THE CORRELATION BETWEEN TRANSPORTATION INDUSTRY AND ECONOMIC GROWTH: THE CASE OF OECD COUNTRIES

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Abstract

In the present study where the correlation between economic growth and transportation investments was scrutinized, whether there was an interaction between transportation investments and economic growth in OECD countries was investigated. Thus, Pedroni and Kao cointegration analysis, FMOLS and DOLS analyses and Canning and Pedroni long-term causality analysis were conducted on 1995-2016 transportation industry infrastructure investments and gross domestic product per capita data for 25 OECD countries included in the study sample. The study findings demonstrated that per capita gross domestic increased the infrastructure investments in the transportation industry in the long-term, however the causality was reciprocal.

Keywords: Transportation industry, economic growth, infrastructure investments

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1. Introduction

It is expected that investments in transportation infrastructure would lead to economic growth via a variety of paths. Accordingly, initially, infrastructure investments would increase the demand for goods and services. Secondly, the development of the transportation infrastructure would shorten the travel time and lead to time and cost savings in passenger and freight transportation (Goetz, 2011). The time savings due to the improvement of transportation infrastructure could lead to economic consequences that would stimulate local production by facilitating access of producers to remote markets and enabling input from a wide range of sources. This would benefit the highway infrastructure investments by reducing corporate inventory (Li and Li, 2013). Third, a better infrastructure would attract direct foreign investments, an important factor for the economic growth. Finally, lower transportation and trade costs could lead to higher labor productivity by accelerating industrial agglomeration and intensifying economic activities (Martin and Ottaviano, 2001; Weisbrod and Treyz, 1998; Gutiérrez et al., 2010). It is possible to mention a general framework that defines the correlation between the transportation system and the economic growth. Thus, the increase in accessibility of transportation would reduce travel time and costs, increase traffic volume, and leads to spatial redistribution of economic activities. It is also expected that in addition to material exogeneity, it would lead to allocating environmental externalities, transportation network economies, labor market mobility, and thus, economic growth. In the theoretical literature, the perception of the role of infrastructure as an engine of economic growth has changed over time. For example, while the neoclassical growth model of Solow (1956) used the mass production function approach and assumed external technical changes, Romer's (1986) study initiated a series of theoretical studies on the intrinsic nature of economic growth. During the last three decades, several theoretical and empirical studies were conducted on the impact of infrastructure on economic development. Analysis of these studies would demonstrate that the hypothesis that transport infrastructure and other infrastructure investments have an impact on economic growth was frequently tested.

Although several studies were conducted on the transportation industry infrastructure and economic development previously, the initial studies demonstrated that transportation was an important factor for economic growth. Studies by Aschauer (1989) and Ford and Poret (1991) were pioneering studies that predicted the impact of infrastructure investments on the US economy. In similar studies, it was concluded that the infrastructure capital had a strong impact on the total factor productivity. However, these studies were later criticized by other researchers for proposing unrealistic conclusions (Sanchez-Robles, 1998). Contrary to the high estimates reported in these early studies, the later studies emphasized more moderate effects. For example, in a study by Kumari and Sharma (2017), it was concluded that the initial investments in infrastructure could have a great impact on the economy, however the investments after the construction of the basic infrastructure would have a comparatively limited impact. It was claimed that the transportation infrastructure, which includes roads, railways, airports and sea ports, were commonly among the main determinants of both productivity and economic development. The lack of an adequate transportation infrastructure (such as lack of roads and poor quality roads) would limit labor migration, material use, and market expansion, etc., which in turn would be a major obstacle to local economic performance. Theoretically, transportation infrastructure and service improvements could improve overall economic performance by reducing transport costs and increasing accessibility, which would directly reduce the cost of input factors, increase private investments, promote trade, create jobs and indirectly increase labor productivity and develop the education.

An efficient, reliable and economic infrastructure is required for economic growth. Especially transportation infrastructure is vital for the regional welfare. First, it provides employment, public services, shopping or social networks for residents, and establishes links between the businesses and workforce consumers and suppliers (Parker et al., 2004). Second, the transportation infrastructure could increase the productivity of existing inputs and / or reduce transportation costs, which could render the region more attractive for investors (Pradhan and Bagchi, 2013). Furthermore, transportation infrastructure affects economic growth through aggregate demand. The significance of transportation infrastructure for economic growth was identified in studies by Wang (2002), Calderón and Servén (2004), and Pradhan and Bagchi (2013). Moreover, the causal connection between infrastructure and growth could exist in the opposite direction, as countries with high production output levels could finance higher infrastructure investments (Deng, 2013).

The aim of the present study that investigated the correlation between economic growth and transportation investments was to test whether there was an interaction between transportation investments and economic growth in target OECD countries, and if there was an effect, to determine whether there was a causality. Accordingly, the study included of five sections. In the first section, the main surface knowledge on the topic is initially provided, and the second section included the applied studies previously conducted the subject. The third section included data collection and analysis methodology. In the fourth section, the analysis results were discussed. The final section included a general assessment.

2. Literature Review

In empirical literature, the correlation between economic growth and the transportation industry was scrutinized using several datasets and different findings were obtained for different countries. It could even be argued that the results differed based on the utilized analysis methods. Thus, studies reported bidirectional or unidirectional relationships between the two variables, and others stated that there was no correlation between the variables. The studies in the literature are summarized including study samples and time periods, data sources and methods and differences in findings in Table 1.

Table 1: Selected Studies in the Literature

Study and Authors	Sample - Period	Data, Resource and Methodology	Findings
Fernald (1999)	29 USA Industries 1953–1989	Study data includes gross output, capital, labor, energy and material inputs. The data were obtained from the US Department of Commerce and the US Federal Highway Administration. Generalized Least Squares Method (GLSM) was used.	The study findings demonstrated that there is a strong correlation between transportation infrastructure investments and economic productivity.
Démurger (2001)	24 Chinese territories 1985–1998	Real GDP, secondary education level, the share of agriculture in GDP, direct foreign investment, railway, roadway length (km), population density, per capita telephone lines were included in the study data and State Statistics Bureau and National Statistics Bureau data were used. Panel Data Analysis method was used in the study.	The study findings demonstrated that transportation facilities were an important factor in explaining the interregional growth differences.
Roller and Waverman (2001)	21 OECD Countries 1970–1990	The study data included GDP, GDP deflator, population, CPI, gross domestic investment, gross domestic savings, public deficit (or surplus), geographical area, population density, labor, transportation and communication infrastructure investments. Study data were obtained from Summers and Heston (1991) database. The Nonlinear Three-Step Least Squares Method was used in the study.	The study evidenced the existence of a causality between telecommunications infrastructure and economic development.
Bose and Haque (2005)	32 Developed Countries 1970–1989	The study data included public investment expenditures in transport and communication industries and GDP per capita growth rate and the data were obtained from the World Bank Country	In the study, a positive impact of growth on public investments was found for developing countries. It was concluded that the

		Economic Reports. Simple Regression Analysis was used in the study.	correlation was due to the investments in the transportation and communication industries.
Ozment (2006)	44 African Countries 1981–1993	Study data included per capita GDP, population, railway distance, asphalt roadway distance, number of available airports, number of airports with permanent runways, TV stations and literacy rate. Study data were obtained from Intelligence Service reports world factbooks. Multiple regression analysis was used.	The study findings demonstrated that the change in the railway line distance was effective on GDP per capita. It was also found that there was a positive correlation between asphalt road distance (km) and GDP per capita.
Boopen (2006)	38 Sub-Saharan African nations 1980–2000	The study data included Transportation Capital and Economic Growth and data were obtained from different sources. Horizontal-Section and Panel Data Analysis were used as the analysis methods.	The study findings demonstrated that transportation capital contributed to national economic development.
Wang (2009)	Xinjiang Province, China 1993–2007	In the study, Gross Domestic Product (GDP) was used for national economic growth and total products, industrial and agricultural products and household consumption data were included in the analysis. Furthermore, freight volume, freight turnover, passenger volume, passenger turnover, railroad distance, highway distance and total freshwater transportation data were used for transportation industry. Study data was obtained from the Xinjiang Statistical Yearbook. The study method was Gray Correlation Analysis.	The study findings demonstrated that there was a bi-directional correlation between transportation and economic growth. Furthermore, evidence was found that the transportation industry could promote the entire economic industrialization process and lead to economic development. The existence of a bidirectional correlation between transportation and economic growth was demonstrated in this study.
Marazzo et al. (2010)	Brazil 1966–2006	In the study, air transport demand (passenger-kilometer: PAX) and economic growth (GDP) data were used and the analyses were conducted with Impact-Response Analysis and Granger causality analysis.	The study findings demonstrated that there was a long-term bidirectional correlation between air transport demand and economic growth.
Guo et al. (2011)	China 1964–2004	The study data included Gross Domestic Product and infrastructure investments, railway and roadway distance data, and the data were obtained from the Chinese Statistical Yearbook. Vector Autoregression (VAR) was conducted in the study.	The study findings demonstrated that long-term railroad investments had a positive effect on GDP and long-term highway investments had a negative effect on GDP.
Hong et al. (2011)	31 Chinese provinces 1998–2007	The study investigated the correlation between transportation infrastructure and regional economic growth. Panel data analysis was used in the study that utilized various data on transportation infrastructure and economic growth.	The study findings demonstrated that transportation infrastructure played an important role in economic growth.
Eruygur et al. (2012)	Turkey 1963–2006	The study data included transportation-communication capital and real output. The study method was the Vector Error Correction Model.	The study findings demonstrated that transportation-communication capital had

			a lagged and positive effect on economic growth.
Kuştepeli et al. (2012)	Turkey 1970–2005	In this study, road transportation infrastructure, highway distance, gross national product growth, total exports and public import investments data were used. Study data were obtained from the Turkey Statistics Institute.	Empirical results demonstrated that the share of exports in GDP had a weak short-term effect on road transportation expenditures. However, it was concluded that the highway infrastructure expenditures had to impact on economic growth and international trade.
Button and Yuan (2013)	USA 1990–2009	In this study, VAR analysis and Granger causality analysis were used to determine whether there was a correlation between employment, personal income, and air cargo volume.	The study findings demonstrated that there was no correlation between income, income changes and air cargo volume.
Chi and Baek (2013)	USA 1996–2011	The study data included revenues, air transportation demand per passenger and distance, and the relevant data were obtained from the US Department of Transportation, Transportation Statistics Bureau and Economic Analysis Bureau. Autoregressive distributed lag (ARDL) model was used.	The study findings demonstrated that both airway passengers and freight services increased with economic growth in the long term. However, in the short-term, only airline passenger demand responded to economic growth.
Pradhan and Bagchi (2013)	India 1970–2010	The study analysis data included Gross Domestic Product; Gross Domestic Capital; Road Transportation infrastructure; and Railway Transportation infrastructure. Related data were obtained from World Bank and Infrastructure Statistics, World Development Indices reported by the Ministry of Statistics and Program Application, as well as various Indian government institutions. In the study, cointegration, VAR analysis and Granger causality analysis were conducted.	The results of the cointegration test revealed a long-term correlation between transport infrastructure, economic growth and gross capital. Furthermore, evidence demonstrated a bidirectional causality between road infrastructure and economic growth and the existence of bi-directional causality between road infrastructure and gross domestic capital.
Liddle and Lung (2013)	107 Countries 1971–2009	Per capita energy consumption in the transportation industry and real GDP per capita data were used. The study method was Cross-Section and Panel Data Analysis.	The study findings demonstrated that there was a long-term causality from per capita GDP to per capita energy consumption in the transportation industry.
Bosede et ol. (2013)	Nigeria 1981–2011	The study data included Gross Domestic Product, transportation industry output, transportation infrastructure investments, public expenditures in the transportation industry and the data resource was the Nigerian Central Bank (CBN) Statistics Bulletin. The Least Squares Method was used in the study.	The study findings demonstrated that transportation infrastacture and transport infrastructure investments had a statistically significant and positive effect on economic growth in Nigeria.
Agbelie (2014)	40 Countries 1992–2010	This study data included demographic data including GDP, the producer price	The findings demonstrated that highway and rail

		index, the share of service industry in gross domestic product, labor force participation rate and unemployment rate provided by the World Bank, the OECD (Organization for Economic Cooperation and Development), the CIA (Central Intelligence Agency), the IRF (International Road Federation). The study method was conducted with panel analysis.	infrastructure expenditures and densities affected GDP. However, the magnitude of this effect varied significantly among countries.
Beyzatlar et al. (2014)	EU-15 Countries 1970–2008	The study data included real GDP per capita and access to domestic freight transportation. Study data were obtained from OECD transportation and economy database and the study was conducted with panel data analysis.	The study findings demonstrated that there was a bidirectional interaction and causality between transportation and revenues.
Badalyan et al. (2014)	Armenia, Turkey and Georgia 1982–2010	The study data included Gross Domestic Product, economic growth, road and rail transportation (million ton-km), road and rail passenger (million passenger-km), road and railway network distance (km) and Vector Error Correction Model was applied.	The study findings demonstrated that there was a bidirectional causality between gross domestic product and economic growth.
Hakim and Merkert (2016)	8 Southern Asian Countries 1973–2014	The study data included total passengers, air freight volume (ton-km) and GDP, and the relevant data were obtained from the World Bank World Development Indicators database. The study method was panel data analysis.	Empirical results revealed a long-term, unidirectional correlation from economic growth to airline passenger traffic, as well as from GDP to air freight transportation activities.
Brida et al. (2016)	Mexico 1995–2013	The study data included real gross domestic product, number of airport passengers. Relevant data were obtained from the National Geography and Statistics Institute and cointegration analysis was used.	The results suggested that there was a bidirectional correlation between real Gross Domestic Product and transportation.
Saidi and Hammami (2017)	75 Countries 2000–2014	Study data included GDP per capita, financial development, trade openness, urbanization, capital stock, total population, direct foreign investment and freight transportation. The data were obtained from the World Bank and the Generalized Moments Method (GMM) was utilized.	The study findings demonstrated that the increase in freight transportation had a significant impact on economic growth. This implied the effect of transportation on economic activities.
Bozkurt et al. (2017)	Turkey and Eurasian Economies1995–2015	The study data included annual GDP growth rate and the share of transportation services in commercial service exports. The study data were obtained from the World Bank database. Panel Data Analysis method was used in the study.	As a result of the panel data analysis, it was determined that there was a positive correlation between annual GDP growth and transportation industry in certain countries.
Saidi et al. (2018)	14 MENA (Miidle East and North Africa) Countries 2000–2016	The study data included economic growth, transportation energy consumption and transportation infrastructure investments. Relevant data were obtained from the World Bank. The study was conducted with Generalized Moments Method (GMM).	Empirical results demonstrated that transportation energy consumption promoted economic growth in MENA countries. A positive and significant correlation was

			found between transport infrastructure and economic growth in all regions in MENA countries.
Kara and Ciğerlioğlu (2018)	Turkey 1988–2015	Study data included GDP per capita, the share of fixed capital investments in gross domestic product, aggregate road and motorway distances (km). Study data were obtained from the World Bank and Turkish statistics office. VAR analysis was used in the study.	The study findings demonstrated that transportation infrastructure had a long-term and positive impact on economic growth in Turkey.

3. Data and Methodology

Two different datasets were used in the study. The first dataset was the per capita gross domestic product (KBGSYH) and was obtained from the World Bank website (https://data.worldbank.org). The data is expressed in fixed US dollar price and calculated as the ratio of the gross domestic product to the mid-year population. Current price movements are exempt from the effects of inflation since these were eliminated with country specific gross domestic product deflator. The second dataset was the infrastructure investments (TSYT) data for the total mainland transportation industry. Related data was obtained from the OECD database website (https://data.oecd.org). Infrastructure investments in transportation industry are an important data that could reveal the industry performance. Relevant data include land, railroad and maritime, as well as sea port and airport investments in the mainland. Furthermore, investments for the reconstruction, renovation and repair of existing infrastructure are considered within the scope of these investments. This data is calculated and serviced at fixed prices similar to KBGSYH. Furthermore, in empirical literature, different transportation infrastructure investment data, similar to transportation infrastructure investment volume, were used by Fernald (1999), Démurger (2001), Bose and Haque (2005), Guo et al. (2011), Hong et al. (2011), Kuştepeli et al. (2012), Pradhan and Bagchi (2013), Bosede et al. (2013), Agbelie (2014), Badalian et al. (2014), Saidi et al. (2018) and Kara and Ciğerlioglu (2018). Thus, it could be suggested that the transportation sector infrastructure investment volume is an important data that represents the transportation industry.

OECD countries were included in the sample of the present study where the analyses were conducted on annual frequency data. Since the transportation industry data is available since 1995, the study included the data between 1995 and 2016, the year for which the latest data is available.

In the period covered in the study, the OECD countries included the USA, Germany, Australia, Austria, Belgium, United Kingdom, Czech Republic, Denmark, Estonia, Finland, France, Netherlands, Ireland, Spain, Israel, Sweden, Switzerland, Italy, Iceland, Japan, Canada, Lithuania, Luxembourg, Hungary, Mexico, Norway, Poland, Portugal, Slovakia, Slovenia, Chile, Turkey, New Zealand, and Greece, and the nations for which continuous data was available were included in the sample. Since some or all data were inaccessible, the countries excluded from the study sample were Netherlands, Ireland, Israel, Switzerland, Portugal, Slovenia, Chile, New Zealand and Greece. Thus, a total of 25 out of 34 OECD countries were included in the study sample.

The descriptive statistics, namely the mean, maximum, minimum, and standard deviation figures for the KBGSYH data for the countries included in the sample in the 1995-2016 period are presented in Table 2.

Table 2: Descriptive Statistics for the KBGSYH Variable

Country	Mean	Maximum	Minimum	Std. Dev.
USA	46.902,02	52.319,16	38.677,72	3.782,95
Germany	40.231,64	45.923,01	34.782,57	3.468,57
Australia	48.226,01	55.731,50	38.093,46	5.349,48
Austria	44.250,99	48.172,24	36.537,99	3.791,74
Belgium	41.914,64	45.457,90	35.228,34	3.185,81
UK	37.760,99	42.039,74	30.674,61	3.300,29
Czech Republic	17.679,72	21.894,11	13.462,99	2.784,75
Denmark	56.922,92	61.174,55	49.122,88	3.387,78
Estonia	13.523,57	18.094,59	7.313,74	3.512,66
Finland	42.904,55	49.363,70	31.997,00	4.881,82
France	39.375,57	41.968,98	34.091,17	2.400,14
Spain	29.246,54	32.459,92	23.686,84	2.486,12
Sweden	48.372,65	56.473,02	37.686,83	5.615,39
Italy	35.528,10	38.236,80	32.829,88	1.590,85
Iceland	40.433,36	48.995,17	31.270,45	5.139,93
Japan	43.817,44	47.660,89	40.368,71	2.069,72
Canada	45.633,34	50.407,34	37.569,47	3.987,56
Lithuania	10.477,43	15.945,52	5.322,42	3.391,92
Luxembourg	97.654,61	111.968,35	74.776,81	11.090,06
Hungary	12.204,51	14.997,20	8.952,04	1.865,95
Mexico	8.967,83	9.871,67	7.522,22	551,95
Norway	85.006,23	91.617,28	70.457,69	5.762,96
Poland	10.627,96	15.067,97	6.539,91	2.618,93
Slovakia	13.853,29	19.275,09	8.698,87	3.423,39
Turkey	10.013,37	14.117,44	7.315,41	2.127,75
Whole Sample	36.861,17	111.968,35	5.322,42	22.340,79

Data are presented in US Dollars.

The Table 2 demonstrates that Luxembourg had the highest mean KBGSYH and Mexico had the lowest KBGSHR. Furthermore, five countries with the highest KBGSYH were Luxembourg, Norway, Denmark, Sweden and Australia, respectively. Standard deviation figures that reflect the fluctuations in KBGSYH demonstrated that the highest fluctuation was observed in Luxembourg as well. Table 1 demonstrated that the mean KBGSYH for the OECD countries included in the sample was USD 36.861 and 15 countries in the sample were above this average.

The descriptive statistics, namely the mean, maximum, minimum, and standard deviation figures for the TSYT data for the countries included in the sample in the 1995-2016 period are presented in Table 3.

Table 3: Descriptive Statistics for the TSYT Variable

Country	**Mean**	**Maximum**	**Minimum**	**Std. Dev.**
USA	73.050,25	85.934,51	62.927,30	6.583,46
Germany	17.728,12	21.461,77	15.187,72	1.876,35
Australia	10.986,94	17.787,56	6.126,44	3.581,84
Austria	2.226,55	2.841,33	1.625,41	376,93
Belgium	1.508,76	1.924,86	1.063,90	255,38
UK	11.577,27	17.251,42	8.787,46	2.200,72
Czech Republic	1.790,63	3.303,17	1.044,66	640,40
Denmark	1.652,21	2.314,30	1.113,61	382,08
Estonia	122,82	244,42	16,81	68,75
Finland	1.215,99	1.671,85	974,05	233,19
France	18.149,27	21.457,93	15.330,68	1.503,58
Spain	11.055,70	18.383,91	5.353,90	3.786,03
Sweden	2.702,93	3.300,26	1.896,81	363,06
Italy	12.833,31	25.024,16	6.800,11	5.333,50
Iceland	104,76	229,77	33,42	50,30
Japan	61.078,02	84.999,16	42.194,75	15.761,29
Canada	8.543,50	16.076,11	5.457,07	3.519,39
Lithuania	278,16	572,38	16,53	169,54
Luxembourg	319,97	446,87	187,94	66,33
Hungary	1.044,24	2.138,02	429,73	542,67
Mexico	2.980,39	5.350,68	1.237,89	1.324,05
Norway	2.682,91	4.630,84	1.712,93	982,44
Poland	3.010,54	9.265,76	740,78	2.261,77
Slovakia	680,37	1.350,98	357,63	225,66
Turkey	3.973,28	10.124,07	1.152,34	2.948,73
Whole Sample	10.051,88	85.934,51	16,53	18.168,20

Data are presented in million Euros.

Table 3 demonstrates that the USA had the highest TSYT and Iceland had the lowest TSYT. Furthermore, the five countries with the highest TSYT were USA, Japan, Germany, France and Italy, respectively. It was observed that the mean TSYT of the OECD countries included in the sample was Euro 10,051 million and that eight countries in the sample were above this mean.

The aim of the present study was to investigate whether there was an interaction between transportation investments and economic growth, and if there was an interaction, to determine whether there was a causal relationship between these variables. Thus, panel data methodology was used to examine whether there was a correlation between transportation industry infrastructure investments and per capita gross domestic product. Panel data methodology is a combination of cross-sectional analysis and time series analysis. In panel data analysis, each section may be homogeneous. Unit root test that would be conducted before the panel data analysis on the series, which would be included in the analysis is the most important determinant of the subsequent processes. Therefore, the presence of unit roots is investigated with various unit root tests based on the methodological hypothesis. In the present study, the unit root tests were conducted with Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003), and Maddala and Wu (1999) tests. Unit root tests examine the presence of unit root in the series or the stationarity of the series based on the constructed hypothesis. Due to the differences between hypotheses and calculation methodologies, more than one unit root tests have been conducted simultaneously in the literature. Accordingly, the null hypothesis for the presence of the unit root is tested with the Levin, Lin, and Chu test, while the null hypothesis for the presence of an individual unit root is tested with the Im, Pesaran, and Shin test. Thus, it can be argued that both tests possess complementary features. In the study, Pedroni panel cointegration test developed by Pedroni (1997, 1999, 2000, 2004) and the Kao panel cointegration test developed by Kao (1999) were implemented subsequently. Two cointegrated regression analyzes were conducted in cases of cointegration, namely the Dynamic Ordinary Least Square (DOLS) method and the Full Modified Ordinary Least Square (FMOLS) method developed by Pedroni (2000, 2001). In the final stage, Canning and Pedroni (2008) long-term causality analysis, which indicates whether there is causality between the variables, allows for causality under cointegration, and discerns long-term causality, was conducted.

4. Findings

The correlation between the ratio of infrastructure investments to the gross domestic product and transportation industry per capita gross domestic product for OECD countries was first linearized by taking the logarithm of the series. The descriptive statistics for Log(KBGSYH) and Log(TSYT) series are presented in Table 4.

Based on the Table 4, it was observed that the Log(KBGSYH) was lower than Log(TSYT) and Log (TSYT) exhibited a higher fluctuation. Whether both series were stationary was

Table 4: Descriptive Statistics for the Series Included in the Analysis

Series	Mean	Maximum	Minimum	Std. Dev.	Observation
Log(KBGSYH)	4,427	5,049	3,726	0,309	550
Log(TSYT)	9,434	10,934	7,218	0,775	

examined by several unit root tests that were frequently used in the literature. Table 5 demonstrates the results of the individual intercept and the individual intercept and trend unit root tests conducted on the Log(KBSGSH) and Log(TSYT) series face and difference levels.

Table 5: Unit Root Test Findings

	Log (KBGSYH)							
	Face I(0)				**Difference I(1)**			
	Individual Intercept		**Individual Intercept and Trend**		**Individual Intercept**		**Individual Intercept and Trend**	
	Statistics	Probability	Statistics	Probability	Statistics	Probability	Statistics	Probability
Levin, Lin and Chu t	-8,663*	0,000	-3,145*	0,000	-12,062*	0,000	-11,475*	0,000
Im, Pesaran and Shin W	-3,468*	0,000	0,339	0,632	-9,335	0,000	-8,288*	0,000
Maddala and Wu	55,989	0,260	31,269	0,982	86,907*	0,001	55,853*	0,009
	Log(TSYT)							
	Face I(0)				**Difference I(1)**			
	Individual Intercept		**Individual Intercept and Trend**		**Individual Intercept**		**Individual Intercept and Trend**	
	Statistics	Probability	Statistics	Probability	Statistics	Probability	Statistics	Probability
Levin, Lin and Chu t	0,097	0,538	-0,544	0,292	-15,574*	0,000	-11,649*	0,000
Im, Pesaran and Shin W	1,191	0,883	-0,262	0,396	-14,005*	0,000	-11,630*	0,000
Maddala and Wu	39,313	0,862	43,497	0,730	95,973	0,000	76,968*	0,008

* depicts %1 significance level. Lag was based on Schwartz information criterion. Bartlet window and Newey-West bandwith were used in the Levin, Lin and Chu test.

Table 5 demonstrates that the Log (KBSGSH) and Log (TSYT) series contained unit toot at face level and the series were stationary at the difference level, hence they did not contain unit root. Cointegration test can be conducted to examine the long-run correlation between the series due to fact that both series were cointegrated at the same degree. The results are presented in Table 6.

Table 6 demonstrates that the weighted and non-weighted statistics in the model, where Pedroni panel cointegration correlation was tested between the series and the Log(KBSGSH) series was the dependent variable, indicated the presence of cointegration in only two of the seven tests conducted in both statistics groups. Accordingly, it is not possible to suggest the presence of cointegration. Furthermore, the fact that ADF t-test statistic was not significant in the Kao test, which was included in the same analysis, demonstrated that there was no cointegration. Thus, the H_0 hypothesis that 'there is no cointegration between the series' cannot be rejected statistically. This finding suggested that there was no statistical finding that evidenced the impact of long-term transportation industry investments in the OECD countries on per capita GDP.

Table 6: Cointegration Test Findings

	Pedroni Cointegration Test							**Kao Cointegration Test**	
	Alternative Hypothesis: Common AR coefficient (In-Group)				Alternative Hypothesis: Individual AR coefficient (Inter-group)				
	Statistics	Probability	Weighed Statistics	Probability		Statistics	Probability	t-statistics	Probability
	Model 1: $Log\ (KBGSYH)_{i,t} = \alpha + \beta Log(TSYT)_{i,t} + \mu$								
Panel v	9,047*	0,000	6,406*	0,000	Grup rho	3,366	0,999		
Panel rho	1,585	0,943	1,950	0,974	Grup PP	0,333	0,630	0,555	0,289
Panel PP	-0,241	0,404	0,033	0,513	Grup ADF	-1,953*	0,0254		
Panel ADF	-1,098	0,136	-0,999	0,158					
	Model 2: $Log(TSYT)_{i,t} = \alpha + \beta Log\ (KBGSYH)_{i,t} + \mu$								
Panel v	0,242	0,402	-2,995	0,617	Grup rho	1,626	0,948		
Panel rho	-0,902	0,183	-6,272	0,265	Grup PP	-3,588*	0,000	-2,540	0,005
Panel PP	-4,745*	0,000	-3,790*	0,000	Grup ADF	-7,113*	0,000		
Panel ADF	-6,338*	0,000	-6,376*	0,000					

* depicts %1 significance level. Cointegration was calculated for intercept and trend models. Lag was based on Schwartz information criterion

Analysis of the weighted and unweighted statistics in the model where the Log (TSYT) series was the dependent variable in Table 6 resulted in findings that supported cointegration in four of the seven tests for both statistical groups. Thus, the presence of a cointegration could be suggested. Furthermore, Kao test statistics supported the presence of cointegration. Accordingly, the H0 hypothesis that 'there is no cointegration between the series' was rejected statistically. This finding demonstrated that per capita GNP affected transportation investments in OECD countries included in the sample in the long-term.

FMOLS and DOLS results found for the cointegration determined in the $Log(TSYT)_{i,t} = \alpha + \beta\ Log\ (KBGSYH)_{i,t} + \mu$ model are presented in Table 7. The FMOLS and DOLS examines the presence of the cross-section and overall panel.

Table 7: FMOLS and DOLS Findings

Countries	**FMOLS**		**DOLS**	
	Coefficient	**t- statistics**	**Coefficient**	**t- statistics**
USA	-0,13	-1,00	-0,59*	-2,38
Germany	-0,97*	-12,72	-1,09*	-22,26
Australia	2,50*	61,52	3,32*	7,52
Austria	0,39	1,34	0,70	1,17
Belgium	1,63*	17,05	0,28	0,38
UK	1,87*	9,91	1,61*	7,19
Czech Republic	0,78*	4,23	1,01*	3,49
Denmark	0,30	0,39	0,57	0,50
Estonia	2,54*	22,18	2,58*	18,62
Finland	0,99*	6,16	-0,19	-0,77
France	-0,92*	-9,64	-0,71*	-3,90
Spain	1,34*	2,03	2,63*	2,62
Sweden	0,48*	5,00	0,90*	3,71
Italy	7,50*	13,29	8,69*	13,65
Iceland	-2,71*	-4,23	-1,95*	-2,37
Japan	-5,85*	-21,48	-5,80*	-18,57
Canada	1,74*	4,64	2,00*	2,69
Lithuania	2,04*	22,81	1,80*	21,29
Luxembourg	1,13*	5,30	1,78*	53,79
Hungary	1,98*	14,39	2,29*	6,53
Mexico	8,53*	11,84	9,22*	7,62
Norway	3,67*	5,05	1,95	1,29
Poland	2,44*	8,70	2,87*	7,49
Slovakia	0,64*	2,72	0,61*	5,67
Turkey	3,53*	50,75	3,81*	35,26
Whole Sample	1,42*	44,05	1,53*	30,04

* depicts %1 significance level.

Both FMOLS and DOLS analyzes produced similar results. Thus, FMOLS or DOLS analysis findings for Australia, Belgium, United Kingdom, Czech Republic, Estonia, Finland, Spain, Sweden, Italy, Canada, Lithuania, Luxembourg, Hungary, Mexico, Norway, Poland, Slovakia and Turkey that were included in the panel data analysis demonstrated that per capita gross domestic product had positive impact on transportation industry infrastructure. Furthermore, the same positive effect was observed for the overall panel is. However, it is possible to suggest a negative impact in the cases of the USA, Germany, France, Iceland and Japan. In other words, investments in the transport sector decreased with the increase in per capita GDP. The findings for Austria and Denmark did not demonstrate a statistically significant correlation.

Although FMOLS and DOLS analyzes demonstrate the direction and significance of the correlation between the date, they do not provide any information on causality. Canning and Pedroni (2008) panel causality analysis results conducted under the presence of cointegration revealed a causality at group mean and cross-sectional levels. The results of the analysis are presented in Table 8.

Table 8: Canning and Pedroni Panel Causality Findings

	λ_2: *Log(TSYT) → Log(KBGSYH)*			λ_1: *Log(KBGSYH) → Log(TSYT)*			$-\lambda_2/\lambda_1$
	Coefficient	t-statistics	Probability	Coefficient	t-statistics	Probability	Median
Group Mean	0,00	0,00	0,50	0,59	1,83**	0,03	0,02**
Lambda Pearson		68,42**	0,04		161,44*	0,00	(0,03)

* and ** depict significance at 1% and 5% levels, respectively. The figures in parantheses depict the probability value for the median.

The results presented in Table 8 demonstrated that the transportation sector infrastructure investments at the group mean level did not lead to a per capita GDP increase, however the null hypothesis H0 that 'there is no long-term causality at group mean level' was rejected (68,42 **). It was found that the causality from gross domestic product per capita to infrastructure investments was significant both at the cross-section and group mean levels based on λ_1 statistics and it was determined that per capita gross domestic product led to transportation industry infrastructure investments (161,44 *). Thus, it was determined that the causality was bidirectional.

In cointegration, it was determined that there was a unidirectional correlation between per capita GDP and transportation industry infrastructure investment, while Canning and Pedroni Panel Causality findings demonstrated a bidirectional causality. It can be suggested that the difference between the two findings was due to the difference between the theoretical background of causality and the theoretical background of cointegration. In other words, the presence of statistical correlations could not establish a basis for causality.

5. Conclusion and Recommendations

Transportation industry infrastructure investments are expected to contribute to the national economy through various mechanisms. These investments could support the mobility required for regional development through labor mobility and could also promote the increase in aggregate demand. In addition to empirical studies that reported a unidirectional or bidirectional correlation between transportation infrastructure investments and economic growth, there are also studies, which reported that there was no correlation. In the present study, whether there was a bidirectional correlation between economic growth and transportation investments was investigated. 1995-2016 annual data were used for the analyzes conducted on 25 selected OECD countries. Based on the Pedroni and Kao cointegration analysis findings, a unidirectional cointegration was determined in the study. Thus, per capita gross national product affected the transportation industry investments in the in the long-term but the opposite effect did not exist. Similar findings were reported by Bose and Haque (2005), Ozment (2006), Guo et al. (2011), Hong et al. (2011), Chi and Baek (2013), Bosede et al. (2013) and Hakim and Merkert (2016) in the literature and the presence of a unidirectional correlation was reported in these studies. Findings in the FMOLS and DOLS analyzes conducted under cointegration revealed that per capita GDP had positive impact on transportation industry investments in the long term. However, it had a negative impact in the US, Germany, France, Iceland and Japan. Canning and Pedroni causality analysis that tested the long-term causality demonstrated a bidirectional causality in the long-term.

In conclusion, the study findings demonstrated that per capita GDP bidirectionally increased transportation investments in OECD countries in the long-term, however the causality was bidirectional. However, the present study findings were valid only for the related sample and there are studies that reported different findings in the literature. Future analyses that include countries in different income classifications would provide more information on the topic, as well as providing new issues for future studies.

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