}

Gross income comprises of income from the work done and the time spent at work, as well as a reward, a bonus that the worker is entitled to (either according to the labor law, or according to the internal company regulations or the general labor contract executed by the worker). Additionally, gross income covers the tax and the obligatory healthcare, pension insurance and unemployment insurance fees the employer pays to the state. The monthly costs of gross income are as follows:

$$C_{st}^{ge} = \frac{n_m \cdot C_m^{ge} + 1.05 \cdot (n_{ed} \cdot C_{ed}^{ge} + n_c \cdot C_c^{ge})}{\sum_{i=1}^{n} N_{km_i}} \qquad \left[\frac{currency}{train\ km}\right] \tag{12}$$

where:

n_m—the number of the transport managers involved in the PSO planning and performance;
C_m^{ge}—the monthly gross income of the transport managers involved in the PSO planning and realization [*currency*];
1.05—the employee monthly dispersion coefficient due to holidays, sick leaves, days off, etc.;
n_{ed}—the number of the engine drivers;

C_{ed}^{ge}—engine drivers' monthly gross income [*currency*];
n_c—the number of conductors on one train;
C_c^{ge}—conductors' monthly gross income [*currency*].

EMU/DMU—C_{ac}^{EMU} Cost Amortization

In order to determine amortization costs, either the method of time amortization (proportional-linear, digressive and progressive) or the method of functional amortization may be applied. In the case of the majority of both international railway and road operators, time amortization for the EMU/DMU is usually calculated as linear, which means that such a calculation is based on the amortization base and the legitimate amortization rate. Since the calculation of train costs per kilometer is the basic goal to achieve, the total amortization costs and the covered distance are reduced. According to this, the monthly costs of time amortization can be calculated in the following manner:

$$C_{ac}^{EMU} = \frac{n_{EMU} \cdot c_{EMU} \cdot p_a^{EMU}}{12 \cdot 100 \cdot \sum_{i=1}^{n} N_{km_i}} \; or/and \; C_{ac}^{DMU} = \frac{n_{DMU} \cdot c_{DMU} \cdot p_a^{DMU}}{12 \cdot 100 \cdot \sum_{i=1}^{n} N_{km_i}} \quad \left[\frac{currency}{train\ km}\right] \tag{13}$$

where:

c_{EMU}—the EMU/DMU amortization base (the supplying value); if it is not a new vehicle, then the vehicle which the operator starts in order to fulfil the PSO [*currency*];
p_a^{EMU}—the amortization rate for EMU/DMU [%].

EMU/DMU—C_{ic}^{EMU} Insurance Costs

The insurance benefit is the basis for defining insurance costs. A benefit is the amount of money paid to the corresponding insurance fund as an insurance price. The calculation of such a benefit can be made by applying individual methods (when the benefit is calculated for each contract individually) or a group of methods (when the benefit is calculated at the level of the certain types of insurance). In practice, especially when railway and road vehicles for public transport are in question, the most frequently applied method is the individual "pro rata temporis" method providing the most precise result of the calculation of the transferred benefit. In any case, the level of the benefit is determined by the insurance company. On the occasion of executing a PSO contract, the IPTS participants should provide the insurance company with an offer for the monthly sum of insurance benefit for the vehicles that will participate in the PTP.

Passenger insurance costs are usually included in the ticket price paid by the passenger.

The Costs of Cleaning the EMU/DMU—C_{cc}

The costs of cleaning the EMU/DMU are determined based on the contract signed between the operator and the cleaning company. Essentially, the costs of the EMU/DMU cleaning and washing per transportation kilometer can be determined as follows:

$$C_{cc} = \frac{c_{mcc} \cdot n_{EMU}}{\sum_{i=1}^{n} N_{km_i}} \; or/and \; C_{cc} = \frac{c_{mcc} \cdot n_{DMU}}{\sum_{i=1}^{n} N_{km_i}} \quad \left[\frac{currency}{train\ km}\right] \tag{14}$$

where:

c_{mcc}—the average monthly costs of cleaning one train set [*currency*];
n_{EMU}—the total number of the EMU/DMU sets deployed for the purpose of providing passenger public transport according to the PSO.

EMU/DMU—C_{sk} Safekeeping Costs

EMU/DMU safekeeping costs per transportation kilometer are determined based on the contract signed with a suitable fire prevention and security service company. It can be calculated as follows:

$$C_{sk} = \frac{365 \cdot 24 \cdot n_{sk} \cdot c_{sk}^{h}}{12 \cdot \sum_{i=1}^{n} N_{km_i}} \qquad \left[\frac{currency}{train\ km}\right] \tag{15}$$

where:

n_{sk}—the number of security guards on a shift in function of the number of the train sets that the signatory agrees upon in the PSO contract;
c_{sk}^{h}—the gross cost of one security guard's workhour [*currency*].

When EMUs/DMUs are deployed for the purpose of performing a PSO contract, there is a need for a station depot, where the EMUs/DMUs are prepared on the roundtrip, so that they could be ready for transport in the direction of the city in the morning. Frequently, operators have no opportunity for safekeeping the train set in those stations, as in the case of the technical-passenger station.

Track Access Charges—C_{tax}

These costs are determined based on the Methodology for Determining the Level of Reimbursement for Using the Railway Infrastructure, Organizing and Regulating Railway Traffic. The cost is determined based on the transport kilometers achieved in each month or in any other time period that has been agreed upon:

$$C_{tax} = c_{km}^{tac} \qquad \left[\frac{currency}{train\ km}\right] \tag{16}$$

where c_{km}^{tac} is the track access charges per transport kilometer calculated based on the Methodology for Determining the Level of Reimbursement for Using the Railway Infrastructure, Organizing and Regulating Railway Traffic [*currency/train km*].

Other Costs—C_{oc}^{rail}

Other costs include: Office costs, the costs of promotional material, the printing and issuance of passenger identification cards, and other administrative costs. These costs are, on average, covered between 3% and 5% of previous gross costs.

$$C_{oc}^{rail} = \frac{p_{oc}^{rail}}{100} \cdot \left(C_{im} + C_{cm} + C_{el}^{EMU} + C_{gr} + C_{st}^{ge} + C_{ac}^{EMU} + C_{ic}^{EMU} + C_{cc} + C_{sk} + C_{tax}\right) \qquad \left[\frac{currency}{train\ km}\right] \tag{17}$$

where p_{oc}^{rail} is the fixed percentage of the administrative costs [%].

The Gross Costs of the Railway Operator

Costs of a railway operator can be determined based on following equation:

$$C_{op}^{rail} = \left(C_{im} + C_{cm} + C_{el}^{EMU} + C_{gr} + C_{st}^{ge} + C_{ac}^{EMU} + C_{ic}^{EMU} + C_{cc} + C_{sk} + C_{tax}\right) \cdot \left(1 + \frac{p_{oc}^{rail}}{100}\right) \qquad \left[\frac{currency}{train\ km}\right] \tag{18}$$

4.1.2. The Bus Operator Costs

Costs of Employees' Salaries—C_{es}

Income costs are determined for the defined car pool used by the operator in order to perform PTP, the defined number of active buses plus the number of the buses kept in reserve, and based on the number of employees (according to their vocation and profession) and the existing level of income according to the title/rank. Gross monthly costs can be calculated in the following manner:

$$C_{es} = N_{mg} \cdot C_{mg} + 1.05 \cdot \left(N_{dr} \cdot C_{dr} + N_{mw} \cdot C_{mw} + N_{aw} \cdot C_{aw} + N_{xw} \cdot C_{xw} + N_{gu} \cdot C_{gu} \right) \quad [currency] \tag{19}$$

where:

N_{mg}—the managers with the gross monthly salary—C_{mg}[*currency*];
N_{dr}—the drivers with the gross monthly salary—C_{dr}[*currency*];
N_{mw}—the vehicle maintenance workers with the gross monthly salary—C_{mw}[*currency*];
N_{aw}—the administrative workers with the gross monthly salary—C_{aw}[*currency*];
N_{xw}—the auxiliary workers with the gross monthly salary—C_{xw}[*currency*];
N_{gu}—the security guards with the gross monthly salary—C_{gu}[*currency*];
1.05—the coefficient of the monthly dispersion of the employees due to holidays, sick leaves, days off, etc.

The Costs of Fuel—C_f^{bus}

The gross monthly costs of fuel can be calculated as follows:

$$C_f^{bus} = \left(\frac{L_{cl} \cdot g_{cl} + L_{sl} \cdot g_{sl}}{100} \right) \cdot c_f \quad [currency] \tag{20}$$

where:

L_{cl}—the gross mileage on city lines (*city lines*) during one month [*km*];
L_{sl}—the gross mileage on suburban lines (*suburban lines*) during one month [*km*];
g_{cl}—the average fuel consumption as per 100 km on city lines [*l/100 km*];
g_{sl}—the fuel consumption on 100 km on suburban lines [*l/100 km*].

The Costs of Tires Change Due to Wear—C_{rt}

The gross monthly costs of tire change due to wear are:

$$C_{rt} = \frac{l_{bus}^{y}}{12 \cdot l_t^{ex}} \cdot n_t^{bus} \cdot N_{bus} \cdot c_t \quad [currency] \tag{21}$$

where:

N_{bus}—the gross number of the buses used by the operator for the purpose of providing the service [*buses*];
l_{bus}^{y}—the average annual mileage per vehicle accomplished while performing the PSO [*km*];
n_t^{bus}—the number of tires as per vehicle [*tires*];
l_t^{ex}—the tire mileage to expense [*km*];
c_t—the current price for one tire [*currency*].

Vehicle Amortization Costs—C_{ac}^{bus}

The gross monthly costs of the vehicle amortization can be determined in the following manner:

$$C_{ac}^{bus} = N_{bus} \frac{C_{bus} \cdot p_a}{12 \cdot 100} \quad [currency] \tag{22}$$

where:

C_{bus}—the base for amortization, the prime/supplying bus value, and if the vehicle in question is not new, the value implemented by the operator for the purpose of executing the PSO [*currency*];

p_a—the amortization rate [%].

The Costs of Insurance, Vehicle Registration and Passenger Insurance—C_{ic}^{bus}

The base for the calculation of passenger insurance, vehicle insurance and registration costs is defined by the corresponding legal act on road traffic vehicles, and is taken from the pricelist of insurance companies and the competent state authorities. As a rule, the level of these costs is changed and adjusted annually. The monthly costs of the insurance and registration of vehicles and passengers are calculated as follows:

$$C_{ic}^{bus} = \frac{N_{bus} \cdot c_{ic} + r \cdot N_{bus} \cdot c_{vr}}{12} \qquad [currency] \tag{23}$$

where:

c_{ic}—the annual costs of the insurance of vehicles, passengers, etc. [*currency*];
r—the number of obligatory bus MOT tests (frequently performed twice a year);
c_{vr}—the costs of the vehicle registration [*currency*].

The Costs of the Regular Vehicle Maintenance Service MOT Tests—C_{rs}^{bus}

The costs of regular maintenance consist of the costs of material and the costs of the spare parts that are subject to replacement after having been used for a certain mileage, in compliance with the manufacturer's specification. It implies the replacement of oil, oil and air filters, as well as the other spare parts that are subject to obligatory replacement. The gross monthly costs of the regular maintenance service are calculated by applying the following equation:

$$C_{rs}^{bus} = \frac{l_{bus}^{y}}{12 \cdot l_{sv}} \cdot N_{bus} \cdot c_{sv} \qquad [currency] \tag{24}$$

where:

l_{sv}—the mileage between two successive maintenance services [*km*];
c_{sv}—the material and spare parts costs for a single maintenance service [*currency*].

The Costs of Vehicle Maintenance—C_{mv}^{bus}

The monthly sum of the maintenance expenses can be calculated as follows:

$$C_{mv}^{bus} = \frac{N_{bus} \cdot C_{mv}^{bus}}{12} \qquad [currency] \tag{25}$$

where C_{mv}^{bus} is the average annual costs of maintaining one vehicle [*currency/bus*].

The annual costs of the maintenance of a single vehicle are often determined based on a certain percentage of the prime cost of the vehicle, which usually accounts for 3%.

Other Costs—C_{oc}^{road}

Other costs include: office costs, the costs of promotional materials, the costs of printing and issuing passenger identification cards, and other administrative costs. These costs are covered by an average of 3–5% of previous gross costs:

$$C_{oc}^{road} = \frac{p_{oc}^{road}}{100} \cdot \left(C_{es} + C_{f}^{bus} + C_{rt} + C_{ac}^{bus} + C_{ic}^{bus} + C_{rs}^{bus} + C_{mv}^{bus} \right) \qquad [currency] \tag{26}$$

where p_{oc}^{road} is the fixed percentage of the administrative costs (%).

The Gross Costs of the Bus Operator

The gross monthly costs of the bus operator as per transportation kilometer are calculated as follows:

$$C_{op}^{road} = \frac{1}{\sum_{i=1}^{n} L_{km_i}} \cdot \left(C_{es} + C_{f}^{bus} + C_{rt} + C_{ac}^{bus} + C_{ic}^{bus} + C_{rs}^{bus} + C_{mv}^{bus}\right) \cdot \left(1 + \frac{p_{oc}^{road}}{100}\right) \quad \left[\frac{currency}{km}\right] \tag{27}$$

where $\sum_{i=1}^{n} L_{km_i}$ is the gross accomplished transportation kilometers of the bus operator per month, "i" is the number of buses involved in the implementation of the PSO.

For the purpose of determining the PSC for bus operator amortization costs, some PSO contracts take into consideration the costs of the buildings for storing and maintaining vehicles, the costs of maintaining the building where vehicles are stored and parked, property insurance, the property tax, and municipal services.

4.1.3. Gross Income and Effects

Gross income (R) in the public transport system can be calculated as follows:

$$R = R_{std}^{m} + R_{emp}^{m} + R_{pen}^{m} + R_{sub}^{m} + R_{dwt}^{m} + R_{vdc}^{m} + R_{add}^{m}\ R_{csm}^{m} + R_{cop}^{m} + R_{oth}^{m} \quad [currency] \tag{28}$$

where:

R_{std}^{m}—income from monthly tickets for students and pupils [*currency*];
R_{emp}^{m}—income from monthly tickets for employees [*currency*];
R_{pen}^{m}—income from monthly tickets for pensioners [*currency*];
R_{sub}^{m}—income from monthly tickets for the persons who have the right to transport subsidies [*currency*];
R_{dwt}^{m}—income from the monthly sale of daily, three-day(weekend) and weekly tickets [*currency*];
R_{vdc}^{m}—income from the monthly sale of tickets in the vehicle, either bought from the driver or from the conductor [*currency*];
R_{add}^{m}—income from extra-payment tickets and warning on a monthly basis [*currency*];
R_{csm}^{m}—income from complaints by means of the customer service on a monthly basis [*currency*];
R_{cop}^{m}—income from carrying out decisions after pressing charges on a monthly basis [*currency*];
R_{oth}^{m}—other income—a group correction, the correction of previous calculations and the collection of the financial deficit on a monthly basis [*currency*].

In some public transport systems, certain tickets are sold annually (e.g., pensioner tickets), in which case those sums should be brought down on a monthly basis.

As was already explained, while determining the PSC, the effects (E) that the operator performs by winning the PSO contract should be taken into account. Those effects can be: income from promotional activities, the sales of the marketing space, the making of movies, videos, commercials, leasing or renting space on/in transportation means participating in the PSO, promotions, etc. These effects can be difficult to measure because, in order not to decrease the PSC that they receive from the authorities, operators can redirect these effects to the other transportation means not taking part or only occasionally participating in the PSO.

Even though the authorities may perform the monitoring of "noticeable/identifiable" effects arising from the performance of the PSO, such effects are impossible to determine only on the basis of the operator's report.

As well as when determining the PSC, the authorities should not expect a significant reduction on the basis of the existence of such effects.

4.2. PSC Allocation

The allocation of funds for the PSC within the IPTS is accomplished on the basis of the arranged percentage of the transport performed in the IPTS, which is defined in detail by contract. The body in charge of monitoring the accomplishment of the PSO issues the final report no later than by the fourteenth day in the current month for the previous month. The final report that includes data on planned and performed roundtrips, effective kilometers, kilometers and working hours on lines, in accordance with the official timetable. In addition, it is necessary that the capacity of the bus and the railway sets (the solo bus, articulated and minibus) be determined.

The level of the operator's PSC can be determined according to each line and the total number of the lines. The gross monthly costs that the IPTS operators are paid are calculated as follows:

$$\begin{aligned}
PSC_{net} = &\left(C_{op}^{rail}\cdot\sum_{i=1}^{n} N_{km_i} + C_{op}^{road}\cdot\sum_{i=1}^{n} L_{km_i}\right)\cdot\left(1+\frac{p_{rp}}{100}\right) - \\
&-\left(R_{std}^{m}+R_{emp}^{m}+R_{ret}^{m}+R_{sub}^{m}+R_{dwt}^{m}+R_{drc}^{m}+R_{add}^{m}+R_{rec}^{m}+R_{cop}^{m}+R_{oth}^{m}\right) - E \quad [currency] \\
PSC_{gross} = &\left(C_{op}^{rail}\cdot\sum_{i=1}^{n} N_{km_i} + C_{op}^{road}\cdot\sum_{i=1}^{n} L_{km_i}\right)\cdot\left(1+\frac{p_{rp}}{100}\right) \quad [currency]
\end{aligned} \tag{29}$$

If an individual PSO contract is signed with operators, then the gross monthly costs of the PSC are calculated in the following manner:

$$\begin{aligned}
PSC_{net}^{rail} = &\ C_{op}^{rail}\cdot\sum_{i=1}^{n} N_{km_i}\cdot\left(1+\frac{p_{rp}}{100}\right) - \\
&-\left(R_{std}^{m}+R_{emp}^{m}+R_{ret}^{m}+R_{sub}^{m}+R_{dwt}^{m}+R_{drc}^{m}+R_{add}^{m}+R_{rec}^{m}+R_{cop}^{m}+R_{oth}^{m}\right) - E \quad [currency] \\
PSC_{net}^{road} = &\ C_{op}^{road}\cdot\sum_{i=1}^{n} L_{km_i}\cdot\left(1+\frac{p_{rp}}{100}\right) - \\
&-\left(R_{std}^{m}+R_{emp}^{m}+R_{ret}^{m}+R_{sub}^{m}+R_{dwt}^{m}+R_{drc}^{m}+R_{add}^{m}+R_{rec}^{m}+R_{cop}^{m}+R_{oth}^{m}\right) - E \quad [currency] \\
PSC_{gross}^{rail} = &\ C_{op}^{rail}\cdot\sum_{i=1}^{n} N_{km_i}\cdot\left(1+\frac{p_{rp}}{100}\right) \quad [currency] \\
PSC_{gross}^{road} = &\ C_{op}^{road}\cdot\sum_{i=1}^{n} L_{km_i}\cdot\left(1+\frac{p_{rp}}{100}\right) \quad [currency]
\end{aligned} \tag{30}$$

When paying, the PSC authorities should take into account the amount of the service provided and, possibly, the amount of the penalties for a failure to meet all of the terms of the PSO contract.

The authors of this study suggest that, when there is a performance exceeding 95% of the scope of the services (SS), it should be considered as 100%. For the lower levels of the performance of the services, a penalty PSC shown in Table 1 is proposed to use.

Table 1. The PSC penalties due to the non-fulfilment of the agreed service level.

The Performed Service Level (%)	Decreasing PSC Penalty (p_u)
91% ≤ SS ≤ 95%	1%
89% ≤ SS < 91%	2%
87% ≤ SS < 89%	3%
85% ≤ SS < 87%	4%
83% ≤ SS < 85%	5%
80% ≤ SS < 83%	5%

This is one possible suggestion. Actual values are matter of negotiations between operator and public authorities, and they significantly depend on the desired level of service quality.

When the level of the performed services is below 80% per adequate route, the consequence of such a state is the permanent elimination of the operator from that route.

The contract defines that the monthly PSO reimbursement that belongs to the operator may be decreased for the amount of the sum of the penalties agreed upon in the contract, and those penalties will be applied if there are any reasons for their application. This is done by the body in charge, licensed by a public authority, and a decrease in the monthly reimbursement is made throughout the final account, supported by an appropriate explanation. The penalty is determined based on the contract terms (the vehicle display does not work, bus drivers do not wear their compulsory uniforms, the vehicle hygiene, a lack of compulsory stickers in the vehicle and the garage number on the vehicle, the vehicle damage, the control of the usage of the AC unit, etc.).

The distribution of the funds obtained from the authorities' budget in favor of the PSO contract counterpart should be carried out as a two-part distribution: The first part, as an advanced payment based on the average percentage, should be paid within the time period no later than until the 15th day in the current month, whereas the payment of the second part should be made after the final account until the 30th day for the prior month.

5. Testing the Model for Determining the PSC and the Analysis of the Results

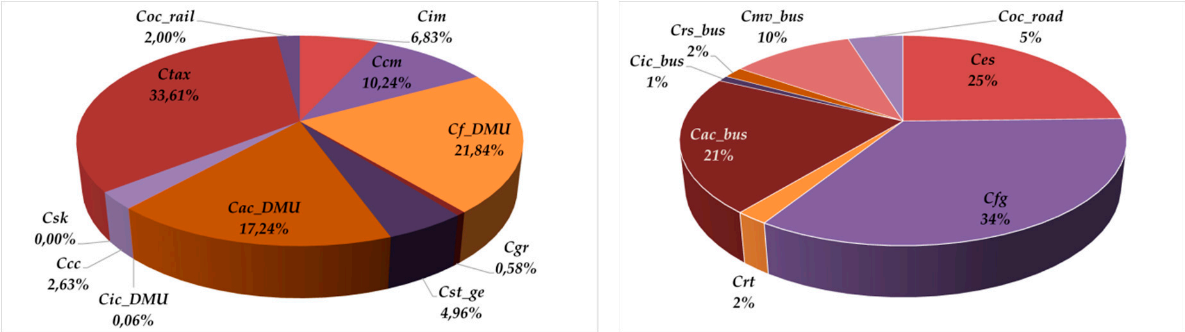
The suggested PSC defining model was tested on the example of the IPTS between the cities of Vršac and Pančevo, AP of Vojvodina (Serbia). On the Vršac–Pančevo transport route, the transport of passengers on the new DMU series 711 trains was planned, and in addition to that, the last transport mile from the railway stations in Vršac and Pančevo was envisaged to be covered by road bus operators. A gross contract with the operators was suggested.

The planned performance of railway passenger transport relied on the frequent cyclic timetable in the period from 4.00 to 24.00 h. The train departure interval in the peak period was 1 h, whereas after and before the peak period that interval was 2 h. For conducting public passenger transport, five DMUs were needed, the three of which were continuously deployed during the day, and the two were only used for certain train rides (during the other periods, the operator could use them for other purposes). The DMU train units accomplished 39,660 train km on a monthly basis. Track access costs per driving kilometer were obtained according to the current methodology of 2416 €/train km. Fuel consumption of DMU is derived from a manufacturer's catalog that has been corrected by empirical traction data (1.57 €/train km). On the basis of the analysis of statistical data, it was established that the reduced costs of investment and current maintenance amounted to 0.49 and 0.736 €/train km respectively, and the costs of driving staff are 0.357 €/train km. For the determination of depreciation costs, a proportional-linear method of time amortization was used (1.24 €/train km). For DMU cleaning, it is planned to hire service companies that charge their services per hour at the central accounting station and at the line-end station (0.19 €/train km). Other costs are insignificant in relation to the stated or did not exist (e.g., storage costs are missing since DMUs are stored at the carrier's garage).

By implementing the model presented in this research study, the result is as follows: $\mathrm{C}_{\mathrm{op}}^{\mathrm{rail}} = 7.189$ /train km. With the suggested percentage of $p_{rp} = 10\%$ the monthly cost was $PSC_{gross}^{rail} = 313,627.00$. The suggested PSC costs distribution per cities (Vršac and Pančevo) is 50%–50%. The PSC structure according to the types of the costs of the railway operator is presented in Figure 2a.

In order to determine the level of the PSC for the bus operator, and only for those buses which take part in the IPTS (without taking into account the whole of the PTP system), the IPTS system was defined (the integrated and adjusted railway traffic timetable was constructed, the turnover of capital was calculated, the necessary number of buses, bus km, the number of the staff member, the amount of the fuel consumed, the expected number of expendable parts, etc. were determined).

The fuel consumption of the bus was obtained on the basis of statistical data analyzes for individual types of bus operators (0.498 €/km). For staff engaged in providing the IPTS were determined costs of 0.358 €/km. The costs of depreciation of buses are also determined on the basis of the proportional-linear method of time amortization (0.307 €/km). The costs of tires change due to wear and the costs of the regular vehicle maintenance service MOT tests were obtained on the basis of operators' statistical data and amounted to 0.029 and 0.025 €/km, respectively. The costs of insurance, vehicle registration and passenger insurance are determined on the basis of the catalog of companies providing such services (0.013 €/km). Other costs are insignificant in relation to the mentioned or do not exist.



(**a**) (**b**)

Figure 2. The PSC structure according to the types of the costs: (**a**) The railway operator; (**b**) the bus operator.

Then, by incorporating the suggested model for the town of Vršac, the cost was $C_{\mathrm{op}}^{\mathrm{road\ VR}} = 1.453$ /km. Taking into account the suggested percentage $p_{rp} = 10\%$ and the planned 5568 km per month, the monthly sum for the IPTS-system participating bus operator of the city of Vršac equaled $PSC_{gross}^{road\ VR} = 8088.10$. When the city of Pančevo is concerned, the calculation resulted in the cost of $C_{\mathrm{op}}^{\mathrm{road}\ PA} = 1.546$ /km. Taking into account suggested percentage $p_{rp} = 10\%$ and the planned 6624 km per month, the monthly amount for the IPTS-participating bus operator of the city of Pančevo was $PSC_{gross}^{road\ PA} = 10,237.40$. The PSC structure according to bus operator type of the costs is presented in Figure 2b.

As can be seen in Figure 2a, one-third of the costs C_{op}^{rail} are allocated to the track access charges (33.61%), only to be followed by the costs of the diesel fuel consumption of around 22%, the amortization costs of 17.24%, the costs of the current maintenance DMU 10.24%, whereas the rest of the costs account for less than 10%. The application of the track access charge calculation methodologies based on Directive 2001/14/EC and the commitment received from Directive 2012/34/EU, as well as a big share in the total costs C_{op}^{rail}, discourage the local government from incorporating railway operators in the PTP. However, the latest regulation (EU) 2015/909 on track access charges is aimed at decreasing the costs of railway transport and aligning track access charges across Europe. The use of a track-friendly rolling stock, stimulated by lower track access charges, which will result in a lower maintenance cost while simultaneously making railway transport more competitive, is recommended [32]. This means that the (EU) 2015/909 is expected to apply in national regulations and that it has come up with new rules for setting track access charges. Its implementation will certainly affect a decrease in the PSC that will, first of all, stimulate local and regional authorities to change and adjust their transport policy towards more friendly means of transport. The second big group of the costs which take part in the total costs is the fuel consumption costs. This cost cannot be influenced and the effect will be insignificant because of the external factors (the oil market price, the oil tax, the specific engine fuel consumption, the railway configuration, etc.) and also the other factors, such as supplying additional devices, different traction modes, the engine driver's conduct, etc. Consumption can be decreased by optimizing the train's traction mode, decreasing the train's mass during a certain period of the day (if the DMU construction permits so and if it does not affect the quality of the service). Normally, however, if there is a possibility of electrification, the traction costs of the EMU are certainly several times lower than those of the DMU. A mention should be made of the fact that, on the example used in this research study, increased insurance costs regarding the DMU have appeared, which is so for the reason of the fact that these are new DMU sets with a higher insurance benefit. Among other costs, the cost of train staff is more significant. Within these costs, the share of the costs of the engaged conductors is significant. As mentioned above, these costs can be significantly reduced because in city-suburban passenger transport, in some cities, conductors are absent and passengers buy and punch tickets on ticket vending machines.

When bus operators are in question, the costs of fuel consumption, and the costs of the salaries of the IPTS participants are almost 60%. The highest costs are the fuel costs, which account for over one-third in the total PSC. A decrease in fuel consumption can be achieved by using a larger number of energy-efficient buses (CNGs, electric buses, etc.). In addition, because of the economic compulsory amortization rate of 10%, the costs of the vehicle amortization (21%) are the second highest-ranked. The rest of the costs included account for a total of 10%. Of these costs, the biggest are the Other Costs (office costs, the costs of promotional materials, the costs of printing and issuing passenger identification cards, and other administrative costs) which account for about 5% of the total costs, as well as the contracted percentage to which reduction can be affected by the negotiations with the operators.

6. Conclusions

By abandoning the traditional way of organizing the PTP, where every subsystem and transport company perform independently, the IPTS systems are developed and base on a hierarchical integration in order to achieve the full intermodality. According to this, the high-level quality services with the maximum rationalization of costs and the transport capacity are achieved. There is a tendency in the world to abandon the traditional way of organizing PTPs, where each subsystem and each operator work independently. In addition, the authorities' ultimate goals with respect to the establishing of the IPTS are: a social and economic cohesion, an easy access to transport, its sustainability, increasing market competitiveness and environment protection.

In this research study, a novel railway-road integrated PSC model is suggested. The model applies the well-planned grid of routes that provides the continuity and intermodality of the public passenger transport service with the minimum passenger delay time at junctions. The developed PSC model takes into account modern methods, trends and EU regulations, the need for achieving the sustainability of the system, and is tested on the real system. The results of the testing done on railway operators have shown that there is a big cost participation of track access charges, which may discourage local governments from introducing the railway operator in the PTP systems irrespective of the comparative advantages of this transport modality. It is implicative of the fact that it is harder to apply the basic concepts of the European transport policy related to overcoming unwanted distribution according to transportation modalities ("Modal Split"). This situation is still present, irrespective of the existence of a large number of strategies, recommendations, regulations and other EU measures in place. In order to create positive transport legislation for adjusting and integrating railway traffic as a part of the EU internal market and increase its share in the transport modal shift, the implementation of the Regulation (EU) 2015/909 should be imperative to the authorities in order for them to create and conduct the transport policy. Even though the Regulation 2015/909 has been in force since 1st August 2015, no its enforcement has not led to any significant improvements whatsoever so far. Its enforcement will push all countries (as the majority owners of the railway infrastructure) into setting aside larger amounts of money in order to cover the expenses of the Infrastructure Manager (IM). A decrease in the costs of fuel consumption may be achieved via the stimulating measures imposed by the state, implicative of a decrease in the fuel tax, as well as the other acts of the state concerning the fuel price for PSO-performing railway and bus operators. The listed measures can decrease local government's costs of the PSC and may lead to the optimization of the PSO.

The developed model, designed for setting the path and level of the PSC, presented in this research study can achieve the majority of the stated effects and savings in the provision of the PTP service. In addition, the PTP system can be optimized, by which all the necessary transport capacities will indirectly be engaged. By doing so, the quality of the transport service with the compulsory economic quantification and costs savings will be improved. The optimization of the PSC and PSO systems can achieve a number of effects, among which the most important are the following:

- An increased number of passengers in public transport (especially regional and suburban), and in the worst case—a decrease in the transport volume can be stopped;
- a higher, stable and more sustainable quality of the transport service can be achieved;
- as a rule, there is a decrease in passenger transport costs;
- a better and more efficient cost control;
- the implementation of intermodality results in the possibilities of a better organization of public transport and a belter modal split, which can be achieved through supported improved connections, e.g., within public transport systems;
- preconditions for the stabilization and reliability of railway companies engaged in the provision of the passenger transport service are achieved;
- a well-organized PTP contributes to society by allowing the achievement of the goals of market competitiveness, better employment, sustainable development and equal regional development, as well as saving the environment.

All of the above-listed facts positively affect the improvements of the operations performed by public transport operators and increase the competiveness of the passenger transport market.

The author's idea was to develop a universal PSC model that can be applied in smaller and larger PTP systems, regardless of whether it is a rail, bus or integrated PTP. Operators may be established by the authorities or be privately owned. However, the model is not applicable to PTP systems involving water and air traffic.

Depending primarily on the required services and conditions of the authorities, the presented cost structure defined by the PSC can be in certain parts changed, omitted (In general, local authorities do not have sufficient financial resources for quality PTPs) or supplemented (e.g., costs of painting vehicles, construction costs, marking and maintenance of stations and stops, uniformity of the personnel participating in the PTP system, etc.).

The proposed PSC model for rail passenger transport costs can be applied only to reformed rail systems (the functions "infrastructure management" and "transport" are financially separated) while the liberalization of the railways market is not a requirement. When it comes to integrated rail companies, it is difficult to apply the model in determining the infrastructure costs of the PTP.

Additionally, in the case of a "net contract", the authorities may recognize other effects not listed in the paper. When it comes to cost calculation of PSC, there is the possibility of displaying unrealistic data by the operator (data on fuel consumption at DMU and buses, maintenance costs, data on realized revenues and effects on net contracts, etc.). There may be an unavailability of certain statistic data. Operators, especially those established by the authorities, may have differently defined the PSC penalties due to the non-fulfillment of the agreed service level.

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