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The Impact of Transport Infrastructure on Economic Growth: Evidence from CEE

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The Impact of Transport Infrastructure on Economic Growth: Evidence from CEE*+

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Abstract

Transport and related infrastructure play a pivotal role in the economic growth and development during the last century and many theoretical, as well as empirical researches recognized it as an important factor in maintaining and promoting economic growth. During the transition period in Central and Eastern European countries, most of the investments were focused on the road infrastructure, while railways are lagging for decades. The main objective of this paper is to empirically investigate the macroeconomic effects of transport infrastructure on economic growth in the Central and Eastern European countries. In our model, we include other control variables which could have positive effect on economic growth, as population growth, gross fixed capital formation and trade openness. We use panel data analysis with three standard estimators: Pooled OLS (POLS), Fixed effects (FE) and Random effects (RE). The results of the estimation show the significant and positive effects of population growth, gross fixed capital formation, trade openness and road infrastructure on economic growth. On the contrary, the effects of railway infrastructure on GDP growth are significant and negative. The results are in line with our initial hypothesis where is evident the long-standing problem of inefficient and outdated railway transport and related infrastructure in Central and Eastern European countries. This paper supports the European Union's guidelines for the need to invest in railway infrastructure in order to ensure the effective transport of passengers and goods in the long term, create their competitive advantages, reduce green-house gas (GHG) emissions and thus simulate sustainable economic growth in CEE countries. These results should be seen in a broader context, especially in the light of ongoing desire to reduce CO2 emissions that are in the large extend produced by road transport, while railway transport is more environment-friendly.

Keywords: Transport infrastructure; economic growth; POLS, FE, RE; CEE

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1. Introduction

Transport and related infrastructure play a pivotal role in the economic growth and development during the last century and many theoretical, as well as empirical researches recognized it as an important factor in maintaining and promoting economic growth. Transport infrastructure may be the prerequisite for economic development, while transport and supporting infrastructure network can be an engine in promoting economic growth. However, the transport infrastructure alone is not sufficient for the economic growth. Transport capacities are especially important in the case of small open economies like Croatia and most CEE countries where an efficient transport system allows for an increase in international trade and thus stimulates economic growth. The share of transportation in the gross domestic product of developed countries accounts for approximately 6 to 12%. It is considered that today, in the era of globalization, the competitive advantage of each economy depends, inter alia, on facilitating more efficient transport of people and goods, while the key obstacle can be the lack of efficient and high-quality transport infrastructure.

During the transition period, precisely since the beginning of 1990s, insufficient investments have been made on railways and railway infrastructure in the Central and Eastern European Member States (hereinafter: CEE), leading to the obsolescence of the transport sector and prioritizing road transport over the railway. In the last few decades the transport sector has grown dramatically in European Union, with the main increase seen in road transport (European Commission, 2012 in Bonča et al., 2017). EU investments in transport infrastructure are one of key, if not the key mechanism that can increase economic development and convergence (Crescenzi & Rodríguez-Pose, 2012). The main problem of the rail system of most CEE countries include the poor state of infrastructure and fleet, problems that reflect the cargo and passenger transport activities, the lack of efficient rail links with maritime and river ports, and insufficient integration of the national network into the European transport network that prevents the implementation of the system interoperability. Even though the pre-accession EU funding investments have enhanced the connectivity and accessibility in these countries considerably, however, the transportation by rail lag far behind (European Parliament, 2016).

Considering that the transport and related infrastructure are of the national and strategic interest of each country, we revisit the question by looking at the impact of transport infrastructure, proxied by kilometres of motorways and kilometres of railways, across eleven Central and Eastern European Member States during the period 1995 to 2016. Furthermore, according to our knowledge, none of the papers were devoted to CEE countries. This is

relevant especially because a significant amount of investment was oriented to infrastructural investment for the programming period 2007-2013. The main novelty of our approach lies in opposing transport infrastructure effects with other factors, such as population growth, gross fixed capital formation and trade openness, which also may play an important role in stimulating economic growth. Furthermore, this work seeks to empirically explore the current state of affairs and to create a framework for further research development. To achieve this aim, we use panel data analysis including three different estimators: pooled ordinary least squares (POLS), fixed effects (FE) and random effects (RE).

The remainder of the paper is structured as follows. Second chapter continues with the theoretical background and literature review. Data description is given in third chapter, while the methodology is explained in fourth chapter. Chapter five discusses the results and policy implications and the sixth chapter presents concluding remarks.

2. Literature Review

Transport infrastructure is widely thought to promote growth thus the impact of transport infrastructure on economic growth has been recognized long time ago in many studies mentioned below. Obviously, the link between transport and economic growth intrigues researchers for decades. According to Rostow (1960), the introduction of railways was a factor of growth and development in the United States, France, Germany, Canada and Russia. In the seventies, Arrow and Kurz (1970) included the theoretical analysis of the effects of transport infrastructure in growth theories. Krugman (1991) argues that transport accessibility affects global development paths and can boost economic growth, but also create a barrier to it.

Many researchers analyse the impact of infrastructure on regional competitiveness, economic growth, income inequality, labour productivity, environmental impact and well-being (Baldwin & Dixon, 2008). Mamatzakis (2008) argues that infrastructure is one of the most important components of economic activity in Greece. His predictions show that public infrastructure reduces costs in most manufacturing industries, boosting resource productivity growth. Aschauer's research (1989) suggests that reducing public investment in transport infrastructure causes a significant decrease in productivity growth. He argues that reducing US public utility productivity may be crucial in explaining the overall decline in productivity growth rates in the country. Efficient infrastructure supports economic growth, improves quality of life and is important for national security (Baldwin & Dixon, 2008).

Authors argue that infrastructure investments can stimulate organizational and management change, for example, the construction of the rail system will lead to standardization of the schedule, which, besides the rail service alone, leads to revenue growth (Mattoon, 2004).

Tsekeris and Tsekeris (2011) discuss that transport investment, especially investment in highway, rail, airport and sea port infrastructure requires long-term financial commitments. Public infrastructure provides geographic concentration of economic resources and a deeper and wider market for growth of output and employment (Gu, Macdonald, 2009). Transport infrastructure can affect economic growth by changing aggregate demand, for example building a transport infrastructure can create and increase demand for intermediate products from other sectors and stimulate multiplier effects in the economy (Pradhan & Bagchi, 2013). Public infrastructure is generally seen as the foundation on which the economy is built (Macdonald, 2008). Aschauer (1989) argues that public infrastructure is the foundation of quality of life: good roads reduce accidents and increase public safety, water supply system reduces disease level, waste management improves health and aesthetics of the environment. Agénor and Moreno-Dodson (2006) investigated the link between the presence of infrastructure, health and education in the community, and their results show that infrastructure services are essential to ensuring the quality and accessibility of health and education, which largely enables the wealth performance.

Demetriades and Mamuneas (2000) argue that the infrastructure has a significant positive impact on income, demand for private production and product delivery in twelve OECD countries. Mentol and Solé-Ollé (2009) have confirmed that public investments in road infrastructure have positively impacted the relative increase in labour productivity in the Spanish regions. Snieska and Bruneckiene (2009) identify the infrastructure as one of the regional competitiveness indicators of a country. This refers to the physical infrastructure (road infrastructure, telecommunications, new built real estate, land access, land and air) as indicator of production factors and competitive conditions in the region.
Martinkus and Lukasevicius (2008) argue that infrastructure services and physical infrastructure are factors that can influence the investment climate at the local level and raise the level of attractiveness of the region. Nijkamp (1986) argues that infrastructure is one of the tools of regional development. It can directly or indirectly affect socio-economic activities and other regional capacities, as well as production factors. The author emphasizes that infrastructure policy is a prerequisite for regional development policy: it does not guarantee regional competitiveness but creates the necessary conditions for achieving the goals of regional development. More recently, Badalyan et al. (2014) investigate the relationship and the direction of causality between transport infrastructure, infrastructure investment and economic growth, using VECM model in the case of Armenia, Turkey, and Georgia. Their results show that gross capital formation and road/rail goods transported have a positive and statistically significant impact on economic growth in the short-run and the existence of bidirectional causality between economic growth and infrastructure investment, and between road and rail passengers carried and infrastructure investment in both, short and long-run. Ismail and Mahyideen (2015) empirically explore the effects of transport infrastructure on international exchange and economic growth in Asia, and the results have shown positive effects on the rise in international exchange as well as on economic growth. Furthermore, Purwanto et al. (2017) analyse the relationship between transport infrastructure investment and its wider economic impacts, namely competitiveness and economic growth and recommend the

methodology improvements. Mohmand et al. (2016) use the unit root, cointegration, and Granger Causality (GC) model to estimate the causal linkages between economic growth and transportation infrastructure exist at national and provincial level. Their results suggest that there is no causality between the two variables in the short run, at the national level, however, a unidirectional causality from economic development to infrastructure investment exists in the long run.

In the case of Croatia, EIZ (2014) study shows that there is a causal link between transport infrastructure and transport services and the level of international exchange. Infrastructure should be viewed as the building blocks of each economy, which provide support to produce goods and services and are not part of the production process.

Since macroeconomic growth theories explicitly do not include the concept of infrastructure systems, although infrastructure plays a very important role in economic development, Carlsson, Otto and Hall (2013) have explored the role of infrastructure in macroeconomic growth theories and confirmed that certain economic functions of infrastructure may be represented in existing macroeconomic models, so new economic geography (growth) enables the presentation of transport infrastructure due to a more spatial approach.

However, some studies (for example Devarajan, Swaroop & Zhou, 1996; Canning & Pedroni, 2008; Nketiah-Amponsah, 2009; Yu et al., 2012; Crescenzi & Rodríguez-Pose, 2012) argue that transport infrastructure alone is not sufficient for reaching higher GDP and that infrastructure endowment is a relatively poor predictor of economic growth. It seems that the vast body of evidence is far from being conclusive and that the role of transport infrastructure depends on different circumstances. Therefore, it is important to be aware of other drivers of economic growth because they have important implications on the transport infrastructure's impact on economic growth

3. Methodology

The aim of this research is to investigate the effects of infrastructure on economic growth. The panel data can be used to look at the unobserved factors which affect the dependent variable which consist of two types: constant and that vary over time (Wooldridge, 2016). To empirically test the effects of transport infrastructure, the following econometric model has been estimated, based on economic model from equation (1):

$$gdp_{it} = \beta_0 + \beta_1 pop_{it} + \beta_2 gfcf_{it} + \beta_3 open +_{it} \beta_4 rail_{it} + \beta_5 road_{it} + \lambda_t + a_i + u_{it} \quad (2),$$

where depended variable is gross domestic product (gdp), used as a proxy for economic growth while population growth (pop), gross fixed capital formation (gfcf) and road and railway are used as regressors. Variable λ_t denotes the unobservable time effect, a_i denotes the unobservable time invariant individual effect and u_{it} is the remainder stochastic disturbance term (Baltagi, 2005). The *i* denotes the cross-sectional unit (country) and *t* the time period (year).

Standard approach in panel data analysis (linear model) includes three different estimators: pooled ordinary least squares (POLS), fixed effects (FE) and random effects (RE).

Although it is *a priori* assumed that the fixed effects model is the most suitable for the analysis, the paper examines the economic model with all three different estimators: POLS, which applies only if the countries are homogeneous (economic and political structure which might affect the observed variables, respectively generate the observations of the observed variables, but can't be measured explicitly and are contained in the error), FE and RE.
These models were selected based on the previous empirical researches using fixed and random effects to assess the effects of transport infrastructure on international trade (Ismail & Mahyideen, 2015) and the effect of vertical separation on the success of railway system (Laabsch & Sanner, 2012).

FE estimator is used when estimating the effects that vary over time, considering that individual panel unit specificities are correlated with one or more regressors. Namely, each unit (country) has its own specifics that do not change over time (i.e. geographic position, culture, language, etc.) and it is expected that these characteristics will be correlated with regressors, i.e. independent variables.

FE estimator removes specificities by time demeaning, resulting in the estimates of the time variating variables only. On the other hand, if we assume that individual specificities are independent of regressors, RE estimator is appropriate. Technically, we use Hausman test to decide which estimator is more suited to the data in hand and as it is usually the case in empirical research, the Hausman test rejects H_0, that is, that RE is consistent and efficient as well as FE and therefore we should stick with FE. Since we work with relatively small sample, we show the results of all three estimators to see whether the results are consistent.

4. Data and descriptive statistics

In this research, the panel data analysis has been used for eleven Central and Eastern European EU Member States (CEE) in the period 1995–2016. The CEE countries analysed in the paper are, 'from north to south': Estonia, Latvia, Lithuania, Poland, the Czech Republic, Slovakia, Hungary, Slovenia, Croatia, Romania and Bulgaria. The original sample included Malta and Cyprus, however those countries were excluded from the estimation since they have no railway network established. We selected CEE countries for our analysis due of following reasons: first, all of them experienced the transition towards market economies, second, they have been receiving significant EU funding to be invested in transport infrastructure since they are new EU Member States and third, there is a gap in the literature investigating these countries.

The economic model employed in this paper includes six variables: Economic Growth (EG), Population Growth (POP), Infrastructure Investment (GFCF), Trade Openness (OPEN), Railway Transport Infrastructure (RAIL) and Road Transport Infrastructure (ROAD), and has the following format:

EG = f (POP, GFCF, OPEN, RAIL, ROAD) (1)

In our analysis we use GDP as a proxy variable for economic growth. As a standard set of control variables which have an impact on economic growth (Barro & Lee, 2010, Ismail & Mahyideen, 2015, Keho, 2017), we use three following variables: variable population growth, then variable gross fixed capital formation as a proxy for infrastructure investment and third variable, trade openness. For the transport infrastructure we follow Pradhan and Badchi (2013), and as a proxy variable for railway infrastructure we use length of total railways while as a proxy variable for road transport infrastructure we use length of total roads network, where both variables are expressed in kilometres. All the data are obtained from the Eurostat Database (2017).

Table 1 contains descriptive statistics of all used variables in the model.

Table 1. Descriptive statistics

Variable	Units	Category	Mean	St. Dev.	Minimum	Maximum
gdp	mil. EUR	overall	58825.47	78879.96	2829	430037.8
gdp		between		72555.98	5648.214	272993.9
gdp		within		36682.12	-105452.7	215869.4
pop	absolute values	overall	8268950	1.03e+07	376433	3.87e+07
pop		between		1.07e+07	403086	3.82e+07
pop		within		337493.6	6762588	9714668
gfcf	mil. EUR	overall	13575.99	17046.76	435.3	86396.1
gfcf		between		15526.54	1174.914	55572.1
gfcf		within		8202.54	-23041.01	44669.77
open	Ratio	overall	1.218494	.5117014	.4367842	3.264139
open		between		.478885	.7190229	2.584769
open		within		.2222736	.6307528	1.897865
rail	kilometres	overall	6028.499	5797.434	925	23986
rail		between		6031.518	1079.92	21013.05
rail		within		473.5529	4246.451	9001.451
road	kilometres	overall	451.4231	378.7293	0	1883.9
road		between		290.9813	0	935.745
road		within		254.6779	-149.3219	1399.578

Source: Authors' calculation

Descriptive statistics consist of seven columns where the most important is the fourth column which shows the standard deviation (σ) of each variable between and within the observed countries. According to the presented data in the Table 1, it could be seen that the standard deviation, e.g. the variation between observed countries is higher than the variation within countries which is reasonable because our sample is heterogeneous. It is quite interesting that in the case of the variable *rail*, the variation between observed countries is more than ten times higher than within countries while in the case of the variable *road* the variation between and within countries is much smaller, indicating that the road infrastructure within the observed countries is much more similar than the rail infrastructure. Certainly, the descriptive statistics itself is not enough to be able to conclude with certainty. The original sample consisted of thirteen countries, eleven mentioned in the data description and Malta and Cyprus. However, Malta and Cyprus were excluded of the estimation once they have no railway network established.

Table 2 shows the measures of strength and direction of the linear relationship between two variables i.e. correlation coefficients.

Table 2. Correlation coefficients

	pop	gfcf	open	rail	road
pop	1.0000				
gfcf	0.9580	1.0000			
open	-0.5135	-0.4424	1.0000		
rail	0.9025	0.9094	-0.4847	1.0000	
road	0.8406	0.8358	-0.4489	0.8194	1.0000

Source: Authors' calculation

According to the presented data, it is evident a moderate negative relationship between variables trade openness and population growth, as well as between trade openness and gross fixed capital formation, and trade openness and road and railway infrastructure. The correlation coefficients of variables transport infrastructure and population growth and transport infrastructure and gross fixed capital formation have a strong positive linear relationship.

5. Results and discussion

The estimated results of POLS, FE and RE are reported in Table 3 The first column shows the results of the test with the POLS estimator, the second column presents the results of the estimator FE and the third column shows the results of the estimator RE.

Table 3. Results of the analysis

	(1) POLS	(2) FE	(3) RE
VARIABLES	gdp	gdp	gdp
pop	0.00403***	0.00914**	0.00880***
	(0.000391)	(0.00340)	(0.000889)
gfcf	3.991***	3.521***	3.577***
	(0.212)	(0.317)	(0.232)
open	16,228***	10,458	11,817*
	(4,255)	(7,655)	(6,865)
rail	-5.454***	-14.77***	-13.49***
	(0.936)	(1.746)	(1.433)
road	14.54***	13.63*	14.16*
	(3.285)	(7.273)	(7.249)
Constant	-18,555***	-2,880	-9,357
	(6,400)	(41,195)	(7,296)
Time Fixed Effects	Yes	Yes	Yes
Observations	217	217	217
R-squared	0.979	0.972	0.953
Number of Country	11	11	11

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculation

According to the obtained results, in the case of the estimators POLS and RE, all the variables are significant, while in the case of FE only variable trade openness is not significant. The results of the regression highlight significant and positive effects on economic growth of all observed variables except the variable railway. Population growth, gross fixed capital formation and trade openness have positive effects on economic growth, while in the case of railway infrastructure, all three estimators show significant ($p<0.01$) and negative effects of railway infrastructure on economic growth in the observed period for eleven CEE countries.

As it has been indicated, the assessment of the impact of transport infrastructure on economic growth should take into consideration other important growth drivers. Our research results confirm the link between economic growth to a combination of human resources, investments, road infrastructure endowment and trade openness. Road infrastructure in the CEE is relatively modern and highly developed and our findings show that total road network has a positive and significant coefficient at least at the 5% significance level, depending on estimator. Some other studies (for example Ismail & Mahyideen, 2015) have also concluded that long road networks lead to easier access to the work place, thus boosting productivity and consequently economic

growth. Developed road infrastructure also allows other economic activities like trade and tourism, which have important effects on GDP growth in all CEE. In a way, these results are even underestimated because, according to Crescenzi and Rodríguez-Pose (2012), the road infrastructure variable does not capture its wider impact on economic performance. The reason is that the Keynesian multiplying effects during the construction phase have not been included in the data. The road infrastructure network is based solely on the quantity (kilometres) of infrastructure actually built and currently in use and are not complemented by any expenditure data. Since official statistics only record new infrastructure after final completion, our proxy captures mainly the *ex-post* impact of transport infrastructure on the economic activity. Still, our research results confirm significant and positive impact of road infrastructure on economic activity and growth.

On the other hand, railway infrastructure does not have positive effect on economic growth. Railway infrastructure in CEE is outdated and inefficient and according to the European Parliament transport analysis in 2016, there are gaps and bottlenecks in connectivity and travel time in CEE railway system. Data shows that travel times in the old member states (EU15) are twice to four times faster than in the CEE. Furthermore, the North-South connection through the three Baltic States constitutes a railway gap. Ports and their railway connections to the hinterland are dealing with the limitations at both ends of the Baltic-Adriatic corridor, while several railway cross-border bottlenecks are recorded between most of CEE countries and between CEE and EU15 countries. It is not surprising that the results of our analysis report negative and significant coefficient ($p<0.01$) in the case of all three estimators.

Significant resources have been invested in transport and related infrastructure in CEE, especially in the pre-accession period and the EU's policies and funds have focused on revitalizing and improving transport infrastructure. However, railways and rail infrastructure are lagging behind for decades in these countries while most of the investments have been focused on the construction and modernization of the motorways. The results of the analysis confirm that actual state of the railway transport infrastructure in the CEE should be improved, especially in the light of ongoing desire to reduce CO2 emissions that are in the large extend produced by road transport, while railway transport is more environment-friendly. This paper supports the European Union's guidelines for the need to invest in railway infrastructure to ensure the effective transport of passengers and goods in the long term, create their competitive advantages, reduce green-house gas (GHG) emissions and thus simulate sustainable economic growth in CEE countries.

6. Conclusion

The role of transport and transport infrastructure in the economic growth and competitiveness of a country has been recognized in many studies, but it is still an ongoing topic in the scientific circles since some research results have been inconclusive. Generally, it is considered that in the era of globalization economic progress of the economy, among other things,

depends on the efficiency of passenger and goods transport, while the lack of inadequate transport infrastructure remains an important obstacle.

Having in mind this wider context, the motivation of this paper is to empirically investigate the effects of transport infrastructure on economic growth in the CEE with taking into account the set of variables that shape the relationship between transport infrastructure and economic dynamics. This study has examined the effects of transport infrastructure on economic growth in Central and Eastern EU Member States using the data for the 1995-2016 period. Using standard three estimators (i.e. POLS, FE, RE), this study has concluded that in the case of all three estimators the results are significant and show that road infrastructure, gross fixed capital formation, population growth and trade openness have positive effects on economic growth, while rail infrastructure has negative effects on the GDP growth. Variable population growth in the case of POLS and RE was significant and positive, while in the case of FE was insignificant.

This analysis is deemed to be indicative in the effective design and implementation of transport policies in the whole European Union and particularly CEE countries. Although significant resources have been invested in transport and related infrastructure in CEE, especially in the pre-accession period, railways and rail infrastructure are lagging behind for decades in these countries because the majority of the investments have been focused on the construction and modernization of motorways. The results of the analysis confirm that actual state of the railway transport infrastructure in the CEE should be improved, especially in the light of ongoing desire to reduce CO2 emissions that are in the large extend produced by road transport, while railway transport is more environment-friendly. Our research supports the European Union's guidelines for the need to invest in railway infrastructure in order to ensure the effective transport of passengers and goods in the long term and promote sustainable economic growth in CEE countries.

Research work contributes to the recognition of the role of the transport system in national and regional economy and represents the framework for further research that can be complemented by the inclusion of other variables that support the need for investment in railways such as environmental protection and energy efficiency.

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