Measuring Transport Efficiency for Three Seas Initiative Countries

Fazıl Gökgöz[1], Engin Yalçın[2]

[1] Ph.D., Professor, Faculty of Political Sciences, Ankara University Turkey

[2] Institute of Social Sciences, Ankara University, Turkey

Abstract

Urban cities have grown recently as a result of the economic development of developing nations. The efficiency of the transportation system is a crucial factor for businesses themselves as well as the broader economic system. The foundation of social and economic development is the transportation system, which also significantly affects the advancement of the national economy and the standard of life in societies. However, it also negatively affects society and the environment. Nearly one-third of all energy used worldwide is used by the transportation industry. In today's mobile world, transportation is a crucial component of the European Union's economy. In this study, we measure transportation sector efficiency in the Three Seas Initiative countries via the Data Envelopment Analysis, which is a non-parametric efficiency measurement technique. Our analysis results reveal that Austria is found to be the most efficient country in the investigated group mostly due to being on electric vehicles oriented. Besides, six countries namely Austria, Bulgaria, Czechia, Estonia, Poland, and Slovenia are found to be efficient over the 2018-2019 period as per super-efficiency DEA results. We may conclude that countries should intensify their efforts to disseminate electric vehicles and their infrastructure.

Keywords: Transportation Efficiency, Data Envelopment Analysis, Three Seas Initiative Countries.

1. Introduction

The world's transportation sector consumes about one-third of all energy (Stefaniec et al. 2020). One of the main economic sectors that significantly affects economic growth is transportation because it is so closely related to the exchange of goods. Although the expansion of transportation services boosts economic growth and raises the living standards of the populace, due to the presence of automobiles and transportation infrastructure. Additionally, it has certain negative effects on society and the environment, including the waste of resources, pollution, and the intensification of natural disasters (Tian et al. 2020). The largest percentage of all transport emissions in 2019 comes from the road, which constitutes 72% of all transportation-related greenhouse gas emissions (European Environment Agency, 2022). Enhancing efficient, secure, and environmentally responsible mobility options is the main objective of the European Union (EU) transportation policy. It also aims to support a competitive sector that can generate growth and employment. Transport concerns that are best addressed at the EU level include traffic congestion, innovation, passenger rights, and financing for infrastructure (European Commission, 2022). We aim to assess the transport efficiency of three sea imitative countries, which were created as a result of the integration of the transport, energy, and digital infrastructure along the north-south axis of the EU. The three seas initiative countries' geographic location, economic potential, and demographic potential make it important to assess their efficiency (Tutak and Brodny 2022). They have the potential to grow economically and demographically. Our research intends to shed light on how efficient the transport industry is in the Three Seas Initiative countries. Our study is structured as follows. A literature review is provided. Then, the research method is introduced and the empirical results of our analysis are presented. The last section concludes our study.

2. Literature Review

Recently, the popularity of academic research in the transportation sector has increased year by year. These studies are mainly based on the Data Envelopment Analysis (DEA) and its enhanced versions. We summarize the main research in this field below.

Zhou et al., (2014) appraised the transport sector efficiency in 30 Chinese areas by the DEA technique. They use non-energy and energy inputs whereas passenger and freight volume are determined as desirable outputs and carbon dioxide (CO_2) emissions as undesirable outputs. According to the results, average transport sector efficiency hit a new low in 2007 and 2008. They also conclude that the Eastern region generally outperformed the Central and Western areas.

Chen et al., (2018) evaluated the dynamic performance of some Chinese cities by the window DEA technique. Transportation investments, the number of staff, and energy consumption are used as inputs while passenger and freight volume are selected as desirable outputs and CO_2 emissions as undesirable outputs. They conclude that Shanghai is found to perform better in comparison to other investigated Chinese cities.

Tian et al., (2020) assessed transport sustainability in a Chinese city by using a super-slack-based DEA technique over 15 years. They consider economic, social, and environmental criteria for transport efficiency. According to the empirical findings, Shaanxi's transportation sustainability is found to be ineffective for over half of the investigated term, and the environmental and social dimensions' ineffectiveness is the main cause.

Stefaniec et al., (2020) analyzed transport sustainability in China by the network DEA technique. They use vehicles, capital, employment, and energy consumption as inputs, while their outputs include social, economic, and environmental criteria. According to the findings, economic growth is linked to decreased social efficiency in the Eastern areas and decreased environmental efficiency in the Central and Western areas. They also show an increase in overall transport efficiency for the five-year development plan in China.

Feng and Wang (2018) evaluated the transportation efficiency of Chinese provinces via the Malmquist Productivity Index. They use labor, capital, and energy as inputs, transportation gross output, and CO_2 emissions are determined as desirable and undesirable output respectively. According to the findings, China's transportation sector's energy efficiency initially declined between 2006 and 2010, primarily as a result of a loss in managerial efficiency and an enlargement of the regional technological gap. Then, between 2011 and 2014, energy efficiency grew as managerial efficiency and the regional technology gap stabilized.

Wang et al. (2022) evaluated the transportation efficiency of the Organization for Economic Co-operation and Development (OECD) countries via the slack-based DEA technique. They use infrastructure, length of roads, labor force, and energy consumption as inputs whereas freight and passenger transport volume are employed as desirable output and CO_2 emissions as undesirable output. According to the findings, in OECD countries, the average total efficiency of land transportation demonstrates a declining tendency.

3. Analysis Method

3.1 The DEA Technique

Numerous fields have used the DEA technique, which is an efficiency technique for comparing the performance of several options. Utilizing the weighted outputs to inputs ratio, efficiency is determined. Using numerous inputs and outputs, the DEA is a mathematical technique used to assess the efficiency of options. The production frontier is where the alternatives are the most effective. Thus, the distance between various alternatives and the ideal unit can be compared. The flexibility to use various inputs and outputs as well as the absence of a previous presumption are the main benefits of the DEA (Nazarko and Šaparauskas, 2014; Xin-gang and Zhen, 2019). The standard DEA model is set up as a performance technique to assess the relative efficiency of options as follows (Fancello et al. 2020).

$$maximize\ Z_{pg} = \frac{\sum_{i=1}^{s} u_{ip} y_{iq}}{\sum_{j=1}^{t} v_{jp} x_{jp}} \quad (1)$$

$$Subject\ to;$$

$$q = 1,2,\ldots.,n \quad (2)$$

$$0 \leq \frac{\sum_{i=1}^{s} u_{ip} y_{iq}}{\sum_{j=1}^{t} v_{jp} x_{jp}} \leq 1 \; q = 1 \ldots, n \quad (3)$$

$$u_{ip} \geq \in i = 1, \ldots s \quad (4)$$

$$v_{jp} \geq \in i = 1, \ldots t \quad (5)$$

where n denotes the number of alternatives, s number of outputs, t number of inputs, $u_{ip}$and v_{jp} weight attached to $i-th\,output$ and $j-th$ input respectively. Z_{pg} is the relative efficiency score, $\in$ infinitesimal constant, y_{iq} and x_{jp} denote the value of $i-th\,output$ and $j-th$ input respectively.

4. Empirical Analysis

We aim to assess the transport sector efficiency in three seas imitative countries, which were developed as a result of common interest in the Baltic, Adriatic, and Black Sea countries of the EU. Our data on technical criteria is retrieved from Eurostat and European Commission. We consider our efficiency criteria based on available papers (Zhou et al., 2014; Feng & Wang, 2018). We determine final energy consumption in the transport sector, transport enterprises as our inputs while freight and passenger volume as our outputs.

Table 1 lists our inputs and outputs selected to evaluate the transport sector of the three seas countries.

Table 1. The Description of Our Variables.

Criteria Type	Technical Criteria	Unit	The Definition of Criteria
Inputs	Final Energy Consumption in Transport Sector	Thousand tonnes of oil equivalent	The total amount of energy used in the manufacturing, use, and decommissioning of all vehicles and infrastructure.
	Transport Enterprises	Total Number	Enterprises used by land for infrastructure, transportation, and the provision of transportation services to move products or people via road.
Outputs	Freight Volume	Million tonne-kilometre	The total volume of goods or cargo carried by commercial vehicles.
	Passenger Volume	Billion pkm	The entire movement of passengers using inland transportation on a specific network is referred to as passenger volume.

Following the presentation of our inputs and outputs, we conduct an empirical analysis to assess the efficiency of three seas initiative countries. Table 2 contains the empirical findings of the transport sector efficiency performed using the DEA and super efficiency DEA models for the 2018-2019 period.

Table 2. The Results of the Transport Sector Efficiency in the Three Seas Initiative Countries (2018-2019 Period).

Three Seas Initiative Nations	2018 Scores	2018 Super-Efficiency Scores	2019 Scores	2019 Super-Efficiency Scores
Austria	1,00	2,75	1,00	2,77
Bulgaria	1,00	1,01	1,00	1,04
Croatia	0,74	0,74	0,81	0,82
Czechia	1,00	1,03	1,00	1,01
Estonia	1,00	1,05	1,00	1,02
Hungary	0,90	0,90	1,00	1,01
Latvia	0,97	0,97	1,00	1,01
Lithuania	0,86	0,86	0,92	0,92
Poland	1,00	1,12	1,00	1,11
Romania	0,85	0,85	0,88	0,88
Slovakia	0,81	0,81	0,91	0,91
Slovenia	1,00	1,08	1,00	1,07
Mean Efficiency	0,90		0,96	

Source: Authors' Calculations.

As the results of the DEA approach indicate, six nations namely Austria, Bulgaria, Czechia, Estonia, Poland, and Slovenia are found to be on the efficient frontier over the 2018-2019 period. In 2019, a slight efficiency improvement is observed in comparison to the previous year. Besides, Latvia and Hungary obtain efficiency levels as well. According to the super-efficiency results, Austria is the most successful nation by far among efficient members of the three seas initiative countries.

Conclusions

In this study, we evaluate the efficiency of the transport sector in three seas initiative countries, which were founded to develop collaboration among member countries. In today's mobile world, transportation is a critical component of the EU's economy. Mobility and transportation are essential to sustainable development. Sustainable mobility may boost the economy, increase accessibility, protect the environment, and increase urban resilience. The EU's transport strategy strives to promote efficient, safe, and environmentally friendly transportation, which supports the free movement of people and products within the EU. This is significant for three seas countries as well. In this regard, we measure the efficiency of the transportation sector in three seas countries over the 2018-2019 period by DEA. Our study considers an output-oriented version. Thus, our analysis results demonstrate the countries obtaining as high as output possible with a given input. In 2018, six countries are found to be efficient while this increased to 8 countries in 2019. Austria is the most successful nation among the countries in the Three Seas Initiative, according to super-efficiency findings. The administration of Austria has been strict on Electric Vehicles (EVs). This has facilitated a decrease in energy consumption in the

transport sector (Seebauer, 2018). Currently, Austria does not impose an engine-related tax on electric vehicles (Gass et al., 2014). Decreasing the cost of electric vehicles through various incentives is significant to contribute to transport efficiency as EVs eradicate the negative effect on the environment and fossil fuel dependence. Thereby, freight and passenger volume can be steadily increased. In this direction, there are now a wider range of manufacturers and models of EVs, which are still costly, have a short driving range, and do not have a widespread infrastructure for charging (Weiss et al., 2015). Hence, we may conclude that governments should intensify their efforts to disseminate EVs and their infrastructure.

Our analysis depends on the transport efficiency level of three seas initiative countries by the DEA. Thereby, we put forth efficient countries and how inefficient countries can achieve efficiency levels.

References

Chen, X., Gao, Y., An, Q., Wang, Z., and Neralić, L. (2018). Energy efficiency measurement of Chinese Yangtze River Delta's cities transportation: A DEA window analysis approach. *Energy Efficiency*, *11*(8), 1941-1953.

European Commission, (2022). Accessed at. https://ec.europa.eu/info/policies/transport_en#:~:text=EU%20transport%20policy%20aims%20to,industry%20generating%20growth%20and%20jobs. Access Date: July 20, 2022.

European Environment Agency, (2022). Accessed at: https://www.eea.europa.eu/ims/greenhouse-gas-emissions-from-transport Access Date: July 20, 2022.

Fancello, G., Carta, M., and Serra, P. (2020). Data Envelopment Analysis for the assessment of road safety in urban road networks: A comparative study using CCR and BCC models. *Case studies on transport policy*, *8*(3), 736-744.

Feng, C., and Wang, M. (2018). Analysis of energy efficiency in China's transportation sector. *Renewable and Sustainable Energy Reviews*, *94*, 565-575.

Gass, V., Schmidt, J., and Schmid, E. (2014). Analysis of alternative policy instruments to promote electric vehicles in Austria. *Renewable Energy*, *61*, 96-101.

Nazarko, J., and Šaparauskas, J. (2014). Application of DEA method in efficiency evaluation of public higher education institutions. *Technological and Economic development of Economy*, *20*(1), 25-44.

Seebauer, S. (2018). The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. *Energy research & social science*, *46*, 311-320.

Stefaniec, A., Hosseini, K., Xie, J., and Li, Y. (2020). Sustainability assessment of inland transportation in China: A triple bottom line-based network DEA approach. *Transportation Research Part D: Transport and Environment*, *80*, 102258.

Tian, N., Tang, S., Che, A., and Wu, P. (2020). Measuring regional transport sustainability using super-efficiency SBM-DEA with weighting preference. *Journal of Cleaner Production*, *242*, 118474.

Tutak, M., and Brodny, J. (2022). Analysis of the level of energy security in the three seas initiative countries. *Applied Energy*, *311*, 118649.

Wang, C. N., Le, T. Q., Yu, C. H., Ling, H. C., and Dang, T. T. (2022). Strategic Environmental Assessment of Land Transportation: An Application of DEA with Undesirable Output Approach. *Sustainability*, *14*(2), 972.

Weiss, M., Dekker, P., Moro, A., Scholz, H., and Patel, M. K. (2015). On the electrification of road transportation–a review of the environmental, economic, and social performance of electric two-wheelers. *Transportation Research Part D: Transport and Environment*, *41*, 348-366.

Xin-gang, Z., and Zhen, W. (2019). The technical efficiency of China's wind power list enterprises: An estimation based on DEA method and micro-data. *Renewable Energy*, *133*, 470-479.

Zhou, G., Chung, W., and Zhang, Y. (2014). Measuring energy efficiency performance of China's transport sector: A data envelopment analysis approach. *Expert Systems with Applications*, *41*(2), 709-722.