Methods for evaluation of integrated transport systems

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ABSTRACT

Integrated transport systems are considered a modern way for management of public transport services in regions. Many new integrated transport systems have been created or are planned in Central European countries. A common method for their comparison and evaluation is necessary considering differences of these systems in many attributes. The results of the evaluation method proposed in this article could lead to improvement in the quality of evaluated transport systems.

KEYWORDS: integrated transport systems, public transport, evaluation methods

1. Introduction

As many new integrated transport systems (ITS) are planned in Central European countries, a method for evaluation of their influence on transport services and on regions becomes more and more necessary. The method proposed for evaluation of influence of ITS on transport services in a region and on a region itself is described below in this article.

2. Methods for integrated transport systems influence analysis

The proposed method is based on criteria, which could be divided into three groups. The first two groups are used for the evaluation of influence on transport services in a region. The first group comprises criteria, which values depend on the origin and destination of the trip. The second group comprises criteria, which values are independent of the particular route. The third group of criteria is used for the evaluation of the influence on the region development.

The particular criteria used in the analysis are as follows:
- dependent criteria for the evaluation of ITS influence on transport services:
  › the transportation time,
  › the transportation price,
  › the number of transfers necessary to reach the destination,
  › the number of connections on weekdays and weekends.
- independent criteria for the evaluation of ITS influence on transport services:
  › a joint ticket,
  › an interval schedule.
- criteria for the evaluation of ITS influence on the region:
  › the number of passengers in the public transport,
  › the gross domestic product,
  › the unemployment rate,
  › the number of inhabitants,
  › the number of traffic accidents.

Criteria of groups I and II give a comprehensive view on the status of transport services in a region according to its definition. Group III comprises criteria, which values are statistically observed and which describe the economic and social situation of a region.

The value of individual criteria for the analysis is calculated by one of the following formulas. For criteria, where the increase in their value is positive, the following formula is used:

$$H^i = \frac{H^i_y}{H^i_x}$$

(1)

where: H^i – the value of criterion for the analysis,
H^i_y – the value of criterion in the year y ,
H^i_x – the value of criterion in the year x ,
y – the last year of reference period ,
x – the first year of reference period.

Formula (1) is used to calculate the values of the following criteria:

- the number of connections on weekdays,
- the number of connections on Saturdays,
- the number of connections on Sundays,
- the number of passengers in the public transport,
- gross domestic product,
- the number of inhabitants.

For criteria, where the decrease of their value is positive, the following formula is used.

$$H^i = \frac{H^i_x}{H^i_y}$$

(2)

where: H^i – the value of criterion for the analysis,
H^i_y – the value of criterion in the year y ,
H^i_x – the value of criterion in the year x ,
x – the first year of reference period ,
y – the last year of reference period.

Formula (2) is used to calculate the values of the following criteria:

- the transportation time,
- the transportation price,
- the number of transfers necessary to reach the destination,
- the unemployment rate,
- the number of traffic accidents.

For soft criteria, which value could not be exactly assessed using mathematic methods, the following formula is used.

$$H^i = \{0;1\}$$

(3)

where: H^i – the value of criterion for the analysis.
Formula (3) is used to calculate the values of the following criteria:

- a joint ticket,
- an interval schedule.

2.1 Dependent criteria for the evaluation of ITS influence on transport services

2.1.1 Transportation time

For the transportation time, the time from the boarding to the first vehicle to leaving the last vehicle at the particular trip (including the transfer times) is used. The value of criterion in particular years is calculated using the following formula:

$$H^t_{rok} = \sum_i \sum_j t_j$$

(4)

where: H^t_{rok} – the value of criterion transportation time in the year,
t_{ij} – the time of journey from the origin i to the destination j.

Whereas the decrease of the transportation time contributes to the improvement of transport services, formula (2) is used to calculate the value of the transportation time criterion.

2.1.2 Transportation price

The sum of prices of tickets for individual sections of the journey is calculated for the transportation price. The price of a joint ticket is used, where possible. In the evaluated regions, the transportation price is calculated for the same trips as the transportation time. The value of criterion in particular years is calculated using the following formula:

$$H^c_{rok} = \sum_i \sum_j c_j$$

(5)

where: H^c_{rok} – the value of criterion transportation price in the year,
t_{ij} – the transportation price from the origin i to the destination j.

The decrease of transportation price is one of methods for increasing the number of passengers in public transport. Based on this, formula (2) is used to calculate the value of transportation price criterion.

2.1.3 Number of transfers necessary to reach the destination

Within the frame of this criterion a typical (most frequent) number of transfers necessary to reach the trip destination from its origin is used. The number of transfers is evaluated for trips, which are used for the transportation

time and price criteria. The value of criterion in particular years is calculated using the following formula:

$$H_{rok}^{p} = \sum_{i}\sum_{j} p_j \qquad (6)$$

where: H^p_{rok} – the value of criterion of transfers number in the year,

p_{ij} – the number of transfers necessary to reach regional centre j from municipality i.

The attractiveness of public transport increases, when the number of necessary transfers decreases. Therefore formula (2) is used to calculate the value of transfers number criterion.

2.1.4 Number of connections

The number of connections is the next of important indicators of the area transport services quality. These are not only the basic transport services, but also other transport services including the possibility of transportation on weekends and public holidays. For this reason, the number of connections is evaluated separately for working days, Saturdays and Sundays and public holidays. The number of connections is evaluated for the same trips as in the case of previous criteria. The value of criterion in particular years is calculated using the following formula:

$$H_{rok}^{s}(D) = \sum_{i}\sum_{j} s_j \quad D \in \{PD ; S; N\} \qquad (7)$$

where: H^s_{rok} (D) – the value of criterion of connections number in the year,

s_{ij} – the number of connections from origin i to destination j or back,

D – type of day,

PD – working day,

S – Saturday,

N – Sunday and public holiday.

When the number of connections increases the attractiveness of the public transport increases as well, because it gives more transport possibilities. Therefore formula (1) is used to calculate the value of connections number criterion.

2.2 Independent criteria for the evaluation of ITS influence on transport services

2.2.1 Joint ticket

This is the criterion independent of the trip origin and destination. This criterion could be met or not, therefore formula (3) is used to calculate the value of joint ticket

criterion. The value of *0* is assigned, when the joint ticket does not exist, the value of *1* is assigned, when the joint ticket for regional transport, which is one of the indicators of functional ITS, exists.

2.2.2 Interval timetable

The value of this criterion is calculated based on formula (3). The value *0* is assigned, when the interval timetable is not established in the region. The value *1* is assigned to the region, where the dominant part of connections is scheduled according to the interval timetable, as usual in the advanced ITS.

2.3 Criteria for the evaluation of ITS influence on a region

2.3.1 Number of passengers in public transport

This is the first criterion for the evaluation of ITS influence on the region. One of main reasons for the ITS establishment is the increase in the number of passengers of public transport and contextual decrease of the number of passengers using the individual automobile transport. Therefore the increase in the number of passengers is the indicator of public transport success. The value of criterion in particular years is calculated using the following formula:

$$H_{rok}^{n} = N_{MHD} + N_{RAD} + N_{RZD} \qquad (8)$$

where: H^n_{rok} – the value of criterion of passengers number in public transport in the year,

N_{MHD} – the number of passengers in the municipal public transport,

N_{RAD} – the number of passengers in the regional bus transport,

N_{RZD} – the number of passengers in the regional rail transport.

The increase in the number of passengers is an indicator of the public transport quality. Therefore formula (1) is used to calculate the value of connections number criterion.

2.3.2 Gross domestic product

The gross domestic product is one of basic macroeconomic indicators describing the economic performance of a region. For that reason the trend in the gross domestic product is evaluated for the analysis of the influence of ITS on a region. The GDP increase reports on

the rising economic performance of a region. Therefore formula (1) is used to calculate the value of gross domestic product criterion.

2.3.3 Unemployment rate

One of the basic aims of transport services is the assuring of transport to the work. This target also used to be defined when integrated transport systems are founded. Taking in consideration that the decrease of the unemployment rate is connected with the improvement in conditions on the labour market, formula (2) is used to calculate the value of connections number criterion.

2.3.4 Number of inhabitants

The depopulation is one of the indicators of region, which is not developing. The depopulation is also related to the bad accessibility of the given area. Therefore the inhabitants number criterion is included in the analysis of ITS influence on the development of a region. Considering the fact that the increase in the number of region inhabitants is connected with the increase in the quality of life in this region, formula (1) is used to calculate this criterion.

2.3.5 Number of traffic accidents

The increase in the number of traffic accidents is the side effect of the increase in the number of vehicles on roads. Therefore the deceleration of increase in their number is one of the main targets of ITS establishment. The transfer of part of passengers from individual automobile transport to the public transport should lead to the decrease of the number of traffic accidents. For the evaluation of this hypothesis, the criterion of traffic accidents number is included in the analysis of ITS influence on a region. Considering that the decrease of number of traffic accidents is positive, formula (2) is used to calculate the value of connections number criterion.

3. Results

The development of transport services in regions with ITS and regions, where ITS is not in place, was evaluated and then the development of these regions was also evaluated. These ITS – IREDO and IDS JMK – were chosen based on the fulfilment of criteria set. The own proposed method was used for the influence evaluation.

A considerable difference in all criteria could be stated except for the number of transfers between regions with integrated transport systems, i.e. Královehradecký region

(Královehradecký kraj - KHK) and South Moravia region (Jihomoravský kraj - JMK), and Vysočina region (Kraj Vysočina - KVys), where ITS is not operated, in favour of regions with ITS. The difference in values of connections number criteria in particular days of week is extremely distinctive. Actually, there a distinctive difference between regions with ITS could be also noted; supposedly it is connected with different quality standards in individual ITS. Just in the case of the number of transfers the value of criterion for Vysočina region lies between values of other regions. This fact is related to the delivery of passengers by buses to the backbone rail transport in ITS. The values of dependent criteria are summarized in table 1.

The different status of integration in individual regions is evident from the evaluation of independent criteria of transport services. The values are summarized in table 2.

The last evaluated group of criteria comprises general criteria of the regional development, which are summarized in table 3. The value of passengers number in public transport is distinctively different for Královehradecký region, where a high increase in the number of passengers was registered in the period. The values for other regions are comparable.

The gross domestic product criterion shows relatively high difference of values for regions with ITS. The value for the Vysočina region lies in the average of values of other regions.

Table 1. Dependent criteria of transport services

Criterion	Year	JMK	KHK	KVys
Transportation time	2004	54.10	50.37	50.28
	2007	48.72	44.90	47.63
	H	1.110	1.122	1.056
Transportation price	2004	2479	2010	1735
	2007	1902	1763	1928
	H	1.303	1.140	0.900
Number of transfers	2004	44	51	28
	2007	45	38	27
	H	0.978	1.342	1.037
Number of connections WD	2004	777	535	390
	2007	1216	738	428
	H	1.565	1.379	1.097
Number of connections Sa	2004	216	112	103
	2007	528	190	105
	H	2,444	1,696	1,019
Number of connections Su	2004	232	125	112
	2007	530	240	108
	H	2,284	1,920	0,964

Source: [2], author

Table 2. Independent criteria of transport services

Criterion	JMK	KHK	KVys
Joint ticket	1	1	0
Interval schedule	1	0	0

Source: author

The unemployment rate criterion for regions with ITS has higher values than in the Vysočina region. However the fact that the unemployment rate was the lowest and consequently there was less scope for the unemployment rate reduction in the region, Vysočina has to be taken into account.

A higher value of inhabitants number criterion could be observed in the case of Jihomoravský region. In other regions the values are comparable.

The value of traffic accidents number criterion is distinctively lower in the Vysočina region as compared with regions with ITS, where the values are comparable.

table 3 Regional development criteria

Based on the results of the evaluation of regional development criteria it could be stated, that the influence of an ITS on the number of passengers in the public transport, gross domestic product and the number of inhabitants was not confirmed. In the case of other criteria (unemployment rate, number of traffic accidents) the values in regions with ITS are significantly higher, indicating the influence of ITS on these criteria values. In the case of unemployment rate the smaller scope for its reduction and consequent increase in the criterion value in the case of region Vysočina has to be taken into account.

4. Conclusion

The proposed method could be used to evaluate the integrated transport systems influence on transport services in a region and on a region itself. The method could be also extended in the future with more criteria, however it is necessary to have in mind that many of them, which were also taken into consideration in the phase of the method creation, could be considered redundant.

Results achieved for regions in the Czech Republic show that even if the ITS influences transport services in a region, its implementation without other arrangements has not significant effect on the region itself.

Table 3. Regional development criteria

Criterion	Year	JMK	KHK	KVys
Number of pass. in public transport (thous.)	2004	410 408.8	49 489.0	41 981.5
	2007	433 899.7	66 379.5	44 571.5
	H	1.057	1.341	1.062
Gross domestic product (mil. CZK)	2004	284 441	135 420	120 038
	2007	362 044	160 462	147 554
	H	1.273	1.185	1.229
Unemployment rate (%)	2004	8.34	7.67	6.85
	2007	5.43	4.70	4.65
	H	1.536	1.632	1.473
Number of inhabitants	2004	1 122 391	546 995	510 227
	2007	1 135 421	550 523	512 555
	H	1.012	1.006	1.005
Number of traffic accidents	2004	18 911	10 180	8 911
	2007	16 022	8 696	8 086
	H	1.180	1.171	1.102

Source: [2], author

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