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A SPATIAL ECONOMIC STUDY OF RAIL FREIGHT IN THE EUROPEAN ECONOMIC AREA

ABSTRACT

The present study explores whether the European Union's transport policy measures of the last decade have fulfilled the expectations, i.e. whether there has been a positive change in the field of rail freight transport in the region. Data on the volumes of freight transport in the recent period have been analysed with freight transport intensity as an indicator. The values have been then translated into a spatial econometric model, looking for spatiality in the European Economic Region, including countries such as Norway, Switzerland or even Russia, extending the scope of the study to 37 countries. It has been proven that there is a spatial correlation between rail freight transport performance and GDP in Europe, which has a positive effect on countries with high GDP and a negative effect on low GDP countries in terms of performance. There is a particularly high intensity of rail freight in the Baltic region, as well as in Ukraine and Russia. Furthermore, it can be stated that rail freight has not undergone any significant changes in the last 10 years.

KEYWORDS

rail freight; Europe; freight intensity; GDP; spatial econometrics.

1. INTRODUCTION

When looking at the global processes in the field of rail freight transport, a number of aspirations and directions can be found that aim to shift goods quantities from road to rail for better freight performance and more favourable emission rates. In addition to the economic effects, perhaps the expected reduction in greenhouse gases may best justify the existence of this area of research. The emergence of railway transport problems is mainly due to the appreciation of climate protection aspects, about which we can already get a fairly accurate picture from different railway-specific emission estimation models [1]. This is in line with the most important goals of the European Union, as set out in the 2011 White Paper, which would shift 50% of road freight over 300 km to rail by 2050 [2]. Consequently, rail freight could play a very important role in reducing the environmental impact. However, current measures do not sufficiently support these directions. Therefore, research is necessary to reveal new directions in this field.

This study reveals whether there is any spatial correlation between the economic performance of individual European countries, not just EU countries, and their rail freight performance. How do they affect each other, and how does each country influence the others? For all this, basic data were collected from public databases, the Eurostat website (2018) [3], the OECD Data (2018) website [4] and the IMF (2018) [5]. As a first step in building our spatial econometric model, several statistical studies were conducted on the freight performance of individual countries over the past decade. After statistical preparation, we set up our spatial econometric model in the next step to explore the above discussed spatial correlation (*Figure 1*).

The aim of this research is not only to present the current situation but also to look back in order to examine the impact of EU aspirations. The time series analysis examined a period of about 20 years in order to see the long-term trends in the region. It then focused on examining a period of nearly 10
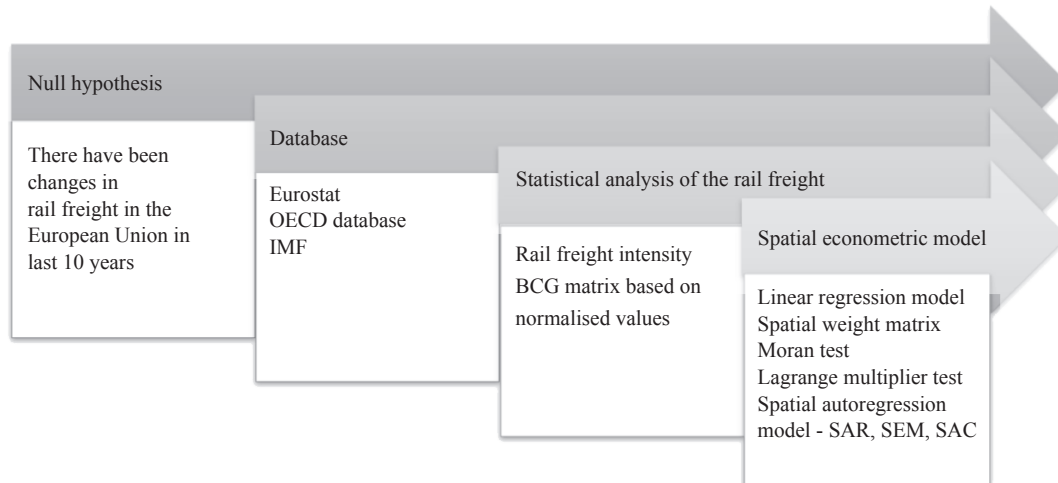
Figure 1 – Research framework

years. One reason for this is the 2008 world crisis. It is supposed that from 2010 onwards its impact was no longer felt, so the analysis of the period after the crisis can provide a credible picture of Europe's freight transport over the last decade. For this, the change between the spatial econometric models of 2010 and 2018 was analysed. In addition to the dynamic vision, the question may arise as to how, in addition to transport policy aspirations, freight transport in Europe has developed over the past 10 years in the surveyed scenarios, to which we also respond based on the models examined.

2. LITERATURE REVIEW

With regard to freight transport, it is difficult to determine whether economic effects generate an increase or decrease in freight transport or vice versa [6]. The situation is further complicated by the fact that we can talk about a particularly special situation in the field of rail freight, as market liberalisation in Europe may have been relatively late in some countries – or has not yet been fully achieved – mainly due to EU accessions [7]. All this has led to a serious competitive disadvantage, both for other transport sectors and for market players within their own sector, which is a serious problem not only in Europe [8, 9].

A significant number of researchers deal with the modelling of spatiality, thanks to the increasingly advanced and complex systems and task management software and the IT tools that provide the appropriate computing and storage capacity. Economic actors and goods can also be identified by their location, so the models could also have a

spatial (geographical) dimension. One of the spatiality modelling possibilities is Spatial Econometrics, which is a part of econometrics that deals with problems generated by spatial autocorrelation and spatial heterogeneity in regression models based on cross-sectional panel data [10].

This article aims to model the spatial development of freight transport over time in the rail freight market. In the case of Europe, the results of rail performance analyses show that the efficiency of rail freight companies needs to be encouraged, while the efficiency of the rail freight system needs to be addressed at a uniform European level [11]. In contrast, a less researched area is the efficiency of current freight networks as well as the interactions between different modes of transport [12]. *Table 1* provides an overview of the latest research findings in the field of rail freight.

It is clear from the table that rail research can be found virtually everywhere globally, be it developed or developing countries, without exception, it is a priority area for transport. The data collected in the table have been selected for the transportation of goods and for the analysis of the railway networks, as they are the two pillars of the present research framework. As shown in the past, in line with the EU efforts, rail freight has excellent potential in the long term, for example, by tackling the problems caused by road freight (environmental pressures, congestion, accidents etc.), exploration of which was the goal of the present study.

Concerning European research, the main question, as we have said before, is the success of the transport policy efforts over the last 20 years in the Community. The majority of articles dealing with

Table 1 – Research directions in rail freight

Citation	Area	Viewpoint	Modelling methodology	Studied parameters
[13]	Turkey	Impact of railway liberalisation	GIS-based analyses	GDP, demand values
[14]	Belgium	The added value of rail freight to the economy	Comparison of productivity and efficiency of rail freight services	Labour, production (industry) and the value added by the rail freight carrier
[15]	Japan	Examining the transition from road to rail	Economic analysis	Railway ownership, investment and access charges
[16]	Pakistan	Estimating the demand for rail freight	Flexibility analysis (Johansen model), time series analysis	Demand
[17]	Brazil	Economic effects of rail freight	Return on investment, dynamic CGE model	Tariff, investment
[18]	China	Reducing CO_2 emissions through pricing	Lyapunov - optimisation, Harmony search algorithm	Rail freight prices
[12]	Canada, USA, EU	Network efficiency	SFA road model	Population density, infrastructural features, geographical features
[19]	World	Autonomous vehicles for the transport of goods by rail	Statistical analysis	Levels of autonomy, CO_2 emissions
[20]	China	Rail-induced traffic	Elasticity models	Rail passenger kilometres
[21]	European Union	Restructuring road traffic into other and energy-favourable transport modes	Fuzzy logic, optimisation model	Freight performance
[22]	European Union	Development of the rail freight system predominantly suitable for the feeder lines	Organisational solutions	Volume of the rail freight
[23]	Europe – Mediterranean	Rail freight growth prospects in a highly congested section of the Mediterranean TEN-T corridor	Cost-benefit and market share standpoints	Volume of the rail freight; infrastructural features; costs
[24]	India	Freight consolidation in multi-modal rail and road transportation	Rail and Truck Allocation Algorithm (RATAA)	Volume discount
[25]	Iran	Sustainable intermodal freight transportation network developing	Stated preference method	Intermodal travelling times and costs

the region concluded that the stated goals did not fulfil their aspirations. In several cases, the developments and investments implemented in railway transport did not cause a significant change in the transport volumes [16]. For example, an analysis of the Mediterranean region has shown that substantial technological investment in existing lines is not the most effective way to increase rail market share [23]. In connection with the articles summarised in the table, mapping the relationship between railways and the economy can be identified

as an additional area in terms of market conditions, such as the analysis of changes due to rail liberalisation and GDP [13, 15]. Another significant area is the development of intermodal transport, including the role of rail freight. Exposure results in many regions show that a controlled rail tariff concession policy, if applied, will not only increase the contribution of intermodal freight to total freight transport but also increase the government's profit from fuel savings after compensating railway companies for losses [24, 25]. From all this, it can be concluded

that even if the solution is not to shift the quantities completely from road to rail, there are several potential applications for engineering and transport policy in intermodal transport.

In addition to the effects of emissions, one of the most important issues at the international level is the analysis of the added value of rail freight transport to the economy and the possibility of increasing its competitiveness, especially against road freight transport. Research for individual regions and countries has almost invariably found that if we create a proper competitive situation in this market, the positive economic impact of the reduction of emission values is unquestionable. However, little research deals with spatial analysis in this area.

In this research, as a first step, the relative value of the basic data was examined, which showed the intensity of freight transport in countries located in Europe. The aim was to decide if there is a reason for spatial econometric analysis and whether there can be any grouping of countries from the perspective of freight transport and GDP. The values were also displayed as a matrix. This was followed by the spatial econometric analysis of the data, and then the Akaike information criterion (AIC) and likelihood-ratio tests were used to verify the models.

In Section 3, the tools of the applied spatial econometric model are presented. Section 4 describes and analyses both the values of the intensity calculation and the results of the modelling and the trends shown by the results. The final Section 5 summarises the article and sets out new research directions.

3. METHODOLOGY

3.1 Basics of spatial econometrics

The basic condition for an adequate econometric analysis of spatial data is the appropriate mapping of the spatial relations between the observation units. The econometric discussion of spatial autocorrelation requires a spatial representation that can capture the relative position of the units [10].

The non-compliance of linear regression models with the Gaussian–Markov theorem can also be caused by spatial autocorrelation between the data [10, 26]. The essence of this is that, like time series, spatial units also influence each other according to the first law of geography [27]. It can be assumed that the demands are spatially concentrated, so they are higher around each centre while lower away

from them. For the measurement of these values, spatial autocorrelation is available; to decide whether spatial autocorrelation exists, Moran's I-test can be applied [28].

The values of test statistics are in the range of [−1; 1]. The positive values of I indicate a positive, while its negative values indicate a negative spatial autocorrelation [10]. If Moran's test shows the possibility of autocorrelation, three types of spatial econometric models are considered: (A) spatial delay models; (B) spatial error models; and (C) a combined model (SAR, SEM, SAC). Lagrange multiplier tests are available to decide which spatial econometric model could be used [29]. These tests examine whether a parameter deviates significantly from zero [30].

3.2 Applied methodology

The first model applied is the spatial delay model, in which the delay is interpreted as sliding in space. The second is the spatial error model, in which spatial autocorrelation is a disturbing factor [10]. The third option is to use the two approaches together. There are several models for this [31], of which the Spatial Autocorrelation Model (SAC) was significant. During the modelling, all the neighbourhood matrices were prepared. First, the correlation between variables was approximated using the least-squares method (OLS) as a base case. After building the OLS, SAR, SEM and SAC models, the results were compared with the Akaike information criterion (AIC). The criterion estimates the relative amount of information lost by a given model: the less information is lost, the better the quality of that model is [32]. If the AIC test differs by less than two when the two models are compared, the two models do not differ significantly. In addition to AIC, the likelihood-ratio test (LRT) was also used [33]. According to this approach, two models can be compared with each other based on their probability ratios. The examined models, in this case, represent exceptional cases of each other. The outlined model is shown in *Figure 2*.

The steps of the presented spatial econometric model are shown in the flowchart (*Figure 2*). A more detailed explanation of the models is given in [34] and [35]. Spatial econometric analyses were performed in the R 3.4.0 environment (Microsoft R Open is an enhanced distribution of Microsoft Corporation R, an open-source platform for statistical
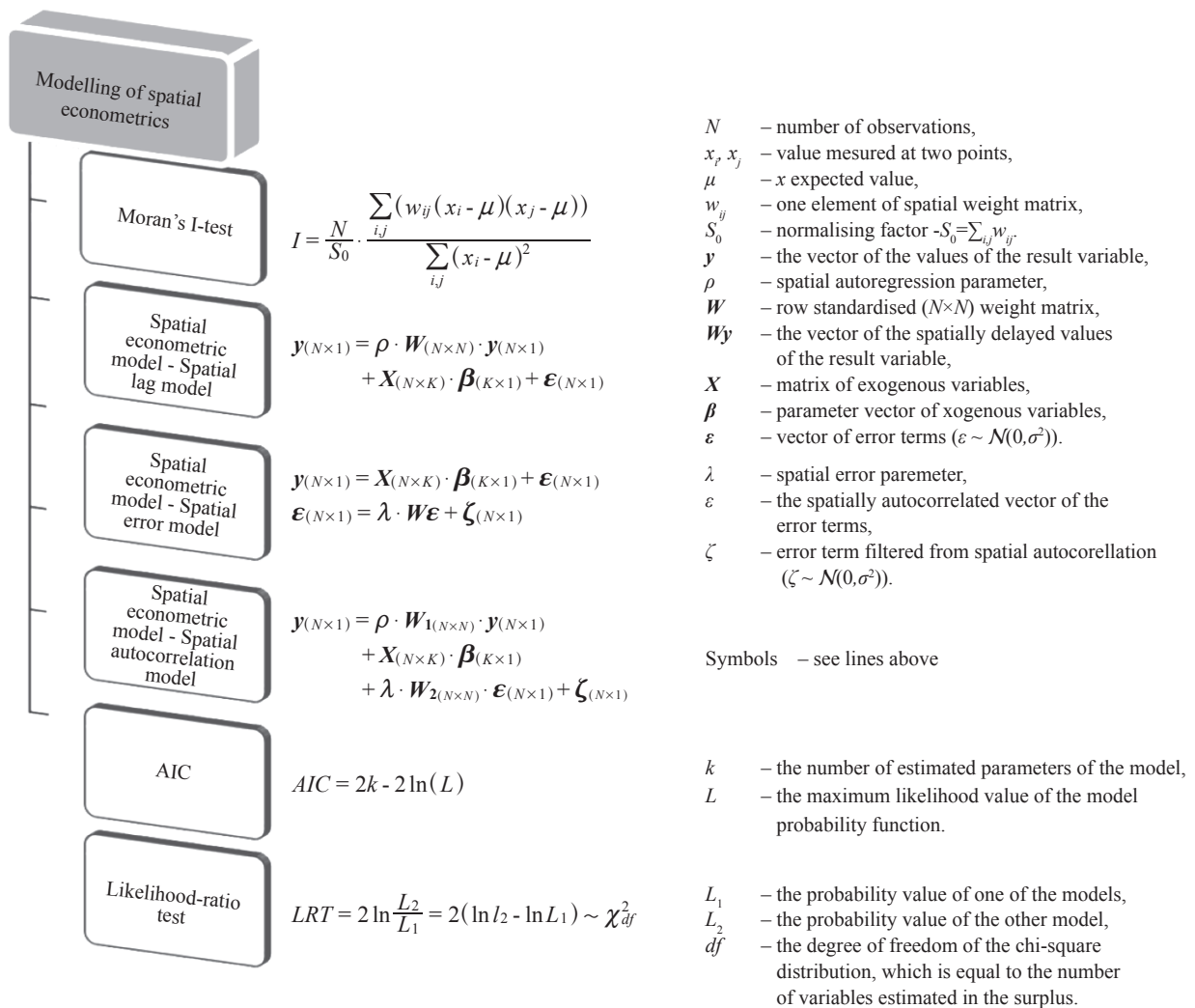
Modelling of spatial econometrics

Moran's I-test	$I = \dfrac{N}{S_0} \cdot \dfrac{\sum\limits_{i,j}(w_{ij}(x_i - \mu)(x_j - \mu))}{\sum\limits_{i,j}(x_i - \mu)^2}$
Spatial econometric model - Spatial lag model	$y_{(N\times 1)} = \rho \cdot W_{(N\times N)} \cdot y_{(N\times 1)}$ $+ X_{(N\times K)} \cdot \beta_{(K\times 1)} + \varepsilon_{(N\times 1)}$
Spatial econometric model - Spatial error model	$y_{(N\times 1)} = X_{(N\times K)} \cdot \beta_{(K\times 1)} + \varepsilon_{(N\times 1)}$ $\varepsilon_{(N\times 1)} = \lambda \cdot W\varepsilon + \zeta_{(N\times 1)}$
Spatial econometric model - Spatial autocorrelation model	$y_{(N\times 1)} = \rho \cdot W_{1(N\times N)} \cdot y_{(N\times 1)}$ $+ X_{(N\times K)} \cdot \beta_{(K\times 1)}$ $+ \lambda \cdot W_{2(N\times N)} \cdot \varepsilon_{(N\times 1)} + \zeta_{(N\times 1)}$
AIC	$AIC = 2k - 2\ln(L)$
Likelihood-ratio test	$LRT = 2\ln\dfrac{L_2}{L_1} = 2(\ln l_2 - \ln L_1) \sim \chi^2_{df}$

N – number of observations,
x_i, x_j – value mesured at two points,
μ – x expected value,
w_{ij} – one element of spatial weight matrix,
S_0 – normalising factor $-S_0 = \sum_{i,j} w_{ij}$.
y – the vector of the values of the result variable,
ρ – spatial autoregression parameter,
W – row standardised ($N\times N$) weight matrix,
Wy – the vector of the spatially delayed values of the result variable,
X – matrix of exogenous variables,
β – parameter vector of xogenous variables,
ε – vector of error terms ($\varepsilon \sim \mathcal{N}(0,\sigma^2)$).

λ – spatial error paremeter,
ε – the spatially autocorrelated vector of the error terms,
ζ – error term filtered from spatial autocorellation ($\zeta \sim \mathcal{N}(0,\sigma^2)$).

Symbols – see lines above

k – the number of estimated parameters of the model,
L – the maximum likelihood value of the model probability function.

L_1 – the probability value of one of the models,
L_2 – the probability value of the other model,
df – the degree of freedom of the chi-square distribution, which is equal to the number of variables estimated in the surplus.

Figure 2 – Formulas used in spatial econometric modelling

analysis and data science that is free to download and use.); map tools, sp, spdep and the spatialreg libraries were applied [36–42].

4. RESULTS AND DISCUSSION

4.1 Rail freight intensity in European countries

After reviewing the literature and presenting the methodology, the first step was a time series analysis of rail freight performance from the last 20 years, which is shown in *Figures 3 and 4*.

In the first case, we examined the total rail freight performance between 1998 and 2018 for the 37 countries we analysed, which was used to map what processes took place in the long run. The time-series analysis shows that the 2008 global crisis left its mark on rail freight and a decline can be seen, but since then a dynamic increase has been witnessed

(*Figure 5*). A huge volume of freight is transported in Russia. Therefore, *Figure 6* excludes Russia from the analysis, which proves that there was a larger decline due to the global crisis and that the difference between the 1998 and 2018 aggregates is negligible; there is no steep increase. All this suggests that while much of the research reports a steady increase in the volume of goods transported worldwide, rail freight transport in Europe is not really in line with this despite serious efforts outlined in the literature [43].

Subsequently, the same values were compared with the GDP of the countries. The freight intensity indicator from the study Sustainable Land Transport Indicators on Energy Efficiency and Greenhouse Emissions in ASEAN [44] was applied to see how countries' freight performance based on freight tonne-kilometres relates to GDP. The indicator can be expressed as the quotient of freight transport performance and the level of the gross domestic
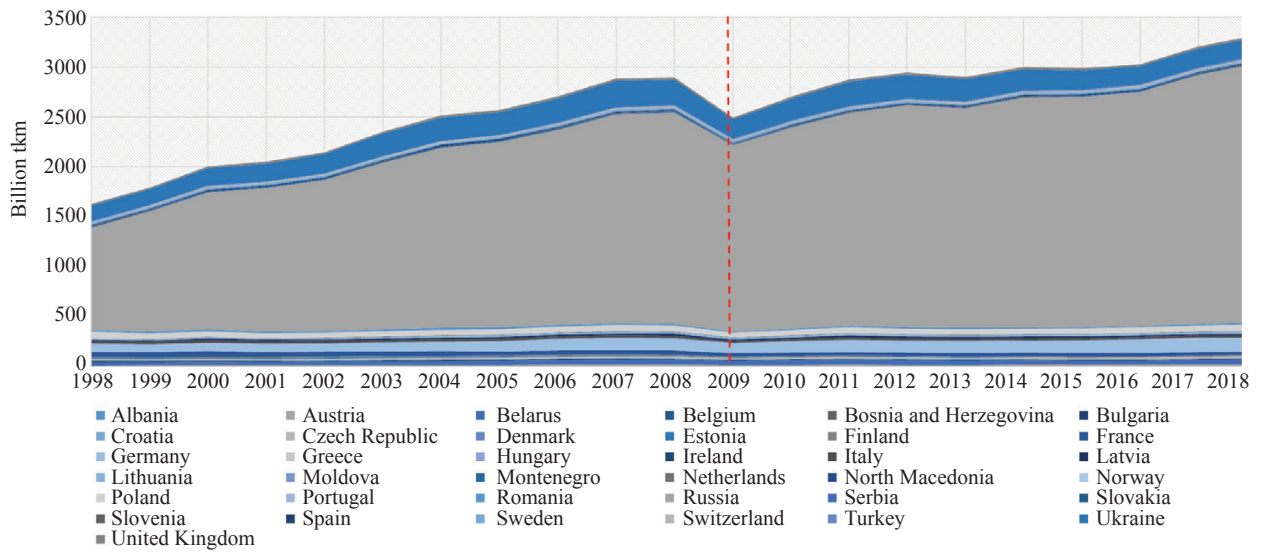
Figure 3 – Continental rail freight performance of the European continent over the last 20 years [5]
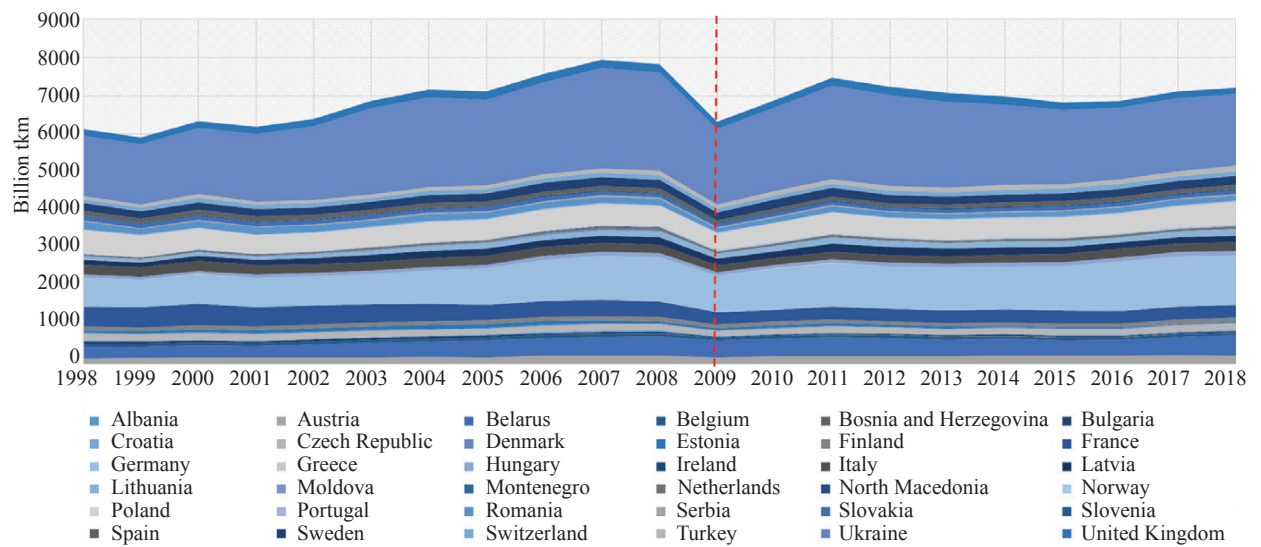

Figure 4 – Rail freight performance on the European continent, excluding Russia, over the last 20 years [5]
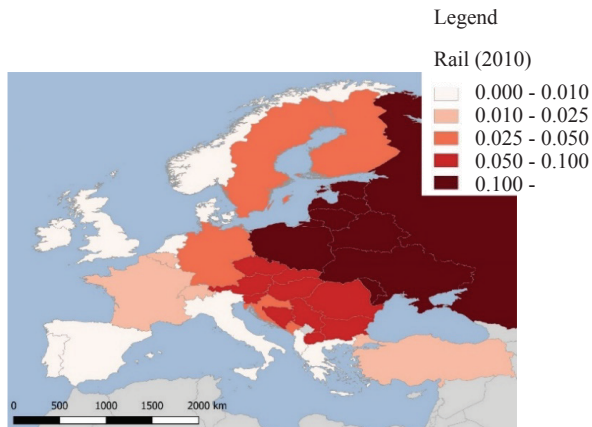

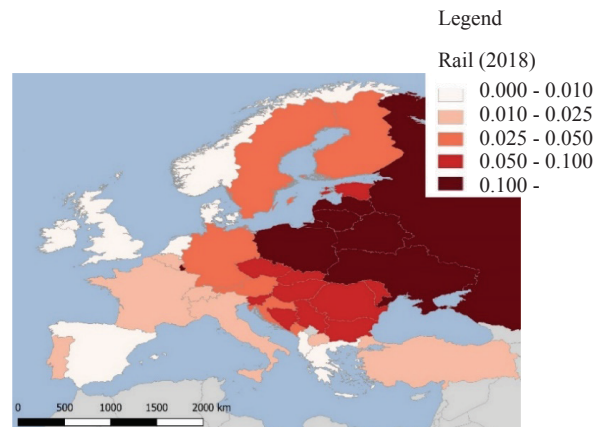*Figure 5 – Rail freight intensity in 2010 [45]*

Figure 6 – Rail freight intensity in 2018 [45]

product of the economy, as it gives the volume of goods transported per unit of GDP required, expressed in tonne-kilometres. Intensity calculation was performed for both 2010 and 2018 data (*Figures 5 and 6*).

The countries can be grouped in terms of railway values: for example, the countries of the Baltic region and the whole of Eastern Europe, as well as the countries with outstanding railway performance, i.e. Russia and Ukraine. It is important to note that these peculiarities can also be largely explained by the history of the countries [46]. Furthermore, it can be observed that moving from east to west we can see the intensity of rail freight transport diminishes. Spatiality is well illustrated in the figures: a significant growth is detected only in one country, Portugal. The reciprocal of the indicator was also analysed, i.e. the amount of GDP produced per unit of goods transported. The indicator was named *Productivity* in terms of freight transport (*Figure 7*).

The chart shows that there has not been a significant change in the last 10 years. This may also mean that, in addition to the smaller volumes transported by rail, rail freight will make a significant contribution to growth. Ireland and Greece have been left out of the representation of the productivity calculation because their freight performance is so low – almost zero – that it distorts results significantly. The countries were ranked according to Intensity and Productivity (*Table 2*).

It can be seen from the tables that there was no excessive change in the first three places in the nearly 10 years examined. All this suggests that GDP in these countries has not changed too significantly

Table 2 – Ranking of countries for railway data

	2010		2018	
	Intensity	Productivity	Intensity	Productivity
I.	Ukraine	Spain	Russia	United Kingdom
II.	Russia	Denmark	Ukraine	Denmark
III.	Belarus	The Netherlands	Belarus	Spain

and also that transport policy measures (even independently of the European Union) have not had a significant effect on freight volumes.

4.2 Railway spatial econometric model

In the spatial econometric model presented here, GDP is the outcome variable, and in both 2010 and 2018, rail freight performance is the explanatory variable. The outcome variable indicates the economic impact of freight transport in a given country, while the explanatory variable determines the freight transport performance required for economic growth. After setting up the empirical model, the spatial structure, i.e. the neighbourhood, is determined using a spatial matrix W, which can be implemented in several ways (*Table 3*).

Moran's I statistic was applied to all weight matrices generated, the results of which are shown in *Table 4*. It was examined whether autocorrelation can be detected in the countries' GDP.

Based on the table, further studies were performed using the weight matrix generated by the Queen criterion; as in this case, we found a stronger spatial econometric relationship with the GDP.
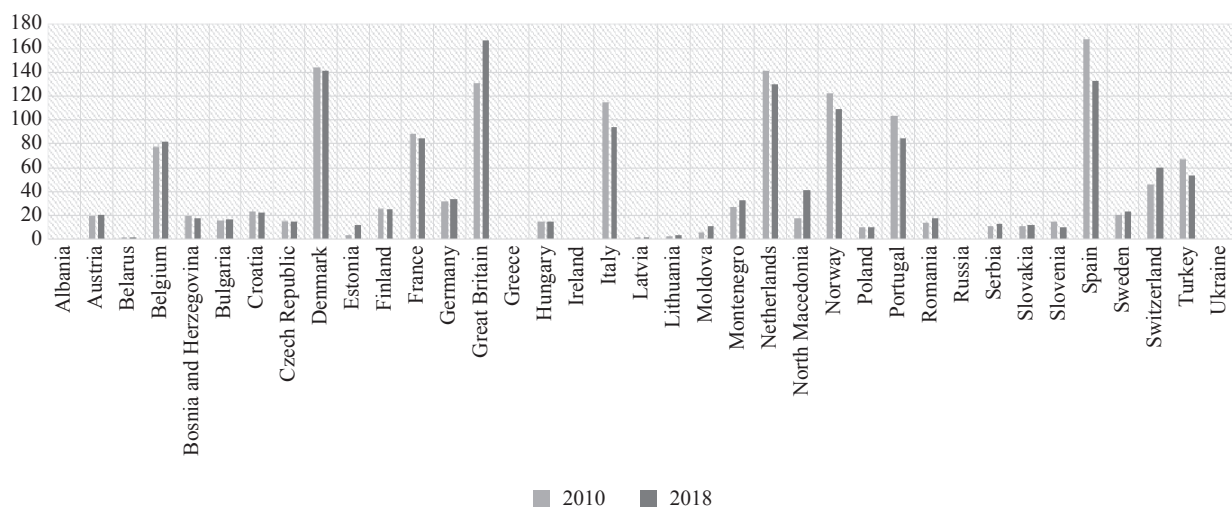

Figure 7 – Productivity: ratio of GDP and freight transport performance of European countries [42]

Table 3 – Description of spatial weight matrices W

Queen criterion	Inverse distance-based criterion
Two countries are adjacent if they have a common border or edge (W_queen).	Inverse distance-based criterion: the *j*-th element of the *i*-th row is one if the *j*-th country is closer to the *i*-th region relative to a predetermined distance. This method was applied in two ways. On the one hand, it was examined how the centres of the countries are located relative to each other (inverse distance); on the other hand, the relative position of the capitals (inverse capital city) was also surveyed. In both cases, the threshold was 750 km, as previous research has shown that this is the value that can be used to model European member states well so that large countries are also neighbouring and smaller regions do not converge.

Table 4 – Results of global Moran's I statistics

Spatial weight matrix	The value of Moran's I-statistic
Inverse-distance 2010	0.003
Inverse-distance 2018	0.029
Inverse capital city 2010	0.038
Inverse capital city 2018	0.063
Queen 2010	0.223
Queen 2018	0.230

As an experiment, we also performed a test with the inverse distance-based weight matrix, but the results did not change significantly; the queen neighbourhood matrix gave better results throughout. The test result suggests a weaker but existing positive autocorrelation with GDP for both the 2010

Table 5 – OLS estimation and the result of the Lagrange multiplier

	2010	2018
OLS - Intercept	4.097e+05	3.996e+05
	(2.770)**	(2.445)*
Railway values	5.511e+00	8.580e+00
	(1.594)	(2.110)*
Sample number	37	37
R^2	0.06769	0.1128
Corrected R^2	0.04105	0.08747
LM_{lag} - test	4.1414*	4.7377*
LM_{error} - test	5.3366*	6.6051*
Robust LM_{lag}-test	0.76968	0.58949
Robust LM_{error}-test	1.9648	2.4569
SARMA	4.6923	7.1946

** $0.001 < p < 0.01$; * $0.01 < p < 0.05$

and 2018 data series. This means that it is possible that the contribution of freight transport performance to GDP matters to neighbouring countries.

Table 5 summarises the results of the ordinary least squares (OLS) and Lagrange multiplier (LM) tests for the spatial and spatial models. The results of the t-test revealing the significance of the coefficients are shown in parentheses. It is used to examine whether a given parameter is significantly different from zero. If so, it has an effect on our model. For the test, the values of the test statistics are shown in the table.

Based on the results of the OLS estimate and the Lagrange multiplier, it was possible to set up spatial econometric models, the results of which are summarised in *Table 6*.

During the modelling, the spatial econometric model in the three applications was also run for all data. Based on the AIC, in each case, the SAC model proved to be the best. In addition to the AIC values, the results of the likelihood-ratio test are presented in *Table 7*, thus proving the applicability of the models.

If we want to estimate GDP based on rail freight, the influence of nearby countries on a given observation unit (GDP) has a negative effect (*lambda* is positive, while *rho* is negative). In the case of the 2010 and 2018 railway data, the SAC model gave the best results. Writing all of these models with equations is shown in *Table 8*.

With regard to the railway equations, our data set for 2018 shows a steeper increase (7.8390) than for 2010 (5.2813), which suggests that even if the EU transport policy efforts over the last 10 years have not fulfilled the hopes placed on them, they had a moderate impact and supported rail freight transport [47], causing a shift in values. In the case of the models, the exact reasons for the changes have remained hidden. They do not provide an answer to this question, so their exploration may represent further research potential.

Table 6 – Results of spatial econometric models

	SAR[1]		SEM[2]		SAC[3]	
	2010	2018	2010	2018	2010	2018
Intercept	2.5071e+05	2.2125e+05	3.2697e+05	3.0051e+05	6.8024e+05	7.1322e+05
	(1.4352)	(1.1647)	(1.9048)	(1.5814)	(1.7388)	(1.6545)
Railway values	6.0986e+00	9.2155e+00	6.9466e+00	1.0519e+01	5.2813e+00	7.8390e+00
	(1.8666)*	(2.4080)*	(2.2063).	(2.8649)*	(2.1678)**	(2.6825)**
Rho	0.19866	0.20023			-0.7037	-0.67857
	(1.4953)	(1.5766)			(-3.5404)	(-3.6128)
Lambda			0.25191	0.27742	0.73255	0.74485
			(1.7871)	(1.9936)	(6.5343)	(6.9414)

*** 0 < p < 0.001; * 0.01 < p < 0.05*
[1] *SAR = Spatial autoregressive/lag model*
[2] *SEM = Spatial error model*
[3] *SAC = Spatial autoregressive combined*

Table 7 – Likelihood-ratio test and AIC values for 2010 and 2018 railway models

	Inferior model		Superior model			LRT	df	
	L_c	AIC		L_c	AIC			
2010								
OLS	-554,850	1115,7	SAR	-553,791	1115,6	2,116	1	
OLS	-554,850	1115,7	SEM	-553,358	1114,7	2,983	1	.
OLS	-554,850	1115,7	SAC	-551,004	1112	7,691	2	*
SAR	-553,791	1115,6	SAC	-551,004	1112	5,575	1	*
SEM	-553,358	1114,7	SAC	-551,004	1112	4,708	1	*
2018								
OLS	-557,519	1121,0	SAR	-556,343	1120,7	2,352	1	
OLS	-557,519	1121,0	SEM	-555,681	1119,4	3,677	1	.
OLS	-557,519	1121,0	SAC	-553,023	1116,0	8,992	2	*
SAR	-556,343	1120,7	SAC	-553,023	1116,0	6,640	1	**
SEM	-555,681	1119,4	SAC	-553,023	1116,0	5,315	1	*

*** 0.001 < p < 0.01; * 0.01 < p < 0.05; . 0.05 < p < 0.1; 0.1 < p <1*

Table 8 – Results of spatial econometric models (SAR model) in the form of equations

2010	$y_{(N \times 1)} = -0,7037 \cdot W_{1(N \times N)} \cdot y_{(N \times 1)} + 5,2813 \cdot X_{(N \times K)} + 0,73255 \cdot W_{2(N \times N)} \cdot \varepsilon_{(N \times 1)} + 3,5076 \cdot 10^{11}$
2018	$y_{(N \times 1)} = -0,6786 \cdot W_{1(N \times N)} \cdot y_{(N \times 1)} + 7,8390 \cdot X_{(N \times K)} + 0,74485 \cdot W_{2(N \times N)} \cdot \varepsilon_{(N \times 1)} + 3,9141 \cdot 10^{11}$

5. CONCLUSION

The present study revealed whether there is a spatial econometric relationship between rail freight performance and the economic activity of a given country as determined by GDP. Taking into account the data for 2010 and 2018, it was examined whether the European Union's transport policy aspirations over the last ten years showed any level of change in terms of spatiality. In terms of timeliness, time series analysis and visualisation of the intensity values gave the result that there was no breakthrough change in the rail freight market. The Baltic and Eastern regions are outstanding in terms of rail freight, owing to historical reasons probably.

The main challenge of the study was to build up a coherent and transparent database of economic activity and transport performance. The change in spatial analysis over time is based on two samples from 2010 and 2018; however, more frequent sampling may slightly alter the results and provide a solid basis for prediction. The results of the research are limited to analysis; it is not possible to make a forecast based on these figures. The model is based on

discrete values, although it can even be examined on a continuous data set, which may already support future predictions. A further limitation is the quasi-static economic and legal environment considered in the analysis. However, according to the railway models, there has been no significant change in the sub-sector in the last ten years. The railway models have very similar values in terms of both quantitative and GDP indicators.

In terms of spatiality, it can be said that there is a spatial correlation between the examined data if we estimate GDP and its development together with the volume of goods transported. In both cases, the SAC model proved to be the most efficient one. This also shows that rail freight has not undergone a significant change in the last 10 years, which also supports the results of the time series analysis. Spatial econometric models have shown that a country with a high GDP today has some kind of "suction" effect on neighbouring countries with a lower GDP, in addition to freight performance, especially for rail freight.

In the light of the results presented, on the one hand, it may be worthwhile to examine the territory of Europe at the regional level, broken down into smaller units, in terms of spatiality, and to define future transport policy options even at a strategic level. In parallel with the present study, further research is underway both for a similar study of road freight transport and for a comparison of the two modes of freight transport, the results of which are also being published. Continuing to explore spatial contexts in Europe, this article can provide a good basis for further research by including additional indicators.

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AZ EURÓPAI GAZDASÁGI TÉRSÉG VASÚTI ÁRUSZÁLLÍTÁSI ELEMZÉSE TÉRÖKONOMETRIAI SZEMPONTBÓL

ABSZTRAKT

Jelen tanulmány azt vizsgálja, hogy az Európai Unió elmúlt évtizedében történt közlekedéspolitikai intézkedései beváltották-e a hozzá fűzött reményeket, azaz történt-e pozitív változás a régió vasúti árufuvarozásában. Az elmúlt időszak árufuvarozási volumenének adatait az áruszállítás intenzitása, mint mutató segítségével elemeztük. Az értékeket ezután térökonometriai modellbe helyeztük, térbeliséget keresve az Európai Gazdasági Régióban, beleértve olyan országokat is, mint Norvégia, Svájc vagy akár Oroszország, kiterjesztve a tanulmány hatókörét 37 országra. Bebizonyosodott, hogy Európában térbeli összefüggés van a vasúti áruszállítás teljesítménye és a GDP között, ami a magas GDP-vel rendelkező országokat pozitívan, az alacsony GDP-vel rendelkező országokat pedig negatívan befolyásolja teljesítmény tekintetében. Különösen nagy a vasúti áruszállítás intenzitása a balti térségben, valamint Ukrajnában és Oroszországban. Megállapításra került továbbá, hogy a vasúti árufuvarozás az elmúlt 10 évben nem változott lényegesen.

KULCSSZAVAK

vasúti árufuvarozás; Európa; fuvar intenzitása; GDP; térökonometria.

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