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Optimization of empirical models of transport planning in railway transport

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Abstract: This paper is focused on analysis of the empirical models of transport planning in railway transport. At first are described general information and basic principles about known models. In the second chapter are mentioned current empirical models used in railways transport. There are explained methods of calculations for Nyvig and Lill´s gravitational model at all and introduced comparison of optimal values with actual values at chosen transport routes according to Lill´s model. The third chapter includes proposal of the extension the current Lill´s model including the practical application at the concrete chosen transport route.

Keywords: Empirical models, Railway transport, Transport routes

JEL L92

1. Introduction

Empirical models and methods are generally used in activities that show certain facts and produce specific results. Empirical methods of exploration occur mainly in the natural sciences. They are based on conceptual thinking and system approach. In the first phase, they are engaged in gathering materials, constantly observing and investigating different processes. Subsequently, the measurement phase consists of a phase of counting and scaling, and finally, the experimental phase in which the process under investigation is carried out in its basic conditions and at the same time is isolated from other unimportant circumstances. Within the experiment, the process is changed based on the measurements, surveyed conditions and other selected criteria. [8]

However, empirical methods should help to generalize these specific results and offer a general solution to the problem, from practical knowledge to theoretical formulation. The main instrument used in the transition to general theoretical knowledge is induction. It is a basic cognitive process, a scientific method that uses the basic forms of the connection of thoughts, when judging from special points of view to general conclusions. [9]

2. Empirical models in railway transport conditions

In the field of railway transport, the various parameters and indicators of the transport process are the specific starting points. The most important and at the same time exactly defined and unchanging parameters are the geographical origins, which mean, in particular, the location of the individual geographic centres and the distance between them. Another important parameter is the demographic characteristics of selected settlements, which mainly include the number of inhabitants and their composition according to various criteria. These demographic bases may be changed partially. However, from the point of view of the transport and transport process, it is necessary to monitor and to analyse the characteristics of the transport infrastructure that connects certain geographic centres with a certain demographic structure. From the characteristics, quality and capacity of the transport infrastructure, further quantitative and qualitative indicators depend on the quality of the transport service of the selected area. In particular, the number of connections to specific transport sessions, the average time of achievement, the average speed of achievement, the time duration of individual connections, the average wait time, these indicators may vary, in particular, depending on the possibilities of implementing measures to increase the permeability of the line sections concerned. A very important indicator is also the availability of individual railway stations and stops and their distance from the centre of individual settlements. [4,7]

The interdependence and synergy effect of the above mentioned quality indicators significantly affects the passenger traffic flows. In the case of optimal values of these indicators, considerably more currents can be considered than if the values of the indicators are less favourable and attractive for the passenger. In practice, this means that the most significant passenger traffic flows can be expected on such stretches of land, where there are seats with a larger number of inhabitants, they are not very distant, they are connected with a high-quality railway infrastructure with the highest degree of permeability and the availability of their stations and stops is most preferred. [2]

In the application to the ŽSR infrastructure according to the above criteria, the highest transport flows are indicated on Bratislava – Trnava route, respectively, long distance route Bratislava - Žilina, Banská Bystrica - Zvolen and Košice - Prešov. On the contrary, the lowest transport flows show certain transport routes on the lines Brezno - Tisovec, Šahy - Čata, Úľany nad Žitavou - Zlaté Moravce. [5]

3. Current empirical models

The mentioned indicators could also serve as the basic criteria for assessing demand for rail transport. In addition to these indicators, other factors, which can not be applied exactly or mathematically, are also included in the issue. They can be included, for example, tourism options, and various others, in particular, subjective passenger themes that affect overall demand. Also, this demand for transportation can be affected by various other stochastic elements. Therefore, it is not easy to accurately determine the amount of traffic streams between two transport points over a certain period of time, in particular because it is difficult to carry out a direct survey of transport demand. Difficult and at the same time very important task is also to determine the direct impact of each mode of transport on total passenger transport performance. For these reasons, empirical models are used in transport planning to help define more accurately and more effectively the potential traffic flows of passengers. The most important empirical models used in transport include the Nyvig and Lill´s gravity model. [3]

3.1. Nyvig model

The Nyvig gravity model serves in particular to determine the portions of the transport of the different modes of transport to a particular area under investigation. The most important criteria for assessing each type of transport are the cost of transport, the transport time and the number of connections for this model. Based on these indicators, the weight of the relevant transport department is then calculated. The Nyvig model is expressed as follows:

$$w_i = \frac{1}{C_i} * \frac{1}{D_i} * S_i * K \qquad (1)$$

and for each i-th Transport mode:
wi - the weight of the relevant transport department,
Ci - transport cost,
Di – transport duration,
Si - frequency of connections,
K - coefficient (the same for all transport departments),
and for all transport departments:

$$\sum_i w_i = 100\% \qquad (2)$$

3.2. Lill´s gravity model

The Lill´s gravity model serves to determine the optimum number of return journeys of all types of public passenger transport between the two selected traffic points. Consider the number of inhabitants of these transport points and the distance between them. The calculated optimal number is directly proportional to the number of inhabitants of both transport points, the K coefficient and the inversely proportional distance of these traffic points. The model has the following formula, the result is always rounded up: [3]

$$j_{1,2} = \frac{A_1 * A_2}{d^n} * K \qquad (3)$$

where:

$j_{1,2}$ - the optimal number of journeys (connections) between selected traffic points over a certain period of time

$A_{1,2}$ – population number (current, in thousands) of selected toll stations representing traffic points

d – distance between transport points [km]

K – coefficient (depends on the character and boundaries of selected areas)

n – the magnitude approaching 2

3.3. Calculation the optimal number of connections on selected transport rotes according to Lille´s gravity model

In practice on ŽSR rail network, however, the use of the gravitational model is not simple and can not be applied to all sessions. This coefficient results in the complexity of the K coefficient, which in most cases takes up around 150, but in the case of two places with a high number of inhabitants and a short distance between them, this coefficient can be significantly reduced. [1]

Using the Lill´s gravity model according to formula (3), the following transport routes are tested:

a) Sabinov – Žilina:

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$$j_{1,2} = \frac{12{,}413 * 83{,}651}{264^2} * 150 = 2{,}23$$

b) Vráble – Zvolen os. st.

$$j_{1,2} = \frac{8{,}843 * 41{,}855}{145^2} * 150 = 2{,}64$$

c) Bratislava hl. st. – Senica

$$j_{1,2} = \frac{419{,}68 * 20{,}352}{89^2} * 150 = 161{,}747$$

d) Humenné - Košice

$$j_{1,2} = \frac{33{,}058 * 239{,}68}{97^2} * 150 = 126{,}32$$

e) Leopoldov – Trnava

$$j_{1,2} = \frac{4{,}143 * 64{,}439}{17^2} * 150 = 138{,}5$$

f) Rimavská Sobota – Medzilaborce

$$j_{1,2} = \frac{24{,}268 * 6{,}703}{284^2} * 150 = 0{,}303$$

The calculated values represent the optimal number of all public passenger transport connections on the given routes. The comparison of the optimal values with the actual ones for these routes is given in Table 1. There are explained particular columns.

1 - Transport route
2 - Population of the 1st transport point
3 - Population of the 2^{nd} transport point
4 – Distance (km)
5 - Optimal value by the model.
6 - Actual value in GVD 2016/2017

Table 1. The comparison of the optimal values with real values for chosen routes

1	2	3	4	5	6
Sabinov - Žilina	12 413	83 651	264 km	3	26
Vráble - Zvolen os. st.	8 843	41 855	145 km	3	6
Brat. hl. st. - Senica	419 680	20 352	89 km	162	26
Humenné - Košice	33 058	239 680	97 km	127	36
Leopoldov - Trnava	4 143	64 439	17 km	139	78
Rim. Sobota - Medzilaborce	24 268	6 703	284 km	1	8

These calculations show that optimal values are mostly different from actual values. Ideally, it would be if the optimal value of the model were about twice as high as the actual values given in time-bale on ŽSR network, as it would be thought that the remaining number missing from the optimal value by model would be made on a given routes by bus. From these transport routes, the Leopoldov - Trnava transport route is the closest to the ideal state. These calculations have shown that the use of the Lill´s gravity model on the ŽSR network is not very relevant and the calculated indicators do not have the required notice value. This model is more advantageous to use in countries where are more inhabitants, respectively conurbations to optimally determine the number of public passenger transport returns on the given routes. [1]

3. Options to extend the current Lill´s gravity model

Due to the large deviations of the optimal values of the Lill´s gravity model and the real values, this section is briefly designed to modify and extend the current formula for model computing to show more realistic values and could also be an objective quality assessor of transport sessions and connections.

The current formula of the Lill´s gravity model only considers the number of inhabitants of the starting and ending point of transport and their distance, which is not sufficient for the objectivity of the evaluation. In addition, the proposed extended model considers the number of residents at transit points within the given sessions, as well as the distance of the railway stations from the centre of the individual municipalities and places of that session. The transit traffic point means, there is a possibility to get on and get off the trains.

These factors can also significantly affect the number of passengers transferred, and also the number of optimal connections for the given routes. Within this extended model, it will be assumed that the number of inhabitants of each settlement is directly proportional to the number of passengers transported, but the distance between the seats and the availability of the railway stations is indirectly proportional to this number. [6]

This altered model will only consider the optimal number of passenger rail connections in one direction only (for both directions the value will be multiplied by two).

The formula for the proposed extended Lill´s gravity model looks as follows:

$$j_{1,2} = \frac{\frac{A_1 * A_2}{d_1 * d_2 * l_1^2} + \frac{A_2 * A_3}{d_2 * d_3 * l_2^2} + \dots + \frac{A_{n-1} * A_n}{d_{n-1} * d_n * l_{n-1}^2}}{n} * K \qquad (4)$$

where:

j1,2 – the optimal number of rides per selected transport session over a given time period

A1 – population of the starting point (headquarters); current in thousands

A2 – the population of the first transit point (s); current in thousands

An – the number of inhabitants of the destination point (s); current in thousands

d1 – availability of the station (its distance from the centre of the residence) starting point [km]

d2 – availability of the station (its distance from the centre of the residence) of the first transit point [km]

dn - availability of the station (its distance from the centre of the residence) destination point[km]

l_1 – the distance between the starting point and the first transit point [km]

l_2 - the distance between the first and second transit points [km]

l_{n-1} – the distance between the last transit point and the destination traffic point [km]

n – number of transport points (stop) within a transport route, inclusive source and destination

K – modified original coefficient of the gravity model

The formula expresses the dependence of the quantitative quality indicator on the number of passengers transported from the population, the distance and the availability of the stop. It follows from its structure that the number of counts in the main fraction numerator is dependent on the number of train stops (trains) in individual stations and stops within the session. With a higher number of stops, counting over this formula will be relatively laborious, but the results should be more objective.

The adjusted coefficient of this model is determined by expert estimation and, as a general rule, it could acquire values of 5 - 25. Depending on the character, distance, or number of individual locations on the given route. In the case of a greater number of stops and a relatively short distance between each traffic point, this coefficient will acquire lower values, but in the case of a lower number of stops and the longer distance between these points will acquire the higher values.

Just for the workload and complexity of counting, there is only one concrete example of transport route Leopoldov - Trnava. Number of trains stopping at Brestovany transit point is calculated especially, for example these are passenger trains or Regional Express trains. Number of trains not stopping at this stop is calculated especially, too. These are fast train or InterCity trains. The input values will be as follows: [1]

- population of Leopoldov: 4 143
- population of the village of Brestovany: 2 554
- population of the city of Trnava: 64 439
- the transport distance between Leopoldov and Brestovany: 8 km
- the transport distance between Brestovany and Trnava: 9 km
- distance from the railway station to city centre in Leopoldov: 1,1 km
- distance from the railway station to village centre in Brestovany: 0,6 km
- distance from the railway station to city centre in Trnava: 0,7 km

Optimal number of passenger trains:

$$j_{1,2} = \frac{\frac{4{,}143 * 2{,}554}{1{,}1 * 0{,}6 * 8^2} + \frac{2{,}554 * 64{,}439}{0{,}6 * 0{,}7 * 9^2}}{3} * 10 = 16{,}96$$

Optimal number of fast trains:

$$j_{1,2} = \frac{\frac{4{,}143 * 64{,}439}{1{,}1 * 0{,}7 * 17^2}}{2} * 20 = 11{,}997$$

At the Leopoldov – Trnava transport route (only in this direction), it is possible to consider 17 personal trains and 12 fast trains.

5. Conclusions

Adduced article offered an analysis of current empirical models that are used in railway transport. Subsequently, a suggestion was created a proposal how to expand the Lill's gravity and to reflect multiple variables and offered a more accurate reflection at the quality of transport routes compared to the current state. Based on the above-mentioned more objective assessment, it would also be possible to estimate more accurately the passenger traffic flows, define bottlenecks of selected transport routes.

Consequently, the new calculated values could form a concrete practical basis for the experiment phase in empirical methods. The results obtained will be generalized and a new theoretical basis will be created for new and efficient ways of optimizing the transport service and the transport process. This process could theoretically be repeated several times, and there would still be opportunities for improvement, and empirical models in transport planning would serve as a tool for constantly improving the transport serviceability of the area. [3]

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Determination of probability distribution of customer input at post office

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Abstract If we want to analyze a real system with a large number of input data, it is very convenient to determine a probability distribution that best fits to given input data. There are many statistical methods to determine the correct probability distribution and one of them is Chi-Square Goodness of Fit Test. This statistical test can be also used to find out a probability distribution of time intervals between arrivals of customers at post office. Intervals between arrivals of customers occur in continuous time and therefore we consider continuous probable distributions.

Keywords probability distribution, customer input, Chi-Square Goodness of Fit Test

JEL L87, L97

1. Introduction

In real systems such as queuing systems at post offices are based on random events. A system is a set of elements that are arranged in a certain way. Models of systems that are affected by random events show random variables of different form. The result of random event is a random variable [10, 12]. These random variables acquire different values and according to the type of these values we divide random variables to discrete and continuous random variables. Discrete random variables are usually integer values. Continuous random variables are values from closed or non-closed interval.

When we examine a particular system, we work with a number of data that represent the values of a random variable. In this case, it is advantageous to determine laws of probability that are attached to the given data. One of them is a probability distribution that describes the probability of the random variable in each value. In other words, probability distribution is the probability of occurrence of each outcome and in the context of queuing system at post office the outcome represents the event - the customer's arrival at the post office.

2. Background

The development of probability theory had a significant advance at the beginning of the 18th century with a predominantly normal distribution. The rapid development of probability theory probably began with DeMoivre's Dootrine of Chances (1713) and continued with Laplace´s and Gauss´s studies at the beginning of the 19th century and even more increased the dominance of normal distribution in statistics. The development of the exponential distribution came later. In 1931 T. Kondo in devoted his article in Biometrika to exponential distribution and Pearson's type X curve. In 1937 Sukhatme for the first time mentioned the idea that exponential distribution may be an alternative to normal distribution in the cases where the form of variation in the population is known and is not normal. In the 19th century Rényi, Epstein and Sobel made a significant contribution to the development of the exponential distribution. Also, very important was the paper by W. Weibull in 1951 in which he examined the expansion of the exponential distribution which now has his name. The first characterization of the exponential distribution was elaborated by Ghurey (1960) and Teicher (1961) which modified the characterization of normal distribution to the exponential distribution. In the main studies of exponential distribution began in the later years when the bases of statistics were basically built. [7]

In 1900, Pearson introduced Chi-Square Goodness of Fit Test that is universally applicable to determine the probability distribution of a given random variable. Pearson found that for a certain amount of data is a distribution approximately chi square with k -1 degrees of freedom. [3] The point of the test that number of classes are fixed, and test is asymptotically chi-square distributed. [2]

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3. Continuous distribution

With respect to this kind of system, which is based on events over time, we consider continuous distributions. A continuous random variable is a random variable with a set of possible values that is infinite and uncountable.

3.1. Uniform distribution

Uniform distribution is defined by two parameters, a is the minimum and b is the maximum. The probability density of the uniform distribution from the interval (a, b) is: [1] [4]

$$f(x) = \frac{1}{b-a}, \qquad x \in (a,b) \tag{1}$$

$$= 0, \qquad \text{otherwise} \tag{2}$$

Uniform distribution R (a,b) has distribution function:

$$F(x)\begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & x \ge b \end{cases} \tag{3}$$

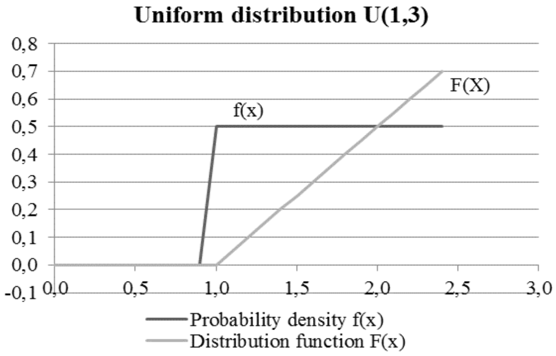

Figure 1. Continuous uniform distribution

3.2. Normal distribution

Regarding to normal distribution random errors are often mentioned as measurement errors caused by a large number of unknown and mutually independent causes. Probability density of normal distribution is given by the following formula: [1] [3]

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp - \frac{(x-\mu)^2}{2\sigma^2}, \qquad \begin{matrix} -\infty < x < \infty, \\ -\infty < \mu < \infty, \\ \sigma > 0 \end{matrix} \tag{4}$$

Normal distribution N (μ,σ) has distribution function:

$$F(X) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{x} \exp\left[-\frac{(t-\mu)^2}{2\sigma^2}\right] dt, \qquad -\infty < x < \infty \tag{5}$$

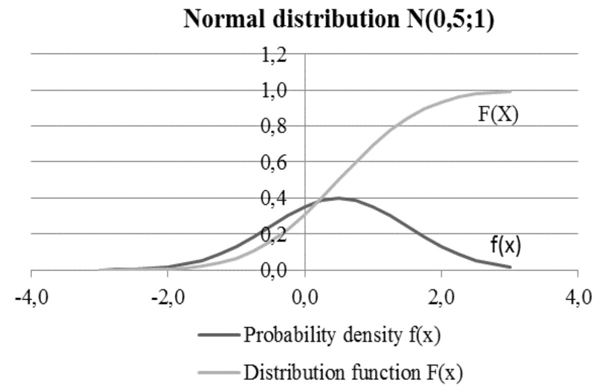

Figure 2. Continuous normal distribution

3.3. Exponential distribution

Exponential distribution reflects the time between randomly occurring events. Probability density of exponential distribution is given by the following formula: [1] [4]

$$f(x) = \lambda e^{-\lambda x}, \qquad x > 0 \tag{6}$$

$$= 0, \qquad x \le 0 \tag{7}$$

Distribution function of exponential distribution Exp (λ) is following:

$$F(x) = \begin{cases} 1 - e^{-\lambda x}, & x \ge 0 \\ 0, & x < 0 \end{cases} \tag{8}$$

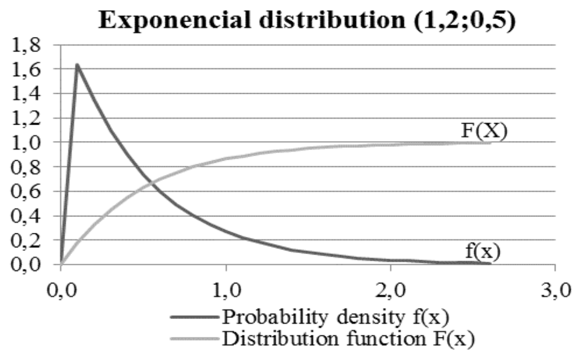

Figure 1. Continuous exponential distribution

3.4. Gama distribution

Probability density of exponential distribution is given by the following formula: [1] [4]

$$f(x) = \frac{1}{\Gamma(\alpha)\beta^{\alpha}} x^{\alpha-1} \exp\left(-\frac{x}{\beta}\right), \qquad x > 0 \tag{9}$$

$$= 0, \qquad x \le 0 \tag{10}$$

While for parameters α and β apply α > 0, β > 0. If the parameter α natural number than gama distribution is called Erlang distribution. The distribution function of the gamma distribution does not exist.

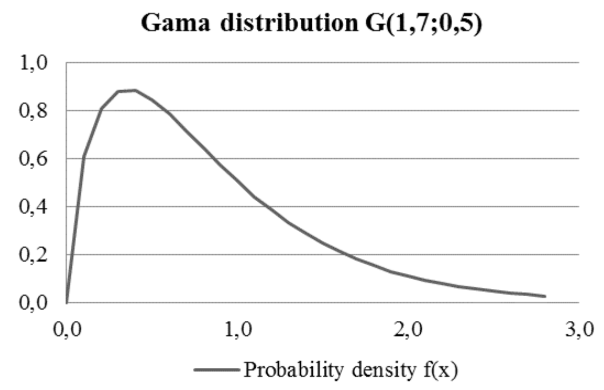

Figure 4. Continuous gama distribution

Working with data in this way is efficient if we want to perform the simulations where we generate data from a given probability distribution. There is a lot of different algorithms for this generation of random values. Using those algorithms, it is possible to transform random variables of uniform distribution from the interval (0,1) into the appropriate distribution.

It is essential to realize that random values are independent values of the uniform distribution from the interval (0,1). There are many mathematical generic formulas that can be used to analyse a particular system. Queuing theory is one of many mathematical sciences that offer such mathematical formulas where using it means obtaining results analytically by fitting specific parameters into the given formulas. If we decide to analyse queuing system this way, it is necessary to select the correct model, model that is the closest to the real model. The individual models offered by the queuing theory are characterized by the basic parameters. To specify the mathematical model of queuing system, it is necessary to specify: [10]

- customer input
- network of service lines,
- average service time,
- rules of entering and exiting into the system,
- other specific elements of the system.

The arrival of customers (customer input) is a stochastic process which probability distribution reflects the length of time intervals between customer arrivals. Customer input, which meets three properties:

- stationarity,
- unconsciousness,
- regularity,

we call the elementary flow. The flow is stationary if the probability of the arrival of the customer does not depend on the particular time placed on the numerical axis. The property unconsciousness is fulfilled if the events occur independently or respectively. It means that customer enters the service system independently of other customers. The regularity of customer input is based on principle there are not two events happening at the same time, we always find a small-time interval in which only one customer enters the system.

4. Objective and methodology

The objective of this paper is to determine the probability distribution of measured data. The probability distribution was determined to examine the random variable that is in our case the customer's arrival at the post office. Intensity of customer arrivals is one the parameter of queuing system at post office. In the order determine the probability distribution of variable and to create model we used Chi-Square Goodness of Fit Test as a tool of inductive statistics. This method allows us to determine the probability distribution that fits, and work predict further behaviour of system.

To determine the quantitative side of the system we used the empirical method such a measurement. The object of the measurements were time intervals between the arrivals of the customers at the Bytča Post office and the measurement was done using timers directly at Bytča Post Office during different part of opening hours of the post office. The basic statistical set is potentially infinite. The required standard deviation is ± 0,05 and the required confidence level is 95%. For the calculation of the sample, we used a relationship for calculating the minimum sample:

$$\sigma = \sqrt{p \cdot (1 - p)} \tag{11}$$

$$\sigma = \sqrt{0,5 \cdot (1 - 0,5)}$$

$$n \geq \frac{t^2_{1-\frac{\alpha}{2}} \cdot \sigma}{\Delta^2} \tag{12}$$

$$n \geq \frac{3,84 \cdot 0,25}{0,0025}$$

$$n \geq 384$$

where $t_{1-\alpha/2}$ is the critical value determined from the tables, σ is variance calculated from the standard deviation, p is variability of the base file and Δ is maximum allowable error range.

The measured values are divided into intervals. To determine the number of intervals and their length, we used the formulas from statistics. Determining the number of classes:

$$k = 1 + 3,3 \log n = 1 + 3,3 \log 384 = 10 .$$

Calculate the interval length:

$$h = \frac{x_{\max} - x_{\min}}{k} = \frac{4,6 - 0,1}{10} = 0,5 \min .$$

For graphical representation of the measured data, we used column graph. We also used the indicative statistics tool. Inductive statistics are concerned with statistical hypothesis testing. Testing is based on verifying the null hypotheses versus alternative hypothesis. Chi-Square Goodness of Fit Test is appropriate for determination of probability distribution. We used this test to verify the correspondence of measured data with exponential distribution.

5. Results

Since the customer´s requests handling system of post office mirror a queuing system with two basic input

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parameters the average interval between customer arrivals λ and the average service time *1/μ*, it was necessary to obtain customer input data. Intervals between customer arrivals at post office are defined in continuous time. Customer arrival process represents stochastic process, meaning that each customer's arrival is random, and no rule is attached to it. In the order to examine the properties of the system at post Office in Bytča we made 7 measurements of customer input. After that, we divided the measured data into interval classes as you can see in the table below. [8]

Table 1. Measured data divided to time intervals

Class *i*	Class interval	Central of interval	Absolute frequency	Relative frequency in %	Cumulative absolute frequency	Cumulative relative frequency in %
1	(0;0,5>	0,25	1100	49	1100	49
2	(0,5;1>	0,75	558	25	1658	74
3	(1;1,5>	1,25	267	12	1925	86
4	(1,5;2>	1,75	134	6	2059	92
5	(2;2,5>	2,25	87	4	2146	96
6	(2,5;3>	2,75	44	2	2190	98
7	(3;3,5>	3,25	26	1	2216	99
8	(3,5;∞>	3,75	12	1	2228	100

In order to create a system model approaching the real system, it is necessary to find out what probability distribution belongs to the measured data. There are many ways and tests for verifying the probability distribution applied in practice. We chose Chi-Square Goodness of Fit Test that verifies if empirical distribution is statistically identical to any of the theoretical probability distribution and this test is generally applicable to discrete and continuous distributions with a sufficient amount of data. In order to determine what probability distribution is could be considered we plotted the measured data into a graph. [8]

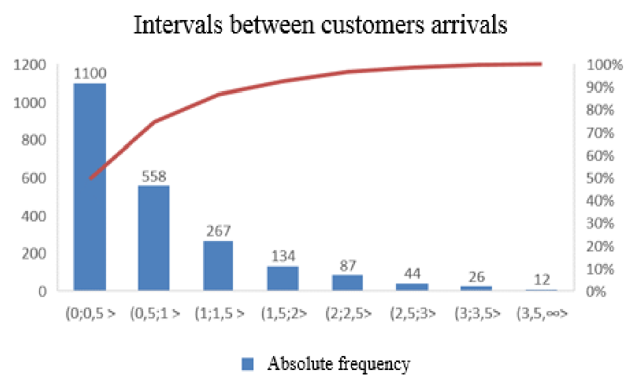

Figure 5. Intervals between customers arrivals

Figure 5. showed us that it could be potentially an exponential or Erlang distribution. Intervals between customer arrivals generally behave according exponential distribution in systems similar queuing system at Post Office [11]. To prove or disprove hypotheses about exponential distribution we decided to verify if measured data fits to exponential distribution: [5] [6]

- Null hypothesis H_0 = Intervals between arrival of customer is modeled by exponential distribution.
- Alternative hypothesis H_1 = Intervals between arrival of customer is not modeled by exponential distribution.

Level of significance reflect probability that we reject the true hypothesis. In general, this probability must be low and therefore we have chosen α = 0,05.

A goal of the Chi-Square Goodness of Fit Test is to compare the calculated test criterion with the critical value that can be found in the table Chi-Square distribution. Calculation of the test criterion is given by the mathematical relationship:

$$T = \sum_{i=1}^{k} \frac{(x_i - np_i)^2}{np_i} \tag{13}$$

where p_i represents the probabilities of individual class intervals. Those probabilities can be calculated using the following formula:

$$p_i = F(b_i) - F(a_i) \tag{14}$$

$$p_i = 1 - e^{-\lambda b_i} - \left(1 - e^{\lambda a_i}\right) \tag{15}$$

where α and β are class interval boundaries, and parameter λ is $1/\bar{x}$ average customer flow. In the table below, we can see probability classes with test criteria values for each class interval. There is also probability condition says that probability of class can not be small than value *5/n* otherwise we have to merge interval classes until condition is not respected. For this testing the condition is following:

$$p_i = \frac{5}{n} = \frac{5}{2228} = 0{,}0022 \tag{17}$$

Table 2. Calculation of test criteria

Class *i*	(a_i,b_i>	x_i	n_i	x_i*n_i	p_i	T_i
1	(0;0,5>	0,25	1100	275	0,4791	0,9915
2	(0,5;1>	0,75	558	418,5	0,2496	0,007
3	(1;1,5>	1,25	267	333,75	0,1300	1,7678
4	(1,5;2>	1,75	134	234,5	0,0677	1,8848
5	(2;2,5>	2,25	87	195,75	0,0353	0,9017
6	(2,5;3>	2,75	44	121	0,0184	0,2299
7	(3;3,5>	3,25	26	84,5	0,0096	1,0268
8	(3,5,∞>	3,75	12	45	0,0104	5,3922
Σ	-	-	**2228**	**1708**	**1**	**12,2017**

After calculating the test criterion, we found the critical value χ^2-distribution of the distribution corresponding to the chosen significance level and the degree of freedom f:

$$\chi^2_{0,05}(8-1-1) = \chi^2_{0,05}(6) = 12{,}5916 \ .$$

If the test criterion value is < critical value, we do not reject the null hypothesis:

$$T < \chi^2_{0,05} \tag{18}$$

$$12{,}2017 < 12{,}5916$$

This inequality is true, meaning that we accept a null hypothesis - the intensity of the customer input at post office in Bytča corresponds to the exponential distribution.

6. Conclusions

Determining a probability distribution of measured data allows deeper analysis of data and to use the mathematical relationships that relate to particular probability distribution. If it´s known the probable distribution of data, it is also possible to simulate the data and predict its evolution based on the characteristics of the theoretical probability distribution. Probability distributions also play a very important role in generating random numbers in simulation models built on algorithms. Simulation models have a wide range of uses in many areas also in postal processes. The determination of exponential distribution that fits to time intervals between customer arrivals at Post Office Bytča can be useful in building a simulation model of queuing system of Post Office Bytča. In this research we were also able to calculate the average customer input, which is one of the basic parameters of queuing system.

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Changes in night-time distribution of goods to the city centres as a tool to meet the requirements of the EU white paper on transport

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Abstract The report focuses on assessing the advantages and disadvantages of night distribution in selected European cities. The first chapter is focused on projects focused on night distribution of goods in the city centre. The second chapter deals with a more detailed analyses of night distribution in some countries of the European Union. It shows concrete example, a solution for night distribution, which can be applied to our Slovak cities. Even in Slovakia, it has to deal with the issue in view of the constantly increase the number and the duration of traffic accidents not only in Bratislava, but also in all regional cities.

Keywords logistics, distribution, city centre

JEL R 41, R42

1. Introduction

In today's modern times, the logistics of supplying cities is becoming more and more important. This importance of logistics is growing steadily. Creating various specific transport service requirements in densely populated areas, in cities and large agglomerations. The term "urban logistics" has emerged that solves the flows of goods, generally with regard to the territory of the city centre. Some European countries have endeavoured to eliminate the negative impacts of supply on the environment, residents in urban agglomerations, but also to reduce the number of vehicles and to create a transport system. [1]. EU transport policy objectives in the field of urban logistics are very ambitious "Reduce the use of" conventionally driven "vehicles in urban transport by mid-2030 by phasing them out of urban traffic by 2050, to achieve the introduction of urban logistics in the centres of major cities, of CO2 emissions by 2030. [9], [10] Urban logistics in the field of freight transport must also contribute to this objective, in addition to exhaust emissions in the field of night traffic in particular, it is an important aspect of traffic noise. EU Member States have

addressed or addressed a number of research projects that have been analysed in the following chapters.

2. Projects relating to night distribution of goods

2.1. NICHES Project

The aim of the NICHES project was to support at a high level the development and deployment of innovative and policy-based urban transport policies that will contribute to the development of sustainable urban transport systems. This project was expected to make a significant contribution to a more efficient and competitive transport system, a healthier environment and improved quality of life in urban areas.

Night Delivery is the delivery to retailers and shops in the inner city area during the night hours when the city is usually quiet and inactive. Typical times are between 10.00 p.m. and 7.00 a.m. In several cities such as Barcelona or Dublin, successful experiences with trials on night delivery are made replacing a (higher) number of vehicles operating during day time by a (fewer) number of vehicles operating during night time.

The Concept Inner-city Night Delivery addresses the following aspects:

- the delivery during night time with specially equipped low noise vehicles (low noise equipment, CNG etc.);
- allowance for larger trucks to enter the city centre which are restricted during the day time.

Key benefits:

- reduces delays for the logistics service providers by using the free road capacities at night;
- reduces emissions and energy consumption (less congestion during night time, direct access to the shops);
- enhances road safety.

2.2. PIEK Project, The Netherlands

The aim of the PIEK program is to reduce noise levels in the evening and night, of supply traffic, loading and unloading activities in residential areas. At the end of 1998 the renewed "Decree Retail Trade Environmental Protection" came into effect. This Dutch decree sets down that the noise emission level must remain within noise emission standards set. It stipulates that the noise emission generated when loading and unloading goods, in particular from trucks, between 19.00 and 7.00 hours must comply with strict peak noise standards:

- 19.00 – 23.00 hours 65 dB and
- 23.00 – 7.00 hours 60 dB.

Research has shown that many loading and unloading actions exceed the 60 and 65 dB noise standards.

The Ministry of Housing, Spatial Planning and Environment, the Ministry for Economic Affairs and the Ministry for Transport, Public Works and Water Management introduced a long-term PIEK (peak noise) program in 1999 in order to bring about the necessary technical adjustments, by tackling the source, to the means of transport, the materials used when loading and unloading goods and the loading/unloading locations.

The long-term PIEK project includes, for example measures:

- transfer of knowledge to the companies involved on a general level;
- stimulate quiet behaviour;
- create the optimal loading and unloading bay;
- low noise trucks (up to 7,5 tons);
- low noise trucks (over 7,5 tons);
- low noise transport refrigeration system;
- low noise take along forklift truck;
- reduce noise of roll containers, pallet-trucks and hand pallet-trucks;
- quiet shopping trolleys;
- electric drive or electric hybrid drive.

Key aspects an important issue during operation of night delivery is that the residents can complain about noise directly to the service centres. A permanent monitoring of the noise levels should guarantee that the noise levels do not increase by the used transport vehicles and drivers.

2.3. CIVITAS Project

CIVITAS is a network of cities for cities dedicated to cleaner, better transport in Europe and beyond. Since it was launched by the European Commission in 2002, the CIVITAS Initiative has tested and implemented over 800 measures and urban transport solutions as part of demonstration projects in more than 80 Living Lab cities Europe-wide. The knowledge garnered through these practical experiences is complemented, and supported, by a number of research and innovation projects (ECCENTRIC, PORTIS and DESTINATIONS), also run under CIVITAS. These research projects look at ways of building a more resource efficient and competitive transport system in Europe.

The project works on 10 thematic areas, related to sustainable transport mobility covering: Car-Independent Lifestyles, Clean Fuels & Vehicles, Collective Passenger Transport, Demand Management Strategies, Integrated Planning, Mobility Management, Public Involvement, Safety & Security, Transport Telematics, Urban Freight Logistics.

2.4. C-LIEGE Project

C-LIEGE is the showcase for good practices and a helpful hand for all European cities striving for cleaner and sustainable urban transportation. On the basis of good practices the project will define an integrated framework for energy efficient Urban Freight Transport (UFT) management and planning. A novel set of integrated solutions and "push-and-pull" demand-oriented measures will be tested and shared in roadmaps for the implementation in European cities. Seven pilot experiments in six European countries ensure the applicability of the C-LIEGE approach: Bulgaria, Italy, Poland, United Kingdom, Germany and Malta.

C-LIEGE empowers a cooperative approach between public and private stakeholders that is targeted on the reduction of energetic and environmental impacts of freight transport in European cities and regions. In order to reach this objective, C-LIEGE will promote cleaner and energy efficient freight movements in urban areas. The aim of the program integrated urban freight transport – more co-operation and better management for more energy efficiency and less CO2.

3. Analysis Of Night Distribution In Selected States

3.1. Broadening Of Loading And Unloading Times - Amsterdam, The Netherlands

Several districts have set time windows for loading and unloading in order to reduce noise and unsafe situations, and to avoid congestion and to optimize parking spaces. Loading and unloading are permitted during certain periods of the day on one or more parking spaces. At congestion areas, one or more delivery bays are usually available. Outside these times, parking spaces are for cars. At certain locations, deliveries times for loading and unloading at night are not permitted. It is permitted within the boundaries of sound legislation: between 19.00 – 23.00 pm, up to 65dB and between 23.00 – 7.00 pm, up to 60dB. In the city of Amsterdam, delivery is available in pedestrian areas between 7.00 and 11.00 am.

Aim of project:

- to reduce the number of trip km per vehicle in order to promote the consolidation of goods among neighbour cities;
- to create flexible time windows by introducing one hour more in order to reduce kilometres per vehicle and freight traffic. With wider delivery times, the carriers will enable to supply more stores per trip, to plan better delivery routes resulting in fewer vans and Lorries in the city.

Results:

- reduction of kilometres:
  Time windows: -4% kilometres of freight transport
  Consolidation of goods: -5% kilometres of freight transport
- reduction of NO-concetrations:
  Time windows: -0,1μh/m3
  Consolidation of goods: -0,2μg/m3
  LEZ´s: -0,6μg/m3
  Electric freight transport: -0,3μg/m3

3.2. Night And Off-Hours Deliveries- Ile De France

Stakeholders on the project are the city of Paris and carriers´ and shippers ‘associations. To deliver every day more than 700 000 establishments and around 11 millions of people, 1 million of deliveries and removals are done in Ile de France. The city of Paris and the most important carriers ‘and shippers ‘associations signed an urban freight transport charter, in which they committed to certain points, which are favourable to the environment, working conditions and the productivity of urban delivery activities. Paris has banned trucks during day time and on-street delivery areas must be at least 10 meter long, to facilitate truck´s manoeuvres and the handling of goods. Some bus lanes are shared with delivery vehicles. In Paris deliveries in the afternoon are only allowed by commercial vehicles that are electric, gas or that follow Euro norms.

Table 1. Benefits of Night Distribution in the Ile de France; Authors based on [11]

	Current delivery	Night delivery	Gains
Departure time	7:22 hod.	21:23 hod.	
Kilometres	41 km	40,5 km	
Duration	2 hod.3 min.	1 hod.37min.	21%
Fuel consumption	32,4 l/100km	27,5 l/100km	10%
CO_2 emission	1137,2 g/km	938,4 g/km	17 %
NO_x emission	4,9 g/km	3,8 g/km	22 %
PM emission	0,22 g/km	0,17 g/km	25 %

3.3. Night Deliveries In Barcelona

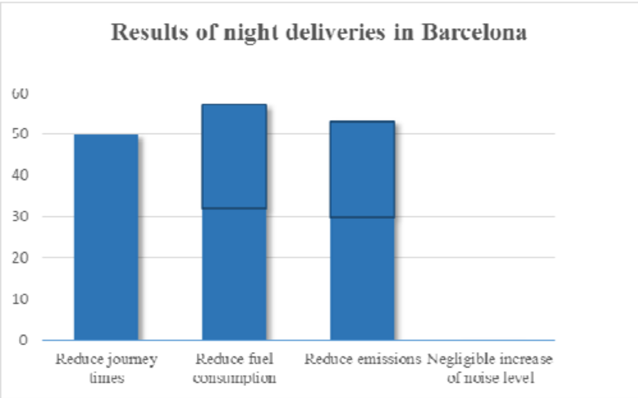
In Spain, all the cities have a provision of load zones and restricted access to zones depending on vehicle weight, normally banning trucks over 3,5t from city centres. There are also strict regulations such as city truck routes. Truck parking is normally limited to a maximum of 30 minutes and only as long as the load/unload operations are being carried out. The freight vehicles are sometimes allowed to use parking places and can be exempted to pay the parking meters. Within Barcelona, a night delivery trial was carried out concentrating the delivery processes between 23.00h and 24.00h in the night and between 5.00h and 6.00h in the morning. 40t trucks were delivering to grocery stores directly during the night instead of going to a regional distribution centre. The equipment used was noise adapted, both for the truck as well as the loading and unloading utilities. As a result, the trial was successful in terms of noise intrusion and from the commercial point of view. About 7 trucks could be replaced during day time allowing 2 large trucks to enter the city during the night time.

The operator Mercadona has demonstrated that quiet delivery is possible with a 30T lorry serving supermarkets with a rather large capacity and with substantial refrigeration facilities. The result is quantified in terms of noise measures compared to ambient noise levels on nights when the delivery was not being made; the average of the minimum values recorded during unloading inside buildings (23.5 dB) was 0.3 dB greater than those recorded before loading started; for maximum values, no difference was recorded for measurements inside buildings (33.4 dB), and the maximum values recorded in the street varied by only 0.1 dB average with unloading of 52.2 dB. It is important to know that in Spain the supermarkets (shop owners) are responsible for the organisation of the goods transports. They even rent trucks and decide directly about the logistics process.

Results:

- reduce journey times: 50%
- reduce fuel consumption: 32%-57%
- reduce emissions: 30%-53%
- more loading capacity
- not possible for small business (staff during night hours),
- Large investments for quiet vehicles and silent loading equipment's,
- Negligible increase of noise level: +0,2dB.

Table 2. Results of night distribution of goods in Barcelona [source: author]



The main arguments in favour of night time delivery from the shop owners' point of view are:

- reduction of cost by use of bigger vehicles during night time (consolidation);
- reduction of cost due to faster driving times during night time (night time driving takes only 1/3 of the time necessary during day time);
- and reduction of complaints from inhabitants.

3.4. Night Deliveries In Stockholm

In Stockholm there are regulations prohibiting deliveries with heavy vehicles in the city centre between 22:00 and 6:00, to avoid night time noise. In 2014 the Stockholm freight plan 2014-2017 an initiative for safe, clean and efficient freight deliveries, was released with goals to improve accessibility and improve efficiency for urban freight transport. One of the activities was to conduct an OPHD pilot giving permissions for night time deliveries to two vehicles during 2015 and 2016. In parallel with the pilot a research project was started to assess the potential efficiency gains from OPHD for the private sector, evaluate the socio-economic benefits for society and the develop low-noise freight distribution solutions.

The evaluation of the pilot study showed that off-peak deliveries in general have better performance regarding driving efficiency, delivery reliability and energy efficiency. The driving speed on the same delivery route in off-peak is approximately 31% higher than in the morning peak using the data from the truck making dedicated deliveries, and the driving speed in the entire urban network in off-peak is 59 % higher than in the afternoon peak based on data from the consolidated deliveries.

However, the sound emitted by the vehicles themselves (especially if noise reduction measures are applied) is less disturbing than the noise accompanying the loading and unloading. It is also important to take into account the basic noise: in zones with busy streets, failure was caused by a negative distribution, but on the other hand a more pronounced impact on the surroundings of small residential areas (4% higher). This suggests that there is no problem in the emergency areas of night-time trucking, while in many streets more measures are needed to reduce the impact of night-time distribution.

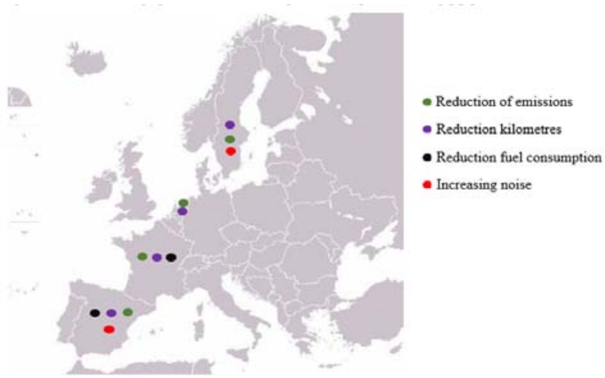


Figure 1. Results of night distribution of goods in selected countries according to analysed projects [source: author]

4. Noise Regulations In The Slovak Republic And Comparison With Selected Countries

At present, the protection of the area against noise in Slovakia is stipulated in the Decree of the Ministry of Health of the SR no. 549/2007 as amended by the Decree of the Ministry of Health of the SR no. 237/2009 Coll., which are the implementing regulations for § 27 of Act No. 355/2007 Coll.

Table 3. Noise level measurement values at night distributions [source: author]

Country	Acceptable sound pressure values for time intervals		Noise level at night distribution
	6:00-22:00	**22:00-6:00**	
Slovakia	60 dB	50 dB	
Spain	65 dB	55 dB	+ 0,2 dB
Sweden	70 dB	55 dB	+ 4%

In tab. No 4, the noise distribution values for night distribution in the selected analysed countries are compared with the values prescribed by the SR legislation. As is evident, the strictest rules are in place in Slovakia. As is true, for example, in shopping centres, in close proximity to residential areas, have control authorities in their competence.

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Measurement of the noise level in Žilina at Škultéty Street, where complaints were made by the inhabitants of the disproportionate increase in freight traffic leading to the industrial part of the town on Kamenná Street. [16]. For example, in the time from 14:00 to 17:00, 128 trucks have crossed this street. The highest measured value was 79.6 dBA at 22:00 and 86.1 dBA between 14:00 and 17:00. (Figure 2).

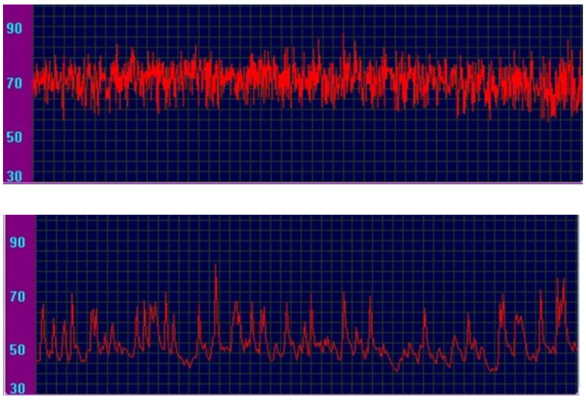

Figure 2. The course of measured noise levels at 14:00 to 17:00 (left) from 22:00. (right); Source: processed by authors [16].

Also, based on the measured data in Žilina, it is clear that we also have problems with freight transport noise in the Slovak Republic and it is therefore necessary to start systems for regulating road freight. In our reviewed street in Žilina, the regulation of road freight has been introduced since 2016.

5. Conclusions

Night distribution has not only an economic, environmental and social benefit that is substantially larger than noise generation through distribution. The night-time distribution system shows that logistics operations can be performed at night or early in the morning without creating a harmful noise problem for the population.

Traffic efficiency has improved from a number of aspects due to night-time distribution of goods in comparison with daily distribution. The truck's idle speed was on average 31% faster than at the time of the morning hours when the traffic is high. Average net network speed is nearly 60% higher than in the afternoon. It is important to keep in mind that in the busy streets the noise that is generated by the distribution is negligible. But on the other hand, the noise had a stronger impact on the surroundings in the quiet residential areas. We recommend that noise measurements be made and that afterwards they are taken.

Night off-peak distribution of goods reduces CO2 emissions but also emissions of other pollutants that pollute the air. Therefore, night distribution of goods can contribute significantly to improving the quality of local air. However, noise abatement measures need to be applied, especially when handling loads and using less noisy Lorries.

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Modelling traffic conditions in the cadaster of Veľká Lomnica

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Abstract This article is focused on the analysis of the current traffic situation in the cadaster of Veľká Lomnica and suggestions for its improvement. The most important intersection of the road I/67 and II/540 is problematic where is also located the railway crossing with a light signalling device. As a basis for the traffic analysis was performed traffic survey at the four positions in the cadastral territory. Its analysis provides information about the current traffic intensity and is also the basis for the simulation of traffic in traffic - planning software AIMSUN. The article contains an evaluation of various proposed solutions on the basis of the results from AIMSUN software and the selection of the appropriate variant.

Keywords intersection, traffic survey, simulation, OmniTRANS

JEL L92

1. Introduction

The aim of this article is the analysis of the current condition of transport in the cadaster of Veľká Lomnica and the proposal of possible solutions for its improvement. Especially, the problematic section in the village is the main traffic flow in the direction of Poprad – Kežmarok and its intersection of the road I/67 and II/540 on which is at the same time located the railway crossing with a light signalling device where collisions and congestions arise during the traffic peak and passing of train.[1]

2. Traffic Analysis of current situation at the intersection of the road I/67 and II/540

The intersection is located in the village of Veľká Lomnica. Road I/67 represents the connection between the Hungary and Poland. Road II/540 begins at the intersection with the road number I/67 in Veľká Lomnica and heads to Tatranská Lomnica, where its end is with junction of the road number II/537. Solved intersection is a unguided level junction. On the Popradská Street, there are two bus stops and a railway station called Studený Potok. [1]

Currently, the bulk of traffic is transit in the direction of Poprad – Kežmarok and in reverse, the most overloaded is road number I/67. Figure 1 represents the intersection scheme (current situation). [1]

Figure 1 Scheme of intersection showing the streets and individual inputs [3]

At the time of traffic peak it leads to formation of congestions, mainly in the direction of Poprad. Vehicles entering the intersection along the road II/540 must stop in front of the railway crossing. Left turning complicates the impaired visibility, which is especially impeded by the crossing house, which is located close to the railway crossing and therefore the vehicles stop either in close proximity to the barrier or even directly on the railroad when they endanger themselves and also operation on the railway track. At the time of the passing train, vehicles turning to the left from the road I/67 from the direction of Poprad must stop at the border crossings and this stops the

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entire traffic flow. To formation of congestions also contributes time, when it is turned on the light signalisation on railway crossings. During the one hour are passing through this zone usually two passenger trains. Light signalisation is turned on during one hour approximately 4 and a half minute. Figure 2 shows the situation on the intersection at the time of afternoon traffic peak. [1]

Figure 2 Situation near the junction during traffic peak [1]

Congestion arises when demand levels approach the capacity of a facility and the time required to use it (travel through it) increases well above the average under low demand conditions. In the case of transport infrastructure the inclusion of an additional vehicle generates supplementary delay to all other users as well, see for example Figure 3. Note that the contribution an additional car makes to the delay of all users is greater at high flows than at low flow levels. [2]

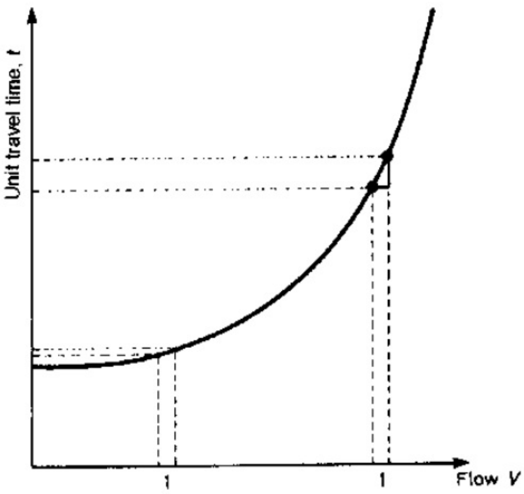


Figure 3 Congestion and its external effects [2]

2.1 Traffic survey in the intersections

Crossroad surveys were performed on Thursday 15th of October 2015 in the time range of 8 hours, from 6 am to 10 am and from 1 pm to 5 pm.

The minimum period for determination the traffic intensity are four hours in the morning and four hours in the afternoon. [3]

We made three crossroad surveys on the intersections of the streets:

- I67 and II/540,
- Popradská and Jilemnického Street,
- Tatranská, Skalnatá and Železničná Street.

The load of individual intersections was processed in traffic – planning software OmniTRAN. The results of traffic surveys at traffic peak hours are shown in Figures 4, 5 and 6.

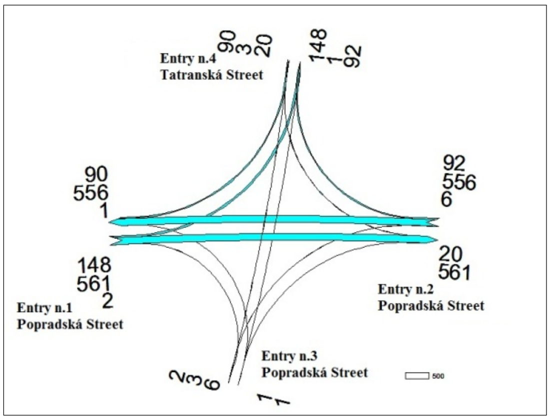


Figure 4 Load cartogram for intersection I/67 – II/540 processed in OmniTRANS software **[1]**

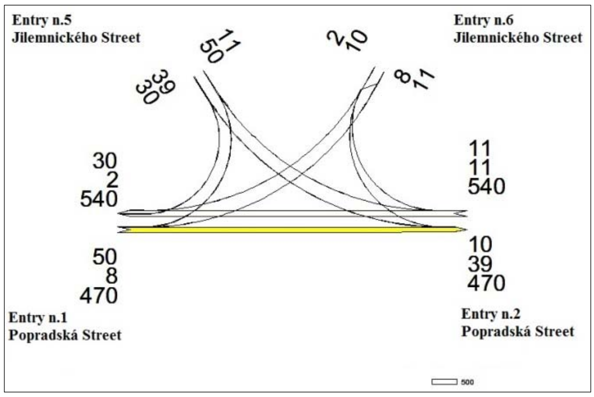


Figure 5 Load cartogram for intersection I/67 – Jilemnického Street processed in OmniTRANS software

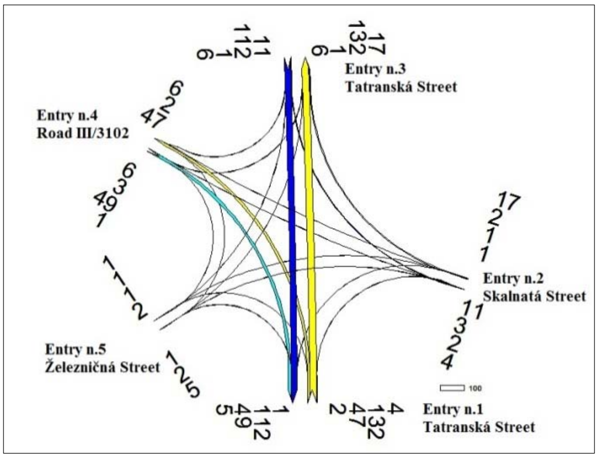


Figure 6 Load cartogram for intersection II/540 – Železničná Street – Skalnatá Street processed in OmniTRANS software

Subsequently we conducted a traffic survey, therefore survey intensity. This was carried out near the gas station, BIO – plus on the road I/67. T here were recorded vehicles passing in the direction from Poprad to the village and in reverse. The intensity survey was carried out simultaneously with other traffic surveys in the cadaster of the village. **[1]**

3. Proposals for improving traffic situation based on simulation

3.1 First draft – Separate left turn lane

First proposal for improving the traffic situation at the intersection of roads I/67 and II/540 consists in the addition of a road lane for the left - hand branch at entry from Poprad, see Figure 7. [1]

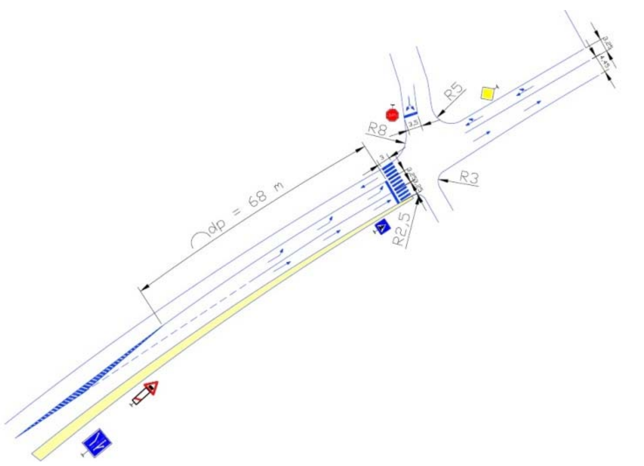


Figure 7 Proposal of traffic organisation at intersection [1]

3.2 Second draft – By-pass road of Veľká Lomnica in direction to High Tatras

After consulting with the Mayor of village about the current traffic problems in the cadaster of the village and on the future perspective, it was decided that a suitable solution for reducing the intensity of vehicles passing through the village was the proposal to bypass the village in the direction to High Tatras. This solution diverts the high intensity of vehicles passing through the village, especially in the winter, when many vehicles are heading to the High Tatras and their aim is the ski resort in Tatranská Lomnica, where the grow in following years is expected.

Proposed by – pass road is shown in Figure 8.

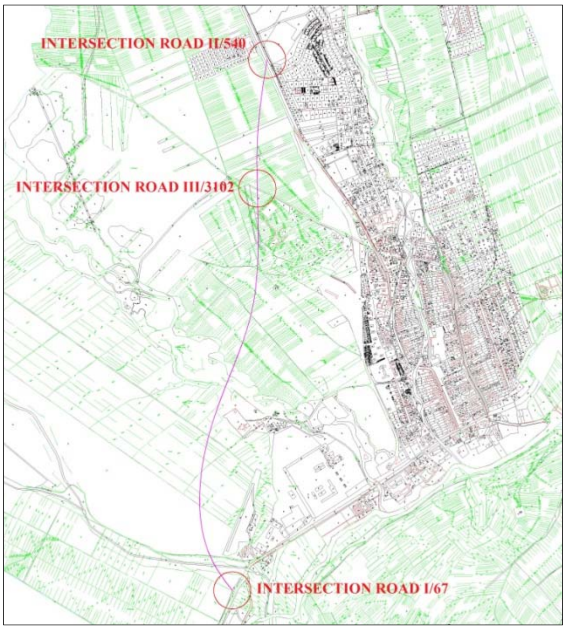
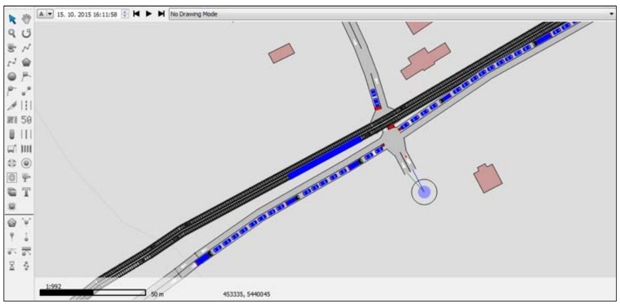


Figure 8 Proposed By-pass road of Veľká Lomnica [1]

3.3 Simulation and evaluation of proposed solutions

In this chapter, we have devoted ourselves to individual



simulations in AIMSUN. For each one proposal, we performed a total of 10 simulations. The tables also show the differences between the individual variables. Consequently, we compared the proposed solutions, especially in terms of simulation results, which should confirm the importance of creating a separate left turn lane at the intersection of roads I/67 and II/540, or the suitability of creating a by - pass road of the village in the direction to High Tatras. In the Figure 9, we can see the situation in the afternoon traffic peak.

Figure 9 View of 2D simulation in AIMSUN software during afternoon traffic peak and passing train **[1]**

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In the first variant, we designed separate lane for the left turn at I/67 and II/540. Table 1 lists the average values of ten simulations.

Table 1 The average values of the simulation in AIMSUN software for the current and proposed status

	Unit	Average current status (1.)	Average proposed status (separate line) (2.)	Difference between 1st and 2nd status
Delay time - all vehicles	[sec/km]	13,12	9,04	-4,08
Density - all vehicles	[veh/km]	2,92	2,79	-0,13
Fuel consumption - all vehicles	[l/100 km]	5,27	4,97	-0,30
Track speed - all vehicles	[km/h]	45,32	47,80	2,48
IEM Emissions CO2 - all vehicles	[g/100 km]	72388,06	72348,69	-39,37
Maximum virtual queue - all vehicles	[veh]	3,40	3,40	0,00
Average queue - all vehicles	[veh]	6,37	2,99	-3,38
Speed - all vehicles	[km/h]	47,54	49,21	1,67
Stop time - all vehicles	[sek/km]	7,56	4,31	-3,25
Total travel time - all vehicles	[hour]	74,27	70,31	-3,96
Travel time - all vehicles	[sec/km]	79,45	75,32	-4,13

From the simulation results for the first variant it follows that by creating a separate lane for the left branch the values of the individual variables have changed. In all cases, improvements have been made. Adding the separate lane would therefore have a positive effect on the traffic flow in this section.

In the case where we designed the by – pass road of the village and separate lane for the left turn, the result simulation values were again better than in the current state. However, there has been an increase in fuel consumption of all vehicles that have passed through the system, as well as an increase in CO_2 emissions. The resulting values are shown in Table 2.

Table 2 The average values of the simulation in AIMSUN software for the current and proposed status

	Unit	Average current status (1.)	Average proposed status (separate line + by - pass road) (3.)	Difference between 1st and 3rd status
Delay time - all vehicles	[sec/km]	13,12	8,59	-4,53
Density - all vehicles	[veh/km]	2,92	2,08	-0,84
Fuel consumption - all vehicles	[l/100 km]	5,27	6,98	1,71
Track speed - all vehicles	[km/h]	45,32	49,70	4,38
IEM Emissions CO_2 - all vehicles	[g/100 km]	72388,06	82432,89	10044,82
Maximum virtual queue - all vehicles	[veh.]	3,40	3,25	-0,15
Average queue - all vehicles	[veh]	6,37	1,64	-4,73
Speed - all vehicles	[km/h]	47,54	51,01	3,47
Stop time - all vehicles	[sec/km]	7,56	2,31	-5,25
Total travel time - all vehicles	[hour]	74,27	67,62	-6,65
Travel time - all vehicles	[sec/km]	79,45	72,44	-7,01

Figure 10 shows a graphical comparison from simulation results for the comparison states (up - current state, down - state proposed).

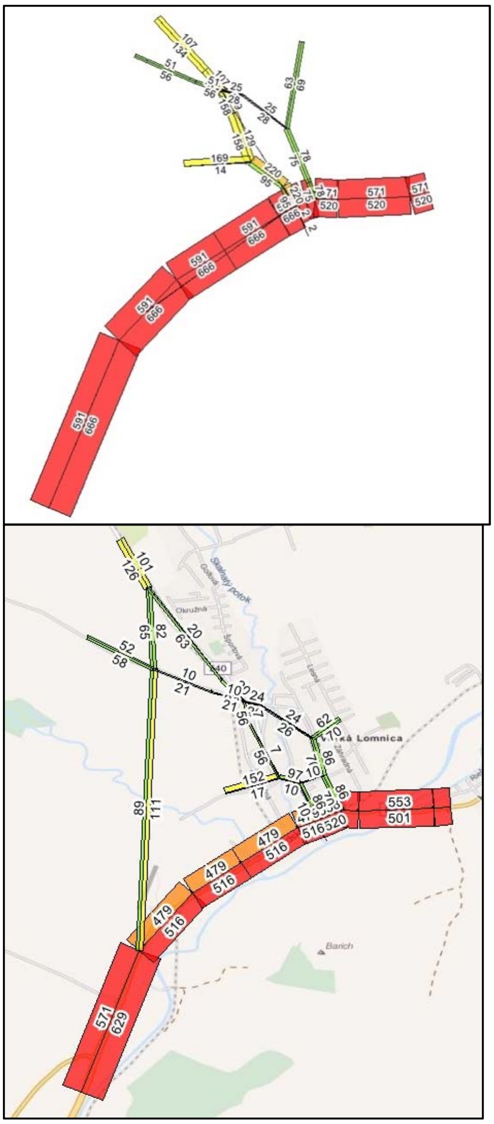

Figure 10 Comparison of current and proposed status load results

Third variant includes a planned by-pass road of Veľká Lomnica in the direction of Kežmarok, which construction should begin in the next few years. The resulting figures have changed significantly against the current situation.

If the traffic in the area will be solved by by - passes and the separate left turn lane proposed by us, first of all, there would be a significant relieving of the village by transit traffic, where all the transit is carried out over capacity roads, and consequently a significant increase in the speed and reduction of delay time also within the village). Average values and comparison among the individual states are shown in Table 4.

Table 4 The average values of the simulation in AIMSUN for the current and proposed status

	Unit	Average current status (1.)	Average proposed status (separate line + by - pass road to High Tatras + by - pass road to Kežmarok) (4.)	Difference between 1st and 4th status
Delay time - all vehicles	[sec/km]	13,12	3,53	-9,59
Density - all vehicles	[veh/km]	2,92	2,08	-0,84
Fuel consumption - all vehicles	[l/100 km]	5,27	8,58	3,31
Track speed - all vehicles	[km/h]	45,32	71,77	26,45
IEM Emissions CO_2 - all vehicles	[g/100 km]	72388,06	89713,88	17325,82
Maximum virtual queue - all vehicles	[veh]	3,40	2,00	-1,40
Average queue - all vehicles	[veh]	6,37	0,60	-5,77
Speed - all vehicles	[km/h]	47,54	77,98	30,44
Stop time - all vehicles	[sec/km]	7,56	0,96	-6,59
Total travel time - all vehicles	[hour]	74,27	47,20	-27,07
Travel time - all vehicles	[sec/km]	79,45	50,17	-29,28

Figure 11 shows a graphical comparison of the simulation results for the comparison states (up - current state, down - state proposed).

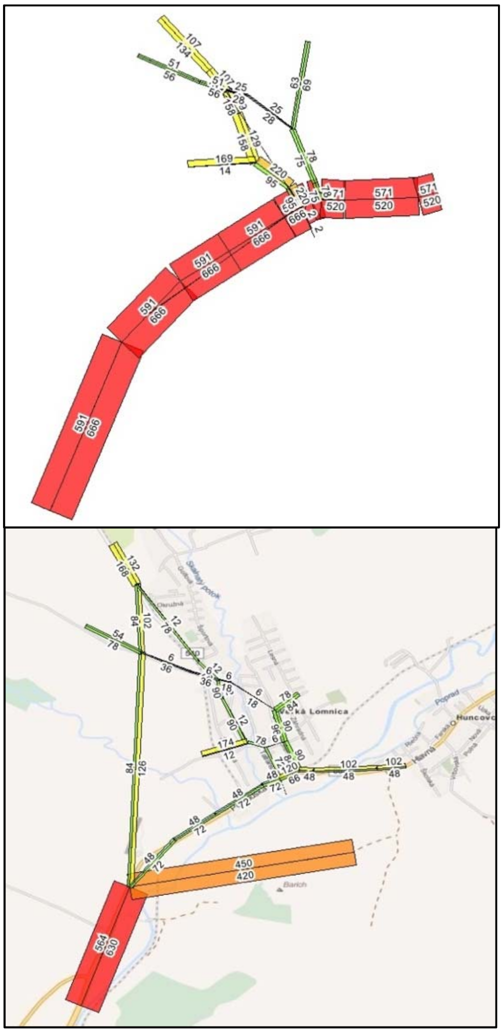

Figure 11 Comparison of current and proposed status load results

Table 5 compares the differences between the proposed solutions. Each solution produces positive results in the form of acceleration of traffic in the area, i.e., speeding up all vehicles, reducing travel time, reducing downtime, resulting in a reduction in total travel time.

Table 5 The difference in the values of the variables between the individual proposed status

	Unit	Difference between 2nd and 3rd status	Difference between 2nd and 4th status	Difference between 3rd and 4th status
Delay time - all vehicles	[sec/km]	0,45	-5,51	-5,06
Dentisy - all vehicles	[veh/km]	0,71	-0,71	0,00
Fuel consumption - all vehicles	[l/100 km]	-2,01	3,61	1,60
Track speed - all vehicles	[km/h]	-1,90	23,97	22,07
IEM Emissions CO_2 - all vehicles	[g/100 km]	-11848,29	19129,29	7280,99
Maximum virtual queue - all vehicles	[veh]	0,15	-1,40	-1,25
Average queue - all vehicles	[veh]	1,35	-2,39	-1,04
Speed - all vehicles	[km/h]	-1,80	28,77	26,98
Stop time - all vehicles	[sec/km]	2,00	-3,34	-1,35
Total travel time - all vehicles	[hour]	2,68	-23,11	-20,42
Travel time - all vehicles	[sec/km]	2,88	-25,15	-22,27

4. Conclusion

Based on the results of traffic survey and simulations in the AIMSUN software, we considered proposal 1 and design 2. It was still compared with the zero variation - the current state. We can say that each of the proposed solutions has a positive impact on the transport situation in the area. Although Veľká Lomnica is a small village, transport is very complicated, and these proposals can not only improve the quality of life of the population but also the development of tourism, thanks to the better accessibility of the High Tatras.

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The impact of University of Žilina´s employees on regional development

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Abstract The university is an important part of the region's infrastructure and has the potential to initiate changes and transform the economy into a diverse range. The presence of a university in a host city or region has a strong impact on regional development. Universities are usually among the largest employers in the city. Their employees, students and visitors spend some of their finances in this city, which have an impact on local and regional economic development. The total size of the impact of university varies depending on the size of the university and the characteristics of the local and regional economy. The primary aim of the contribution is identification of the selected short-term impacts of the University of Žilina to the city and region, where it has its registered office. To achieve the stated goal, primary research was carried out primarily focused on the economic impact of university staff on the development of the Žilina´s region.

Keywords university, regional development, backward impact, residence employees, non-residence employees

JEL I25, O12, O15, O18, R11

1. Introduction

Current modern universities are an active actor in the development of the region and their impact is much wider and more diverse. The impact of universities is classified in eight areas: knowledge creation, human capital formation, know-how transfer, technological innovation, capital investment, regional leadership, knowledge infrastructure creation and influencing local and regional environment. [1]

The importance of universities in the development of human resources and the region's irreplaceable, especially in terms of the benefits of innovation and technology. For this reason, it is important that local and regional authorities, which play a coordinating role in the development of the region, actively cooperate with universities. [2]

In addition to the education of university students, they also provide education directly in companies or non-profit institutions. Universities collaborate on applied, joint and customized research with companies. Universities also support the establishment of spin off companies and provide their hardware to businesses.

Top university staff often work in consultative bodies and committees established at local, regional or national level. Through their knowledge and moral authority, they contribute to the establishment of consensus, overcoming conflicting situations, identifying new development opportunities. Universities also increase the attractiveness of the local and regional environment for potential migrants as well as businesses. [1]

University for their role in the host region improve the quality of life, developing greater value territory, but their main task is to shift the economy to become the primary source of wealth and prosperity. [3]

All the above-mentioned aspects of the university's impact on the development of the region deals currently solved project APVV-14-0512 “Universities and economic development of regions”.

2. Theoretical background

The impact of universities on the host city or region can be divided into two groups: long-term and short-term impacts. [4] The University's long-term impact tracking focuses on analysing the impact of universities on increasing human capital, generating new knowledge and the overall attractiveness of the city or region. Knowledge, human capital, and infrastructure are accumulated over a long period of time, so the abolition of university would be manifested with greater time distance. [1] These effects can also be referred to as "forward" relationships. [5]

In the context of monitoring the university's short-term impact, an analysis of the impact of expenditures associated with the university's presence is made. The analysis includes expenditure on staff, university students, and university expenditure on goods and services. [4] These short-term effects would eventually disappear if the existence of the university had been abolished. University offers additional funding to the city or region that affects the revenue of local businesses, household income and tax revenue. [1] Short-term effects may also be referred to as "backward" relationships. [5]

2.1. Residence and non-residence consumers

Employees and students of the university are within our primary research distributed to consumers who live and work in the studied region (ie. residents) and those who do not live and do not work in the studied region (ie. non-residents). Assuming that the university did not exist it can be divided into consumer spending following 4 groups:

- non-resident consumers who would work and study at another university in another region → expenditure would not be realized in the surveyed region if the university did not exist;
- resident consumers who would work and study at another university in another region → expenditure would not be realized in the surveyed region if the university did not exist;
- resident consumers who would work and study at another institution in the region surveyed → expenditures would be realized in the surveyed region if the university did not exist;
- non-resident consumers who would work and study at another institution in the surveyed region → expenditures would be realized in the surveyed region if the university did not exist. [6]

3. Aim and methodology

The primary aim of the contribution is to analyse selected short-term impacts of University of Žilina (UNIZA) on the development of the host city and the region in 2015.

To achieve the stated objective was conducted primary research aimed to determine the effect of university employees to develop the city of Žilina and Žilina region. The subject of the survey was UNIZA employees in 2015.

The research problem was defined as "Finding the Economic Impact of UNIZA Employees on the Region of Žilina".

The aim of primary research is to find out if UNIZA employees would remain in the city of Žilina, even if UNIZA did not exist. Another aim is to determine how much an average% of total income spent UNIZA resident employees for the purchase of goods and services in Žilina in 2015. In calculating the average expenditure % were considered UNIZA employees who worked on UNIZA continuously throughout the year 2015.

Following research objectives, the following research assumptions were set:

1. research assumptions: At least 30% of non-resident UNIZA employees would work in another city if UNIZA did not exist.

2. research assumptions: UNIZA Resident Employees throughout the year spent an average of at least 40% of total income in the city of Žilina as non-resident employees.

3.1. Selection sample size

Quantitative research was carried out to find the necessary data. Information was obtained through oral questioning using a structured questionnaire. The target group of research was UNIZA's pedagogical and non-pedagogical employees in 2015. Based on the formula to calculate the size of the research sample in the base set (1), we obtained the minimum sample size, j. 308 respondents (employees) for the whole UNIZA.

$$n \geq \frac{N * t^2_{1-\frac{\alpha}{2}} * \sigma^2}{(N-1) * \Delta^2 + t^2_{1-\frac{\alpha}{2}} * \sigma^2} \; ; \; \sigma = \sqrt{p*(1-p)} \qquad (1)$$

n – minimum sample size (minimum number of respondent)
t1-α/2 – critical value determined from tables
σ2 – variance calculated from the standard deviation
p – variability of base file (character share)
Δ – maximum allowable margin of error
N – base file size

UNIZA employed 1,545 employees in 2015. The structure of the employees was as follows:

- university teachers - 647 (professors - 100; docents - 166; professional assistants - 344; assistants - 8 and lecturers - 29);
- researchers - 181;
- professional employees - 167;
- administrative employees - 208;
- operating employees - 342.

When performing the survey, the required confidence interval of 95% was selected, which according to the table value corresponds to 1.96. The maximum permissible error range was ± 5%. Since the value of the share of the character was not known, the standard value of the character part, was used in the calculation.i.e. 0.5.The survey was attended by 263 UNIZA employees (respondents), representing 86% of the return on demand. Due to the difficulty of the search, this return was post-accountable for our purposes. Microsoft Excel charts and spreadsheets were used to evaluate the results. We've analysed and graded the data we obtained in accordance with the required criteria using the Excel filters tool to validate or reject predefined research assumptions.

4. Results

The structure of respondents (total number of respondents 263) was as follows: 96% (253) of 263 respondents were employees living in Žilina region. Of these, 72% (180) live in the city Žilina and 28% (73) commute to UNIZA from other cities in the Žilina region. 4% (10) of the respondents were employees who commute to UNIZA from other regions of Slovakia.

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41% (108) of 263 respondents were university teachers, 19% (49) respondents were operating employees, 19% (49) respondents were administrative employees, 12% (33) respondents were researchers and 9% (24) respondents were professional employees.

Of the total number of respondents (263) were 69% (136) of such respondents who studied at UNIZA. 24% (48) of 263 respondents studied at another university in Slovakia and 1% (3) respondents studied at another university in Žilina. University education do not have 27% (71) of 263 respondents.

Concerning the duration of employment of employees at UNIZA in 2015, we found out that 91% (241) of the total number of respondents 263 worked at UNIZA throughout the year 2015. 9% (22) of respondents worked at UNIZA only a few selected months in 2015.

One of the research objectives was to find out what respondents would most likely do if UNIZA did not exist. The results of the findings are as follows:

- 59% (154) of interviewed respondents would work in Žilina at other institutions / in another sector;
- 29% (76) of respondents would work in another city at other institution / in another sector;
- 7% (19) of respondents would work at another university in another city / region;
- 5% (14) of interviewed respondents would work at another university with a detached workplace in Žilina.

Another aim of the research was to determine the percentage of respondents' expenditure (employees working at UNIZA the whole year 2015) of their total income in 2015. This included expenditure on the purchase of goods and services in Žilina. Figure 1 shows the structure of employees according to their expenditures as a percentage spent in the city of Žilina.

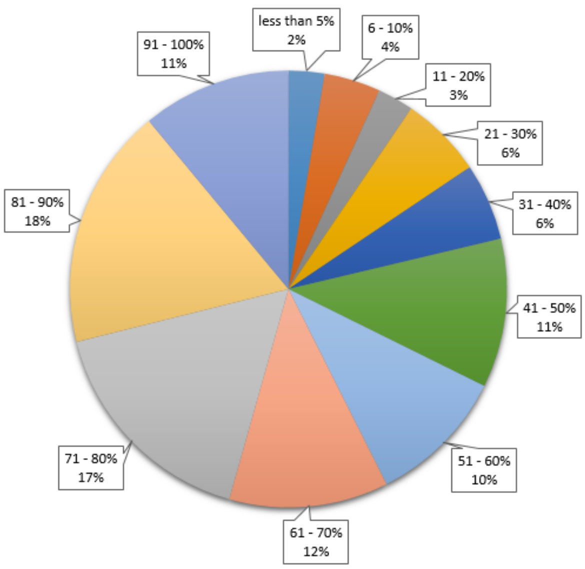

Figure 1. The structure of UNIZA's employees according to their expenditures as a percentage spent in the city of Žilina in 2015.

The largest share of their income (81-90%) spent in 2015 in Žilina 18% of respondents. Of these, 77% were resident employees and 23% were non-resident employees. The smallest share of their income (less than 5%) spent in 2015 in Žilina 2% of respondents. Of these, 83% were non-resident employees and 17% were resident employees.

Based on the research objectives, the research assumptions (see Chapter 3. Aim and methodology) have been established. We confirmed or rejected these by analyzing the collected data.

The first research assumption (finding the percentage of non-resident UNIZA's employees who would work in another city if UNIZA did not exist) was confirmed: 55,42% > 30%. We assume that such a group of people accounts for at least 30% of UNIZA's employees.

83 respondents from all respondents do not live in Žilina. Of these, 46 respondents would work at another university, at other institution or in other sector in another city / region if UNIZA did not exist. 37 respondents said they would work at another university, at other institution or in other sector in Žilina, even if UNIZA did not exist. The findings show that 55,42% of non-resident UNIZA's employees would work in another city if UNIZA did not exist.

The second research assumption (finding of the annual average percentage share of UNIZA's employees expenditure in the total income in Žilina) was rejected: 35% < 40%. We assume that UNIZA's employees living in Žilina spend in a year at least 40% more of total income than the employees who come from another city. In this case, we took into account the employees who worked at UNIZA in the whole year 2015.

Resident UNIZA's employees spent in Žilina on average 69% of their total income in 2015. Non-resident UNIZA's employees carried in Žilina city out on average 45% of their total income in 2015. It follows from the above that resident UNIZA's employees spent in Žilina in 2015 on average 35% more of their expenditures then non-resident respondents.

5. Conclusions

UNIZA is an important institution in its host city and region. It acts here as a stable employer, educator and resource for the local economy.

Through primary research, we found, in particular, the positive short-term impacts of the university on the host city and the region. By interpreting the information obtained, two research assumptions were confirmed and one research assumption was rejected.

More than half of UNI-ZA non-resident employees would work in another city if UNIZA did not exist. Thanks to the existence of UNIZA, this category of employees is regularly visited by the city of Žilina and thus contributes to the development of the local economy.

Resident respondents UNIZA spent an average of 35% of their expenses in Žilina as respondents living outside the city of Žilina. It follows that non-resident employees spend less than a third of their income in Žilina than resident UNIZA employees. Both groups of respondents have quite the same and also significant impact on the development of the local and regional economy.

More than half of UNIZA's university teachers living in the Žilina region have completed their university studies at UNIZA. UNIZA provides a stable source for the local economy because of that almost 68% resident university teachers are realized expenditure since their student days.

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Driver salary identification by hypothesis testing

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Abstract This paper outlines comparing two independent samples, particularly average driver salary in Slovakia and the other EU countries. Significant differences between salaries are pointed out through two examples dealing with hypothesis testing. For Western European Union countries, the level of salaries in road transport is higher in absolute terms compared to the salaries of drivers in the central and eastern parts of the European Union. Different salaries and requirements of wage regulations create a discriminatory environment among entrepreneurs however harmonization of salaries in the field of road transport is specific because carriers offer transport throughout the whole European Union market.

Keywords driver, salary, hypothesis testing, comparing

JEL J31, R40

1. Introduction

In practice, we often need to compare the basic characteristics of a random variable in two basic sets based on the knowledge of the sample data only. For example, we want to compare average salaries of drivers and their variability in individual countries or the annual tax on motor vehicles and the like. If the comparison is based on the results of the sample research, the statistical induction methods must be reused for the interval estimates of the difference or share of the comparison parameters of the basic files or for verifying the hypotheses of their compliance.

2. Comparing Two Independent Samples

In the two-parameter match tests, independent choices is considered in which the collection of statistical units from a single base file does not depend on removing units from the second base file. Based on independent selections, the hypotheses of matching the parameters of two basic sets are verified, using selection characteristics with known probability distributions. These distributions often depend on whether the variance in the basic files is the same or not.

2.1. Testing a Difference of Two Variances

The random variable X is monitored in two basic files. Its probability distribution is normal for both files. It is assumed that in both the basic files, the random variable X has the same variability, which is expressed by the hypothesis

$$H_0:\ \sigma_1^2 = \sigma_2^2 \tag{1}$$

The test characteristic is used as the test criterion for its test. If the null hypothesis is true, the test is

$$F = \frac{\tilde{s}_1^2}{\tilde{s}_2^2} \tag{2}$$

and Fisher's probability distribution $F(n_1 - 1;\ n_2 - 1)$ which has number of degrees of freedom $v_1 = n_1 - 1$ and $v_2 = n_2 - 1$. An overview of critical regions for various alternative hypotheses is given in Table 1 [5], [6].

Table 1. Critical Region for Various Alternative Hypotheses (F-Test)

Alternative hypothesis	Critical Value	Critical Region
$H_1:\ \sigma_1^2 \neq \sigma_2^2$	$F_{\frac{\alpha}{2}}, F_{1-\frac{\alpha}{2}}$	$v_\alpha = \left(0, F_{\frac{\alpha}{2}}\right) \cup \left(F_{1-\frac{\alpha}{2}}, +\infty\right)$
$H_1:\ \sigma_1^2 > \sigma_2^2$	$F_{1-\alpha}$	$v_\alpha = (F_{1-\alpha}, +\infty)$
$H_1:\ \sigma_1^2 < \sigma_2^2$	F_α	$v_\alpha = (0, F_\alpha)$

2.2. Testing a Difference between Two Means - Normal Distribution

If we know the variances $\sigma^1{}_2$, $\sigma^2{}_2$ of these distributions and test the null hypothesis

$$H_0:\ \mu_1 = \mu_2 \tag{3}$$

against any alternative, as a test criterion we can use a characteristic assuming the null hypothesis is valid

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \quad (4)$$

and normal probability distribution N (0; 1). Selected level of significance α and critical regions for different types of alternative hypotheses are given in Table 2.

Table 2. Critical Region for Various Alternative Hypotheses (Z-Test)

Alternative hypothesis	Critical Value	Critical Region
$H_1:\ \mu_1 > \mu_2$	$-z_{1-\frac{\alpha}{2}}, z_{1-\frac{\alpha}{2}}$	$v_\alpha = \left(-\infty, -z_{1-\frac{\alpha}{2}}\right) \cup \left(z_{1-\frac{\alpha}{2}}, +\infty\right)$
$H_1:\ \mu_1 > \mu_2$	$z_{1-\alpha}$	$v_\alpha = (z_{1-\alpha}, +\infty)$
$H_1:\ \mu_1 > \mu_2$	$-z_{1-\alpha}$	$v_\alpha = (-\infty, -z_{1-\alpha})$

If we do not know the variances $\sigma^1{}_2$, $\sigma^2{}_2$ but we can assume its equality $\sigma^1{}_2 = \sigma^2{}_2$, the null hypothesis H_1: $\mu_1 = \mu_2$ is tested against any alternative by the test characteristic, which is in the case of null hypothesis

$$T = \frac{\bar{X}_1 - \bar{X}_2}{\tilde{s}_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \quad (5)$$

and distribution $t(n_1+n_2-2)$.

Critical values are determined at the chosen level of significance α as the appropriate fractil of Student's distribution t ($n_1 + n_2$-2) according to Table 3 [5], [6].

Table 3. Critical Region for Various Alternative Hypotheses (T-Test)

Alternative hypothesis	Critical Value	Critical Region
$H_1:\ \mu_1 \neq \mu_2$	$-t_{1-\frac{\alpha}{2}}, t_{1-\frac{\alpha}{2}}$	$v_\alpha = \left(-\infty, -t_{1-\frac{\alpha}{2}}\right) \cup \left(t_{1-\frac{\alpha}{2}}, +\infty\right)$
$H_1:\ \mu_1 > \mu_2$	$t_{1-\alpha}$	$v_\alpha = (t_{1-\alpha}, +\infty)$
$H_1:\ \mu_1 < \mu_2$	$-t_{1-\alpha}$	$v_\alpha = (-\infty, -t_{1-\alpha})$

If we do not know the variances $\sigma^1{}_2$, $\sigma^2{}_2$ and we cannot assume its equality, a suitable test criterion is the characteristic which, in the case of the null hypothesis validity and in the case of validity of the null hypothesis $\mu_1 = \mu_2$ is

$$T = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\tilde{s}_1^2}{n_1} + \frac{\tilde{s}_2^2}{n_2}}} \quad (6)$$

and the division $t(v_r)$.

Critical regions in various alternative hypotheses are given in Table 3 with the difference that we are looking for the fractile of t-distribution at degrees of freedom v_r.

2.3. Testing a Difference between Two Means – Other or Unknown Distribution

The assumptions about the consistency of the mean values of the two base files in which the random variable X does not have normal but any distribution or unknown probability distribution is tested if the sample files have a large range, $n_1 \rightarrow +\infty$, $n_2 \rightarrow +\infty$. The formula for the test statistic in this case is

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\tilde{s}_1^2}{n_1} + \frac{\tilde{s}_2^2}{n_2}}} \quad (7)$$

and normal probability distribution $N(0;1)$.

The normality of its distribution is a consequence of the validity of the central limiting theorem and the use of selective variances instead of the variances of the base sets is due to the consistency of point estimates [9], [10].

2.4. Testing a Difference between Two Means – Alternative Distribution

This is a special case of the average value match test of two arbitrary distributions. If X has a distribution $A_{(\pi 1)}$ in the first one and $A_{(\pi 2)}$ in the second base file, the formula for null hypothesis about the consistency of mean values is

$$H_0:\ \pi_1 = \pi_2 \quad (8)$$

An appropriate test criterion in its test against any alternative is the characteristic, which is simplified in the case of the validity of the null hypothesis

$$Z = \frac{(P_1 - P_2)}{\sqrt{\frac{P_1(1-P_1)}{n_1} + \frac{P_2(1-P_2)}{n_2}}} \quad (9)$$

Assuming n_1→∞, n_2→∞, the Z – test has normalized normal distribution and the assumption or rejection of the null hypothesis H_0: $\pi_1 = \pi_2$ is decided based on Table 2 [12], [13].

3. Driver Salary Identification

Regarding the remuneration of drivers, we conducted a research of drivers' compensation in selected transport companies. The research was conducted from January to March 2017 and the drivers of transport companies from 10 different EU states participated on it. Overall, drivers from 310 transport companies took part in the research. The countries were chosen so that in the research were the states which uphold the introduction of a minimum salary for the work of international road transport drivers (Germany and Austria), Western European countries which incline to a certain protection of the transport market (Belgium, Denmark, the Netherlands, Luxembourg, Italy) and the countries of the central and eastern part of the European Union which are against the unification of the minimum salary across the EU (Czech Republic, Poland, Slovakia).

In the research, the drivers responded to the form of remuneration and the amount of remuneration which appertain to them. The drivers were divided into groups according to whether they are remunerated with a monthly or hourly rate. On average, the highest hourly salary rate is reached by drivers in Luxembourg, it is 15.875 € / hour (Table 4). By the rates above € 10 / hour are also remunerated drivers in Germany and Austria. Significantly lower rates are in the Czech Republic and Slovakia, where they are below 5 € / hour.

In several countries, drivers are not remunerated with € / hour, but with monthly salaries. The highest average salary for drivers is in Luxembourg, Germany and the Netherlands and it is above 2000 € / month.

Table 4. Remuneration of drivers in international road transport

Country	Wage (€/h)	Wage (€/km)	Wage (€/month)
Germany	12.875	-	2347
Austria	10.33	-	1633
Belgium	-	-	1605
Denmark	-	-	1600
Netherlands	-	-	2100
Luxemburg	15.875	-	2381
Italy	-	0.15	1516
Czech Republic	3.77	0.083	1115
Poland	-	0,08	1400
Slovakia	4.33	0.131	1282

3.1. Example 1 – Salary Comparison of Slovak and Czech Driver

From research we know the average salaries of drivers in two different countries. In the SR we determined the average salaries of drivers with random sample of size 116 (all entries are in euro):

1380; 1500; 1050; 1170; 1250; 1350; 1400; 900; 550; 600; 1600; 2400; 1200; 1500; 1200; 1600; 1800; 850; 1700; 1800; 2000; 1200; 1200; 1700; 1200; 1550; 1300; 1650; 1500; 1400; 1500; 1500; 800; 850; 900; 1200; 1200; 750; 1200; 1600; 1100; 1000; 1350; 1400; 600; 1400; 550; 1500; 1200; 600; 1200; 1600; 1200; 1000; 700; 1000; 1600; 2000; 1500; 500; 1000; 1450; 1500; 600; 650; 1400; 750; 450; 2500; 1200; 2000; 1400; 600; 800; 1400; 550; 2500; 1100; 650; 1100; 1300; 900; 700; 800; 1300; 1500; 1000; 530; 2300; 1000; 1400; 1500; 2200; 1400; 750; 1600; 1200; 2100; 1100; 1600; 1200; 1500; 1300; 1750; 2000; 540; 404;1400; 900; 1810; 1500; 1200; 500; 1300; 1400; 1500.

In the Czech Republic we determined the average salaries of drivers (all entries are in euro recalculated on the basis of the National Bank of Slovakia exchange rate sheet on 2.7.2017) with random sample of size 31:

1356; 573; 1600; 1146; 620; 1612; 1774; 2063; 1070; 1375; 554; 1135; 688; 1146; 1176; 722; 1031; 1713; 1135; 879; 1146; 825; 840; 722; 928; 1031; 877; 2475; 722; 933; 1719.

At the level of significance $\alpha = 0.05$, we assume that average salaries are the same in both countries. We want to verify the hypothesis H_0: $\mu_1 = \mu_2$ versus the alternative H_1: $\mu_1 \neq \mu_2$. The sample size is large with an unknown variances $\sigma^1{}_2$, $\sigma^2{}_2$. In order to be able to choose a test criterion correctly, we must first verify the hypothesis H_0: $\sigma^1{}_2 = \sigma^2{}_2$ against the alternative H_1: $\sigma^1{}_2 \neq \sigma^2{}_2$.

Next, we calculate the mean and variance for each sample. Doing so gives us:

$\bar{x}_1 = 1258.5690$

$\tilde{s}_1^2 = 211810.4563$

$\tilde{s}_1 = 460.2287$

$\bar{x}_2 = 1149.8757$

$\tilde{s}_2^2 = 210709.1835$

$\tilde{s}_2 = 459.0307$

Now we can fit into the test criterion and get it:

$$F = \frac{\tilde{s}_1^2}{\tilde{s}_2^2} = \frac{211810.4563}{210709.1835} = 1.0052$$

Then we determine critical values of F-distribution with degrees of freedom α = 0.05:

$$F_{\frac{\alpha}{2}} = \quad F_{0,025} = 0,59, F_{1-\frac{\alpha}{2}} = \quad F_{0,975} = 1,87$$

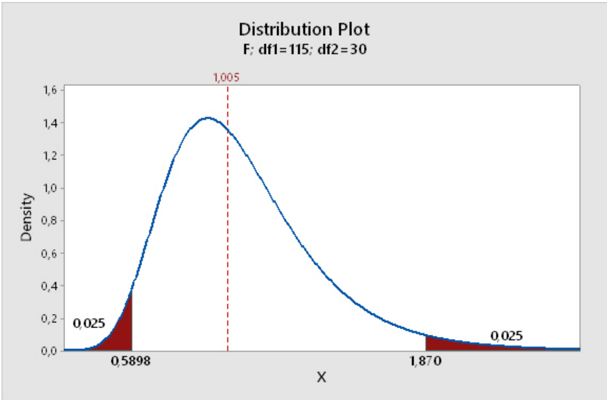

Figure 1. Distribution Plot – F-test

The value of the test criterion does not belong to the critical region (Fig. 1.)

$$v_\alpha = \left(0, F_{\frac{\alpha}{2}}\right) \cup \left(F_{1-\frac{\alpha}{2}}, +\infty\right) \qquad (10)$$

therefore we accept the null hypothesis at the level of significance α = 0.05.

A test criterion is appropriate for verifying the hypothesis H_0: $\mu_1 = \mu_2$. First, we calculate the combined standard deviation:

$$\tilde{s}_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)\tilde{s}_2^2}{(n_1 + n_2 - 2)}}$$

$$= \sqrt{\frac{115x211810.4563 + 30x210709.1835}{(116 + 31 - 2)}} = 459.9811$$

Now we calculate our test statistic:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\tilde{s}_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} = \frac{1258.5690 - 1149.8757}{459.9811\sqrt{\frac{1}{116} + \frac{1}{31}}} = 1.1687$$

In Excel, using the TINV function, we find the 0.05 critical values for a T-distribution with 145 degrees of freedom to be −1.98 and 1.98. So to accept the null hypothesis, we need out test statistic to satisfy $t < 1.98$ [12], [13].

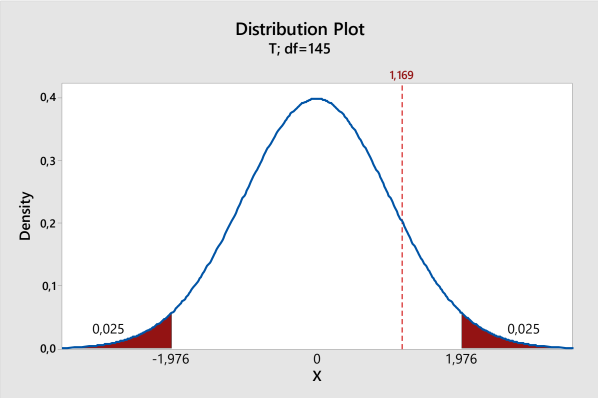

Figure 2. Distribution Plot – t-test

The value of the test criterion does not belong to the critical area (Figure 2.), therefore we assume the null hypothesis H_0: $\mu_1 = \mu_2$ for the significance level $\alpha = 0.05$. At the level of significance α = 0.05 we assume that in the SR and the Czech Republic the average salary of drivers is not significantly different.

3.2. Example 2 – Salary Comparison of Slovak driver and drivers from the other EU countries

From research we know the average salaries of drivers in SR and the other EU countries. In the SR we determined the average salaries of drivers with random sample of size 116 (the same salaries as example 1 are considered).

In selected EU countries (Belgium, Denmark, Luxembourg, Netherlands, Norway, Poland, Austria, and Italy) we determined the following average salaries of drivers with random sample of size 60 (all entries are in euro):

500; 1750; 2450; 1500; 630; 2200; 2160; 1650; 1600; 900; 1500; 1750; 2500; 2500; 2100; 2180; 3690; 2500; 1850; 2300; 2100; 4301; 1400; 1600; 1600; 1700; 1750; 600; 2200; 1356; 573; 1600; 1146; 620; 1612; 1774; 2063; 1070; 1375; 554; 1135; 688; 1146; 1176; 722; 1031; 1713; 1135; 879; 1146; 825; 840; 722; 928; 1031; 877; 2475; 722; 933; 1719.

At the level of significance α = 0.05, we assume that average Slovak salaries are the same as salaries in selected EU countries.

We want to verify the hypothesis $H0$: $\mu_1 = \mu_2$ versus the alternative H1: $\mu_1 \neq \mu_2$. The sample size is large with an un-known variances $\sigma^1{}_2$, $\sigma^2{}_2$. Next, we calculate the mean and variance for each sample:

$\bar{x}_1 = 1258.5690$

$\tilde{s}_1^2 = 211810.4563$

$\tilde{s}_1 = 460.2287$

$\bar{x}_2 = 1517.4500$

$\tilde{s}_2^2 = 240216.0465$

$\tilde{s}_2 = 490,1184$

Now we can fit into the test criterion and get it:

$$F = \frac{\tilde{s}_1^2}{\tilde{s}_2^2} = \frac{211810.4563}{240216.0465} = 0.8817$$

Then we determine critical values of F-distribution with and degrees of freedom (115; 59) α = 0.05:

$$F_{\frac{\alpha}{2}} = F_{0,025} = 0,65, F_{1-\frac{\alpha}{2}} = F_{0,975} = 1,59$$

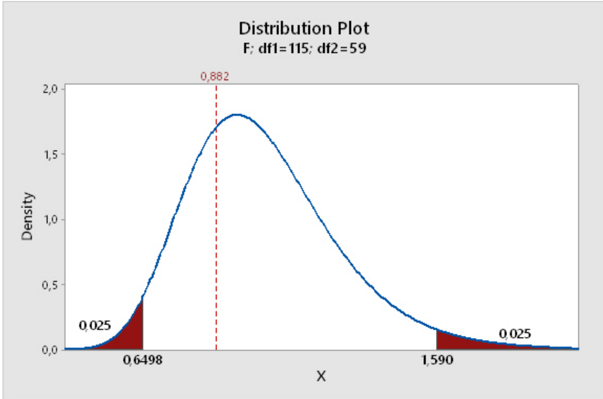

Figure 3. Distribution Plot – F-test

The value of the test criterion does not belong to the critical region (Fig. 3.)

$$v_\alpha = \left(0, F_{\frac{\alpha}{2}}\right) \cup \left(F_{1-\frac{\alpha}{2}}, +\infty\right) \quad (11)$$

therefore we accept the null hypothesis H_0: $\sigma^1{}_2 = \sigma^2{}_2$ at the level of significance $\alpha = 0.05$.

A test criterion is appropriate for verifying the hypothesis H_0: $\mu_1 = \mu_2$. First, we calculate the combined standard deviation:

$$\tilde{s_p} = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)\tilde{s}_2^2}{(n_1 + n_2 - 2)}}$$

$$= \sqrt{\frac{115x211810.4563 + 59x240216,0465}{(116 + 60 - 2)}} = 470.5765$$

Now we calculate our test statistic:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\tilde{s}_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} = \frac{1258.5690 - 1517.4500}{470.5765\sqrt{\frac{1}{116} + \frac{1}{60}}} = -3.4595$$

In Excel, using the TINV function, we find α 0.05 critical values for a T-distribution with 174 degrees of freedom to be -1.97 and 1.97 [12], [13].

Since $t = -3.4595$ is inside of our critical region (Fig. 4), we accept the null hypothesis and we can conclude at α 0.05 significance level that that the average salary of the driver in the Slovak Republic and in the other analysed EU countries is significantly different.

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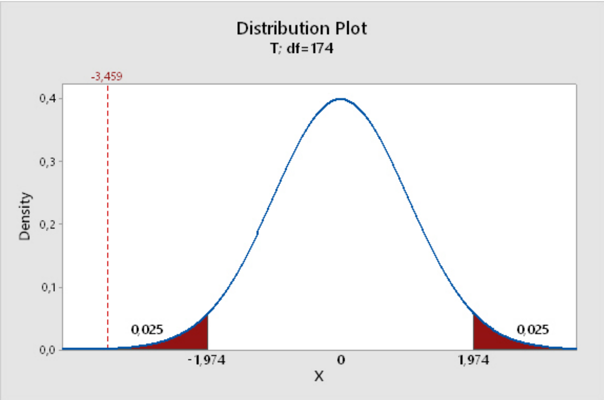

Figure 4. Distribution Plot – t-test

Since *t = -3.4595* is inside of our critical region (Fig. 4.), we accept the null hypothesis and we can conclude at *α 0.05* significance level that that the average salary of the driver in the Slovak Republic and in the other analysed EU countries is significantly different.

5. Conclusions

On the basis of testing hypotheses, we can conclude that there are differences between driver salaries in the selected EU countries. Testing has proven that in the Slovak Republic and the Czech Republic the average salary of drivers is not significantly different at the level of significance α 0.05 but on the other hand there are significant differences between the average salary of the driver in the Slovak Republic and in the other analysed countries, mostly Western European Union countries. For Western European Union countries, the level of salaries in road transport is higher in absolute terms compared to the salaries of drivers in the central and eastern parts of the European Union. Therefore, it can be expected that in the western part of the EU drivers are less interested in this profession, and companies are often looking for workers from the eastern part of the EU or from outside the EU. The harmonization of salaries in the field of road transport is specific because carriers offer transport throughout the whole European Union market. Every carrier established in the European Union and with a license issued by the Community has the same access to this market. Individual states put pressure on increase of salaries in international road transport with the use of national regulations in order to reduce the competitive pressure of lower prices of carriers located in the central and eastern parts of the European Union.

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The impact of roof box on fuel consumption

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Abstract Passenger vehicles are major petroleum consumers and contributors of greenhouse gas and criteria pollutant emissions in many countries around the world. The amount of fuel consumed affects the environment, status of health of human population as well as financial costs that are associated with vehicle operation. The roof box is one of the often used vehicle attachments. The aim of the paper is to measure the increase of fuel consumption affected by an installed roof box. The impact of roof box on the increase of fuel consumption is measured at the speeds of 50 $km.h^{-1}$, 90 $km.h^{-1}$ and 130 $km.h^{-1}$. The introduction of the paper describes particular harmful constituents of exhaust gases and their effects. Another part of the article includes the methodology of measurement and its results. The last part of the article involves the evaluation of results and recommendations relating to reduction of the increase of fuel consumption affected by roof box.

Keywords air resistance, emissions, fuel consumption, roof box

JEL L92

1. Introduction

Personal vehicles account for a large proportion of consumption of fuels derived from oil and they contribute to pollution of the environment in the world. A transport in the roof box of a vehicle is one of the most widely-used ways of cargo transport. The aim of the research is to measure the increase of fuel consumption affected by the installation of a roof box.

2. Effects of Fossil Fuels Combustion

Every motor vehicle fuelled by petrol or diesel produces carbon dioxide emissions. Combustion of 1 litre of petrol leads to production of 2.5 kg of the gas. Carbon dioxide has the biggest impact on global climate changes [1]. It is considered to be the most harmful greenhouse gas and accounts for about 55 % in the greenhouse effect [2]. Combustion of fossil fuels can also produce other harmful emissions. Carbon monoxide is produced as a result of incomplete oxidation of carbon and is highly toxic. Combustion of fossil fuels further produces particulate matter with its responsibility for 32,000 premature deaths per year. Other harmful constituents are nitrogen oxides, sulphur dioxide, benzene, benzine and others. It is needed to point out that combustion of 1 kg of fuel means combustion of approximately 15 kg of air [3]. The increase in fuel consumption of diesel vehicle with an average annual driven 20,000 km by 1 $l.100\ km^{-1}$ means the increase in annual costs of fuel by 220 € at a price of 1.10 €/l. The amount of fuel consumed has thus an impact on the environment, on the state of human population health as well as on the economic situation.

An engine must do the work in order to overcome the driving resistances. These are rolling resistance, acceleration resistance, inertia resistance and air resistance [4]. A roof box increases air resistance that further results in the increase in the work of engine needed for overcoming such resistance, and thus the increase in fuel consumption. The increase in fuel consumption affects the increase in production of emissions. According to [4], fuel consumption caused by a roof rack is about six times larger than the expected fuel savings from vehicles with fuel cells. And, only one quarter or, according to some studies, only one eight of the drives with a roof box is realized with using a box for luggage transport. The vast majority of drives are therefore realized with an empty box [4]. The air resistance depends on air density, vehicle speed, or head wind speed, coefficient of air resistance and size of vehicle front face. The relation for calculation of air resistance can be seen as follows:

$$O_v = 0.5\ .\ \rho\ .v^2\ .c_x\ .S \tag{1}$$

ρ *air density [$kg.m^{-3}$]*
v *vehicle speed [$m.s^{-1}$]*
c_x *coefficient of air resistance [-]*
S *vehicle front face [m^2]* [5]

By increasing a front face together with coefficient of air resistance, there is also an increase in air resistance [6].

3. Methodology of Measurement

Measuring the impact of roof box on fuel consumption was conducted by driving tests on the road. It was carried out by personal vehicle Škoda Fabia II with diesel engine 1.9 PD, 77 kW. The roof rack was Moby Dick with volume of 305 l.

Figure 1. Vehicle with installed roof box

The fuel consumption was measured by software VCDS 15.7. During the measurement, there was also the air flow rate measured continuously by means of anemometer in order to avoid the distortion of results. Prior to the start of measuring, it was needed to mark out two fixed points on the road indicating the beginning and the end of the section where the measurement was carried out. The measurement was performed always on the same section, in one direction to avert the impact of elevation profile of the road. The impact of roof box on fuel consumption was measured at the speeds of 50 km.h-1, 90 km.h-1 and 130 km.h-1.

Process of measuring:

- Acceleration of a vehicle at given speed,
- stabilization of the required vehicle speed,
- running of the fuel consumption measurement when passing the first marked point,
- fuel consumption measurement at the stabilized vehicle speed,
- stopping of the fuel consumption measurement when passing the second final marked point,
- check of the value of anemometer and driving back to the beginning of the measuring section.

Each measurement was repeated 3 times. The measured data are shown in the Table 1.

Table 1 Measured values

	50 km.h^{-1}	**90 km.h^{-1}**	**130 km.h^{-1}**
Fuel consumption without roof box [l.100km^{-1}]	3.4	4.3	6.3
Fuel consumption with roof box [l.100km^{-1}]	3.6	4.9	7.8

The results are also shown in the form of graph to provide better display. Fig. 2

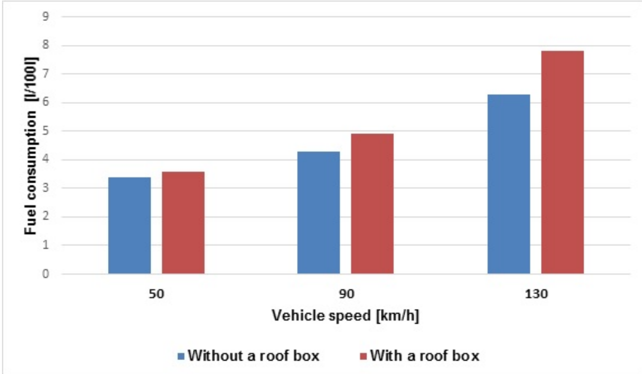

Figure 2. Graphical display of the measured results

4. Assessment of the Results of Measurements

The installation of roof box caused the increase in fuel consumption; specifically, at the speed of 50 km.h-1 by 0.2 l.100 km-1, at the speed of 90 km.h- 1 by 0.6 l.100 km-1, and at the speed of 130 km.h-1 the vehicle consumed more than 1.5 l.100 km-1. The results of measurement have shown that a roof box has relatively big impact on fuel consumption. The installation of roof box led to increase in the vehicle front face as well as the increase in air resistance coefficient cx [7]. The roof box disturbs the air flowing around the vehicle body and increases a proportion of turbulent flow at the expense of laminar flow [8]. The results also indicate that it is necessary to focus on the limitation in the number of drives of vehicles with empty roof box. It is essential to review the possibilities in the legislation, education of future drivers in the driving schools as well as producers of boxes. Concerning the legislation, there should be mandatory energy labelling that will make consumers to buy roof boxes with aerodynamic shape, and producers to develop and produce boxes with lower cx. Education of drivers regarding the impact of roof box on fuel consumption is also very important. Issues of eco-driving and impacts of particular factors on fuel consumption should be, in a great extent, included in driving schools' syllabi. Concerning the producers, it is necessary to pay attention to those solutions of design that would lead to shortening of time needed for mounting and dismounting of a roof box. It is assumed that shortening of time needed for mounting and dismounting would reduce the number of drives with empty boxes. In relation to measured values, it is necessary to take into consideration the fact that these were measured in specific conditions, with particular vehicle and type of roof box. Using of other vehicle and type of roof box would lead to the change in measured values. The change could also occur due to the change of air pressure or air temperature, since these values affect the air density. Despite all the specific conditions of each measuring, it is obvious that a roof box significantly increases fuel consumption, and hence causes the increase in emissions and costs of fuel. For this reason, it is necessary to use a roof box only justifiably and to minimize the operation of vehicle with an empty roof box.

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Statistical survey of road freight transport performance indicators

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Abstract This paper deals with the statistical survey of road freight transport performance indicators in the Slovak Republic and Europe. The aim is to point out disagreements in statistical data. The data will be compared in the databases of the Statistical Office of the Slovak Republic and Eurostat databases. These disagreements concern performance indicators for road freight and transport of passengers. The first part of the article describes the role of the Statistical Office of the Slovak Republic and Eurostat. Further, the survey data is shown. In the middle part there are disagreements in the statistics. At the end of the article are explained problems with collecting data from road freight transport companies.

Keywords statistical survey, road freight transport, transport of goods

JEL R40

1. Introduction

Transport is one of the key sectors that have a significant impact on socio-economic development and the growth of living standards. It is also necessary to measure and express certain indicators to measure the market situation and possibly to anticipate developments.

Measuring performance in transport, whether costly or personal, is an important factor in gaining a picture of the transport market. We should not forget to monitor the development of costs and prices in transport. Nevertheless, Regulation (EC) No 1071/2009 of 21 October 2009 shows that statistics on transport costs and prices need to be monitored, the Statistical Office of the Slovak Republic does not provide this information. The objective of this Regulation is also to establish common rules applicable to market access in the international carriage of goods by road in the EU and the conditions under which non-EU carriers may operate transport services in that country.

2. Transport Performance Measurement of the Statistical Office of the SR and the Statistical Office of the European Union

2.1. Performance indicators monitored by the Statistical Office of the Slovak Republic

According to the Statistical Office of the Slovak Republic, the transport activities of persons engaged in the transport of goods and persons in national and international transport, including auxiliary transport activities (excluding travel agencies), are included in the transport. Other land transport includes road transport, urban public transport and taxis.

Statistical Office of the Slovak Republic monitors these indicators:

- transport of goods,
- performances,
- passengers-kilometres.

More detailed information concerning the calculation of the distribution of these indicators is available at the Statistical Office of the Slovak Republic> Statistics> Sector Statistics> Transport and Postal Services> Methodological Explanatory Notes - selected data.

Table 1 shows the road freight traffic indicators monitored by the Slovak Statistical Office

Table 1. Indicators of road freight transport monitored by the Statistical Office of the Slovak Republic

Transport of goods / Performances	*transport of goods for own account and hire account together*	thous. tons / mil. tkm
	of which: national transport	
	import	
	export	
	cross trade transport	
	international cabotage	

2.2. Performance indicators in road transport monitored by Statistical Office of the European Union

The aim of Regulation (EU) No 70/2012 with recast version of Council Regulation (EC) 1172/98 of 25 May 1998 and the subsequent changes are to consolidate the legal basis for the collection of road transport data and align it with the Treaty of Lisbon.

This Regulation shall be binding in its entirety and directly applicable in all Member States. Member States shall compile statistical data relating to the following areas:

- vehicle, journey and goods.

In road freight transport are indicators divided to:

- **type of operation and type of transport** (1000 t, Mio Tkm, Mio Veh-km)
- **type of goods and type of transport** (1000 t, Mio Tkm)
- **transport by region of loading** (1000 t, Mio Tkm, 1000 Jrnys)
- **transport by region of unloading** (1000 t, Mio Tkm, 1000 Jrnys)
- **transport by distance class** (1000 t, Mio Tkm, Mio Veh-km, 1000 BTO)
- **transport by distance class with breakdown by type of goods** (1000 t, Mio Tkm, Mio Veh-km, 1000 BTO)
- **transport by axle configuration** (Mio tkm, Mio Veh-km, 1000 Jrnys)
- **transport, by age of vehicle** (Mio Tkm, Mio Veh-km, 1000 Jrnys)
- **transport by maximum permissible laden weight of vehicle** (Mio Tkm, Mio Veh-km, 1000 Jrnys)
- **transport by NACE Rev. 2** (Mio tkm, Mio Veh-km, 1000 Jrnys)
- **transport vehicle movements, loaded and empty, by reporting country** (Mio Veh-km, 1000 Jrnys)
- **transport of dangerous goods, by type of dangerous goods and broken down by activity** (Mio Tkm, Mio Veh-km, 1000 BTO)
- **transport by type of cargo and distance class** (1 000 t, Mio tkm, Mio Veh-km, 1000 BTO)

More detailed information on the collection of these data, vehicle variables, driving, goods is contained in EC Regulation no. No 70/2012 of the European Parliament and of the Council of 18 January 2012 on statistical returns in respect of the carriage of goods by road.

2.3. Comparison of statistical data on road freight traffic between Statistical Office of the European Union and the Statistical Office of the Slovak Republic

During comparison categories, it was found that data from Eurostat and the Statistical Office of the Slovak Republic corresponded to the categories listed in Table 2.

Table 2. Appropriate categories of identified indicators

Category		**Unit**
Statistical Office of the European Union	**Statistical Office of the Slovak Republic**	
total transport	transport of goods for own account and hire account together	thous.tons / mil.tkm
loaded vehicle - national transport	of which: national transport	
freight transport - goods unloaded in reporting country	import	
freight transport - goods loaded in reporting country	export	
cross trade transport	cross trade transport	
Road cabotage transport	international cabotage	

In the further examination of the categories, it was found that Eurostat has data on the Slovak Republic in the category "International transport - loaded vehicles together", which the SR does not provide. This category consists of the categories - import, export, cross trade transport and cabotage.

Furthermore, Eurostat has the categories: no-loaded vehicles together, no-loaded vehicles - domestic transport and no-loaded vehicles - international transport together. There is no data about Slovak Republic in these categories.

For the appropriate categories was made statistical comparisons were also made where differences were found.

Table 3. Differences in statistical data on road freight

	Category	**Average difference [%]**
Transport of goods [thous. tons]	*transport of goods for own account and hire account together*	**0,087**
	of which: national transport	**0,0153**
	import	**1,8334**
	export	**0,6914**
	cross trade transport	**0,6459**
	international cabotage	**7,9319**
Performances [mil. tkm]	*transport of goods for own account and hire account together*	**0,3998**
	of which: national transport	**0,3666**
	import	**1,739**
	export	**0,9649**
	cross trade transport	**0,433**
	international cabotage	**16,446**

In table 3 are the average differences (expressed in absolute value) for each category separately. The average differences were calculated for the period from 2004 to 2015,

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where the basis for comparison was data from Statistical Office of the Slovak Republic. The most significant differences are in the category of international cabotage, up to 7.9319% in the freight transport (thousand tons) and 16.45% in the freight transport performance (mil. tkm). The smallest differences are in the category domestic transport of goods (thousand tons), namely 0.0153%.

Differences in personal transport data were also investigated, where differences were also found. However, due to the limited number of pages, it is not possible to publish this data.

2.4. Performance tracking in road transport companies

The Statistical Office of the Slovak Republic performs statistical surveys to obtain information on the state and development of the economy and society of the Slovak Republic and for international comparisons.

The reporting obligation to fill in the statistical form results from the transport company from § 18 of Act 540/2001 Coll. on State Statistics as amended. If the transport undertaking did not carry out any activity or did not carry out the activity covered by this statistical survey during the reference period, it shall submit a report filled in by the available data.

In the case of statistical surveys, the selection of intelligence units is divided into two groups. The first are the intelligence units (transport companies) with the number of employees max. 19 and the second group are companies with a number of 20 or more employees. For the first group (up to 19 employees), a sample survey is conducted, with a sample of about 600 to 700 organizations. For statistical units with a staff of 20 or more, exhaustive surveys are under way (approximately 600 organizations). These sample organizations are selected from the registry of statistical units, which is available to the Statistical Office of the Slovak Republic in Bratislava. Furthermore, this collection of selected organizations is sent to the statistical office of the Slovak Republic in Zilina (Department of Transport Statistics). The Transport Statistics Department is tasked with sending individual reports to selected statistical units and then evaluating them.

The Transport Statistics Department sends these reports to selected statistical units:

- annual report of transport,
- monthly report of transport,
- weekly report of the operation of a road motor vehicle.

The reporting agents are required to complete this report each month and send it no later than the 17th day of the following month.

Annual report of transport

The annual report on transport mainly identifies the following:

- public and non-public road transport, domestic and international road transport,

- transport by type of goods, import and export, transport of dangerous goods, transport performance.

Monthly report of transport

Because of the scope of the article, it is not possible to list all the data. Template of this report is on the website of of the Statistical Office of Slovak Republic in the section metadata / industry statistics / transport and postal services / monthly transport report

Weekly report of the operation of a road motor vehicle

This weekly survey has been introduced in the EU since 1997. The sample is made up by the operators of the vehicle to which the VEH is assigned and the payload of the vehicle is greater than 1 000 kg.

This sample consists of 250 vehicles per week. Monitoring and verifying the accuracy of data provided by statistical units is subject to internal controls. These are done when irregularities are found in the evaluation of reports. Subsequently, a check is in order to verify the accuracy of the data or to explain irregularities.

3. Problems related to collecting statistical data of road freight transport companies

After a meeting at the workplace of the Statistical Office of the Slovak Republic in Zilina with Ing. Eva Sopoušková, Head of Transport Statistics, has found that one of the main problems of statistical surveys in road haulage enterprises is news discipline.

In the past there was a situation where the carrier was willing to pay a fine for not complying with the obligation to fill in the statistical form (Section 18 of Act No. 540/2001 on State Statistics as amended) to provide data to the Office. The question arises as to the capacity of the Statistical Office of the Slovak Republic in Zilina to legally resolve these rejections.

Another problem mentioned was contacting respondents. Even though the carrier by Act No. 56/2012 on road transport implies the obligation to publish the transport rules at its website, there are still companies that do not even have this seat. There are also foreign companies that often do not have the contact information listed. Written calls sent by post are returned to the undelivered office. In this way, their activity can not be monitored.

The problematic aspect of the survey of transport statistics is foreign companies, which are based in the Slovak Republic, but their vehicles are still outside Slovakia because they are not even addressed by the SR.

A complicated part of the survey is that the SO SR does not contact persons who have a trade to run a foreign motor vehicle. Employees of the Statistical Office of the SR obtain data contacting the statutors of companies, who often fail to respond to the call to complete the transport report. This situation could be solved by contacting not the company's lawyer, but the transport manager, who may, under certain conditions, lose the license of transport. Under this threat, intelligence discipline may gradually improve.

Weaknesses in the acquisition of statistical data can also occur by the fact that the Statistical Office of the Slovak Republic monitors (distributes) the enterprises according to the number of employees. Office does not monitor the number of vehicle licenses operated in company. This may lead to a situation where a company falls into a group with fewer than 20 employees, but actually operates many more vehicles (for example 70 vehicles). This could be removed by linking multiple databases. The Single Road Transport Information System has a database of individual transport companies and licenses issued to them. If this information were interconnected with the database on the number of employees, it would be possible to eliminate the misstatement of reporting units in the above-mentioned statistical groups.

At present, the license to practice a road transport operator is currently issued by district offices at the headquarters of the county. These authorities verify all the conditions necessary for the granting of this authorization and thus have all the necessary information regarding the applicant. The communication of the Statistical Office of the Slovak Republic and the district authorities could help to remove the aforementioned problems.

4. Conclusions

Tracking the transport market is a necessary step to make transport as such as better and more efficient. Currently regulates market access Regulation (EC) No 1071/2009 and Regulation (EC) No 1071/2009 of 21 October 2009. These regulations show not only that states are to monitor transport performance in the transport market, whether in passenger or freight transport, but also to monitor the development of costs and prices in transport.

Statistical survey of indicators in road freight transport is currently an important factor. Incorrect data can lead to inconsistencies. When selling a transport company, one of the important factors is also the market share of the company. If statistics are poor, this leads to further mistakes.

The statistical survey should be as accurate as possible and the results should give a real picture of the transport market.

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The purpose of long-distance passenger trains in public passenger transport system

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Abstract: Current economical trends create new requirements to population mobility. People always travel for many reasons and they are very dependent on the system of passenger transport. There are several modes of transport, but passengers mostly use road and rail transport. Passenger transport system is influenced by many qualitative factors with various impacts. Long-distance passenger trains have got significant position on the transport market, what represents demand and offer in the passenger transport system. These trains connects far places therefore transport accessibility in the region or country is better and passenger railway transport is more attractive for traveling public. This article is focused on main purpose of these trains from operational and economical point of view.

Keywords: railway transport, passenger transportation, long-distance trains

JEL: R420

1. Introduction

Passenger transport is generally considered as an activity, which arises as the consequence of spatial division of places, where people are in exact time and their need to move. Requirements for transport of passengers originate in their need to move, while the passenger transport is dependent on the willingness of travelling [1]. In passenger transport, there are mostly individual passengers, so it is difficult to determine all transport requirements. Passenger transport is divided into individual and public. Individual passenger transport includes walking, cycling and car transport. Public passenger transport includes railway, road, water, air, city and unconventional transport. From spatial point of view, passenger transport is divided into local, regional and long-haul, which is then divided into interregional transport (in one country) or international transport (among two or more countries) [2]. From economical point of view, passenger transport is classified into tertiary sphere – services. It means that there are not any material production values, but it is reflected in costs. In general, passenger transport has got a great social and political importance. Primary function of the transport system is providing transport for passengers on regional, national-interregional and international level [3].

2. Railway Passenger Transport in General

Key element in railway passenger transport is a customer – traveller, who requires the transport from one place to another. A basic precondition for accomplishing the main requirement – transport, is making the complete offer which provides not only transport, but also other associated services. Motivators for moving could be commuting – job or education, dealing with personal or working matters, travelling for vacation – hiking, sport, health, cultural and social facilities, visiting relatives and friends. From operational point of view, passenger transport is the sum of acts for providing mass transport of passengers which includes boarding, selling and checking the travel tickets, transfer of passengers' luggage, ensure all individual needs of passengers and organizing of other complementary services [4].

One of the most important roles of the railway passenger transport is providing transport services for passengers, who travel for long distances. There are various types of long-haul passenger trains, which jointly create integrated transport system. Quality of this transport system depends on train routes topology, timetable of trains, number and location of all stations, where these trains stop. Primary function of the transport system is providing transport for passengers on regional, national-interregional and international level [5].

3. Passenger Transport Quality Criteria

Practically, there are many associated criteria with passenger transport, for example safety, duration, price, reliability, comfort and complementary services. Safety is the dominant criterion and it is guaranteed normative by licences, permissions, certificates and verifications. Safety is measured by indicator of accidents per one billion passenger-kilometres [6].

Another criterion is transport duration, what means the exact time of passenger moves from one place to another and it is closely related with speed. It does not mean the speed of the transport vehicle, there are other periods, such as time to go from home to the station, time to buy the travel ticket, boarding time, transport time, time to get off the train and time to reach the destination point. In case, where the traveller combines the trains, time for waiting to another train is also counted. Very important criterion is transport price. It is dependent mostly on economic indicators. In market economy, there are three factors: costs, demand and competition. Other factors with significant impact are reliability, offer of travel possibilities, vehicle occupation and coherence of passenger transport system [5].

Travel comfort is also very important for passengers, especially nowadays. It consists of vehicle construction, interior hygiene, physiological and psychical influences. Subjective feelings and experiences has also great impact along with current mood of each passenger. Overall subjective feeling is the result of different conditions with different seriousness. Other complementary services with some impact to quality of traveling are services provided on board or in stationary facilities [6].

Entire quality is defined as an ability to satisfy all requirements of customers. Specific signs for services in transport are insubstantiality, impossibility to store, inseparability, variability, complexity and uniqueness. Level of service quality can be perceived as a disharmony among expectation and perception. Customers - passengers have got different priorities which are connected with quality of service. They usually remember low quality and high quality is a standard for them. The main challenge is to identify the passengers' needs and satisfy them in all cases because every transport is realized in different conditions [7].

4. The Importance of Different Types of Trains Connectivity

Long-haul passenger trains are intended to transport passengers mainly for long distances. Their routes usually connect regional centres with higher population. Regional passenger trains are adjusted to long-haul passenger trains transport system, therefore people from smaller towns and villages can also use long-haul passenger trains, which do not stop in their town or village.

According to long-haul railway passenger transport, the transport attendance in some area is dependent on accessibility of long-haul passenger trains in the centre of the area, and other transport hubs in this area. Transport hub is a place, where passengers enter, change or exit the transport system. Considering to long-haul railway passenger trains, transport hubs are all stations and stops, where these trains usually stop. The route of the train consists of exact number of transport hubs. All transport hubs are characterized by localization and discesion. Localization is variability of transport hubs on the route, which means the exact number of stations and stops, where long-haul passenger trains stops. Discesion is mutual layout of transport hubs on the route to each other. Railway passenger station is some kind of transport hub – a starting and finishing point for flows of passengers. Passengers have the opportunity to change the train type from long-haul train to regional train or contrariwise or simply enter or leave the system of railway transport.

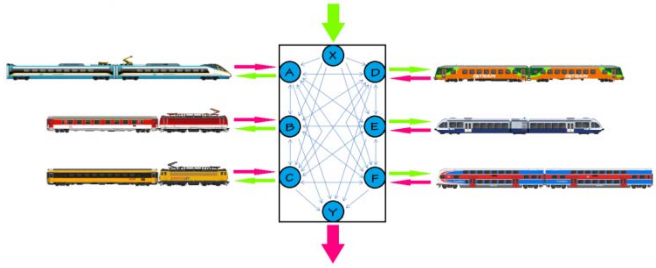

Figure 1. Simple scheme of railway passenger station with marked passenger flows there.

In the picture, there are illustrated flows of passengers between train types which arrive from different directions and depart to different destinations. Points A, B, C, D, E and F represent trains whereas point X represents input to the transport system and point Y represents output from the transport system where passengers use another mode of transport instead of railway transport.

In central Europe, there is a modern trend of establishing integrated passenger transport systems in selected regions. Cores of these systems are terminals, where passengers can change vehicle and also the mode of transport, for example get off the bus and get on the train. These terminals are hubs, whence all routes and lines from some region or district are connected. Building these new terminals will improve transport accessibility in the selected region. Operators, who participate in the integrated passenger transport system, are more effective and notice increased demand for transport services.

Figure 2. Integrated passenger transport terminal in Moldava nad Bodvou mesto, Slovakia [8].

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Current trend is to optimize connectivity in railway passenger transport by reduction of transfer time – starting at home and finishing in the transport destination. It is important to synchronize arrivals and departures of all connected trains in all points, where passengers can get on, get off and change the vehicle. Minimizing of waiting time will increase quality of passenger transport in general. Particular emphasis must be put on reliability of all included vehicles, because delays could have serious consequences to the whole system. Preconditions for optimization of train connectivity in railway passenger transport are: dominance of passenger, timetable dependent on passengers' needs, synchronized arrivals and departures in all point in the transport system, harmonised conditions for all operators in the transport system, high reliability and punctuality [6].

5. Economic Impacts in Railway Passenger Transport

Railway passenger transport has to be evaluated from economical point of view. Basic evaluation method is operating costs calculation. Costs are financial representation of company sources consumption for realizing services per time. Internal costs of the transport company arise from operation of trains on railways. Thanks to calculation, the exact amount of these costs is known. In railway passenger transport, the calculation unit is the service – transporting of passengers. It can be defined by quantity (number of trains, vehicles), time (staff working time, time of traveling) or other way (passenger-kilometers, train-kilometers) [3].

In general, there are these costs: vehicle costs (price for vehicle, repairs and maintenance, insurance, operational cleaning), railway infrastructure access, staff costs (wages of vehicle-drivers and stewards), traction energy consumption and other indirect costs (management, marketing, travel ticket selling system, information system etc.). Sum of all costs, which are converted to one typified train on the route, is the base for making the tariff charges [7].

Railway vehicle costs are calculated this way:

$$r^{RV}_{trkm} \frac{D_Y + \ \Sigma RM_Y + OC_Y + \ INS_Y}{Ø\ annual\ vehicle\ kilometrage} \quad (1)$$

where: r^{RV}_{trkm} – railway vehicle costs rate for train-kilometre [€/trkm]; D_Y – depreciation of vehicle per year [€]; ΣRM_Y – entire costs for repairs and maintenance of vehicle per year [€]; OC_Y – entire costs for operational cleaning of vehicle per year [€]; INS_Y – entire costs for vehicle insurance per year [€]; Ø annual vehicle kilometrage – average kilometrage of railway vehicle per year [km].

$$C_{RV} = \ \Sigma trkm\ .r^{RV}_{trkm}\ .NRV_{tr} \quad (2)$$

where: C_{RV} – entire railway vehicle costs per route [€]; Σtrkm – sum of train-kilometres per route; r^{RV}_{trkm} – railway vehicle costs rate for train-kilometre [€/trkm]; NRV_{tr} – number of railway vehicles in the train on the route [vehicles].

Staff costs are calculated this way:

$$r^{S}_{emph} = \frac{price\ \ for\ \ working + equipment}{\Sigma\ \ work\ \ time} \quad (3)$$

where: r^{S}_{emph} – staff costs rate for employee-hour [€/emph] price for working – all month company's costs for the employee [€]; equipment – month costs for equipment of employee [€]; Σ work time – entire month work time of employee [hours].

$$C_S = t_r\ \ .CR_S\ \ .s^{S}_{emph} \quad (4)$$

where: C_S – staff costs per route [€]; t_r – train ride time [hours]; CR_S – conversion ratio: train ride time →employee-hour; r^{S}_{emph} – staff costs rate for employee-hour [€/emph]

Traction energy consumption costs are calculated this way:

$$C_{TEC} = \frac{\Sigma gtkm\ \ .mc_{TE}\ \ .s_{TE}}{1000} \quad (5)$$

where: C_{TEC} – entire traction energy consumption costs per route [€]; Σgtkm – gross-tons-kilometres per route; mc_{TE} – measurable consumption of traction energy per thousand gross-tons-kilometres; r_{TE} – traction energy rate [€]

From operating costs calculation, tariff rates can be appointed. The tariff reflects valuable relations among the operator and passengers. These rates have to include internal goals of the operator (increasing profit, decreasing costs, market share etc.), social sphere (quality and offer of public transport, reducing regional gaps etc.) and environmental aspects. Current transport demand and complementary transport offer are also important part of setting tariff rates.

6. Conclusions

The purpose of long-haul passenger trains is transporting passengers for long-distances. Together with regional passenger trains, they form the railway passenger transport system – basic part of the whole passenger transport system. This purpose of long-haul trains is influenced and evaluated from many points of view. According to passengers' will, transportation in long-haul trains should be safe, fast, cheap and comfortable. A great emphasis is put on connectivity with other types of trains to eliminate waiting time in stations or terminals, where passengers have to change the vehicle. It would also influence transport accessibility in some region. Economic aspects are stated operating costs calculation, what is necessary for operation of long-haul passenger trains in each route worldwide. Quality of the whole passenger transport system is dependent on effective operation and economics of the transport companies.

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Calculation of total costs when ensuring railway passenger transport at the Bratislava to Banská Bystrica line

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Abstract Nowadays, great emphasis is placed on the quality of services provided in rail passenger transport, which is influenced by several factors. The competition between operators in the public tender when ordering paths in long-distance rail passenger transport is very significant. The aim of this article is to analyse steps of the Slovak government in the announcement of the first public tenders to provide subsidized transport of a selected line and to determine conditions for this tender. During 2015, Slovak Ministry of Transport began to take steps towards the liberalisation of the long-distance domestic rail passenger service on the Bratislava to Banská Bystrica line, which opened up the market for domestic passenger services to a new railway company. The Bratislava to Banská Bystrica line was chosen because of the provision of sufficient transport performance and passenger flows. The liberalisation process of the Bratislava to Banská Bystrica line is still ongoing, and has entered competitive conditions and criteria stage, although the tender had yet to be concluded in 2015.

Keywords liberalization passenger transport, public tenders, long-distance transport

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1. Introduction

The partial liberalisation of the rail market in the European Union (EU) was already underway in 2010, when all European railway companies with the necessary licences and safety certificates gained access to railway infrastructure in all Member States. One of the current objectives of the common transport policy laid down in The fourth railway package is to open up the market for national rail passenger services in all Member States from 2019, while making public tenders for transport service contracts compulsory, in the public interest. A fundamental step in the liberalisation of the rail freight market has been the separation of railway infrastructure managers from railway companies and consequently providing non-discriminatory access to railway infrastructure to the railway companies in all Member States. [1]

The biggest problem in the opening up of domestic passenger transport is that the tracks upon which traffic is controlled is also subsidised by the State, because it is impossible to create a natural competitive market. The situation has improved because of the impact of European reforms, although the operation of these lines remains costly, so it is not possible to create transparent competition. For this reason, the State continues to control and subsidise traffic performance but the possibility of public competition to secure operations on selected routes followed by their state subsidies is increasingly coming to the fore. [2]

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In 2009, the European Parliament and Council Regulation EC No. 1370/2007 came into force, which sets out the selection procedures for the award of contracts in public rail transport. The Slovak Republic's Ministry of Transport, and Development (MDV) contracted with the best railway company operating rail services (Železničná spoločnosť Slovensko, a.s., The Railway Company Slovakia Inc., or ZSSK) to carry out transport services in the public interest for a period of nine years (2011 to 2020). This contract also includes operations in regional transport, which are agreed together with operations in long-distance transport. [2].

2. Call for public tender in railway transport in Slovakia

There are two railway companies with which the State has concluded contracts for transport services in the public interest for domestic passenger transport in the Slovak Republic: ZSSK and the private railway company, RegioJet, Inc. At present, there are two options of providing transport services in the Slovak Republic. The first is when a railway company provides transport services at its own business risk and this principle is applied to lines with sufficient capacity and performance, where there is less risk of potential financial loss to the company. Currently this type of provision of transport service is used by RegioJet Intercity on the Bratislava to Košice line. The second type is when a railway company provides transport services in the public interest. [3]

In January 2012, there was a change on the Bratislava to Košice line because of a sufficient number of services and passenger traffic flows. ZSSK started to operate its Intercity trains as commercial trains from a contract on traffic performance in the public interest. For these trains, there is a separate tariff policy, they are not subsidised by the State and the railway company operates at its own business risk. In December 2014, RegioJet started providing the same transport services on the same line, with the result that ZSSK stopped operating its Intercity trains in January 2016. In December 2016, ZSSK began to provide transport services by Intercity trains again.

There are two forms of contracts for transport services in the public interest, either by tendering the competition for traffic performance following the end of a contract, or by directly entering the selected railway company. A contract for transport services in the public interest by direct assignment to a railway company was realised on the Bratislava to Komarno line. The Ministry of Transport carried out a tender and awarded the transport service to a specific railway company, RegioJet. The contract was agreed in December 2010 for a period of nine years from March 2012 to December 2020 and the contracted transport performance was stipulated at 1.3 million train kilometres. [3]

The analysis by Ministry of Transport showed that, after RegioJet took on the railway passenger transport March 2012, there was visibly increased train traffic on this track (from Dunajska Streda to Bratislava there is a one hour period during the day, and half an hour period during peak time), and as a result there is a significant increase in transport performance. Year on year, in the period October 2012 to October 2013, there was an increase of 74% in train kilometres, 146% in passenger kilometres, and 115% in the number of passengers of. It was also noted that there was a reduction in the cost per train kilometre of 5.7€, which represents a cost reduction of 16% when compared with a national carrier. [3]

In September 2015, the first competition for subsidised services in the public interest started, when advance notice of invitation to tender for the long-distance Bratislava to Banská Bystrica line was published and, in November, the tender was declared without publication of the estimated value of services. The price of the services, however, was estimate at over 10 million euros. The deadline for this competition was January 2016 and eight candidates enrolled. The competition was not evaluated. [4]

3. Long-distance line Bratislava to Banská Bystrica

The object of the competition was to ensure safe, effective and quality transport services to passengers between the cities of Bratislava and Banská Bystrica by long-distance trains. The contract for transport services in the public interest will be concluded with an eventual candidate under the Act of Railroad No. 514/2009. Annual transport performance is expected to be in the range of about 1.5 million train kilometres and the extent of transport operations for the year will be specified by a special addition to the contract. For realised traffic performance, the State will reimburse verifiable losses to the railway companies. In 2016, the extent of total transport performance at ZSSK represented 31,304 million train kilometres, thus the competitive amount represents 4.79% of train kilometres operated by ZSSK. [3]

The Ministry declared that one of the objectives of the competition was to generate the most favourable economic conditions for both the State and the passenger, while ensuring the operation of services achieved the required quality. The State currently reimburses around 6.7€ per train kilometre to ZSSK. Provisionally in this contest it envisaged the inclusion of eight pairs of express trains, which run daily, and two pairs of relief trains running on Friday and Sunday. [5]

The 2016/17 timetable on the Bratislava - Banská Bystrica line operates nine direct express trains, including eight trains in a two-hour period during the day. Also in the opposite direction, there are nine direct express trains, including three trains in the morning one-hour period and the remaining six trains in a two-hour period. The transport has a length of 230 kilometres, achieved travel time is three hours 24 minutes and the average cruising speed is 67.6 kilometres per hour.

4. Proposal for ensuring rail passenger transport on Bratislava – Banská Bystrica line

When creation proposal of long-distance rail passenger transport of Bratislava – Banská Bystrica line we take into account the conditions, which were set out in the Notice of public tender announced by the Ministry of Transport. The total extent of the services is defined as the minimum level. To fulfil the object of the contract it is required at least 7 trains or train units with a minimum capacity of 530 seats for each train or train unit. It is also required the creation of at least one operational reserve (one train or train unit). An analysis of the current timetable for the case study contemplated 9 pairs of trains category fast train (R). Based on the circulation of train sets were found to be necessary to ensure the required performance to the line 6 trains or multiple units and 1 operational margins. We will consider deploying the classic sets composed of an electric locomotive eligible operating on AC electric systems and 7 wagons of classical construction, also seven locomotives and 49 wagons together. For ensuring long-distance transport on the Bratislava - Banská Bystrica line was selected the bi-current locomotive

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class 361.1. This locomotive has four axles, a box shape and it's design speed is 160 kilometres per hour. It is designed for trains on electrified lines, where the electricity supply system is changing. To ensure rail passenger transport in required quality services, they were also selected second class carriages (Bdteer class) for passengers. These wagons are intended for long-distance transport and designed to meet the requirements of international transport and interoperability. Bdteer carriage has open-space interior and the automatic sliding entrance doors, which speed up passengers boarding. [3]

Calculation of total costs, which may be incurred when providing passenger rail transport at the selected relation, is based on the average costs calculated per year.

Railway infrastructure costs

When calculating railway infrastructure costs, it is needed to find out the gross train weight according to the formula (1): [7]

$$Q = Q_{ruš} + Q_{vz} + n_{miest} \cdot 0{,}08\ [t] \qquad (1)$$

where Q is gross train weight [t], $Q_{ruš}$ is locomotive weight [t], Q_{vz} is carriages weight, n_{miest} is number of seats available and then the gross train weight calculation is:

$$Q = 86 + (7 \cdot 46) + (7 \cdot 80) \cdot 0{,}08 = 452{,}80 \cong 453\ t$$

Railway infrastructure costs are calculated according to the Decree of the Railway Regulatory Authority No. 3/2010 setting the charges for the access to railway infrastructure. These costs include charge for the minimal access package and charge for the access to the service devices. There are six line categories in the Decree, and because of this, lines have to be divided into categories. There is the first category line Bratislava - Palarikovo with its length 81 kilometres and the second category line Palarikovo – Banská Bystrica with its length 149 km.

First, it is needed to calculate charge for the minimal access package, according to the formula: [6], [7]

$$U_{mp} = U_1 + U_2 + U_3 \qquad (2)$$

where U_1 is charge for ordering and allocation of the capacity, U_2 is charge for the management and organization of traffic, U_3 is charge for ensuring the infrastructure serviceability. Second, there is needed the calculation of charge for the access to the service devices, following the formula: [6], [7]

$$U_{tp} = U_{tp1} + U_{tp2} \qquad (3)$$

where U_{tp1} is charge for using of electrical supply device and U_{tp2} is charge for using railway stations. Charges for the access to railway infrastructure according to track category are shown in the Table 1.

Table 1. Charges for the access to the railway infrastructure [€/one train]

Category	1.	2.
Track section	Bratislava - Palárikovo	Palárikovo – Banská Bystrica
U1	1.6767	2.831
U2	77.598	131.269
U3	48.10452	85.11372
Utp_1	27.0894	
Utp_2	25.929	

Total charges for the access to railway infrastructure is 399.6113 € per one train and 2 625 446.5 € per one train per one year.

Cost of rolling stocks

It was not possible to determine an exact rent of rolling stocks (because of trade secret) then the rent was based on acquisition cost of locomotive and carriages. Rental price was set at 65 € per hour per locomotive and 28 € per hour per carriage. The necessary number of wagons to ensure conditions for a minimum capacity of 530 seats in the train's seven wagons Bdteer series, which consists of 560 seats in the train. The cost of the carriages and locomotive are both calculated by the following formula: [6], [7]

$$N_{R,V} = P_{R,V} \cdot n_{rok} \cdot t \cdot n_{R,V}\ [€/year] \qquad (4)$$

where $N_{V,R}$ are total rolling stock costs, $P_{V,R}$ is rent for locomotive/carriages, n_{rok} is number of days per year, t are hours per day, $n_{V,R}$ is the number of locomotives/carriages in all trains. Then the calculation of locomotive costs is:

$$N_R = 65 \cdot 365 \cdot 24 \cdot 7 = 3\ 985\ 800\ €$$

$$N_V = 28 \cdot 365 \cdot 24 \cdot 49 = 12\ 018\ 720\ €$$

The total rolling stock costs (for locomotives and for carriages together) are 16 004 520 € per one year.

Costs of locomotive and train crews

Costs of locomotive and train crews are calculated by using the gross wage of train drivers and conductors. The high of gross wage is based on analysis of the costs of operating the trains on the relation Bratislava – Komárno. These data were recalculated by index. The gross wage is set on 920 € for the train drivers and 750 € for the conductors. Indirect costs for train drivers is set 500 € and 300 € for the conductors. When formation the working turn for employees, the number of train drives was set on 22 people and the number of conductors was set on 88 people. Employer's contributions are at 35.2 % of gross wages. Costs of locomotive and train crews are calculated by the following formula: [6], [7]

$$N_{RČ,VČ} = P_{RČ,VČ} \cdot (CCP + N_n) \cdot I_{inf}\ [€] \qquad (5)$$

where $N_{r,s}$ are costs of train drivers/conductors, $P_{r,s}$ is the number of train drivers/conductors, CCP is the total labour cost (gross wage + employer's contributions) and N_{nep} are indirect costs of train drivers/conductors. Then the final calculations of locomotive and train crews are:

$$N_{R\check{C}} = 22 \cdot (1317.94 + 500) \cdot \left(1 + \frac{11.33}{100}\right) = 44\,526.07\ €$$

$$N_{V\check{C}} = 88 \cdot (1014 + 300) \cdot \left(1 + \frac{11.33}{100}\right) = 128\,733.11\ €$$

Total costs of all locomotive crews are 512 534.11 € per year and for locomotive crews are 1 544 797.27 € per year.

Costs of energy

$$N_E = \frac{1}{1000} \cdot Q \cdot L \cdot m_e \cdot S_e [€] \qquad (6)$$

where *Q* is total gross weight of train, L_e is the length of crossing electrified tracks, m_e is energy consumption for specific type of locomotive and S_e is rate of energy (price for 1 kWh of electricity). Then the calculation costs of energy are: [6], [7]

$$N_E = \frac{1}{1000} \cdot 453 \cdot 230 \cdot 25 \cdot 0.15 = 390.54\ €/per\ one\ train$$

Energy consumption for the locomotive type 361.1 is 25kwh/1000 hrtkm according to the Study of the Transport research centre in the Czech Republic. Total costs of energy are 2 565 847.8 € per year.

Total costs

Total costs are comprised of direct and indirect costs. Direct costs are calculated above, it means the summation of railway infrastructure costs, costs of rolling stocks, costs of locomotive and train crews and costs of energy. Indirect costs include costs of the tickets selling, costs of services for passengers in railway stations, insurance costs etc. and comprise 20 % of direct costs. The high of direct and indirect costs is shown in the Table 2.

Table 2. Calculation of total costs

Total costs [€/year]	
Direct costs	23 274 924.5
Indirect costs	4 654 984.9
Total costs	**27 929 909.4**

Revenues

The high of revenues was determined based on the current occupancy of all connections on the relation Bratislava – Banská Bystica last year. The occupation is divided into three track sections on this relation (Bratislava – Sala, Sala – Levice, Levice – Banská Bystrica). There are two tables for occupancy because of considerably different number of passengers during the peak and off-peak hours. The occupation, which we consider when calculating average revenues, was decreased of the number of passengers using complimentary transport. It was considered the average rate 0.066 € per one kilometre when calculating the revenues. The occupancies (with and without the complimentary transport passengers) and revenues during the peak and off-peak hours on selected track section are shown in the Table 3 and the Table 4. Then total average revenues for all trains on the Bratislava – Banská Bystica line according to current occupancy are 17 205 828.34 € per one year.

Table 3. Revenues during the peak hours

Track section	Occupancy [%]	Occupancy by paying passengers [%]	Distance [km]	Revenues for one train [€]
Bratislava - Šala	95	54.15	60	1 085.79
Šala - Levice	65	37.05	72	891.49
Levice – Banská Bystrica	50	28.50	98	933.40
Banská Bystrica – Levice	60	34.20	98	1.121.08
Levice – Šala	70	39.90	72	960.07
Šala - Bratislava	85	48.45	60	971.50

Table 4. Revenues during the off- peak hours

Track section	Occupancy [%]	Occupancy by paying passengers [%]	Distance [km]	Revenues for one train [€]
Bratislava - Šala	40	22.80	60	457.18
Šala - Levice	35	19.95	72	480.03
Levice – Banská Bystrica	45	25.65	98	840.06
Banská Bystrica – Levice	30	17.10	98	560.04
Levice – Šala	45	25.65	72	617.19
Šala - Bratislava	60	34.20	60	685.76

The difference between revenues and costs is shown in the Table 5. The amount of compensation for provided services on the Bratislava - Banská Bystrica line ranges from 13.8 to 16.3 million € per year by available information.

Table 5. Revenues and costs

Revenues	18 278 923.22 €
Direct costs	23 274 924.50 €
Indirect costs	4 654 984.90 €
Total costs	**27 929 909.40 €**
Difference	**-9 650 986.18 €**

There will be new modern and well equipped trains or train units on selected line, which will provide good conditions for passengers while travelling and also ensure the higher quality and comfort ability. New selected railway undertaking has to ensure more train connections (in both directions), what will probably increase the number of passengers. Based on this, there are expected higher revenues about 10 % in future. Increasing of revenues will reduce the amount of compensation of economically justified costs.

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5. Conclusions

Nowadays it is expected arrival of a new railway undertaking that will provide its transport services on selected line. Therefore, it is important to design appropriate solutions that would be beneficial not only for new provider of transport services, but also for all the travelling public. This is a significant moment in the railway market in the Slovak Republic, preparing the opening up of the market for domestic long-distance passenger rail transport for competition in the provision of transport services in the public interest. This is a comprehensive process that achieves the desired effect only if it is well prepared. The priority, from the perspective of the passenger, is transit time and it should be noted that the line for competition already has a significant competitor in the form of road traffic, with the completion of the highway R1, where travel time is two hours and 50 minutes by bus and two hours and five minutes by car.

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