TAŞIMA ALTYAPI YATIRIMLARININ LİMAN ÇIKTISINA ETKİSİ: BİR ETKİNLİK YAKLAŞIMI

Abdullah AÇIK[1], İlke Sezin AYAZ[2]

Öz

Küreselleşme süreci ile birlikte ticaret ve sermaye hareketlerinin önündeki engeller büyük ölçüde azalmıştır. Böylece uluslararası ticaret kavramı ekonomik, sosyal, kültürel ve siyasal açıdan ülkeler için vazgeçilmez bir hal almıştır. Literatürde taşımacılık altyapılarının uluslararası ticarete olan etkisi incelenen önemli bir konudur. Ancak sadece yatırımları göz önünde bulundurarak taşıma altyapılarının etkin kullanılıp kullanılmadığının araştırılmaması eksik değerlendirmelere sebep olabilmektedir. Bu çalışmanın amacı kara yolu ve demir yolu taşımacılığının etkinliklerinin uluslararası ticarete olan etkisini Türk limanlarındaki yük trafiği aracılığıyla tespit etmektir. Bu doğrultuda öncelikle DEA analizi uygulanarak iki taşıma modunun etkinlik değerleri tespit edilmiştir. Daha sonra, elde edilen değerler liman çıktısını modelleyen regresyon modellerinde bağımsız değişken olarak kullanılmışlardır. Veri seti 2004 ve 2018 dönemlerini kapsayan yıllık bazda 15 gözlemden oluşmaktadır. Elde edilen sonuçlar her iki taşıma modunun da etkinliklerinin son yıllarda arttığını gösterirken, liman trafiğinde demiryolu taşımacılığının etkinliğinin daha etkili olduğunu ortaya koymuştur.

Anahtar Kelimeler: *Liman trafiği, demiryolu taşımacılığı, karayolu taşımacılığı, veri zarflama.*
JEL Sınıflandırması: *C51, H54, L92.*

IMPACT OF TRANSPORT INFRASTRUCTURE INVESTMENTS ON PORT THROUGHPUTS: AN EFFICIENCY APPROACH

Abstract

With the globalization process, the obstacles to trade and capital movements have been greatly reduced. Thus, the concept of international trade has become indispensable for countries in economic, social, cultural, and political aspects. In the literature, the impact of transportation infrastructures on international trade is an important issue examined. However, considering the only investments and not considering whether the transport infrastructures are used efficiently can cause misleading evaluations. This study aims to test the impact of road and rail transportation efficiencies on international trade through cargo traffic in Turkish ports. Accordingly, first of all, the efficiency values of the two modes of transport were determined by Data Envelopment Analysis. Then, the obtained values were used as independent variables in the regression estimations modeling the port throughput. The data set consists of 15 observations on an annual basis covering the period between 2004 and 2018. The results obtained showed that the efficiencies of both modes of transport have increased in recent years and the efficiency of rail transport in port traffic is more influential.

Keywords: *Port traffic, rail transport, road transport, data envelopment.*
JEL Classification: *C51, H54, L92.*

[1] Corresponding author, Res. Asst. Dr., abdullah.acik@deu.edu.tr, Dokuz Eylül University, Maritime Faculty, Department of Maritime Business Administration, ORCID: 0000-0003-4542-9831.
[2] Res. Asst., ilke.ayaz@deu.edu.tr, Dokuz Eylül University, Maritime Faculty, Department of Maritime Business Administration, ORCID: 0000-0002-7053-3940.

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1. Introduction

Commercial activities between the countries have always provided a substantial contribution from the point of augmenting wealth among the global population (Smith, 1776). Nowadays, world merchandise exports increased by 2.5 percent, while imports expanded by 3.1 percent. Also, the GDP growth of economic transition countries developed from 2.1 percent in 2017 to 2.8 percent in 2018 (UNCTAD, 2019). In light of these statistics, considering the relations between the countries, it is seen that international trade has great importance for the developments of the countries.

International trade cannot be carried out without international transportation. Because of the more than four-fifths of world merchandise trade in terms of volume is transported by sea, maritime transport remains the most important part of the world trade and the supply chain system of manufacturing. Ports are one of the principal elements of the transportation sector and are directly connected with the growing world economy in the last decades. Ports are key to integrating with the global economy and the heart of maritime transport. Within the port area, many different operations are performed; for example, infrastructure services which are provided by port authorities in general, cargo handling services which are obtained from private firms most of the time, and other services such as mooring, towage, etc. Each of these operations of ports shows different features according to their technology (Dwarakish and Salim, 2015: 296-297; UNCTAD, 2019).

The accessibility of the ports is also a very important subject in terms of international trade. Many studies related to the seaport-hinterland relations state that containerization has enlarged the links of seaports to the hinterland. Consequently, port competition has deepened (Hayuth 1981; Slack 1993) and the existence of smooth hinterland links has raised substantially. According to the last empirical studies, it can be seen that deep-sea container carriers determine container ports and container terminals based on the existence of hinterland links, reasonable tariffs, and closeness to consumers (Horst and Lugt, 2009). Because of these reasons; railway and road connections of ports, effective use of these networks, and investments in port infrastructures have a substantial importance in increasing the competitiveness of ports, port traffic, and port throughputs.

This paper aims to indicate the importance of ports in international trade and examine the impact of transport infrastructure investments on port throughputs through the efficiency approach. Several studies in the literature investigate the impact of infrastructure investments with factors such as transport infrastructure length. However, the fact that such investments have been made does not indicate that the infrastructure is used effectively. Infrastructure parts that are not used effectively can lead to misleading results. In this context, in this study, we analyzed the impacts of road and rail transport on port traffic through their efficiencies to investigate whether their investments contribute similarly or not.

In the second part of the study, the importance of investment in port infrastructure and road and rail investment projects in Turkey were explained and after that, the literature review section is included in the third part of the study. The methods we used in our research are introduced in the fourth part. The data set used in the analysis is explained and examined in the fifth part. After the results obtained from the analyzes are presented in the sixth part, the findings are evaluated in the last part.

2. Road and Railway Infrastructures and Ports

The inland transportation and transportation infrastructures of the countries have an important effect on the international trade volume. Countries with weak transportation infrastructures can't gain an advantage in international trade. Developing countries, especially with poor transport infrastructure, have significant disadvantages in international trade because of these reasons (Coşar and Demir, 2016: 232).

Infrastructure investments are also very important for ports which are one of the most significant components of international trade. Because, today operations in ports are not limited to cargo handling activities and logistics service procuration at the international level has become a substantial issue for the business (Wang and Cullinane, 2006). Investments in transportation and transportation infrastructures reduce logistics costs in long-distance international trade and provide competitive power for the countries (Şimdi et al., 2017). In this direction, high priority is given to road and railway investments in Turkey.

Road transport is a type of transport that countries with land connections frequently apply in international trade. The roadway infrastructures and transportation networks of the countries are significantly affected by their physical, historical, and economic geographies. However, the economic geographies and economic growth rates of the countries also have an impact on the infrastructure investments of road transport (Albarran et al., 2013: 880). In countries that mainly use the roadway in domestic transportation, investments, and improvements to the roadway infrastructure can increase the export performance of these regions (Martincus et al., 2012: 1).

The most preferred type of transportation for passenger and freight transportation in Turkey is roadway transportation. As of 2017, 88.9% of domestic passenger transportation and 90% of freight transportation is made with a highway. Freight transportation by roads in 2017 reached 263 billion tons-km, passenger transportation reached 315 billion passenger-km, and the total road use reached 128 billion vehicles-km. Also, there are still many projects related to road transportation. Until 2023, 2,226 km (368 km completed) highway construction is planned with a build operate transfer model. Turkey's highway network will reach 4,509 km in 2023 and it will reach 8521 km in 2035 according to the projections. Also, the divided road length will reach 31,864 km. Many of these roadway projects also will have a positive effect on the ports of our country. For example, with the Gebze - Orhangazi-İzmir Highway Project, a connection will be provided with İzmir Port, Marmara Region Ports, and Çandarlı Port. Also, with the completed Menemen – Aliağa – Çandarlı Highway Project, the reach of commercial enterprises located in İzmir city center, Izmir Bay and Aliağa district in the north to the Aegean Region Ports has been facilitated to a great extent. Furthermore, with the Kınalı –Tekirdağ – Çanakkale - Balıkesir Highway Project, the integration of ports, railway, and air transport systems in Marmara and Aegean Regions with road transport will be ensured. Also, there are many tunnel projects planned to be built in the Black Sea Region which will facilitate access to the regional ports by roadway (UDHB, 2018). With these projects, it is seen that although passenger and freight transportation by roadway has a high rate, the accessibility of ports by roadways is tried to be increased and attention is given to the development of passenger and freight transport by seaways.

Railway transportation, which is one of the most significant components of integration and economic development, is also very important for international trade. The rail transport industry forms an important role in the global economy. Railway transportation is superior in terms of safety, energy costs, and environmental effects in realizing mass transportation compared to other transportation modes (Çekerol and Nalçakan, 2011: 325). Turkey's main principles and strategies in terms of the transport sector which is agreed by the EU that eliminating the imbalance between roadway and railway transportation usage by making the necessary investment in railways (TMMOB, 2009: 1). For this purpose, many investment projects about railways are still ongoing in Turkey.

It is aimed to increase the high-speed + speed railway line from 1,213 km to 12,915 km, and the 11,497 km conventional railway line from 11,497 km to 12,293 km, thus reaching a total length of 25,208 km in 2023. Also, it is aimed to increase the share of rail transport to 10% for passengers and 15% for freight and complete the renewal of all lines by 2023. Besides, many railway projects are also related to the ports. For example, with the Mersin - Adana High-Speed Railway Project, by increasing the line capacity, it is aimed to ensure that the cargo from Konya, Karaman, Kayseri, and Gaziantep are transferred to Mersin Port more quickly. Also, with the completion of Kırıkkale

(Delice) – Kırşehir – Aksaray - Niğde (Ulukışla) Railway Project, it is aimed to provide the rail connection between Samsun and Mersin ports and to transport cargo from north to south of Turkey in a short time. Also, investments continue on the Egeray / Izban suburban line of the city of Izmir, which has an important potential with its industry and port. Infrastructure works for extending the suburban line from Aliağa to Çandarlı port connection - Bergama (50 km) is still ongoing (UDHB, 2018).

As can be understood from all these road and railway projects, there is a great effort on the development of transport infrastructure in Turkey. It is expected that the results of this project will be reflected positively in Turkey's accessibility of ports, port traffics, and throughputs.

3. Literature Review

The benefits of investing in transport infrastructure is an important issue studied in many directions and fields. In their study, Çoşar and Demir (2016) examined how domestic transportation infrastructure affects entry to international markets based on the infrastructure investments made in Turkey starting from the 2000s. In their study, they used foreign trade statistics and data on capacity changes for roads connecting these provinces to overseas borders of Turkey in the 2003-2012 year. According to their results, while an effective logistics network causes a country to be included in the global supply chain system, it reveals the superiority of that country over other countries. In the other study, Martincus and Blyde (2013) investigated the effects of domestic infrastructure works on trade. In their study which is combined geographic information with Chile's one company's export data, they found that decrease in transportation infrastructure has a noticeable negative effect on the export of a company. Duranton et al., (2013) investigated how highways affect the commercial structures of cities in their study. As a result of the study's econometric models, it has been found that the highways of the cities have a great effect on the export weight of the city. On the other hand, they have little impact on the total export values, therefore, locations with more highways specialize in the industries producing heavy goods. Şimdi et al., (2017) analyzed the impact of Turkey's length of highways on international trade between 1984 and 2014. According to the results, there is a short-run interaction between export-import and highways, divided ways, and asphalt ways. Besides, there is no causal relationship between the variables.

Since the effect of the efficiency of transportation modes on port traffic is examined, studies about port infrastructure and port performance in the literature are also very important. There are many studies in the literature about the effect of port infrastructure on port performance. For example, Felicio et al., (2015) examined the effects of port and terminal characteristics on port performance. According to the study results, five essential characteristics have an impact on container terminal performance. These characteristics were regional and continental location, accessibility of port from land and sea, maritime shipping services, port authority dynamism, and terminal organization, and logistics integration. In the study, it was emphasized that it is very important to provide access and logistics integration to the port by road and railways in terms of port performance. Similarly, Turner et al., (2004) affirmed the significance of inland accessibilities' impact on performance, and Gaur (2005) determined drivers that affect the terminal performance such as connections with the hinterland. Also, as stated by Fleming and Bair (1999), port accessibility and location have an effect on the degree of competitiveness for inter-port competition between two ports.

Apart from the infrastructure, some other factors affect port traffic. One of the main factors affecting cargo traffic in the ports is the production levels within the country. In a study conducted by Açık et al. (2019a), industrial production levels in Turkey were found to be effective in cargo traffic in Turkish ports. While these production levels that are subject to international trade are sent abroad, some modes of transport or multimodal mode of transport can be used. In any case, transport infrastructures in the country are of great importance and play a vital role. Also, the exchange rate (Kim, 2016; Chi and Cheng, 2016; Kim, 2017; Açık et al., 2019b) and transportation costs (Kim, 2016; Açık, 2019) are also important factors affecting port outputs.

4. Methodology

Two analysis methods are used for the study. First of all, the efficiency scores of road transport and rail transport are obtained by Data Envelopment Analysis (DEA). Then, the effect of efficiency values on cargo traffic in Turkish ports is modeled in separate regression models.

4.1. DEA Analysis

DEA (Data Envelopment Analysis) is a mathematical programming technique that performs efficiency evaluation by examining the outputs obtained with certain inputs for different units. The method was proposed by Charnes et al. (1978) with the development of the concept of efficiency introduced by Farrell (1957). In this method, the efficiency frontier is determined and the relative efficiencies are calculated by positioning homogeneous Decision-Making Units (DMU) with this frontier. Units on the frontier are considered to be efficient, while units that are far from the frontier are considered inefficient. For efficient DMUs, the efficiency value is set to 1, while the values of inefficient ones are positioned according to this efficient DMU.

There are many types of data envelopment models. In this study, we used the constant return to scale (CCR) model proposed by Charnes et al. (1978). Thus, when comparing all DMUs, which are years in our study, we thought that the constant return assumption would be more useful than the variable one. Another situation related to DEA is whether the model will be input-oriented or output-oriented. The choice of this is related to the purpose of the research. If the purpose is to identify the over-used resources, the input-oriented model is more suitable. On the other hand, if the aim is to see the amount of output that can be made with the available inputs, the output-oriented model is more suitable (Cook et al. 2014). In other words, efficiency can be achieved by reducing the resources according to the input-oriented model, and efficiency can be achieved by increasing the output according to the output-oriented model. Finally, the number of DMUs must be at least three times the number of inputs and outputs for robust results (Cooper et al., 2001).

4.2. Regression Analysis

After the results obtained from Data Envelopment Analysis, we applied regression analysis by using DEA scores as independent variables. Regression analysis is a common type of analysis used to determine the functional relationship between variables (Chatterjee and Hadi, 2015: 1). Through the information obtained, theoretical relationships can be proposed or tested. There are many types of regression analysis according to their purpose and usage area. In this study, we used linear regression analysis. The model of linear regression analysis is simply as in (1). Y refers to the dependent variable, while X_1 refers to the independent variable. ε is the residual represents the part of the dependent variable which cannot be estimated by the model (Gordon, 2015:5). While regression models containing one independent variable are called simple regression models (Gaurav, 2011:3), models containing more than one independent variable are called multiple regression models (Allen, 2004:4).

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon \tag{1}$$

β obtained after model prediction indicates how much the changes in the independent variable affect the dependent variable. It also provides an understanding of whether the effect is positive or negative. When there are multiple independent variables, it can be determined which one has more effect (Esquerdo and Welc, 2018:2). In this way, it can be stated 1 unit change in each independent variable causes how much change in the dependent variable (Archdeacon, 1994:148). In our study, we used the log-log regression model and thus aimed to determine the elasticity of *Y* relative to *X*. Thus, we tried to determine the percental response of *Y* to %1 change in *X* (Gujarati, 2004:176).

Several diagnostics tests should be applied to the residuals of the model to control several assumptions, which are (i) the conditional mean of ε is zero, (ii) coefficient constancy which reveals that both β and ε are fixed over the sample period, (iii) serial independence in the disturbances of ε, and (iv) a distributional assumption of normality for ε (Pagan and Hall, 1983). If some of these assumptions cannot be met, some corrections are applied to standard errors and the results are interpreted.

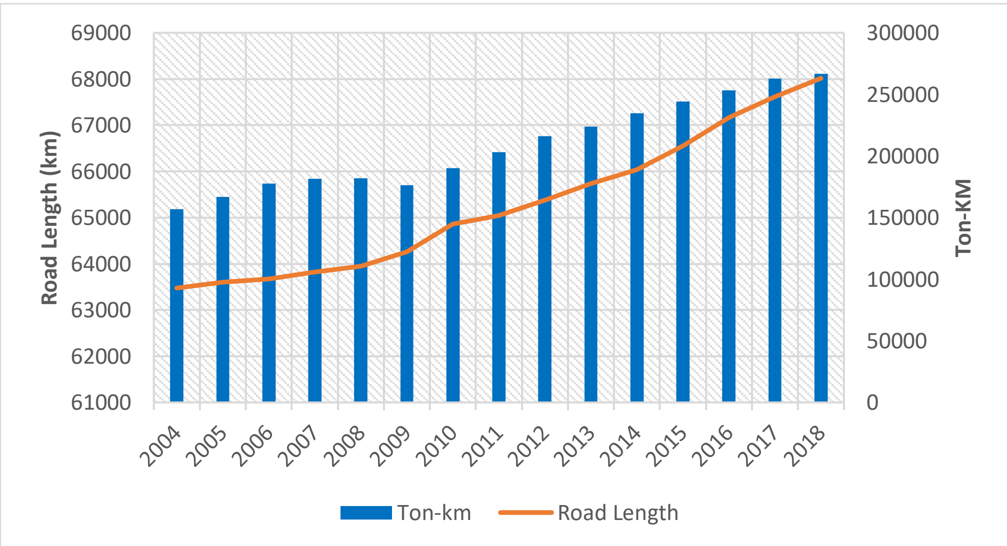
To determine the consistency in the observations of the estimated models, we used Influence Statistics. This method makes it possible to detect influential or outlier observations. The strength and leverage of a single observation change in regression results can be determined (Guide, 2007: 231). In this way, outlier observations affecting the explanatory power of the regression model can be detected (Banerjee and Frees, 1997). The model can be made more consistent by removing that observation or by using the dummy variable.

5. Data

The data set used in our study consists of 15 observations on an annual basis covering the period between 2004 and 2018. Since the port cargo statistics are available since 2004, the sample was partially narrow. Port cargo statistics are obtained from the website of the Ministry of Transport and Infrastructure (MTI, 2020) and its unit is metric tons. Data on road and rail transportation are obtained from the TUIK (2020a;2020b) website. The units of the lengths of the road and rail are Km, while the performance units are Ton-Km. For the length of highway data, the sum of state highways, provincial roads, and motorways is used. The village road is excluded considering its insignificant role in commercial cargo transports to the ports.

Graphical representation of data on road transport is presented in Figure 1. Transport activities carried out by road transport have increased in parallel with the total length of the roads. However, a shrinkage was observed in 2009 due to the impact of the global crisis in 2008. Road lengths increased by 6.6% in 2018 compared to 2004, following an ever-increasing trend thanks to the investments made. As for the cargo-carrying performance, there has been a 70% increase in the last year compared to the first year in our sample.

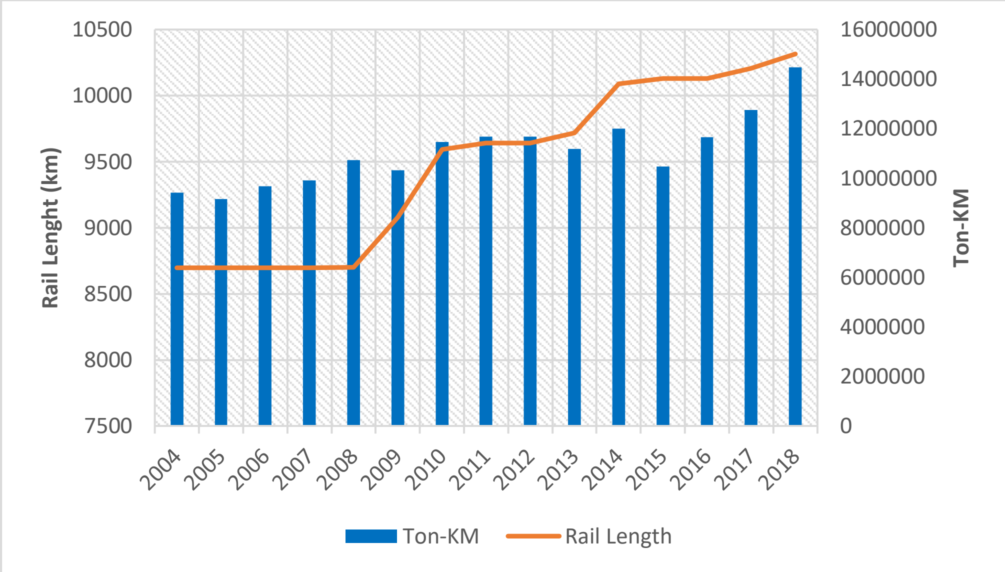
Figure 1: **Road Data**



Source: TUIK (2020a).

Railway transport performance is more irregular than road transport. The density, which remained irregular until 2015, followed an increasing trend after this year and reached its highest rate in 2018. Railway lengths followed an increasing trend after 2008. By 2018, a 15.6% increase in length was achieved compared to 2004 thanks to investments. It is approximately 2 times the increase rate experienced in highways and indicates the importance shown to the sector. As for the cargo transporting performance, there has been a 53.4% increase in 2018 compared to 2004.

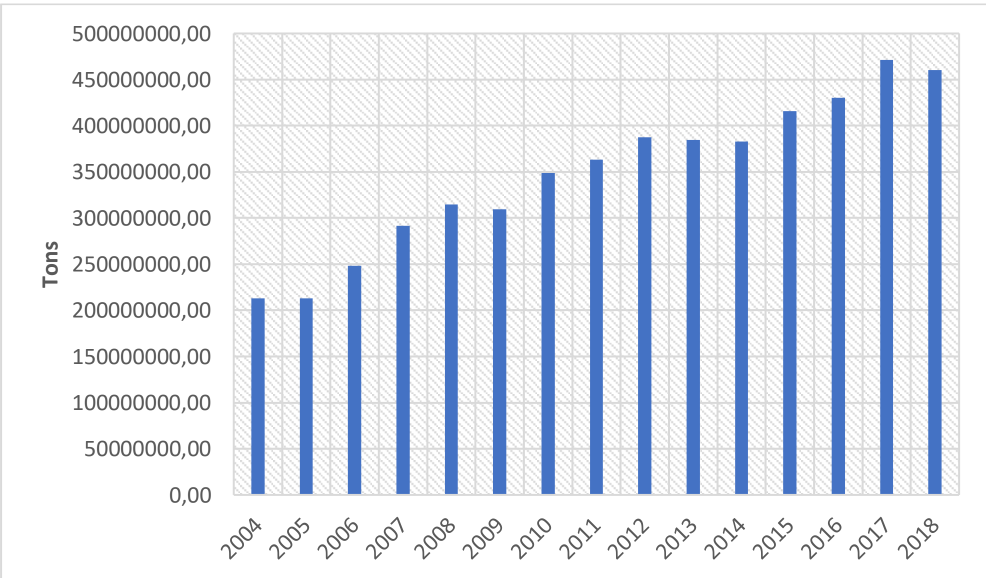
Figure 2: **Rail Data**



Source: TUIK (2020b).

Data on cargo traffic handled in Turkish ports is presented in Figure 3. Cargo traffic, which generally followed an increasing course, experienced decreases in some periods. For example, a contraction occurred in 2009 due to the impact of the 2008 global crisis. Similarly, in 2014 and the last year of our sample, shrinkages were also experienced. From the first year to the last year in our sample, cargo traffic increased by 115%.

Figure 3: **Port Throughput**



Source: MTI (2020).

Descriptive statistics about the data set used in the study are presented in Table 1. It consists of 15 observations and covers the period between 2004 and 2018.

Table 1: **Descriptive Statistics of the Variables**

	Port Cargo	**Railway Length**	**Railway Ton-Km**	**Highway Length**	**Highway Ton-Km**
Mean	349000000.0	9468.9	11105867.0	65279.9	209040.8
Median	363000000.0	9642.0	11177000.0	65049.0	203072.0
Maximum	471000000.0	10315.0	14481000.0	68016.0	266502.0
Minimum	213000000.0	8697.0	9152000.0	63476.0	156853.0
Std. Dev.	82671997.0	642.8	1395597.0	1529.6	36599.8
Skewness	-0.28	-0.14	0.72	0.44	0.25
Kurtosis	2.04	1.41	3.38	1.89	1.66
J-B.	0.78	1.63	1.40	1.24	1.27
Probability	0.68	0.44	0.50	0.54	0.53
Obs.	15	15	15	15	15

Source: MTI (2020); TUIK (2020a; 2020b).

After investigating the data set, DEA and regression analyzes were applied to analyze the impact of transport efficiency on port throughputs.

6. Findings and Results

The analyzes mentioned in the method were applied and the results are presented in this section. First of all, efficiency values were obtained for both road and rail by the DEA method. Then, the differentiation in the effect of the modes was modeled by estimating the cargo traffic at the Turkish ports with the related efficiency value.

6.1. DEA Results

CCR Input oriented model was used while analyzing the efficiencies of transport modes. In this way, besides the efficiency analysis, it was also aimed to determine the inefficiencies in the use of the resources. In the efficiencies examined for both road and rail transportation, the inputs consist of the lengths of the lines (Km) and the outputs consist of the transportation performance on the lines (Ton-Km). Inputs, outputs, and analysis results of the models were presented in Table 2.

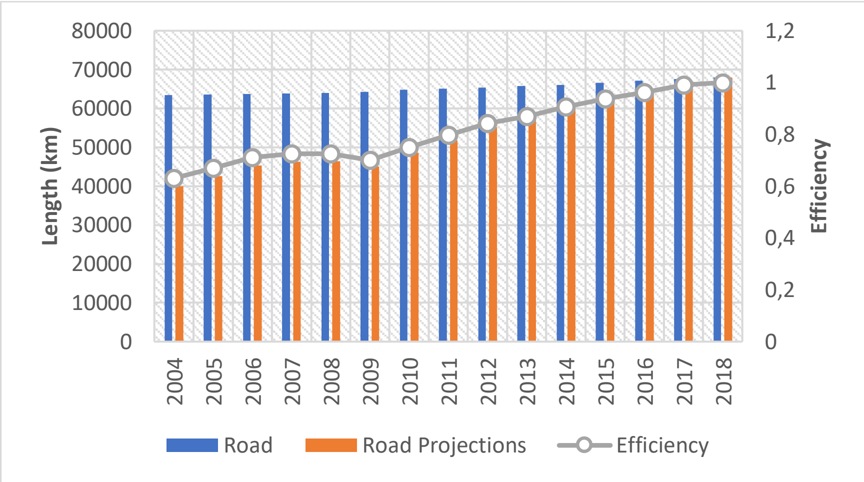
Table 2: **CCR I Scores**

	ROAD Transport			**RAIL Transport**		
Year	**Input**	**Output**	**Score**	**Input**	**Output**	**Score**
2004	63476	156853	0.631	8697	9417000	0.771
2005	63606	166831	0.669	8697	9152000	0.750
2006	63672	177399	0.711	8697	9676000	0.792
2007	63820	181330	0.725	8697	9921000	0.813
2008	63945	181935	0.726	8699	10739000	0.879
2009	64255	176455	0.701	9080	10326000	0.810
2010	64865	190365	0.749	9594	11462000	0.851
2011	65049	203072	0.797	9642	11677000	0.863
2012	65382	216123	0.844	9642	11670000	0.862
2013	65740	224048	0.870	9718	11177000	0.819
2014	66032	234492	0.906	10087	11992000	0.847
2015	66560	244329	0.937	10131	10474000	0.736
2016	67161	253139	0.962	10131	11661000	0.820
2017	67619	262739	0.992	10207	12763000	0.891
2018	68016	266502	1.000	10315	14481000	1.000

When the efficiency of road transportation is examined, it can be mentioned that there is an ever-increasing efficiency from the beginning of the sample. Only in 2009, there was a small decline due to the impact of the global economic crisis. The highest value was obtained in 2018, the last year of our sample. Considering the length as a resource, 2018 was the most efficient period of the usage of the resource. The efficiency of rail transport is much more volatile and irregular compared to the values of road transport. While a very high efficiency of 87% was achieved in 2008, there was a partial decrease after the global crisis. 2018 was the most efficient year for rail transport as well as for road transport.

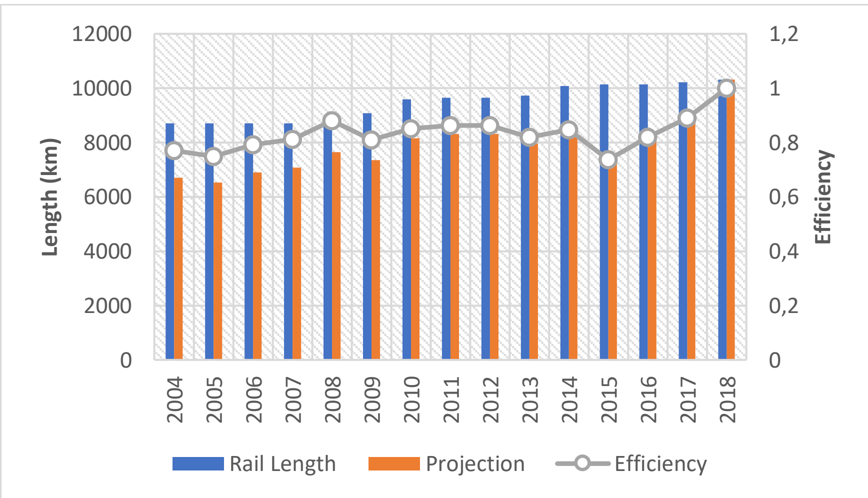
The course of the value of road transport efficiency and projections by years was presented in Figure 4. Since the analyzes were carried out with the input-oriented model, the projection values indicate whether the source is used efficiently. For instance, the least efficient period is 2004 and the difference between the columns reflects this. According to the efficiency in 2018, there is a 37% inefficiency in input usage in that year.

Figure 4: **Road Length Projections**



The course of the value of rail transport efficiency and projections by years was presented in Figure 5. Since the analyzes in this mode of transport were made with the input-oriented model, the difference between the columns shows the efficient usage of the input. The year with the lowest efficiency in this mode is 2005 and there is a 25% ineffectiveness in the use of the railway infrastructure this year.

Figure 5: **Railway Length Projections**



After determining the efficiency values of the modes, these values were used in regression analysis to be independent variables.

6.2. Regression Results

The results obtained from the DEA method were considered as independent variables in the regression models that model port output. The regression models estimated for both the road and rail transport were constructed as in (2). Also, a regression model as (3) was also estimated which includes efficiency scores of two transport modes. Logarithms of the series were taken to determine the percental response of the dependent variable to a 1% change in the independent variable. Also, logarithms of the variables provide better distribution properties (Shahbaz et al., 2017).

$$lnPortThroughput_t = ln\beta_0 + \beta_1 lnEfficiency_t + \varepsilon_t \quad (2)$$

$$lnPortThroughput_t = ln\beta_0 + \beta_1 lnEfficiencyRoad_t + +\beta_2 lnEfficiencyRail_t + \varepsilon_t \quad (3)$$

Since the variables used in the regression analysis are time series, the unit root test should be applied first. For this, augmented Dickey-Fuller (Dickey and Fuller, 1979) unit root and Kwiatkowski-Phillips-Schmidt-Shin tests (Kwiatkowski et al., 1992) stationarity tests were applied to the series, and the results are presented in Table 3. According to the ADF unit root test, the null of unit root hypothesis could not be rejected at the level in all variables. This test shows that the null could be rejected when the first differences are taken. On the other hand, according to the KPSS test, the null of the stationary hypothesis could not be rejected at the level in all variables. In this case, it was decided that all variables are stationary at the level based on the KPSS test.

Table 3: **Unit Root and Stationarity Test Results**

		Level		First Difference	
		Constant	**Intercept & Trend**	**Constant**	**Intercept & Trend**
ADF	**Port Cargo**	-1.73	-1.566	-3.42**	-4.38**
	Efficiency Road	-0.83	-3.13	-2.61	-2.49
	Efficiency Rail	-2.05	-2.46	-3.94**	-3.82*
KPSS	**Port Cargo**	0.58***	0.14***	0.27*	0.50
	Efficiency Road	0.60***	0.08*	0.08*	0.07*
	Efficiency Rail	0.32*	0.08*	0.16*	0.12*

Null of unit root is rejected at ***1%, **5%, *10% for ADF test. Null of stationarity cannot be rejected at ***1%, **5%, *10% for KPSS test

Regression analyses were applied and the results were presented in Table 4. As a result of the analyzes, all of the models and variables were significant. However, as a result of tests applied to residuals, both autocorrelation and heteroscedasticity were detected in the road model, and the only autocorrelation was detected in the rail model. Therefore, robust results were obtained by applying HAC (Newey-West) correction to the road model and Huber-White correction to the rail model to obtain robust standard errors. In the model estimated for road transport, it was determined that a 1% change in transportation mode efficiency caused a 1.58% change in port outputs. Also, the efficiency change in this mode of transport explains 87% of the change in cargo traffic at the ports. In the first model estimated for rail transport, a 1% change in transport mode caused a 1.97% change in cargo traffic at the ports and the explanatory power of this model was about 34%. However, when we analyzed the influence statistics presented in section A of Appendix 1, RStudent, DFFITS, and COVRATIO indicators showed that years of 2015 and 2018 were outliers in the model and decreased explanatory power. Therefore, we added the dummies to these dates and re-estimated the model, and presented the results in the table. Accordingly, a 1% change in railway efficiency causes a 3.97% change in port traffic and the R-squared value increases to 70%. According to the results examined with two different models, the changes in the efficiency of rail transport affect port traffic more than the road. However, estimating separate models for transport modes may not clearly reflect the impact distribution between modes. Therefore, it may be useful to include the efficiency values of both modes together in the single model. In this respect, the model as in equation (2) was estimated and presented in the table. When the Influence Statistics of the estimated model presented in section B of Appendix 1 were analyzed, 2015 and 2018 years were determined as outliers as in the railway model. Therefore, the model was re-estimated by assigning dummy variables to those dates. In the estimated model, the effect of a 1% change on the railway efficiency was 1.84%, while the effect of the change on the road efficiency was 1.22%. Also, the explanatory power of the model increased to 95%. In line with the results obtained from the previous single estimated models, it was determined that the impact of the railway was higher in this model. According to dummy variables, apart from the changes in independent variables, there was an increase in port traffic in 2015 while a decrease was observed in 2018. When the raw data in Table 2 were analyzed, it can be said that this is due to the railway efficiency, as a great decrease in the transport performance in 2015 was observed while a great increase was observed in 2018.

Table 4: **Regression Models**

Model	ROAD	Robust ROAD	RAIL	Robust RAIL	ROAD & RAIL
Efficiency Rail	-	-	3.97 [0.000]	3.97 [0.000]	1.84 [0.00]
Efficiency Road	1.581 [0.000]	1.581 [0.000]	-	-	1.22 [0.00]
Constant	19.98 [0.000]	19.98 [0.000]	20.35 [0.000]	20.35 [0.000]	20.25 [0.00]
F Stat.	92.35 [0.000]	92.35 [0.000]	8.88 [0.002]	8.88 [0.002]	49.33 [0.00]
R-Squared	0.876	0.876	0.707	0.707	0.95
Adj. R-Squared	0.867	0.867	0.628	0.628	0.93
Durbin-Watson	0.460	0.460	1.513	1.513	1.96
Autocorrelation	Yes	-	Yes	-	No
Heterosc.	Yes	-	No	-	No
Normality (JB)	0.363 [0.833]	-	0.723 [0.696]	-	0.900 [0.63]
Wald F Stat.	-	50.602 [0.000]	-	-	-
D1 2015	-	-	0.706 [0.003]	0.706 [0.000]	0.23 [0.04]
D2 2018	-	-	-0.40 [0.107]	-0.40 [0.042]	-0.30 [0.01]

Probabilities are shown in []

In the interpretation of the findings of the study, the information belonging to Turkey's exports and imports made by modes of transport may be useful. When the average density of the modes in terms of monetary value is examined in 2010 and 2018, the following results appear; the rate of exports made was 55% by sea, 33% by road, 9% by air, 0.6% by rail, and the rate of imports was 57% by sea, 17% by road, 11% by air, and 0.7% by rail (TUIK, 2019). As seen, the highest rate of trade is carried out by sea transportation. There is a considerable difference between the rates of road and rail transport, which are the subject of our study. While 33% of exports and 17% of imports are by road, these rates are not even 1% in rail transport. When the performances of the modes in ton-km are analyzed in our sample, the average of railway transportation is 11105867.0, while the average of road transportation is 209040.8. Considering the technical features, it may be wrong to compare the two with these data, but this information reveals how intensively rail transportation is used in domestic transportation as well. Also, the fact that there is very little overseas trade output of rail transportation is due to the intensive use of this mode of transportation as a means of domestic transportation and a means of reaching the ports.

Infrastructure's impact on international trade has been investigated in the literature by various studies and significant results have been obtained (Çoşar and Demir, 2016; Martincus and Blyde, 2013; Duranton et al., 2013; Şimdi et al., 2017). However, the physical properties of infrastructures were mostly used in these studies. In our study, we also considered whether the transport modes are used efficiently rather than the process that ends with the investments. We aimed to determine the impact of transport mode efficiency on international trade through port cargo traffic and on the preferences of cargo owners in transportation to ports. There are also factors such as industrial production (Açık et al., 2019a), the exchange rate (Kim, 2016; Chi and Cheng, 2016; Kim, 2017; Açık et al., 2019b), and transportation costs (Kim, 2016; Açık, 2019), but effective access to ports is also very important. In this context, it was determined that the increase in the efficiency of rail transportation had more impact on port traffic than road transportation.

As far as the authors know, a study dealing with the same philosophy as our study does not exist in the literature, so we cannot compare our results one-to-one. Nevertheless, our study can be positioned in the literature from another perspective as follows; an intersection of the positive impact of infrastructure on international trade and factors affecting port traffic. Because just handling the investment amounts does not show how beneficial the investment is, maybe that investment has been an inefficient investment. On the other hand, when variables such as industrial production and exchange rates that show the production and trade potential in the country are considered alone, the role of transportation infrastructure in trade is ignored. In this respect, the intersection of the two concepts can be revealed with the efficient use of transportation infrastructure. Very high values in efficiency may indicate that the infrastructure is inadequate and investment is needed. Too low values may indicate that the investment is unnecessary. In this respect, examining the effect of the change in efficiency values on port traffic and international trade can provide more practical results. In this respect, our findings formed a complementary structure to the results of the studies that determine; (i) the positive impact of infrastructure on international trade (Duranton et al., 2013; Martincus and Blyde, 2013; Çoşar and Demir, 2016; Şimdi et al., 2017; (ii) the positive impact of infrastructure on port traffic (Turner et al., 2004; Gaur, 2005; Felicio et al., 2015); and (iii) the positive impact of economic variables in the country on port traffic (Kim, 2016; Chi and Cheng, 2016; Kim, 2017; Açık et al., 2019a; 2019b).

7. Conclusion

Today, ports are outstanding as one of the most important logistics constituents embedded in the global supply chains that structure international trade. Compared to the past, the functions of the ports are more complex now. For these reasons, infrastructure investments that will increase the accessibility of ports are very important for the success and competitiveness of countries in international trade. In this direction, great importance is attached to infrastructure investments in our country and there are many road and railway projects that are completed or still ongoing.

The main research question of our study is to determine the effect of transportation mode investments on international trade through cargo traffic in Turkish ports. Besides, we wanted to determine which mode can be more effective in accessing the ports and which can be influential in the decisions of the cargo owners while accessing the ports. While doing this, instead of using pure transport mode length data, we considered the efficient use of these lengths. The reason for this is that investing in a mode of transport does not indicate that that mode of transport is being used efficiently, because history is full of wasted investment projects. In this context, after determining the efficiencies of the transport modes considering infrastructure lengths used in road and rail transportation by DEA analysis, we subjected them to regression analysis with port throughputs. As a result, we determined that the increase in efficiency in rail transportation affects port traffic more than road transport.

Considering environmental and economic sustainability, it is thought that investing to increase the efficiency of rail transport will increase the country's competitiveness in the international arena by improving its connection to the global supply chain. In this way, foreign trade activities carried out by road transportation can also be shifted to railway transportation, and the problems such as environmental pollution, noise pollution, and traffic, which are the biggest problems of the country, can be alleviated. With the investments facilitating foreign trade by rail transport directly, more expensive investment requirements can be prevented by reducing the workload on road transportation. Thanks to the network connections strengthened with the ports, it can be easier to trade not only in the areas accessible by the rail and road transport, but in every corner where the sea extends worldwide, and the development of the national economy can be accelerated.

As the biggest constraint of our study, the data range could be mentioned, and if we could reach older data, more comprehensive results could be obtained. Also, the number of inputs in DEA analysis can be increased and the efficiencies of the transport modes can be examined with more microdata while the efficiency of the transport modes is measured in further studies.

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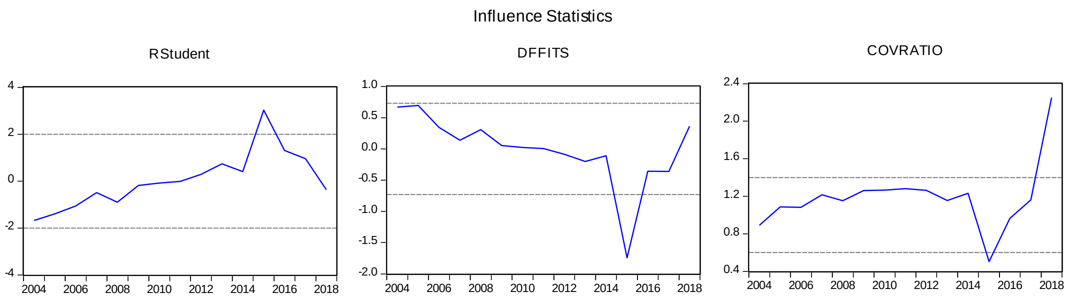
Appendix 1. Influence Statistics of the Model

A. Statistics for Rail Transport Model



B. Statistics for Multi Transport Model