ISSN 1330-3651 (Print), ISSN 1848-6339 (Online)
DOI: 10.17559/TV-20160218095139

ESTIMATING MARGINAL INFRASTRUCTURE COST IN NEW INFRASTRUCTURE CHARGING MODEL

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Original scientific paper
Competitiveness of rail transport compared to road transport has been reducing, especially on regional railway lines. To improve this situation, the EU adopted various directives and regulations to increase efficiency of railway undertakings. In this paper we present an organizational and economic model based on European policies for local railway system. The organizational model is based on multi-criteria decision analysis. For the economic model we used an econometric approach to estimate the cost function and marginal costs in regional lines, which constitute the basis for railway charges. By implementing such an organizational model, the functioning of the railway network will improve. The research found that a change in the existing model of calculating costs of infrastructure use would bring economic effects for the railway infrastructure manager and the providers of transport. Using the proposed model we also found that it is reasonable to increase the flow of goods on unused regional railway lines because the railway infrastructure maintenance costs are inelastic with regard to transported gross tons.

Keywords: *econometric cost function; infrastructure charging model; maintenance cost; marginal costs; railway infrastructure*

Procjena marginalnih troškova infrastrukture u novom modelu opterećenja infrastrukture

Izvorni znanstveni članak
Konkurentnost željezničkog prijevoza u usporedbi s cestovnim se smanjuje, naročito na regionalnim željezničkim prugama. Kako bi se poboljšala ta situacija, EU je donijela razne direktive i pravila u svrhu povećanja učinkovitosti željezničkih poduzeća. U ovom radu predstavljamo organizacijski i ekonomski model koji se zasniva na europskoj politici vođenja lokalnog željezničkog sustava. Organizacijski model se temelji na analizi odluke o više kriterija. Za ekonomski smo model primijenili ekonometrijski pristup u procjeni funkcije troškova i marginalnih troškova na regionalnim prugama, koji predstavljaju osnovu troškova na željeznici. Primjenom takvog organizacijskog modela, poboljšat će se funkcioniranje željezničke mreže. Istraživanjem se ustanovilo da bi promjena postojećeg modela izračuna troškova korištenja infrastrukture donijela ekonomske koristi rukovodiocu željezničke infrastrukture i onima koji su zaduženi za promet. Primjenom predloženog modela također smo ustanovili da ima smisla povećati protok robe na nekorištenim željezničkim linijama jer su troškovi održavanja željezničke infrastrukture neelastični u odnosu na prevezene bruto tone.

Ključne riječi: *ekonometrijska funkcija; funkcija troškova; marginalni troškovi; model terećenja infrastrukture; troškovi održavanja; željeznička infrastruktura*

1 Introduction

During the past decade, the competitiveness of railway transport has been reducing. The EC Council adopted a Directive on EC Railway development in 1991 [1], which aims to adjust the railway systems according to the needs and requirements of the common market for the purpose of efficiency and competitiveness with other transport systems. The aim of this Directive is to provide access to the network of member states for international railway associations and transport companies. This way, the effective use of railway infrastructure and competitiveness of rail transport companies would increase. The market of transport companies developed in line with the Directive 95/18/EC regarding the issuing of transport licences in railway transportation [2], which regulate the conditions that the member states use to issue, renew or alter the licences for railway transport companies that operate or will operate within the Community. In the European transport policy [3] the Commission of EU laid down the so called "revitalization" package for railways as one of the fundamental objectives, based on internal market development, modernisation of services and optimal use of infrastructure.

For the optimal use of railway infrastructure, the Directive 2001/14/EC [4] sets out rules for setting infrastructure charges and for capacity allocation to increase the efficiency of railway undertakings. Three basic approaches are used for calculating charges, i.e. based on marginal social costs, marginal social costs with marks-up and the approach of covering total costs. The legislation determines that the charges are determined by reference to the costs that incur as a direct result of operating the train service [4]. When using an approach based on marginal costs, it is necessary to determine the marginal costs of maintaining infrastructure, which are the basis for calculating charges for regional railway lines. Munduch et al. [5] note that the marginal costs for secondary lines (i.e.regional) are higher than the marginal cost of main lines. Despite the fact that the weighted marginal costs represent only 27 % of the average cost, Munduch et al. (ibid.) propose using marginal pricing because of its consistency with the goals of the EU to enhance efficiency and competition in the railway sector. Thomas [6] argues that marginal maintenance and reconstruction costs represent 10 % to 30 % of the average maintenance and reconstruction costs. To cover the deficit caused by the use of marginal cost pricing, Johansson and Nilsson [7] proposed charging external costs. Despite the findings, the costs of maintaining the infrastructure due to its scale and structure constitute the most important component of charges. Dablanc [8] suggests short-haul railway freight transport, yet points out that a more comprehensive and sustainable solution could be found with an emphasis on economic and environmental advantages. McKinstry and Bounajm [9] argue that when looking at short-haul railroads, road traffic externalities need to be compared to railway traffic externalities. Essen et al. [10] find that the marginal external costs of longer and heavier lorries (LHVs) are five times higher than those of railway freight transport.

However, the costs of railway infrastructure maintenance are the most important element when calculating utilization charges due to their scope and structure.

To be able to provide a comprehensive solution for rail transportation, it is necessary, apart from the economic measures, to introduce organizational ones as well. Jeong et al. [11] propose an implementation of hub and spoke systems with consolidation of cargo at individual hubs. Using an improved organizational model, the proposed system provides economic and environmental effects, but the model takes into account only the main flows of goods within Europe. Following the globalization of industry, it is necessary to replace the existing organizational methods with a state-of-the-art approach to organizing these flows, since small and more frequent shipments are increasingly occurring along with increased service level demands. In this respect, Groothedde et al. [12] propose an introduction of collaborative networks with consolidation of goods in central hubs.

Based on these preliminary findings, the article will focus on assessing the marginal costs of railway infrastructure maintenance. In doing so, we will use the econometric approach to assess the cost function and marginal costs that we will subsequently compare with findings from other relevant studies. Based on the calculated weighted marginal costs we aim to provide an economic comparison between the existing and the proposed model. The main contribution of the article thus lies in the application of the econometric model to assessing maintenance costs in the short term, using dummy variables to observe temporal effects on the cost function for regional railway lines. The proposed economic model will be integrated into the hub-and-spoke system. The latter differs from those from other countries due to specific technical and geographical characteristics.

In Slovenia, the field of managing railway infrastructure and charging is regulated by the Railway Transport Act [13]; (hereafter RTA) and the Act Amending the Railway Transport Act [14]; (hereafter AARTA). In the article 15. d the AARTA sets criteria, based on which the charges for railway infrastructure use are determined. The Decree on the allocation of train paths and the user fees for the use of public railway infrastructure [15], which further specifies the area of usage charging, was adopted in 2009 based on the RTA. Article 24. of this Decree is most important for our research since it determines discounts and exemptions of payment for usage charging. Discounts which are limited in time can be granted to encourage the development of new railway services or to promote the use of lines that are underexploited (these are mostly regional railway lines).

In Slovenia, the throughput efficiency of regional railway lines lies between 30÷50 %, however, the percentage of passenger transport exceeds 80 % due to public service provision. The current model is based on the full cost calculation and train kilometres, taking into account the weighting of railroads, towing vehicles and types of trains. The charge per train kilometre is 1.133 EUR excluding VAT [16]. In accordance with the Decision of the Government of the Republic of Slovenia [17], passenger transport is exempt from paying these charges, which results in a loss of income, given that passenger traffic represents more than 80% of traffic volume on regional lines. Therefore, revenue from usage charges is based solely on freight traffic charges, which due to low market demand is uneconomic, since the average length of freight trains is 200 m, the average gross weight is 450 tons, and the proportion of full wagons ranges between 50 and 60 %. This problem can be observed in several countries that facilitate the increase in rail traffic volume in different ways, within the framework of existing European legislation.

Above mentioned legislation enables the development of a model for usage charging by implementing a system of central and peripheral hubs. Such improvements in the railway system would contribute towards strengthening the local economy and developing the local environment and at the same time present the base for local transport policies.

2 Methodology

As can be seen from Figure 1 below, in this research, the relevant data were first defined from datasets that were obtained from the company Slovenian Railways. The data are further explained in Section 2.1. Using DEXi methodology, Section 2.2 (e.g. Fig.1, Stage 2) explains how the hub-and-spoke system on railway lines was determined. Section 2.3 provides a definition of the cost function econometric model for the new charging model between hubs. The new charging model is based on marginal infrastructure costs (e.g. Fig. 1, Stage 3).

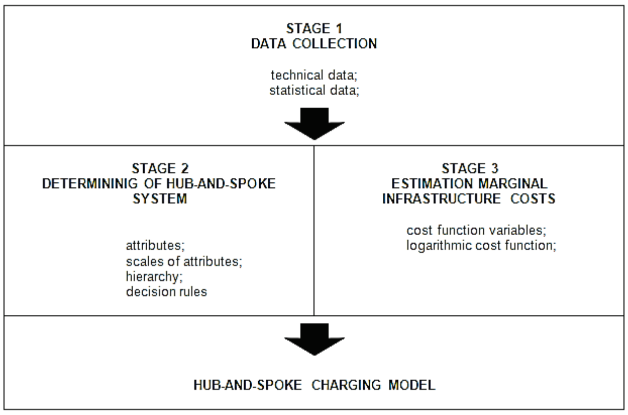

Figure 1 Research model

2.1 Data collection

The study is focused on the regional railway lines as a part of the local transport system, which is under-used in many countries due to decreased demand for railway services. Information relating to technical characteristics of the infrastructure and statistical data was obtained from the company Slovenian Railways. Regional railway lines are divided into 28 sections, in accordance with Network Statement of the Republic of Slovenia – Technical data of rail lines [16]. For each section, technical and statistical data from 2008 to 2012 have been observed.

Due to lack of data and indirect links to the Slovenian railway network, one section, which represents less than1 % of regional railway lines, was eliminated from the analysis. However, given the percentage, it is not representative. In the model, we analysed 27 regional rail sections in the period from 2008 to 2012, which represents a total of 135 observations.

Based on the relevant research findings [5; 7; 18; 19] and Slovenian legislation in the field of railway transport [13; 15] we identified a group of factors that affect the cost function. For each section of the regional railway lines we obtained the data given in Tab. 1.

Table 1 Section data

Variable	Description
C	Variable maintenance costs
km	Track length
gr_ton	Gross ton
gr_tkm	Gross ton kilometres
sig	Number of signals
sw	Number of switches
cr	Number of level crossing
sta	Number of railway stations
tq	Track quality
train	Number of trains

In determining the fixed and variable costs, they were reduced to minimum access package, provided by the Directive 2012/34/EU [20] and Decree on allocating train paths and levying users fees on the public railway infrastructure [15]. Minimum access package of services according to the definition in the legislation imposes costs on maintenance of infrastructure and traffic management costs as a result of train control signalling, regulation, dispatching and communication.

For each of the cost categories, it was determined whether and to what extent they are fixed and short-term [21] on the basis of professional judgment. The analysis included only variable costs in the short-term [5]. Variable costs represent production costs of ordinary and major maintenance on railway infrastructure. Operation of network and traffic control is considered fixed [18]. Monetised variables were deflated to the base year 2012 where the harmonized index of consumer prices was used.

Ordinary and major maintenance is carrying out maintenance work on the rail line and in all parts of railway infrastructure (signalling devices, switches, crossings and railway stations). We take into account variables such as the length of each section, the number of signals, the number of switches and the number of level crossings for the structuring of the cost function. The number of railway stations in the section was excluded as an explanatory variable, as the cost of maintenance of railway stations in the short-term is fixed.

The quality of the track is determined on the basis of measurements of track geometry parameters at least once a year. Lower parameters of track geometry mean a higher quality railway line and there is no need for additional maintenance that affects the cost increase. Average values of specific cost function variables are presented in Tab. 2.

Table 2 Average values of specific cost function variables

Variable	2008	2009	2010	2011	2012
Variable maintenance costs per km (EUR)	6274,43	6141,79	5984,12	5757,82	4885,14
Track length (km)	21,52	21,52	21,52	21,52	21,52
Gross ton kilometres in track section	18 741 700	15 839 435	17 591 586	16 969 831	14 507 161
Number of signals in track section	16,04	16,04	16,04	16,15	16,33
Number of level crossing in track section	23,70	23,63	23,37	24,07	24,15
Number of switches in track section	23,18	23,18	23,18	23,18	23,18
Coefficient of track quality KT in track section	207,04	207,89	204,41	203,30	193,37
Number of trains in track section	5604	5265	5393	5458	5904

2.2 Determining the hub-and-spoke system

The choice of central and peripheral hubs was performed using the DEXi methodology, which is a combination of two approaches: multi-criteria decision analysis and expert system. The DEXi methodology is based on quantitative or qualitative criteria. The phases of this methodology are [22]:

- determination of attributes,
- scales of attributes,
- hierarchy of attributes
- decision rules.

In setting the criteria for determining central and peripheral hubs, the research was based on relevant literature, where the variables and hierarchies were set based on findings from research into intermodal technologies in alternative transport networks [23, 24, 25] A railway intersection between a main and a regional railway line is defined as a central hub, and a node on a regional railway line, which suits the set criteria, is defined as a peripheral hub. Existing railway infrastructure was taken into account when setting the criteria. The scales were determined based on own professional judgment. The hierarchy of the decision criteria is shown in Tab. 3.

Table 3 DEXi model for determination of railway hub-and-spoke system

Attribute	Scale of attributes
Determining the hub-and-spoke system	inappropriate; appropriate
Logistics technology	unacceptable; acceptable
Number of tracks	to 2; 3÷4; more
Loading ramp	no; yes
Flexibility	small; medium; high

Potential hubs can be evaluated as appropriate or inappropriate according to the set criteria, and are dependent on the existing logistics technology and the flexibility of a potential hub. The suitability of logistics infrastructure is defined with the criteria of the number of tracks and the presence of a loading ramp, since technological demands for modern transport concepts are focused on fast manipulation [23], and the set criteria enable this. Flexibility is determined by technical and organizational characteristics obtained from the Slovenian railways.

Decision rules are shown in Fig. 2 (e.g. if the flexibility is medium and logistics technology is changeable, then the hub is appropriate) and are dependent on the utility function:

$$f: X_1 \times X_2 \times \ldots \times X_n \rightarrow Y,$$

where the rows represent decision rules and can be interpreted as an *if-then* rule of the form:

if X_1 = value_1 **and** X_2 =value_2 **and** …**and** X_n =value_n**then** Y =value (see Bohanec [22])

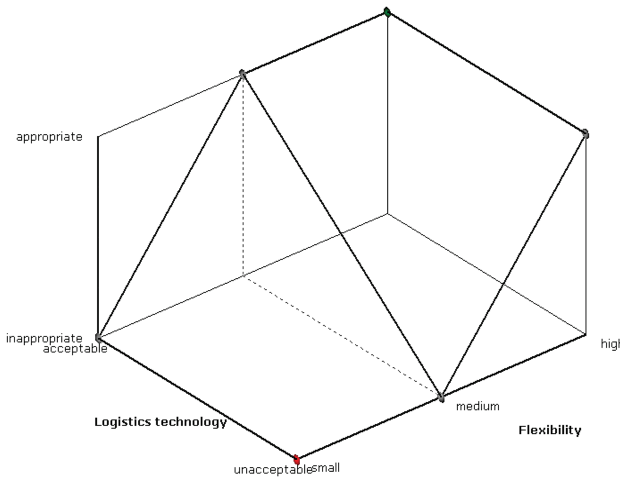

Figure 2 Decision rules for hubs

2.3 Estimation of marginal infrastructure costs

Christensen, Jorgenson and Lau [26] were one of the first who used the transcendental logarithmic function (translog) to calculate the cost of rail transport. A similar methodology was also used by Munduch et al. [5] for estimating marginal costs for the Austrian railway system, by Johansson and Nilsson [7] in their economic analysis of track maintenance costs, by Tervonen and Pekkarinen [18] in estimating marginal rail infrastructure costs in Finland, and by Andersson [19] in estimating railway infrastructure costs with fixed effect.

For the purpose of this study, we used an adapted logarithmic cost function, whereby we introduced a dummy variable with the objective to observe statistical differences for individual years:

$$\log C_i = a_0 + a_1 D_{1i} + a_2 D_{2i} + a_3 D_{3i} + a_4 D_{4i} + a_5 \log(km_i) + a_6 \log(gr_{ton_i}) + a_7 sig_i + a_8 sw_i + a_9 cr_i + a_{10} tq_i + a_{11} \log(gr\_ton_i) \cdot sig_i + a_{12} \log(gr_{ton_i}) \cdot sw_i + a_{13} \log(gr_{ton_i}) \cdot cr_i + a_{14} \log(gr_{ton_i}) \cdot tq_i + a_{15} \log(km_i) \cdot sig_i + a_{16} \log(km_i) \cdot sw_i + a_{17} \log(km_i) \cdot cr_i + a_{18} \log(km_i) \cdot tq_i + \varepsilon_i \quad (1)$$

where C_i is the cost function, i is the regional section, D_j year dummies (j=1 for year 2008, j=2 for year 2009, j=3 for year 2010 and j=4 for year 2011), a_i are parameters for estimation, other variables are presented in Tab. 1.

Regression model was estimated by the least squares method. Statistical data analysis and evaluation of econometric model were performed with the program EViews 7.0

Marginal costs are additional maintenance costs if gross tonne kilometres increase. The preferred unit for calculating marginal costs from the cost function are gross tonne kilometres. However, since in this case the distance between the sections remains the same, we can use the following equation [5]:

$$\partial(gr\_tkm_i) = \partial gr\_ton_i \cdot km_i \quad (2)$$

where km_i is the distance of a particular section.

On the basis of Eq. (2), we can calculate the marginal cost for each section of the regional railway lines.

$$MC_i = \frac{\partial \widehat{C_i}}{\partial gr_{tkm_i}} = \frac{\partial \widehat{C_i}}{\partial gr_{ton_i}} \cdot \frac{1}{km_i} = = \left(\frac{\partial \widehat{C_i}}{\partial gr\_ton_i} \cdot \frac{gr\_ton_i}{\widehat{C_i}}\right) \cdot \frac{\widehat{C_i}}{gr\_tkm_i} \quad (3)$$

where $\left(\frac{\partial \widehat{C_i}}{\partial gr\_ton_i} \cdot \frac{gr\_ton_i}{\widehat{C_i}}\right)$ presents cost elasticity with respect to the gross-tons and is calculated using the equation

$$\hat{C} = \exp(\log(C_i) + 0.5 \cdot (se)^2) \quad (4)$$

Weighted marginal costs for all track sections are expressed as [5]:

$$\overline{MC} = \sum MC_i \cdot \frac{gr\_tkm_i}{\sum gr\_tkm_i} \quad (5)$$

3 Results

Locations of central and peripheral hubs were determined using a multi-parameter decision model. Among potential candidates for central hubs, only two locations did not meet the required decision criteria due to the existing logistical infrastructure, which does not allow for development of quality services of railway transport.

Among the candidates for peripheral hubs, 27 locations were eliminated. The most appropriate charging model in hub-and-spoke system based on the elimination of individual variables using Schwarz and Akaike criterion, value of determination coefficient, F statistic and t-test of individual variables, is:

$$\log(C_i) = a_0 + a_1 D_{1i} + a_2 D_{2i} + a_3 D_{3i} + a_4 D_{4i} + a_5 D_{1i} \cdot \log(km_i) + a_6 \log(km_i) + a_7 \log(gr\_ton_i) + a_8 sig_i + a_9 \log(km_i) \cdot cr + a_{10} \log(km_i) \cdot sw_i + a_{11} D_{1i} \cdot tq_i + a_{12} D_{2i} \cdot tq_i + \varepsilon_i \quad (6)$$

The results of the estimated parameters and test statistics are shown in Tab. 4.

Table 4 Estimated parameters

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	6,666249	0,603127	11,05280	0,0000*
D1	-1,702275	0,644124	-2,642774	0,0093*
D2	-1,082777	0,566077	-1,912773	0,0581**
D3	0,233052	0,131081	1,777920	0,0779**
D4	0,215321	0,131041	1,643152	0,1029
D1*log(km)	0,229512	0,115310	1,990391	0,0488*
log(km)	0,843165	0,088845	9,490315	0,0000*
log(gr_ton)	0,147705	0,040600	3,638012	0,0004*
sig	0,023070	0,006407	3,600737	0,0005*
log(km)*cr	-0,001432	0,000752	-1,905852	0,0590**
log(km)*sw	-0,002107	0,001230	-1,713750	0,0891**
D1*tq	0,005771	0,002297	2,512441	0,0133*
D2*tq	0,006556	0,002649	2,475168	0,0147*
R^2	0,774694	Mean dependent var		11,18612
Adjusted R^2	0,752533	S.D. dependent var		0,967831
S.E. of regression	0,481458	Akaike criterion		1,467342
Sum squared resid	28,27977	Schwarz criterion		1,747109
Log likelihood	-86,04555	Hannan-Quinn criter.		1,581031
F-statistic	34,95722	Durbin-Watson statistic		1,969679
Prob. (F-statistic)	0,000000			

All parameters are statistically significant at 5 %* or 10 %**, except the dummy variable for the year 2011. The adjusted coefficient of determination is 0,75, which shows the great power of the explanatory variables of the selected model. On the basis of the tests carried out in the model, the problem of multicollinearity (VIF, the correlation matrix) and heteroscedasticity (White test) was not recognized. The Ramsey Reset test indicates that the regression function of assessing the costs of maintaining the infrastructure was correctly specified, since the value of the F-statistics was 0,40, with a probability of 0,53.

The estimated parameters for the length and gross tons are statistically significant at 5 %. Cost elasticity, based on the length of the section, is 0,84, whereas in relation to transported gross tonnes it is just 0,15. In 2008, the length of the section had a greater impact on maintenance costs. In this study, we have found that by increasing gross tonnage transported by 1 % the variable costs of maintaining the infrastructure increase by 0,15 %. Similar results can be found in Trevonen and Pekkarinen [18] when assessing the cost function of the cross section data.

The research also revealed that there are statistical differences in maintenance costs between individual years compared to 2012, except for 2011, where there are no statistical differences in maintenance costs. Statistically lower costs compared to 2012 were found in 2008 and 2009, which is also reflected in the poor quality of the infrastructure measured by the coefficient for track quality. Investments in rail infrastructure in Slovenia from 2008 to 2012 were increased by more than 30 %. From 2008 to 2012, transported gross tonne kilometres decreased by 22 %, the volume of work, however, decreased by just15 %, which means higher maintenance costs compared to transported gross tonnage.

The calculated marginal costs vary between 0,0003 and 0,13 EUR/gr_tkm. Weighted marginal costs for the sections of regional line sections amounted to 0,0009 EUR/gr_tkm. The function of marginal cost is decreasing.

The calculated parameters can be compared with calculations in the relevant research findings, which analyzed regional railway lines.

The research findings are presented in Tab. 5. Compared to other relevant research findings we may conclude that the marginal costs (MC) are comparable to, or lower than, those identified in individual countries.

Table 5 Relevant research findings

	Slovenia	Tervonen and Pekkarinen (Finland)	Munduch et al. (Austria)	Johansson and Nilsson (Sweden)	Andersson (Sweden)
MC	0,00090	0,00094*	0,00309**	0,001023***	0,00083****

* weighted marginal cost from cross section data for 2005
** weighted marginal cost from panel data in constant prices with respect to the base year 2000
*** weighted marginal costs from cross section data in Sweden
**** fixed effects estimation of marginal railway infrastructure costs for 1999-2002 (all lines)

The largest deviations for calculated marginal costs were observed in comparison with Austria, which, when based on rail system characteristics, can be best compared with Slovenia. According to Eurostat [27], Austrian labour costs, in 2012 excluding agriculture and public administration, amounted to 30,5 EUR/hour, whereas in Slovenia they were 14,9 EUR/hour. The most striking difference was in the construction sector, where the labour costs in Austria amounted to 30 EUR/hour and in Slovenia just 11.4 EUR/hour. In the analyzed period from 2008 to 2012, the growth in labour costs in Slovenia was 4,9 %, and in Austria 18,9 %. The calculated marginal costs in Austria refer to the period from 1998 to 2000. However, during this period the difference between labour costs in Austria (23,81 EUR/hour in 2000) and Slovenia (9,6 EUR/hour) was still significant.

For each section of the regional railway line between the spokes, weighted marginal costs of infrastructure maintenance were calculated using equations (2) and (3). To compare the economic effects of the new charging model, a comparison with the existing model of charging and two variants of the proposed new model were made, whereby the first variant took into account the estimated marginal costs of 0,0009 EUR/ gr_tkm for all studied sections. The second variant, on the other hand, accounted for the estimated marginal costs for each individual section.

When using the calculation according to the gross tonne-kilometres and the price 0,0009 EUR/gr_tkm for all sections, the calculated charge increases by 3 % compared to charge calculated using the current model. Positive economic effects are on the side of the railway infrastructure manager, as the revenue from usage charges increases. At 11 regional rail line sections the charge increases, which has a negative impact on carriers' costs. However, additional costs can be reduced through optimization of transport processes and by increasing occupancy of trains, because the share of empty wagons ranges between 40 % and 60 % per trainset. In addition, consolidation of goods in the spokes increases the demand for transport services and enables a better utilization of the trainsets.

When using the calculation according to the gross tonne-kilometres and different prices for individual sections, the charge decreases by 9,79 % compared to the current model. Positive economic effects are on the carrier's side, particularly for those sections where most of the gross tonne-kilometres are performed. The function of marginal cost is decreasing. This means that by increasing gross tonne- kilometres, the positive economic impact for carriers also increases. The increase in transported gross tons has no effect on the increase in variable costs of maintaining the infrastructure as variable costs are inelastic with respect to transported gross tons.

Based on the calculated maximum benefit the most appropriate model is shown in Fig. 3. Short term, the infrastructure manager revenues will decrease. However, by increasing the gross tonnage of goods transported the revenues will increase, whereas the variable costs of maintaining the infrastructure will not increase due to the inelasticity.

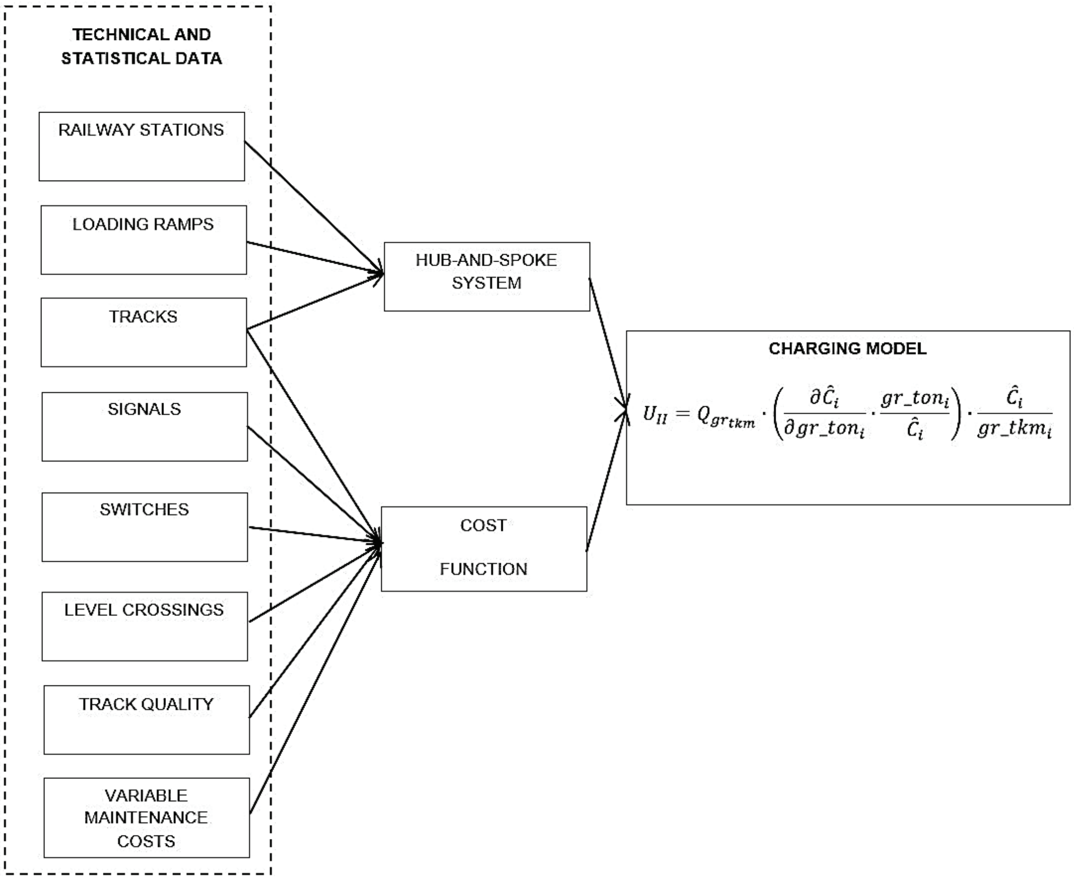

Figure 3 New charging model for regional railway system

4 Conclusion

The research found that a change in the existing model of calculating costs of infrastructure use would bring economic effects for the railway infrastructure manager and the providers of transport. It is important to emphasise that this maximises the economic benefits for the transport providers, who lower costs due to a change in the way of calculating infrastructure usage charges.

Based on economic and technological criteria, a model of central and peripheral hubs for regional railway lines in Slovenia was formed, with a goal of increasing the frequencies among selected locations and improving the quality of railway transport services. Selected central and peripheral hubs possess adequate railway infrastructure, which enables the development of holistic and competitive transport services that include services of manipulation and accompanying logistical services in addition to transport.

The results of the econometric analysis of maintenance costs are expected from the professional viewpoint and are comparable with other relevant studies. Estimated variables are statistically significant according to the scientific literature. Minor deviations are the result of differences in labour costs between the countries for the period 2008 - 2012. Based on the estimated cost function we calculated the marginal costs, which represent the basis for calculating the charge using gross tonne kilometres.

The results of the proposed model are also in accordance with guidelines of European transport policies on the field of railway transport, which are aimed towards developing an internal railway market in Europe, where a holistic approach to managing freight corridors has to be ensured. The improvement of efficiency on corridors cannot be ensured without efficient connections towards regional areas, which tend to be overly neglected during global connectivity, but represent an unused potential. Besides this, regional areas are poorly researched in light of railway transport and infrastructure use charging, since most research focuses on main railway routes.

By implementing a new organizational model based on an econometric cost function and estimates of marginal costs, the functioning of local railway networks would be improved, which would represent an important segment of development for local economies and society.

The practical implementation of the model demands further research of demand for railway services and of possibilities for encouraging widespread use of railway transport.

The model use is limited to underused railway routes, although a wider application for the whole railway network would be possible with minor modifications.

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