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Research on Relationship Between Road Freight Transport and Infrastructure in European Countries

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Abstract The article deals with research of relationship between the performance of road and freight transport and transport infrastructure (motorways) in EU countries. The main goal is to find out how transport infrastructure has a relationship and influence on the development of transport performance. The relationship between transport performance and transport infrastructure has been examined by correlation and regression analysis. Research has shown that the strength of these relationships is different for states. There is a strong direct and indirect dependence between transport infrastructure and transport performance.

Keywords road freight transport performance, motorway, road infrastructure,

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1. Introduction

Transport is an indispensable basis for the support of almost all economy's sectors. It is necessary to support and safeguard social and economic processes connected to transport [1]. Transport services are important for economic growth and society development [2]. It has a wider impact on microeconomic factors of productivity such as the labor market, domestic and international trade, investment and innovation. Transport infrastructure is an integral part of a transport system of any city or state. In connection to the development of societies and intensification of international relations due to the globalization processes, the importance of transport as a factor for economic and social development has enhanced [3]. Infrastructure development is one of the visible signs of technological progress. Many studies state that transport infrastructure is one of the most important factors of the regions' development, which enables the creation of new businesses or supports contacts with other regions. Many different factors affect the economic growth, but they are all directly or indirectly related to infrastructure development [4, 5]. As example it may be given that the construction of motorways increases regional accessibility and enhances human activities along the transportation routes. Well-developed transport infrastructure can be seen as a precondition for regional economic integration. For instance, transport of agricultural products can develop faster and faster in farming areas. Transport accessibility is determined by the way the area is developed making it possible to move in various conditions [6]. What is the correlation between the development of the transport infrastructure and the growth of the freight transport performance in road and rail transport? Growth in transport performance is related to the growth of gross domestic product [7, 8].

2. Transport Infrastructure and Its Importance

One of the most important presumption and factors of the social and economic development of the states and their regions is road infrastructure. This is also true in the Slovak Republic as road transport is the most widespread transport sector [9].

The development of transport infrastructure has been regarded long as the main instrument for promotion of economic development. Several studies point to a close link between investment in infrastructure and the economic development of a region [10, 11, 12].

Tuhin Subhra Maparu and Tarak Nath Mazumder showed existence of long-run relationship between transport infrastructure and economic development and that the direction of causality is from economic development to transport infrastructure in most of the cases thus drawing support in favour of Wagner's law [13].

It was not possible to obtain complete data on all EU countries. In their next review, only those states that had the data

for the given period for transport performance and infrastructure at the same time were selected. For road transport 25 countries of Europe could be analysed (Tab.1).

Table 1. Length of motorway infrastructure in European countries (km)

	2010	2011	2012	2013	2014	2015	2016
Bulgaria	437	458	541	605	610	734	740
Czech Republic	734	745	751	776	776	776	1 223
Germany	12 819	12 845	12 879	12 917	12 949	12 993	12 996
Estonia	115	115	124	140	141	147	145
Ireland	900	900	900	897	897	916	916
Spain	14 262	14 531	14 701	14 981	15 049	15 336	15 444
France	11 392	11 413	11 413	11 552	11 560	11 599	11 612
Croatia	1 244	1 254	1 254	1 289	1 290	1 310	1 310
Italy	6 668	6 668	6 726	6 751	6 844	6 943	6 943
Cyprus	257	257	257	257	257	272	272
Lithuania	309	309	309	309	309	309	314
Luxembourg	152	152	152	152	152	161	161
Hungary	1 477	1 516	1 515	1 767	1 782	1 884	1 924
Netherlands	2 646	2 651	2 658	2 666	2 678	2 730	2 756
Austria	1 719	1 719	1 719	1 719	1 719	1 719	1 719
Poland	857	1 070	1 365	1 482	1 556	1 559	1 640
Portugal	2 737	2 737	2 988	3 035	3 065	3 065	3 065
Romania	332	350	550	644	683	747	747
Slovenia	768	768	769	770	770	773	773
Slovakia	416	419	419	420	420	463	463
Finland	779	790	780	810	881	881	890
Sweden	1 971	1 957	2 004	2 044	2 088	2 119	2 118
United Kingdom	3 672	3 686	3 733	3 756	3 760	3 768	3 764
Norway	381	393	392	392	392	392	392
Switzerland	1 406	1 415	1 419	1 419	1 429	1 440	1 447

The development and length of road infrastructure is different for individual EU countries. It is possible to assert that almost all states have been recorded with the growth of the infrastructure. For some countries, growth was weak or not. The most significant growth was in the Czech Republic. The drop is recorded only for the United Kingdom and Estonia. However, this decrease is negligible.

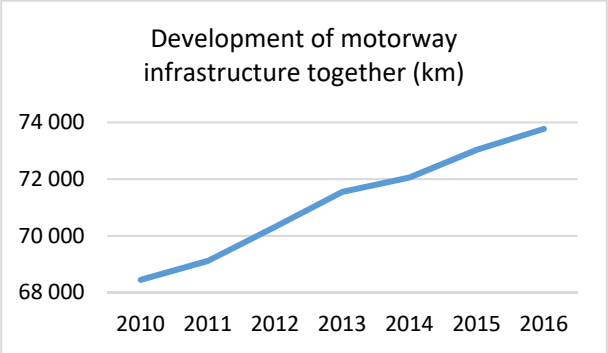

Figure 1. Development of motorway infrastructure for selected European countries together

In graph (Fig. 1) is possible to see that the length of infrastructure for these states has grown together gradually. This would also mean the growth of transport performance.

In tab. 1 is the data on the length of the motorway network in the EU.

3. Development of Transport Performance in European Countries

The development of transport performance in road freight was not uniform. The most significant growth was in Poland. It can be noticed that the western EU countries have experienced a decline (eg Spain, France, Italy). On the other hand, the countries of the eastern EU recorded growth (Romania, Bulgaria, Hungary). The most noticeable growth was recorded by Poland, where despite the crisis the transport performance grew.

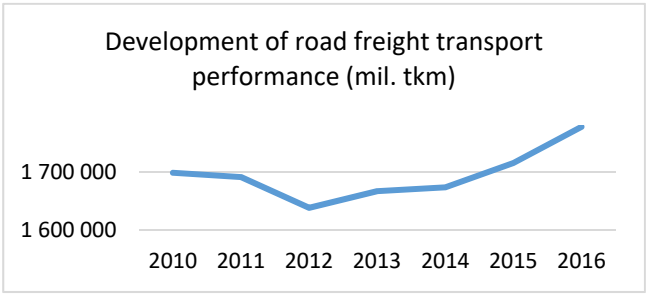

Figure 2. Development of road freight transport performance for selected European countries together (mil. tkm)

When we compare the development of transport performance and road transport infrastructure, it is possible to estimate that they have a similar pattern since 2012. It is also important to examine the transport performance relationships with the length of the infrastructure for each country. The following chapter deals with this relationship.

Table 2 show the statistical data on transport performance in case of freight road transport. Data are expressed individually for selected European countries. Outputs are expressed in millions of tonne-kilometers. The tonne-kilometer ratio is a more reliable indicator because the performance measured only in the tonne of transferred tonnage does not take into

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account the number of kilometers driven by the transport infrastructure with use of loaded vehicle. The expression in tonne-kilometers (transport performance) expresses the multiple of the weights of things and the distance traveled with these things. For this reason, we will discuss only the transport performance expressed in tkm.

Table 2. Development of road freight transport performance (mil. tkm)

	2010	2011	2012	2013	2014	2015	2016
Bulgaria	19433	21214	24372	27097	27854	32297	35409
Czech Rep.	51832	54830	51228	54893	54092	58715	50315
Germany	313104	323833	307009	305744	310142	314816	315774
Estonia	5614	5912	5791	5986	6310	6263	6716
Ireland	10939	10108	9976	9215	9751	9900	11616
Spain	210068	206843	199209	192597	195767	209390	216997
France	182193	185685	172445	171472	165225	153580	155843
Croatia	8780	8926	8649	9133	9381	10439	11337
Italy	175775	142843	124015	127241	117813	116820	112637
Cyprus	1087	941	896	634	538	563	703
Lithuania	19398	21512	23449	26338	28067	26485	30974
Luxembourg	8694	8835	7950	8606	9599	8850	9324
Hungary	33721	34529	33736	35818	37517	38353	40002
Netherlands	76836	75543	70085	72081	72338	68900	67779
Austria	28659	28542	26089	24213	25260	25458	26138
Poland	202308	207651	222332	247594	250931	260713	290749
Portugal	35368	36453	32935	36555	34863	31835	34877
Romania	25889	26349	29662	34026	35136	39023	48176
Slovenia	15931	16439	15888	15905	16273	17909	18707
Slovakia	27575	29179	29693	30147	31358	33540	36139
Finland	29532	26863	25460	24429	23401	24488	26846
Sweden	36268	36932	33481	33529	41964	41502	42673
United K.	146685	148733	150949	139703	135393	150101	155042
Norway	19751	19188	20171	21317	21594	23136	20910
Switzerland	13237	13567	12966	12817	13067	12441	12134

4. Research on Relationship Between Road Freight Transport and Infrastructure in European Countries

In the context of research on the relationship between freight transport performance and transport infrastructure in EU countries, methods of regression and correlation were used:

- correlation analysis,
- regression analysis.

The variables in the correlation and regression analyses were chosen as follows:

- dependent (explained) variable *Y* as transport performance,
- independent (explanatory) variable *X* as the length of the infrastructure.

After selecting the variables, the correlation coefficient was calculated:

$$r = \frac{cov(x,y)}{s_x * s_y} = \frac{\overline{xy} - \bar{x} * \bar{y}}{\sqrt{\overline{x^2} - \bar{x}^2} * \sqrt{\overline{y^2} - \bar{y}^2}} \quad (1)$$

To determine the correlation strength, the following criteria were identified:

- weak dependence, if $0 < |r| < 0.3$,
- middle dependence, if $0.3 \leq |r| < 0.8$,
- strong dependence, if $0.8 \leq |r| < 1$.

The dependency we have searched for was modeled by a linear function in the form (line equation):

$$y = a + bx, \quad (2)$$

where we do not know the coefficients of the line a (locating constant), b we are looking for the variables X and Y.

The following tables (Tab. 3) show the results of analyse. The significance level was selected at the level α = 0,01.

Table 3. Analysis results

	Country	Correlation coefficient	Determination coefficient	Coefficient *a*	Coefficient *b*	*P-value a*	*P-value X*	*Significance F*
strong direct dependence	Austria	0.9983	0.9966	0	15.321	X	0.000	0.000
	Bulgaria	0.9881	0.9991	0	45.549	X	0.000	0.000
	Hungary	0.9568	0.6738	15 163.4	12.435	0.003	0.001	0.001
	Slovakia	0.9040	0.9977	0	72.171	X	0.000	0.000
	Poland	0.9019	0.8135	107 390.5	97.654	0.014	0.005	0.005
	Slovenia	0.8737	0.7633	-341 673.3	465.362	0.012	0.010	0.010
	Romania	0.8709	0.9814	0	57.327	X	0.000	0.000
	Croatia	0.8546	0.7304	-29 788.0	30.741	0.039	0.014	0.014
	Estonia	0.8127	0.6605	3 232.5	21.537	0.017	0.017	0.026
middle direct dependence	Sweden	0.7343	0.9942	0	18.647	X	0.000	0.000
	Lithuania	0.6432	0.9801	0	81.324	X	0.000	0.000
	Ireland	0.5375	0.9953	0	11.306	X	0.000	0.000
	Luxembourg	0.3231	0.9972	0	57.157	X	0.000	0.000
	Norway	0.3161	0.9969	0	53.431	X	0.000	0.000
weak direct dependence	Spain	0.1465	0.9980	0	13.711	X	0.000	0.000
weak indirect dependence	United K.	-0.1089	0.9980	0	39.270	X	0.000	0.000
	Germany	-0.1164	0.9996	0	24.230	X	0.000	0.000
middle indirect dependence	Cyprus	-0.4322	0.9334	0	2.921	X	0.000	0.000
	Portugal	-0.4483	0.9936	0	11.700	X	0.000	0.000
	Czech Rep.	-0.4664	0.9516	0	62.312	X	0.000	0.000
	Finland	-0.4937	0.9871	0	30.984	X	0.000	0.000
	Italy	-0.7616	0.5800	1 089 217.1	-141.080	0.031	0.047	0.047
strong indirect dependence	Netherlands	-0.8208	0.9966	245 056.2	-64.511	0.006	0.024	0.024
	Switzerland	-0.8605	0.7405	53 714.2	-28.649	0.004	0.013	0.013
	France	-0.8960	0.8028	1 481 243.4	-114.007	0.004	0.006	0.006

Individual countries are ranked according to the correlation coefficients in Table X. From the strongest direct dependence to the strongest indirect dependence. If the locating constant was insignificant, it was eliminated from the regression model.

Results of the analyses (table X) show that the interconnection of infrastructure with the development of road freight transport performance is different in the countries observed. Based on our established criteria for determining the strength of the correlation, strong direct dependence was found in Austria, Bulgaria, Hungary, Slovakia, Poland, Slovenia, Romania, Croatia, Estonia.

Average direct dependence was observed with Sweden, Lithuania, Ireland, Luxembourg, Norway. Spain has a weak direct dependence.

We see weak indirect dependence on the United Kingdom and Germany. Intermediate strong dependence is reached by Cyprus, Portugal, Czec Republic, Finland and Italy.

Strong indirect dependence is observed in the states of Netherland, Switzerland and France.

The significance level of the whole model (Significance F), coefficients a (P-value a) and b (P-value x) was less than 0.05 for each examined relationship. The determinative factor in 17 countries was higher than 0.9. The lowest determinant was in Italy (0.58).

The year-to-year correlation between transmission capacity and infrastructure length for selected countries were calculated as the next step.

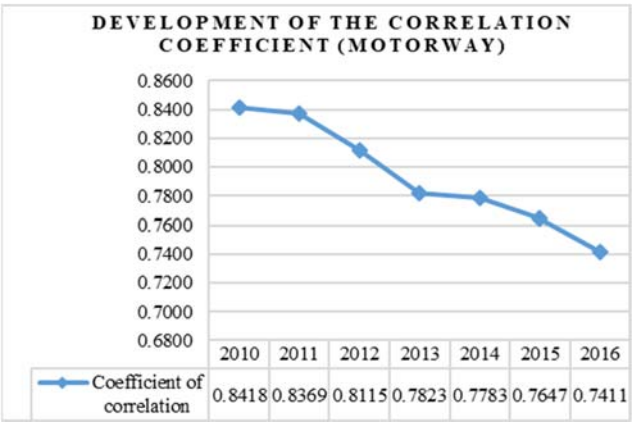

Figure 3. Development of correlation coefficient for road transport and transport performance

On graph (Fig. 3) can be seen that the strength of the relationship for all countries surveyed for road freight is gradually decreasing. In 2010, the correlation coefficient between transport performance and the length of the infrastructure had a strong direct dependence value (0.8418). However, in 2016, the correlation coefficient reached only moderate direct dependence (0.7411). From this it can be deduced that the dependence between the freight transport performance and the road freight infrastructure is weak every year.

5. Conclusions

The contribution showed that the growth of road infrastructure lengths (motorways) also increases transport performance, but the correlation decreases with only moderate direct dependence (0.7411). This means that transport performance will increase despite the fact that the length of motorways does not increase. It should be noted that, especially in Western European countries, the length of motorways does not increase significantly but increases their permeability by increasing the number of lanes, introducing intelligent transport systems, etc. In the Central and Eastern European countries, large volumes of transport performance are mainly carried out on Class I roads. Also, the increase in transport performance in road freight transport is strongly linked to the growth of gross domestic product [X]. The pace of construction in some countries unfortunately does not copy GDP growth and revenue into the state budget. The shift of construction dates and the completion of contiguous sections of motorways may, in particular, in international road freight transport, influence the direction of transit traffic if other corridors exist.

Especially in road freight transport, it would be interesting to examine the dependence between the length of the motorways and the transport performance by individual states, respectively. exploration to be extended to lower category journeys where road haulage can be carried out.

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