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Research paper

Accident costs on the railway network in the Czech national conditions

Tomáš Funk[1], Vít Hromádka[2], Jana Korytárová[3], Eva Vítková[4]

Abstract: The issue of assessing socio-economic impacts represent a key element of the decision-making process on the implementation of major public investment projects. The correctness of the decision depends both on the chosen principle of the socio-economic analysis and the input data. The presented article focuses on updating selected input values for the socio-economic assessment of railway infrastructure projects. Specifically, the simplified values of the estimated rail accidents costs. Accident costs are used for considering the change in the safety. At present, these values, which are also stated in the national methodological resources, are based on statistical data of the entire European Union and thus do not reflect the possible national specifics of projects implemented in the territory of individual Member States. The principle of updating values is from a methodological point of view based on the original calculation principles, however, involves a set of information items on the occurrences that emerged in the past in a specific area. The output of the article is a set of methodological steps considering national conditions when determining the average accident costs, subsequently verified on a case study of the railway network in the Czech Republic. The outputs of the presented article directly build on the results of the research project in which the team of article authors has been involved. The research results refer to different values of accident costs uniformly determined for the entire European Union territory and those determined individually for the conditions of the railway infrastructure in the Czech Republic.

Keywords: economic efficiency, socio-economic impacts, accident costs, railway network

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1. Introduction

The article focuses on updating partial steps of the socio-economic assessment of public projects in the field of transport, specifically railway, infrastructure. The task of the project socio-economic assessment is to assess ex-ante the expected societal benefits of the planned public investment project and provide information on whether the assessed project should be recommended for financing from public sources and subsequently implemented. In general, it can be stated that the socio-economic assessment is carried out in the pre-investment phase of the project and it is usually carried out by the CBA (Cost-Benefit Analysis) which is the subject of the article. The CBA method is currently considered to be a classical method for the socio-economic assessment of public projects and has, therefore, been very well developed from a methodological point of view. Currently, a key document for the implementation of the CBA method in the EU is the European Commission tool called "Guide to Cost-Benefit Analysis of Investment Projects" [1] which defines the principles of the method and its use as well as presents pilot case studies focusing on examples of socio-economic assessment for sub-areas of public investment, including transport, infrastructure projects. This document forms a methodological basis for the Departmental Methodology of the Ministry of Transport of the Czech Republic [2] which represents a methodological framework for carrying the CBA analysis of transport infrastructure projects in the conditions of the Czech Republic. The Departmental Methodology addresses most types of transport infrastructure projects, i.e. road infrastructure, railway infrastructure and transport-significant water constructions altogether. The socio-economic assessment carried out by the CBA method is, in principle, based on the comparison of the socio-economic impacts (benefits and costs) arising from the variant with the project and the variant without a project. The socio-economic impacts of the transport infrastructure projects are generally represented by the following items:

- Investment costs,
- Residual value of the infrastructure,
- Operating costs of the users,
- Time savings,
- External impacts:
  - traffic accidents,
  - emissions of harmful substances,
  - noise emissions,
  - greenhouse gas emissions.

The article focuses mainly on updating the socio-economic impacts by transforming the current values of unit impacts specified in the valid methodology into values corresponding to the current conditions in the Czech transport infrastructure. Specifically, it is an update of the unit impacts of traffic accidents (occurrences) on the railway network.

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2. Present-state references

As already mentioned in the introductory part, the key methodological materials for the CBA analysis of transport infrastructure projects are the Guide to CBA of Investment Projects [1] at the EU level and the Departmental Methodology of the Ministry of Transport [2] used for the analysis of transport projects in the Czech Republic. When determining unit impacts of transport-related externalities, both materials use as the basis of the External Costs of Transport in Europe document [3]. This document brings the total and average cost estimates and provides a strong basis for comparing the socio-economic impacts of various transport modes. They also serve as a basis for transport pricing or are used in cost benefit analysis (CBA). The update of the input information for the economic analysis of the transport infrastructure projects is subsequently presented in the Handbook on the External Costs of Transport [4], which has been developed in the study 'Sustainable Transport Infrastructure Charging and Internalisation of Transport Externalities' commissioned by the European Commission. The objective of this study is to assess the extent to which the 'user pays' and the 'polluter pays' principles are implemented in EU Member States and in other developed countries. The presented article is related with the safety on railways. The development of the railway safety issue in relation to the rail transport price is addressed by material [5], which is oriented mainly on the regulations leading to the increase of the safety of the railway. The key publications related to the presented topic are texts focusing on the detailed principles of the CBA analysis use in the railway infrastructure project assessment. The key references related to this topic are publications [6–9]. The issue of economic assessment of projects increasing the quality level of rail transport is covered by paper [6], which is oriented on the CBA analysis and socio-economic impacts evaluation. The outputs of the paper also include ex-post assessment of implemented projects as a key step towards verifying the functionality of the assessment systems. A broader context of the CBA principles application in the assessment of railway infrastructure projects is discussed in the article [7]. Moreover, the subject of the article [7] brings the comparison of the CBA usage in selected countries like Norway, Sweden, Denmark, the UK, France, Germany and Switzerland. Efficiency assessment of the railway network innovation process using a modified CBA approach is presented in the paper [8]. However, this paper is oriented mainly on the efficiency of services provided on railways. The CBA principles application to a tourist railway line in Italy is illustrated in a case study in the document [9]. As evident from publication [6–9], the issue of the utilization of the CBA analysis on railways is widely known and used, there exists adequate amount of experiences published in the scientific publications. The consequent very important issue related with presented paper is the safety on railways and its economic evaluation. The safety on railways is the subjects of references [10–17]. The issue of rail transport safety and its economics is the subject of paper [10], which reviews the statistics and economics of railway safety in Great Britain, the European Union and the United States. However, this paper is oriented mainly on the safety on railway crossings, what is not the crucial matter solved within the presented paper. The topic of the unreliability of rail transport is addressed in more detail in the article [11]. The article is concerned with the assessment of generalized user cost reductions in the cost-benefit analysis (CBA) of transport policies that aim at reducing unreliability. Johnsen et al. deal with the issue of risk analysis of critical infrastructure in rail transport in their article [12]. The paper discusses the significant findings of an extended risk assessment of the key communication infrastructure used in emergency communication in railways in Norway. The risk assessment presented within this article was based on a socio-technical approach. Petrova focuses on the issue of assessing rail transport safety and risk in Russia in her paper [13]. The paper is oriented mainly on the analysis of the main causes and triggers of railway accidents and traced their temporal variations and spatial distributions within the country with the triggering factor of accidents so-called "human factor". Railway accidents, their frequency, historical development and economic impact on European railways in the 1980–2009 period form the subject of a paper [14], where the trend in the number of fatal train collisions and derailments per train-kilometre is estimated. Santos-Reyes et al. carry out a systematic analysis of rail accidents in their article [15], the analysis is oriented on the several serious train accidents from the UK. Klockner and Toft deal with the analysis of occurrences on the railway network from the point of view of socio-economic modelling [16]. This research was interested in using non-linear network interactions and relationships as a more complex systems-oriented way of understanding accident taxonomy. Sustainable management of railway network with regard to the development of its safety and reliability is the subject of the article [17]. Proposal of a new approach for evaluating the damages resulting from railway accidents is the subject of the paper [18]. The approach is intended for the evaluation of the railway accidents on Korea Railroad, considering the accident damages, such as the train delay time, the number of trains delayed and the cost of considering the accident count responses, for the period 2008 to 2016.

From the list of mentioned publications, it is evident that the issue of economic evaluation of projects on the railway, including consideration of impacts associated with railway safety, is sufficiently substantiated by methodological documents (at EU level and at the national level of the Czech Republic) and scientific publications. At the same time, however, the analysis of the current situation points to the fact that some inputs expressing the impacts on rail safety are available with EU-wide data, but these are not area-specific data. These are mainly "unit external costs" (defined in Czech conditions in the document [2], for which the Czech methodological documents use general data set for the EU as a whole, specific national data are not available here. For this reason, the subject of the article presented in the introductory part is considered to be important and justified.

3. Methods

The article focuses on updating the socio-economic impacts of traffic accidents emerging on the railway network. The methodology for assessing the impacts associated with traffic accidents is generally based on an internationally accepted material for carrying out a CBA analysis called "Guide to CBA of Investment Projects" [1], for the Czech environment, the methodology was adapted in the "Departmental Methodology of the Ministry of Transport CR" [2]. The socio-economic impacts are presented in two versions in the

"Departmental Methodology". In the first version, detailed information on the impacts of traffic accidents depending on the severity of the accident can be used for a more detailed analysis of traffic accidents and changes in their impacts as a result of the assessed project implementation. The unit impacts listed in Table 1. were determined for these purposes.

Table 1. Societal accident costs in CZK, CO 2021 [2, 4]

Impacts/source	Departmental methodology [2]	Handbook [4]
Fatality	24,736,284 CZK	102,989,315 CZK
Serious injury	5,989,060 CZK	14,566,729 CZK
Minor injury	773,143 CZK	1,124,099 CZK
Material loss	410,368	

1 € = 25.545 CZK

The impacts related to traffic accidents given in the Departmental Methodology are expressed per one person for fatality, serious injury and minor injury and per one accident for the material loss. The values given in the Departmental Methodology ([2], p. 127) were determined using the calculation of the Transport Research Centre (a public research institution within the competence of the Ministry of Transport) for the conditions of the Czech Republic. The unit impacts given in the Departmental Methodology were for comparison supplemented by the third column of Table 1. representing values taken from the "Handbook on the External Costs of Transport" ([4], p. 44). Values in both columns of the Table 1. are expressed in Czech Crowns in prices of the year 2021.

In the second version, the socio-economic impacts related to traffic accidents are expressed in aggregate and are related to the purpose unit, which is a passenger-kilometre (pkm) for passenger transport and a tonne-kilometre (tkm) for freight transport. An overview of unit impacts for partial transport modes can be seen in Table 2.

Table 2. Unit external accident costs in CZK, CO 2017 ([2], p. 127)

Mode of transport (Unit)	Mode of transport	Average specific costs
Passenger transport (CZK/1,000 pkm)	Road passenger total	1,080
	Rail	19
Freight transport (CZK/1,000 tkm)	Road freight total	547
	Rail	6

1 € = 25.545 CZK

As can be seen from Table 2, the external costs associated with rail transport are many times lower than the external costs associated with road transport. The presented research results are intended to reduce the differences between the mentioned transport modes.

However, the presented contribution is strictly focused on the calculation of external costs for railway transport.

The important fact, however, is that while the detailed impact values given in Table 1. are based on the national conditions and calculations, the aggregate values given in Table 2 are taken from the "External Costs of Transport in Europe" material [3]. However, these are not national data reflecting the transport specifics of the Czech Republic, but average European data without direct relation to the conditions of the Czech Republic. This difference, therefore, leads the author team to a research question as follows: "Do the average values of unit external accident costs on the railway network stated in the Departmental Methodology correspond to the real conditions on the Czech railways?"

The research question was addressed by means of calculations, in which the ongoing results of the applied research project assessing the benefits associated with increased safety and reliability of the railway network due to the implementation of security equipment projects were used. The research used a detailed Database of Occurrences [19] which contains detailed records of more than 8 thousand occurrences emerging on the railway network in the Czech Republic in the 2009–2018 period. These records represent more than half a million items of information on occurrences, including the following data:

- Impacts on the health of the population
  - number of fatalities,
  - number of serious injuries,
  - number of minor injuries,
- Impacts on travel time
  - in the passenger transport,
  - in the freight transport,
- Material loss.

Using the above-listed data, it was possible to determine the average total impacts of occurrences as well as the average impacts of occurrences per sub-categories.

The information on the frequency of occurrences on the Czech railway network and the information on the average societal costs per one occurrence were used to determine the average values of unit external accident costs on the railway network. The occurrences were not classified in more detail for the purposes of this calculation, the impacts were determined per one average occurrence. The calculation of the frequency of occurrences is elaborated in chapter 3.1, which presents key information on occurrences occurring on the railway transport network in 2009–2018. In chapters 3.2 and 3.3 the authors consequently assess the frequency and unit impact for passenger and freight transport separately. The analysis and subsequent calculations are focused exclusively on rail transport, the update of unit external costs is also directed only to the railway infrastructure.

3.1. Frequency of occurrences

Each year, an average of 1,131 occurrences emerged on the Czech railway network including occurrences caused by suicides during the 2009–2018 period. In the overview below, the statistical data was adjusted by these occurrences and at the same time, all occurrences caused by road vehicles were excluded from the data, while the principle of the culprit was applied in the selection of occurrences. Thus, all occurrences where a road user was identified as the person who caused the accident were excluded from the list of occurrences. When more persons caused the accident, the consequences of occurrence were included only by the ratio defining the degree of culpability of rail transport. The average annual number of occurrences for that period resulted in 729 occurrences per year, 9 fatalities, 36 serious injuries, 69 minor injuries and CZK 164.5 million material loss. The above-listed information was taken from the Database of Occurrences [19]. An overview of occurrences and their impacts for the 2009–2018 period is given in Table 3.

Table 3. Overview of occurrences for the 2009–2018 period [19]

Year	Number	Fatalities	Serious accidents	Minor accidents	Material Loss (CZK)
2009	939	5	52	125	127,278,624
2010	1,042	12	62	74	199,184,633
2011	775	12	52	84	183,812,852
2012	796	8	34	64	113,119,200
2013	622	9	25	33	108,465,183
2014	589	5	26	48	162,379,202
2015	566	9	24	65	284,741,645
2016	606	12	31	46	144,579,359
2017	683	14	30	73	148,142,510
2018	674	7	25	79	173,225,956
Total	**7,292**	**93**	**361**	**691**	**1,644,929,164**
Average	**729**	**9**	**36**	**69**	**164,492,916**

1 € = 25.545 CZK

The information in Table 3 is derived by the authors from the Database od Occurrences [19] and is used to determine the average socio-economic impacts related to one average occurrence. Socio-economic impacts include impacts on health and material damage. Material damage includes damage to the property of carriers, line operators and third-party property. In addition, impacts in the form of delays for passenger and freight trains are considered in the next steps. The Table 3 shows that the lowest number of occurrences was reached in 2015 (566), the highest number of occurrences was reached in 2010 (1,042). However, the development in the number of occurrences is not subject to a clear tendency for their increase or decrease over time.

The number of occurrences emerging on the railway network was related to the purpose unit for the subsequent calculations. In general, it was calculated with a purpose unit referred to as a train-kilometre (trainkm), for further calculations in passenger train transport - a passenger-kilometre (pkm) and in the freight transport – a tonne-kilometre (tkm).

The development of transport performance on the railway network within the Czech Republic for the 2009–2018 period is presented in the chart in Fig. 1.

Fig. 1. Development of transport performance on the railway network within the Czech Republic [20]

The following methodological steps were addressed separately for passenger rail transport and freight rail transport due to different input data.

3.2. Passenger rail transport

An analysis of the Database of Occurrences [19] shows that the average frequency of an occurrence caused by a passenger train was 0.052 occurrences per one million passenger-kilometres and 3.245 occurrences per one million train-kilometres in the 2009–2018 period. The presented research uses the indicator determined as occurrence per passenger-kilometre to be consistent with current practice. The incidence of occurrences related to the passenger transport performance for the 2009–2018 period is presented in Table 4. Data from the Table 4 is derived from the Database of Occurrences [19] and the Statistical yearbook of the Railway Administration [20].

Table 4. Statistics on the frequency of occurrences related to passenger transport performance [19,20]

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Occurrence/ mil. pkm	0.087	0.098	0.063	0.052	0.042	0.040	0.038	0.039	0.041	0.038
Occurrence/ mil. train km	4.511	5.241	3.432	3.048	2.542	2.486	2.538	2.747	3.007	2.944

The average values for the whole monitored period are given above.

It was necessary to define an average occurrence to determine the average societal cost in CZK. The parameters of the average occurrence in passenger transport can be derived from the Database of Occurrences [19]. The average occurrence in passenger transport causes

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the following societal impacts, which are derived from the database of Occurrences [19] using the approach defined in [21, 22]:

- 0.017 fatalities,
- 0.071 severe injuries,
- 0.146 minor injuries,
- CZK 233,193 of material loss,
- 131.3 minutes of passenger transport delay,
- 23.7 minutes of freight transport delay.

The societal impacts of the average occurrence in passenger transport can be determined using the following equations (3.1), (3.2) and (3.3) [21]:

$$\mathrm{UI_P} = \sum_{i=1}^{3} \mathrm{AIH}_i + \mathrm{AITD_P} + \mathrm{AML_P} \tag{3.1}$$

where:

$\mathrm{UI_P}$ – unit impact (unit impact of the average occurrence in passenger transport, CZK/occurrence),

AIH_i – average impact on health (average impact of the occurrence in passenger transport on health: 1 – fatalities, 2 – serious injuries, 3 – minor injuries, CZK/occurrence),

$\mathrm{AITD_P}$ – average impact on transport delay (average impact of the occurrence in passenger transport on travel delay, CZK/occurrence),

$\mathrm{AML_P}$ – average material loss (average material loss by the occurrence in passenger transport, CZK/occurrence).

$$\mathrm{AIH}_i = \mathrm{AH}_i \times \mathrm{UIH}_i \tag{3.2}$$

where:

AIH_i – average impact on health (average impact of the occurrence of the relevant category on health: 1 – fatalities, 2 – serious injuries, 3 – minor injuries, CZK/occurrence),

AH_i – average number (average number of affected people by the occurrence in passenger transport: 1 – fatalities, 2 – serious injuries, 3 – minor injuries, CZK/occurrence),

UIH_i – unit impact on health (unit impact of the occurrence in passenger transport on health of one person, 1 – fatalities, 2 – serious injuries, 3 – minor injuries, CZK/occurrence).

$$\mathrm{AITD_P} = \mathrm{PTU} \times \mathrm{ADP} \times \mathrm{UIDP} \tag{3.3}$$

where:

$\mathrm{AITD_P}$ – average impact of travel delay for passenger transport,

PTU – passenger train utilization (average passenger train occupancy, person/train),

ADP – average delay of passenger trains (average total delay of passenger trains due to occurrence of the relevant category, train·hour/occurrence),

UIDP – unit impact of passenger train delay (unit cost of passenger time, CZK/hour·person).

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These equations were derived from the results of the previous research [21] and were subsequently used to calculate the impact of the average occurrence in passenger transport, which was then related to transport performance in passenger transport [20] (see Table 4).

3.3. Freight rail transport

The analysis of the Database of Occurrences shows that the average frequency of an occurrence related to freight trains was 0.022 occurrence per one million tonne-kilometres and 8.69 occurrences per one million train-kilometres in the 2009–2018 period. The presented research uses the indicator determined as occurrence per tonne-kilometre to be consistent with current practice.

The frequency of occurrences related to freight transport performance for the 2009–2018 period is presented in Table 5. Data from the Table 5 is derived from the Database of Occurrences [19] and the Statistical yearbook of the Railway Administration [20].

Table 5. Statistics on the frequency of occurrences related to freight transport performance [19, 20]

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Occurrence/ mil. pkm	0.029	0.029	0.025	0.029	0.022	0.019	0.017	0.017	0.018	0.017
Occurrence/ mil. train km	10.14	10.72	9.396	11.40	8.549	7.821	6.974	7.036	7.747	7.187

The average values for the whole monitored period are given above.

It was necessary to define the average occurrence to determine the average societal cost in CZK. The parameters of the average occurrence in freight transport can be derived from the Database of Occurrences [19]. The average occurrence in freight transport causes the following societal impacts, which are derived from the database of Occurrences [19] using the approach defined in [21, 22]:

– 0.007 fatalities,
– 0.022 severe injuries,
– 0.030 minor injuries,
– CZK 215,845 of material loss,
– 52.3 minutes of passenger transport delay,
– 66.5 minutes of freight transport delay.

The societal impacts of the average occurrence in freight transport can be determined using the equations (3.1) and (3.2), which are common to passenger and freight transport, and equation (3.4) which is specific for freight transport [21]. Equation (3.4) was used for the assessment of the impacts of the delay of freight trains.

$$\mathrm{AITD_F} = \mathrm{FTU} \times \mathrm{ADF} \times \mathrm{UIDF} \tag{3.4}$$

where:

$\mathrm{AITD_F}$ – Average impact of travel delay for freight transport,

FTU – Freight train utilization (average cargo weight of a freight train, tonnes/train),
ADF – Average delay of freight trains (average total delay of freight trains due to an occurrence of a relevant category, trains·hour/occurrence),
UIDF – Unit impact of freight trains delay (unit time cost of transported cargo, CZK/hour).

Similarly, to passenger transport, this equation was derived from the results of the previous research [21] and were subsequently used to calculate the impact of the average occurrence in freight transport, which was then related to the transport performance in freight transport (see Table 5).

The unit rates of impact on health and train delay both for passenger and freight transport were taken from material [22].

4. Results

The calculation of unit costs related to traffic accidents on the railway network was performed using the equations (3.1)–(3.4). The input quantities for the calculations were taken from the Database of Occurrences [19] and the results of previous research [22], which were based on statistical documents of the Railway Administration of the Czech Republic and Czech Railways [21] and the Departmental Methodology of the Ministry of Transport of the Czech Republic [2]. The calculation was carried out separately for passenger transport and freight transport. An overview of the input quantities for the calculation derived from the Database of Occurrences [19] can be seen in Table 6.

Table 6. Overview of input quantities for the calculation derived from the Database of Occurrences [19]

Input quantity (For an average occurrence)	Value for passenger transport	Value for freight transport
Average number of fatalities (person)	0.047	0.013
Average number of serious injuries (person)	0.097	0.034
Average number of minor injuries (person)	0.198	0.043
Material loss (CZK)	294,235	261,651
Average delay of passenger trains (min)	133.1	53.7
Average delay of freight trains (min)	20.3	66.3

1 € = 25.545 CZK

An overview of input quantities derived from statistical data of the Railway Administration of the Czech Republic and Czech Railways [20] or taken from the Departmental Methodology of the Ministry of Transport of the Czech Republic [2] are given in Table 7.

Information on health effects is taken from the Departmental Guideline ([2], p. 127) and also listed in Table 1 of this contribution at the price level of 2021. Further information

Table 7. Overview of input quantities derived from the statistical data [20] and Departmental Guideline [2]

Input quantity (Per purpose unit)	Passenger transport	Freight transport
Unit impact on health – fatalities (CZK/person)	24,736,284	24,736,284
Unit impact on health – serious injuries (CZK/person)	5,989,060	5,989,060
Unit impact on health – minor injuries (CZK/person)	773,143	773,143
Passenger (Freight) train utilization (person(t)/train)	64.64	400.54
Unit impact of passenger (freight) train delay (CZK/hour·person(t))	324.82	40.77

1 € = 25.545 CZK

concerning the train utilization and unit impact of delay has been taken from previous parts of the research [21, 22].

An overview of partial results of calculations carried out using equations (3.1)–(3.4) is given in Table 8.

Table 8. Overview of the average impacts of an occurrence for passenger and freight transport

Impact (Per average occurrence)	Passenger transport	Freight transport
Average impact on health – fatalities (CZK/occurrence)	429,197	170,062
Average impact on health – serious injuries (CZK/occurrence)	427,372	129,139
Average impact on health – minor injuries (CZK/occurrence)	112,608	22,953
Average impact on travel delay – passenger transport (CZK/occurrence)	45,935	18,315
Average impact on travel delay – freight transport (CZK/occurrence)	6,441	18,111
Average material loss (CZK/occurrence)	233,193	215,845
Total average impact (CZK/occurrence)	1,254,746	574,425

1 € = 25.545 CZK

Table 8 offers the results of calculations of partial socio-economic impacts related to one occurrence. Input data from Table 6 and Table 7 are used for the calculation, the results are subsequently determined using relations (3.1)–(3.4). The total average impact for passenger and freight transport is determined by the sum of the partial impacts given in Table 8. The partial results shown in Table 8 show that the key socio-economic impacts per occurrence are fatalities and serious injuries in passenger transport and material loss in case of freight transport. Less significant are the effects on train delays, which apply to both passenger

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and freight transport. The average frequency of occurrences could be determined at 0.0515 occurrences per 1,000,000 pkm from the average transport performance of passenger transport, which amounted to 7,939.48 million pkm in the 2009–2018 period and the average number of 409.2 occurrences per year.

A simplified traffic accident cost in passenger rail transport in the amount of CZK 64.67 per 1,000 pkm could be derived from an economic cost of CZK 1,254,746 per one average occurrence.

The average frequency of occurrences could be determined at 0.0218 occurrences per 1,000,000 tkm from the average transport performance of freight transport, which amounted to 146,969 million tkm in the 2009–2018 period and the average number of 320.0 occurrences per year.

A simplified traffic accident cost in freight rail transport in the amount of CZK 12.51 per 1000 tkm could be derived from an economic cost of CZK 574,425 per one average occurrence.

5. Discussion

As can be seen from the results of the presented research, for the passenger rail transport, the accident costs derived from the real data by the Czech Railways was set at CZK 64.67 per 1,000 pkm, which is 2.86 times higher than the original value stated in the Departmental Methodology and based on the EU average values (CZK 22.6 per 1,000 pkm).

A similar result can be seen for the freight rail transport. For the freight rail transport, the accident costs derived from the real data by the Czech Railways were set at CZK 12.51 per 1,000 tkm, which is 1.76 times higher than the original value stated in the Departmental Methodology and based on the EU average values (7.1 CZK per 1,000 tkm). The methodological part of the article states a research question in the following wording: "Do the average values of unit external accident costs on the railway network stated in the Departmental Methodology correspond to the real conditions on the Czech railways?"

The research question was answered using the calculations and achieved results presented above and the answer to the research question is negative. The original values taken over from the European documents are significantly lower than the values corresponding to the real conditions in the Czech railway network which leads to the suggestions given in the Conclusions chapter.

6. Conclusions

The presented article focuses on the review and subsequent update of selected input quantities for the socio-economic analysis of the projects of transport, especially railway infrastructure. Specifically, the authors address the costs associated with traffic accidents on the railway network, which are stated in the methodological documents in a simplified form in monetary units related to passenger-kilometres for passenger transport or in monetary units related to tonne-kilometres for freight transport. The original values of the monitored costs are based on the documents, stated on the data from the entire European Union and yet form part of the national methodological documents. The research activities carried out by the authors of this article address in detail the issue of socio-economic impacts of the emergence of occurrences on the railway network in the Czech Republic, the results of this research were used to update the input data to the conditions of the Czech rail transport. The updated values are different from the values originally stated in the methodological materials. As can be seen both from the Results and Discussion chapters of this article, the values of accident costs related to the purpose unit (passenger-kilometres for the passenger transport, tonne-kilometres for the freight transport) determined by the author team are significantly higher than the values taken from European statistics and national methodology. This fact can significantly affect the economic assessment of railway infrastructure projects. Following the results presented in this article, the authors suggest updating the input values for determining the accident costs stated in the Departmental Methodology by the values determined by the research described in this article. The reason is to respect the national conditions in rail transport in the Czech Republic more realistically.

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