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THE EFFECT OF HUMAN DEVELOPMENT ON THE LOGISTICS EFFICIENCY OF THE COUNTRIES

ÜLKELERİN LOJİSTİK ETKİNLİKLERİ ÜZERİNDE İNSANİ GELİŞMİŞLİĞİN ETKİSİ

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Abstract

This study has two main aims. The first aim of the study is to determine the logistics efficiency of the countries. For this purpose, the logistics efficiency of 160 countries was measured by Data Envelopment Analysis, using six sub-indicators of the Logistics Performance Index (LPI). The second aim of the study is to investigate how the logistics efficiency of countries is affected by human development classes and indicators. For this purpose, the Kruskal Wallis H test and Multiple Linear Regression analysis were used. The findings show that countries in the Very High Human Development class have higher efficiency scores than other countries. The logistics efficiency of Sub-Saharan African Countries, which have a low level of Human Development, was found to be low. In addition, HDI sub-indicators explain logistics efficiency by 67.8%. GNP per capita and Expected Years of Schooling have a significant impact on logistics efficiency. The findings show that achieving a meaningful improvement in logistics depends on catching a leap in the economy through R&D, innovation, and high technology and considering long-term education programs.

Keywords: Logistics Performance Index, Human Development Index, Data Envelopment Analysis.

Öz

Bu çalışmanın iki temel amacı vardır. Çalışmanın ilk amacı ülkelerin lojistik verimliliklerini belirlemektir. Bu amaçla 160 ülkenin lojistik verimliliği, Lojistik Performans Endeksi'nin (LPE) altı alt göstergesi kullanılarak Veri Zarflama Analizi ile ölçülmüştür. Çalışmanın ikinci amacı, ülkelerin lojistik verimliliğinin insani gelişme sınıfları ve göstergelerinden nasıl etkilendiğini araştırmaktır. Bu amaçla Kruskal Wallis H testi ve Çoklu Doğrusal Regresyon analizi kullanılmıştır. Bulgular, Çok Yüksek İnsani Gelişme sınıfındaki ülkelerin diğer ülkelere göre daha yüksek verimlilik puanlarına sahip olduğunu göstermektedir. İnsani Gelişme düzeyi düşük olan Sahra Altı Afrika Ülkelerinin lojistik verimliliği düşük bulunmuştur. Ayrıca, İGE alt göstergeleri lojistik verimliliğini %67,8 oranında açıklamaktadır. Kişi başına düşen GSMH ve Beklenen Eğitim Süresi, lojistik verimlilik üzerinde önemli bir etkiye sahiptir. Bulgular, lojistikte anlamlı bir iyileşmenin sağlanmasının, Ar-Ge, inovasyon ve yüksek teknoloji yoluyla ekonomide bir sıçramayı yakalamaya ve uzun vadeli eğitim programlarını dikkate almaya bağlı olduğunu göstermektedir.

Anahtar Kelimeler: Lojistik Performans Endeksi, İnsani Gelişmişlik Endeksi, Veri Zarflama Analizi.

GENİŞLETİLMİŞ ÖZET

Çalışmanın Amacı

Küreselleşen dünyada ülkelerin lojistik faaliyetlerinin etkinliği, rekabet güçlerinin önemli bir belirleyicisidir. Bu nedenle, ülkelerin lojistik alanındaki etkinliği üzerinde belirleyici olan faktörlerin araştırılması önemlidir. Bu anlayıştan hareketle bu araştırmanın iki temel amacı bulunmaktadır. Çalışmanın ilk amacı, ülkelerin lojistik alanındaki etkinlik skorlarını belirlemektir. Çalışmanın ikinci amacı ise ülkelerin lojistik etkinliğinin insani gelişmişlik sınıflarından ve insani gelişmişlik göstergelerinden nasıl etkilendiği araştırmaktır. Çalışmada, ülkelerin lojistik etkinliğini belirlemek amacıyla lojistik performans endeksi ve alt göstergeleri, insani gelişmişlik seviylerini belirlemek amacıyla insani gelişmişlik endeksi ve alt göstergeleri kullanılmıştır.

Araştırma Soruları

Çalışmanın amacı kapsamında ilk olarak, hangi ülkelerin lojistik alanında etkinlik sınırında yer aldığı, etkin ve etkin olmayan ülkelerin ekonomik ve coğrafi profillerinin ne olduğu sorgulanmıştır. İkinci olarak, ülkelerin insani gelişmişlik sınıfları lojistik etkinlik skorlarını etkiliyor mu? Sorusuna cevap aranmaktadır. Son olarak, hangi insani gelişmişlik göstergelerinin ülkelerin lojistik etkinlik skoru üzerinde etkili olduğu sorusu araştırılmıştır.

Literatür Araştırması

Literatürde lojistik performans endeksine ilişkin çok sayıda çalışma bulunmaktadır. Bu çalışmalar üç temel grupta toplanabilir. İlk gruptaki çalışmalar, lojistik performans endeksinin makro ekonomik göstergeler ile ilişkisini araştıran çalışmalardır. Bu çalışmalarda, lojistik performans endeksi ile ülkelerin makroekonomik göstergeleri arasında çoğunlukla anlamlı ilişkiler bulunduğu görülmektedir. İkinci gruptaki çalışmalar, lojistik performans endeksinin farklı endeksler ile ilişkilendirildiği çalışmalardır. Bu çalışmalarda, ülkelerin lojistik performansları ile rekabet, ticaret, inovasyon, pazarlama ve finansal performanslarının ilişkili olduğu ortaya konmuştur. Son grupta yer alan çalışmalarda ise ülkelerin lojistik performans endeksine göre kümelendiği, sınıflandırıldığı ve etkinlik ölçümü yapıldığı görülmektedir. Literatürde, son yayınlanan lojistik performans endeksi sonuçlarına dayanarak tüm ülkelere ilişkin bir etkinlik ölçümü çalışmasına ve lojistik performans endeksinin doğrudan insani gelişmişlik endeksi ile ilişkisinin araştırıldığı bir çalışmaya rastlanılmamıştır.

Yöntem

Çalışmanın ilk amacı doğrultusunda, ülkelerin etkinlik skorlarının belirlenmesinde veri zarflama analizi kullanılmıştır. Bu analizde lojistik performans endeksinin altı göstergesi literatürdeki uygulamalara dayanarak üç girdi ve üç çıktı olarak ele alınmış, lojistik performans endeksi yayınlanan 160 ülke karar verme birimi olarak belirlenmiştir. Ülkelerin farklı insani gelişmişlik sınıflarının lojistik etkinlik skorunu etkileyip etkilemediğini belirlemek amacıyla, veriler normal dağılmadığından, tek yönlü varyans analizinin parametrik olmayan karşılığı olan Kruskal Wallis H testi uygulanmıştır. Son

olarak, hangi insan gelişmişlik göstergelerinin ülkelerin lojistik etkinlik skoru üzerinde etkili olduğunu belirlemek amacıyla çoklu doğrusal regresyon analizi uygulanmıştır.

Sonuç ve Değerlendirme

Ülkelerin lojistik etkinliği ölçüldüğünde, 160 ülke arasından 5 ülkenin etkin sınırda yer aldığı belirlenmiştir. Etkinlik skoru bakımından en iyi 20 ülkenin çoğu Avrupa kıtasında yer almaktadır. Son 20'deki ülkelerin ise çoğunun Sahra Altı Afrika ülkesi olduğu görülmüştür. Ülkelerin lojistik etkinlik skorlarına göre sıralanmaları ile insani gelişmişlik endeksine göre sıralanmaları arasında oldukça güçlü ve anlamlı bir ilişki bulunmuştur. Çok yüksek insani gelişmişlik sınıfında yer alan ülkelerin lojistik etkinlik skorlarının diğer sınıftaki ülkelerden anlamlı bir şekilde yüksek olduğu görülmüştür. Diğer sınıflar arasında ise lojistik etkinlik skoru bakımından bir fark bulunmamıştır. İnsani gelişmişlik göstergelerinden kişi başına düşen milli gelir ve beklenen okullaşma süresi göstergelerinin ülkelerin lojistik etkinliği üzerinde etkili olduğu belirlenmiştir. Göstergelere ilişkin parametreler incelendiğinde, anlamlı bulunan göstergelerdeki artışların lojistik etkinliğine ancak uzun vadede etki edebileceği düşünülmektedir.

1. INTRODUCTION

Logistics activities ensure the movement of products between countries in a safe, fast, and low-cost way. Thus, logistics plays a key role in a country's success in international trade. The important role of logistics in international trade has become more and more important with the increasing competitiveness of the backward regions (Martí et al., 2017). With globalization, trade has developed to cover almost all countries. With this development, logistics has become one of the main factors of development for countries (Rezaei et al., 2018). While the positive performance of a country in logistics increases the country's effectiveness in international trade and industrialization; The unfavorable logistics performance has a negative impact on the country's economy due to high stock levels and long waiting times (Wong & Tang, 2018).

Countries need to evaluate their logistics systems on a macro scale, to determine the sub-systems that need to be optimized, and to decide on new subsystems that need to be created or developed to gain a competitive advantage in logistics. Countries need to compare their logistics systems with other countries to understand the current opportunities and threats (Beysenbaev & Dus, 2020). Therefore, a quantitative measurement tool was needed to evaluate the logistics performance of countries (Martí et al., 2017).

The Logistics Performance Index (LPI) is an international benchmark tool that measures the trade and transportation performance of countries. LPI is published by the World Bank, thereby identifying the opportunities and challenges facing countries (Yu & Hsiao, 2016). LPI helps to raise awareness of trade and logistics issues, research industry priorities, and improve trade and logistics in countries (Martí et al., 2014). With these features, LPI is important in understanding the logistics performance of countries (Arvis et al., 2018).

The World Bank published the first LPI in 2007. After 2007, the index was published five more times by the world bank. 150 countries in 2007, 155 countries in 2010 and 2012, and 160 countries in 2014, 2016, and 2018 were evaluated with the LPI (Logistics Performance Index, 2021).

Logistics efficiencies of countries can be determined by using LPI. There are various efficiency measurement studies using LPI in the literature (Martí et al., 2017; Sternad et al., 2018; Markovits-Somogyi & Bokor, 2014). However, no efficiency measurement study was found in the literature based on the 2018 LPI. In this context, the first aim of this study is to determine the logistics efficiency of countries based on the LPI published in 2018. Another aim of the study is to investigate the impact of human development on the logistics efficiency of countries. A similar study focusing on the relationship between logistics efficiency and human development has not been found in the literature. Based on these two gaps in the literature, it is aimed that the study will contribute to the literature. For these purposes,

six sub-indicators of LPI were used to measure the logistics efficiency of countries. The Human Development Index (HDI) was used as the human development indicator of the countries.

The study is structured in 5 sections. In Section 2, the literature review on LPI and HDI is discussed. In Section 3, the research model, the variables, the data sources, and the efficiency measurement method used is explained in detail. In Section 4, the findings of the research are evaluated. In Section 5, the results of this study are discussed.

2. LITERATURE REVIEW

2.1. Literature Review on LPI

LPI has been examined in many studies in the literature. Uca et al. (2015) revealed that the logistics performance of countries has a significant effect on GNP. In the study, LPI's sub-indicators were used as an indicator of the logistics performance of the countries. Following this study, Uca et al. (2019) determined that the mediating role of LPI in the impact of corruption perception on GDP is statistically significant. Bozma et al. (2017) examined the effect of LPI on economic growth based on 2007-2014 period data. Başar and Bozma (2017) investigated the political and macroeconomic variables affecting LPI in the study. Similarly, Wong and Tang (2018) focused on the political and economic determinants of LPI. In the study, it was determined that infrastructure, technology, education, and labor force indicators have a significant effect on LPI. In parallel with this study, Jhawar et al. (2014) revealed that developing a qualified workforce has a significant effect on LPI. Yangınlar (2019) compared G7 countries and Turkey on LPI and GDP. In these studies, it is seen that there are the most significant relationships between the LPI and the macroeconomic indicators of the countries.

There are also studies in the literature that examine the relations of LPI with different indices. Buramoğlu (2012) conducted a study examining the effect of countries' national innovation indicators on logistics performance. In this study, a positive relationship was found between the innovation indicators of countries and their logistics performance. In a similar study, Altıntaş (2020) examined the relationships between the global innovation index and LPI with canonical correlation analysis and determined statistically significant and strong positive relationships between the two indices. Cengiz and Çetinceli (2020) evaluated countries based on the LPI and information and communication technologies development index. Erkan (2014) used LPI as the dependent variable and determined that some sub-indicators of the global competitiveness index have a significant effect on LPI. Çemberci et al. (2015) measured the moderator effect of the global competitiveness index for each sub-indicator of LPI by the hierarchical regression method. it was seen that the moderator effect of the global competition index was statistically significant in 3 of the 6 sub-indicators of LPI. In a similar study, Civelek et al. (2015) investigated the mediator effect of LPI in the relationship between global competitiveness index and GDP and determined a statistically significant effect. Ofluoğlu et al. (2018) examined the role of LPI in explaining the international trade performance of countries. Akdoğan and Durak (2017)

investigated the relationships between logistics companies' logistics performance, relationship marketing trends, and marketing performance. Green et al. (2008) designed a logistics performance model. In this model, the relationships between financial performance, marketing performance, supply chain management system, and logistics performance are investigated by the structural equation model. In these studies, where the relations of LPI with different indices are discussed, it has been revealed that the logistics performance of the countries is related to competition, trade, innovation, marketing, and financial performances.

In the literature, many studies are evaluating the logistics performance of countries by using LPI in recent years. Eygü and Kılınç (2020) investigated the factors affecting the LPI performance of OECD countries. Cansız and Ünsalan (2020) examined various countries in the context of parameters affecting LPI. Ulutaş and Karaköy (2019a) proposed a model for weighting the LPI's sub-indicators and listed the European Union member countries accordingly. Ulutaş and Karaköy (2019b) created a model to rank G-20 countries according to LPI. In another study where countries were ranked, Oğuz et al. (2019) evaluated some Asian countries using the TOPSIS method according to LPI. Bozkurt and Mermertaş (2019) compared Turkey and the G-8 countries using the LPI indicators. Kılınç et al. (2019) compared Turkey, Russia, and China's Logistics performance by using LPI. Aksungur and Bekmezci (2020) investigated the LPI performance of Turkey for the 2007-2018 period. In another study, Yıldız et al. (2020) evaluated the position of Turkey among 90 countries by using cluster analysis. Yapraklı and Ünalan (2017) analyzed Turkey's logistics performance between 2007-2016 and its situation in the international market, based on LPI. On the other hand, Gergin and Baki (2015) evaluated the logistics performance of Turkey's regions with multi-criteria decision-making methods.

Among these studies where countries are evaluated based on LPI, there are also studies in which the logistics efficiency of countries is measured. Sternad et al. (2018) based on the LPI data published in 2016, measured the logistics efficiency of some European countries with DEA. Based on the LPI data published in 2010, Markovits-Somogyi and Bokor (2014) determined the logistics efficiency of 29 European countries in comparison with DEA and DEA-PC methods. Yu and Hsiao (2016) compared the logistics efficiency of 150 countries for different income groups. Lu et al. (2019), investigated how 112 countries' environmental logistics performance index (ELPI) efficiencies are affected by income levels and different geographic regions. Rashidi and Cullinane (2019), examined the relationship between sustainable logistics performance efficiency and LPI among OECD countries. Martí et al. (2017) measured the logistics efficiency of 141 countries with DEA under three different input-output scenarios and investigated whether the logistics efficiency scores of countries are affected by different income levels and geographic location with variance analysis.

2.2. Literature Review on HDI

In the literature, it is seen that HDI is associated with issues such as environment and energy, economy, cultural differences, education, health, infrastructure, working and living conditions, transportation.

Studies examining the relationship between environmental and energy issues and the HDI have found a positive relationship between environmental quality and HDI (Kirkman et al., 2020; Sumargo et al., 2021). HDI has also been observed to cause high CO2 emissions (Mohmmed et al., 2019; Wang et al., 2018). It is stated that for sustainable urbanization, it is necessary to increase the HDI and at the same time reduce the ecological footprint (Long et al., 2020). Increasing the HDI has been proposed to design a sustainable renewable energy system (Mauleón, 2020).

In a study examining the relationship between the socioeconomic structure of countries and the HDI, it was seen that income inequality negatively affected HDI. Therefore, it is recommended to implement social protection policies (Sarkodie and Adams, 2020). In a study examining the relationship between HDI and cultural conditions, it was found that cultural diversity has an impact on human development in the Caribbean region (McGowan, 2021). In another study, a negative correlation was found between low HDI and the young birth rate (Martinez & da Roza, 2020). Infrastructure services, which are an important determinant of living conditions, were also found to be highly correlated with the HDI (Novitasari et al., 2020). In a study conducted in the field of education, it was determined that the increase in school participation rate had a significant effect on HDI (Sudirman & Hapsara, 2021). Diarrhea-related deaths and infection rates in children, which are health indicators, were also found to be negatively correlated with HDI (Riahi et al., 2018; Liu et al., 2020).

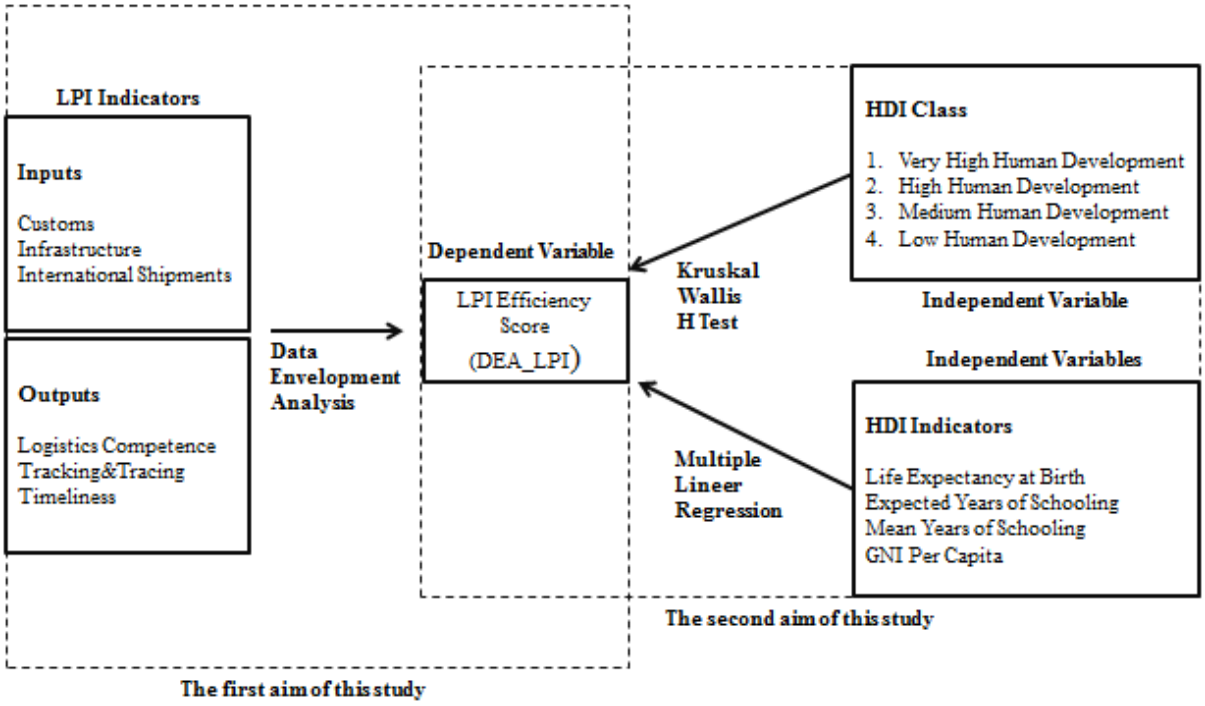
3. RESEARCH MODEL, DATA AND METHOD

3.1. Research Model

The research model created for the two main purposes of this study is given in Figure 1. To determine the logistics efficiency of the countries, the six sub-indicators of the LPI are divided into two groups as inputs and outputs. In this distinction, applications in the literature were used (Martí et al., 2017; Sternad et al., 2018; Markovits-Somogyi & Bokor, 2014). Data Envelopment Analysis (DEA) was used to determine the logistics efficiency of the countries. The efficiency score (DEA_LPI) obtained for each country as a result of DEA was used as the dependent variable in the second phase of the study. In line with the second aim of the study, the effect of the human development of the countries on the logistics efficiency of the countries was investigated with two different models. Kruskal Wallis H Test, which is the non-parametric alternative of One-Way Analysis of Variance (ANOVA), was used to determine whether human development classes (HDI Class) affect the DEA_LPI. In this model, the dependent variable is DEA-LPI and the independent variable is HDI Class. Finally, multiple linear

regression analysis was used to investigate the effect of HDI's sub-indicators on the logistics efficiency of countries. In this model, the dependent variable is DEA_LPI and the independent variables are four sub-indicators of HDI: Life Expectancy at Birth, Expected Years of Schooling, Mean Years of Schooling, and GNI per capita. Each variable used in the research model is explained in Section 3.2.

Figure 1. Research Model



3.2. Data

The LPI was created based on a global survey of companies operating in the industry. The survey has been prepared with the contributions of more than 800 professionals operating in different fields of the industry. Survey participants were asked for data on the 8 countries with which they have the most commercial relations at the international level. The data collected by the questionnaire were analyzed with Principal Component Analysis, which is a statistical dimension reduction method, and a large number of inputs were represented with six main components. In summary, LPI was created by reducing a large number of inputs to six main components by Principal Component Analysis. Countries score between 1 and 5 for each of the six main components of LPI. A higher score represents better logistics performance (Martí et al., 2017). LPI is calculated using the arithmetic mean of these six sub-indicators (Jhawar et al., 2014).

In Table 1, six sub-indicators of LPI are divided into two groups as input and output for efficiency measurement. The input-output distinction between sub-indicators has been made based on studies in the literature (Petrovi et al., 2017; Martí et al., 2017; Sternad et al., 2018). In this study, 160 countries whose LPI values were published in 2018 were included in the analysis. LPI data for countries are obtained from the World Bank database (Logistics Performance Index, 2021).

Table 1. Logistics Performance Index

Sub-indicators	Description	Category
Customs	It shows the efficiency of customs procedures.	Input
Infrastructure	It specifies the quality of the infrastructure required for trade and transportation.	Input
International Shipments	It is an indication of the ease of creating shipments at prices competitive with the market.	Output
Logistics Competence	It shows the adequacy and quality of the logistics services offered in the country.	Input
Tracking&Tracing	It reflects the traceability performance of the shipments created.	Output
Timeliness	It is an indication of the frequency with which shipments reach buyers within expected delivery times.	Output

As stated before, the second purpose of this study is to determine whether the logistics efficiency scores of countries are affected by human development classes and variables representing human development. The Human Development Index (HDI) is used to determine the human development levels of the countries. HDI is calculated by taking the geometric mean of four sub-indicators: Gross national income per capita, expected years of schooling, mean years of schooling, and life expectancy at birth. With this index published by the United Nations for each country, countries are divided into four classes as "Very High Human Development", "High Human Development", "Medium Human Development" and "Low Human Development" (UNDP, 2021a). In this study, the human development class of each country whose logistics efficiency was measured for 2018 was considered as categorical data and the four sub-indicators of HDI were considered as continuous data. Table 2. shows the four sub-indicators and scope of HDI.

Table 2. HDI Sub-indicators and Descriptions (UNDP, 2021b)

Indicator	Description
Life Expectancy at Birth	The year a newborn is expected to live if current mortality rates remain stable.
Expected years of schooling	If the current school enrollment rates remain constant, the expected duration of education for a child who has just started school
Mean years of schooling	Average education period of 25 years old and above
Gross national income (GNI) per capita ($)	Per capita income

3.3. Data Envelopment Analysis

In this study, DEA was used to measure the logistics efficiency of countries. DEA is a linear programming model developed by Farrell (1957) for efficiency measurement in the case of multiple inputs and single outputs. Charnes et al. (1978) adapted this model to multiple inputs and multiple outputs. In this method, organizations using the same multiple input-output combinations, whose efficiencies are desired to be measured, are named as decision-making units (DMU's). It is seen that

DEA is applied in many areas. DMU's frequently used in these applications are countries, cities, universities, hospitals, ports (Akdamar, 2018).

DEA determines the efficiencies of decision-making units by using only observation values. This method does not require a distribution assumption for variables (Cooper et al., 2000). Another important feature of DEA is that it can analyze variables that have different measurement units at the same time (Blose et al., 2005).

With DEA, the efficiencies of DMU's are compared by taking the DMU with the highest efficiency score as a reference. Therefore, to make an accurate comparison, it is necessary to select homogeneous units that use the same inputs and outputs for the same purposes (Golany & Roll, 1989; Okursoy & Tezsürücü, 2014). For an accurate measurement of efficiency in DEA, the number of decision-making units should be more than the total input and output.

Dyson et al. (2001) suggested that there should be at least twice as many decision-making units as the total input and output in the analysis. On the other hand, Cooper et al. (2001) suggested that at least 3 times the total input and output should be included in the analysis. Since 3 inputs, 3 outputs, and 160 decision-making units are used in this study, it is seen that the number of decision-making units is sufficient.

In DEA, where a large number of inputs and outputs are handled together, the efficiency of homogeneous decision-making units is found by proportioning the weighted sum of the outputs to the weighted sum of the inputs (Talluri, 2000). DEA models can be classified as input-oriented, output-oriented, and non-oriented models under constant returns to scale (CRS) and variable returns to scale (VRS) (Charnes et al., 1995).

Input-oriented models used in cases where the decision-maker has control over the input determine the extent to which inefficient DMU's should reduce their inputs to achieve the desired output and aim at input minimization. The output-oriented models used in cases where the decision-maker has control over the output determine the extent to which inefficient DMU's should increase their current inputs and outputs and aim for output maximization (Murat, 2020).

In the literature, the model developed by Charnes et al. (1978) and named as Charnes-Cooper-Rhodes (CCR) is divided into two as input and output-oriented under constant return to scale (CRS). CCR defines the model as follows:

$$Maxh_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

Subject to (1)

$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \;\; j = 1, \ldots, n$

$u_r, v_i \geq 0; \;\; r = 1, \ldots s; \;\; i = 1, \ldots m$

In Model above (1), m is the number of inputs, s is the number of outputs, n is the number of DMU's, y_{rj} is the r. amount of output of the j. DMU x_{ij} is the i. amount of input of the j. DMU, u_r is the weights assigned to the output variable, v_i is the weights assigned to the input variable.

In this model, the objective function is the ratio of the weighted sum of the outputs to the weighted sum of the inputs. The DMU chooses the weights that will maximize the objective function. Constraints ensure that the weights ($u_r ve\ v_i$) are positive or zero, and the objective function takes a value between 0 and 1.

The input-oriented proportional CCR model expressed in (1) is a fractional programming model. Linear transformation is applied to this model, which is difficult to solve compared to the linear programming model, as in (2) (Cooper et al., 2011). A linear programming model in (2) is run n times to determine the efficiency scores of DMU's. The weights that will maximize the efficiency score are determined for each DMU. When the efficiency score is 1, the DMU is efficient, and when it is lower than 1, it is inefficient (Murat, 2020).

$$Maxz = \sum_{r=1}^{s} \mu_r y_{r0}$$

Subject to (2)

$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$

$\sum_{i=1}^{m} v_i x_{i0} = 1$

$\mu_r, v_i \geq 0$

From this point of view, the structure of the output-oriented CCR model is defined as in (3) (Cooper et al., 2011).

$$Minq = \sum_{i=1}^{m} v_i x_{i0}$$

Subject to (3)

$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0$

$\sum_{r=1}^{s} \mu_r y_{r0} = 1$

$\mu_r, v_i \geq 0$

The model named as Banker-Charnes-Cooper (BCC) is developed by Banker et al. (1984). Just as CCR, this model is divided into two as input and output-oriented under variable returns to scale (VRS). Unlike CCR, convexity constraint is added to the BCC model (Cooper et al., 2006). Thus, the input-oriented BCC model is created as in (4) (Banker et al., 2004).

$$Maxz = \sum_{r=1}^{s} u_r y_{r0} - u_0$$

Subject to (4)

$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_0 \leq 0$

$\sum_{i=1}^{m} v_i x_{i0} = 1$

$u_r, v_i \geq \varepsilon$; u_0 free in sign

From this point of view, the output-oriented BCC model is defined as in (5).

$$Minq = \sum_{i=1}^{m} v_i x_{i0} - v_0$$

Subject to (5)

$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} - v_0 \geq 0$

$\sum_{r=1}^{s} \mu_r y_{r0} = 1$

$\mu_r, v_i \geq \varepsilon$; v_0 free in sign

DEA is applied in three basic stages. First, the DMU's whose efficiencies will be measured are determined. Secondly, the model suitable for the study is selected and the analysis results are interpreted at the last stage (Akdamar, 2018).

4. RESULTS

Before the efficiency analysis, descriptive statistics regarding input and output variables of 160 countries are given in Table 3. The values of these variables vary between 1 and 5 as stated before. As seen in Table 3, among the LPI sub-indicators, timeliness has the highest mean. In other words, the survey participants (professionals working in the field of logistics) who answered the questions about LPI gave a more positive score to the delivery performance of the products on time compared to other indicators. According to the standard deviations for the sub-indicators, Infrastructure has the highest variability. Based on this, it can be said that the logistics infrastructures between countries differ more than other indicators. Notably, Germany has the highest value in all input variables. Germany, which has advanced transportation systems and logistics infrastructure and attaches importance to the use of information technologies at a high level, is also in the first place in Europe in terms of logistics villages

and centers where intermodal transportation is applied intensively. In addition, when the professionalization of logistics as a profession is considered, it is seen that university-level education and vocational training programs in the field of logistics are given great importance in the country. In addition to all these, the country, which aims at sustainable progress in the field of logistics, has many new investment projects to achieve this goal (Dinçer, 2021). On the other hand, Belgium has the highest value in both international shipments and timeliness indicators. This success of Belgium can be explained by its developed ports, airports, road, rail, and inland waterways connections. In addition, Belgium's central location in Europe provides an important advantage (Doncker, 2017). Research carried out by Prologis company confirmed Benelux's advantageous position in logistics (Prologis, 2016). Based on sub-indicators, three countries (Angola, Guinea, and Libya), excluding Papua New Guinea and Bhutan, are African countries. Guinea is the country with the lowest value in terms of both infrastructure and timeliness indicators.

Table 3. Descriptive Statistics on Input and Output Variables

Variable	Mean	Std.Dev.	Min.	Max.
Inputs				
Customs	.6732	.57791	1.57 (Angola)	4.09 (Germany)
Infrastructure	.7228	.67421	1.56 (Guinea)	4.37 (Germany)
Logistics competence	.8159	.61081	1.88 (Papua New Guinea)	4.31 (Germany)
Outputs				
International shipments	.8299	.51530	1.80 (Bhutan)	3.99 (Belgium)
Tracing&Tracking	.9012	.61304	1.64 (Libya)	4.32 (Finland)
Timeliness	.2365	.57545	2.04 (Guinea)	4.41 (Belgium and Denmark)

For the first purpose of this study, the efficiencies of 160 countries were measured. Efficiency measurement has been applied with the input-oriented BCC model. While customs, infrastructure, and logistics competence were used as input in the analysis; International shipments, tracking and tracking, and timeliness indicators were used as outputs.

The objective function is minimized in input-oriented models. This may result in the desired input reduction for a country. One of the methods suggested in the literature to solve this problem is to take the inverse of the inputs and transform them (Lovell et al., 1995). With this application, inputs are taken to the analysis as 1 / input. Thus, decreasing 1 / input value means increasing the input value. Based on similar applications in this subject (Martí et al., 2017; Murat, 2020; Sezer, 2017; Limaei, 2020) 1 / input variables were used as inputs in the analysis.

Descriptive statistics regarding the calculated efficiency scores of 160 countries are presented in Table 4 to obtain a general view of the efficiency measurement results. Accordingly, it is seen that 5 countries are at the efficiency frontier. The logistics efficiency of half of the countries is below the score of 0.6395, while the other half is above this score. The fact that the arithmetic mean of the efficiency

scores is greater than the median value indicates that the data is skewed to the right. In other words, efficiency scores tend to accumulate at low values. According to the 3rd Quartil value given in Table 4, the efficiency score of 75% of the countries is below 0.7709. Based on this, it can be said that most of the countries are insufficient to carry out an efficient logistics activity. In other words, the logistics efficiency score of a small number of countries (25% of the countries or 40 countries) is above 0.7709. This finding can be considered as an indication that certain countries have a say in the logistics sector. These countries have the resources that enable them to carry out efficient logistics activities.

Table 4. Descriptive Statistics on Efficiency Measure Results

Number of Efficient DMU	5
Mean	0.6782
Std. Dev.	0.1400
Median	0.6395
Min	0.4454
Max	1.0000
3. Quartile	0.7709

Table 5 shows the best and worst 20 countries among 160 countries in terms of efficiency scores related to the BCC model.

Table 5. Countries' Efficiency Rankings and Scores for 2018 LPI

	20 Best Countries				
Rank	Country	Efficiency Score	Rank	Country	Efficiency Score
1	**Belgium**	1.000000	11	United Kingdom	0.939675
2	**Germany**	1.000000	12	New Zealand	0.932715
3	**Sweeden**	1.000000	13	Hong Kong	0.931540
4	**Denmark**	1.000000	14	United States	0.926773
5	**Finland**	1.000000	15	Switzerland	0.921114
6	Japan	0.975550	16	United Arab Emirates	0.919908
7	Austria	0.967532	17	France	0.915332
8	Netherlands	0.963387	18	Canada	0.904872
9	Singapore	0.951276	19	Spain	0.885086
10	Australia	0.946210	20	Italy	0.881070
	20 Worst Countries				
Rank	Country	Efficiency Score	Rank	Country	Efficiency Score
41	Somalia	0.533643	51	Cuba	0.510441
42	Myanmar	0.530562	52	Haiti	0.508121
43	Senegal	0.530562	53	Zimbabwe	0.501160
44	Guinea-Bissau	0.529002	54	Liberia	0.496520
45	Guetamala	0.528117	55	Niger	0.487239

46	Equatorial Guinea	0.522042	56	Gabon	0.480278
47	Eritrea	0.520782	57	Iraq	0.464531
48	Libya	0.514874	58	Sierra Leone	0.464037
49	Venezuela	0.512761	59	Angola	0.464037
50	Gambia	0.512761	60	Afghanistan	0.445476

According to the findings, Belgium, Germany, Sweeden, Denmark, and Finland are the most efficient countries in logistics. Looking at the countries in the top 20 according to efficiency score, it is seen that all of these countries are 20 countries in the original LPI ranking. Notably, all active countries are located in the European continent and 3 of these 5 countries are Northern European countries. On the other hand, 17 of the top 20 countries are members of the Organization for Economic Co-operation and Development (OECD). Singapore, Hong Kong, and the United Arab Emirates were the three countries in the top 20 that are not OECD members. When the HDI rankings of these countries, which are at the top in terms of logistics efficiency are examined, it is seen that 16 of these countries are also in the top 20 in the HDI ranking.

According to the efficiency ranking, it is seen that 16 of the worst 20 countries are in the last 20 in the LPI ranking. Also, 12 of these 20 countries, which are at the bottom of the list, are Sub-Saharan African countries. These countries also have low scores according to HDI and are in the low and medium human development classes. In other words, it has been observed that Sub-Saharan African countries, which are countries with low and medium human development levels, also have low logistics efficiency. Sub-Saharan African countries also feel the negative consequences of the decline in human development in the field of logistics.

Based on these findings, it was investigated whether there is a statistically significant relationship between the countries' LPI rank (LPI_Rank), efficiency rank (DEA_LPI_Rank), and HDI rank (HDI_Rank). In Table 6, Spearman's Rho correlation coefficients calculated to determine the relationship between three different rankings are given.

Table 6. Relationship Between Countries' Logistics Performance, Logistics Efficiency and Human Development Rankings

		LPI_Rank	DEA_LPI_Rank	HDI_Rank
Spearman's rho	LPI_Rank	1.000	.961**	.811**
	DEA_LPI_Rank		1.000	.795**
	HDI_Rank			1.000

** Correlation is significant at the 0.01 level (2-tailed).

The findings in Table 6 show that there is a very strong statistically significant relationship between the LPI rankings and efficiency rankings of countries ($r = 0.961; p < .01$). This finding

reveals the accuracy of the performed DEA. On the other hand, a strong relationship has been determined between the efficiency rankings and human development rankings of countries ($r = 0.795; p < .01$).

To examine the relationship between the human development classes of the countries and their logistics efficiencies in more detail, it has been investigated whether the logistics efficiency scores of the countries differ between different human development classes

In this study, which is planned to be carried out with the one-way analysis of variance (ANOVA), the human development classes of the countries (Very High Human Development, High Human Development, Medium Human Development, and Low Human Development) were taken as the independent variable and the logistics efficiency scores of the countries were taken as the dependent variable. Since ANOVA requires the assumption of normal distribution of the data related to the dependent variable, the Shapiro Wilk test was used to examine whether the logistic efficiency scores were normally distributed. As a result of the test, it was determined that the data were not distributed normally ($W = .925; p < .05$). Therefore, the study was continued with the Kruskal Wallis H test, which is the non-parametric alternative of ANOVA.

As a result of the analysis, it was determined that the logistics efficiency scores of the countries differ significantly in different human development classes. Hence, it can be said that the human development classes of countries affect their logistics performance. Based on this finding obtained with ANOVA, it can be said that the logistics efficiency of the countries will also change as the human development classes change. Therefore, the improvement in education, health, and economy indicators, which are indicators of a country's human development and determine the human development class, positively affect logistics efficiency. The extent of this effect was further investigated by multiple linear regression analysis in Table 8.

Multiple comparison tests were applied to determine which classes there was a significant difference. Findings are given in Table 7.

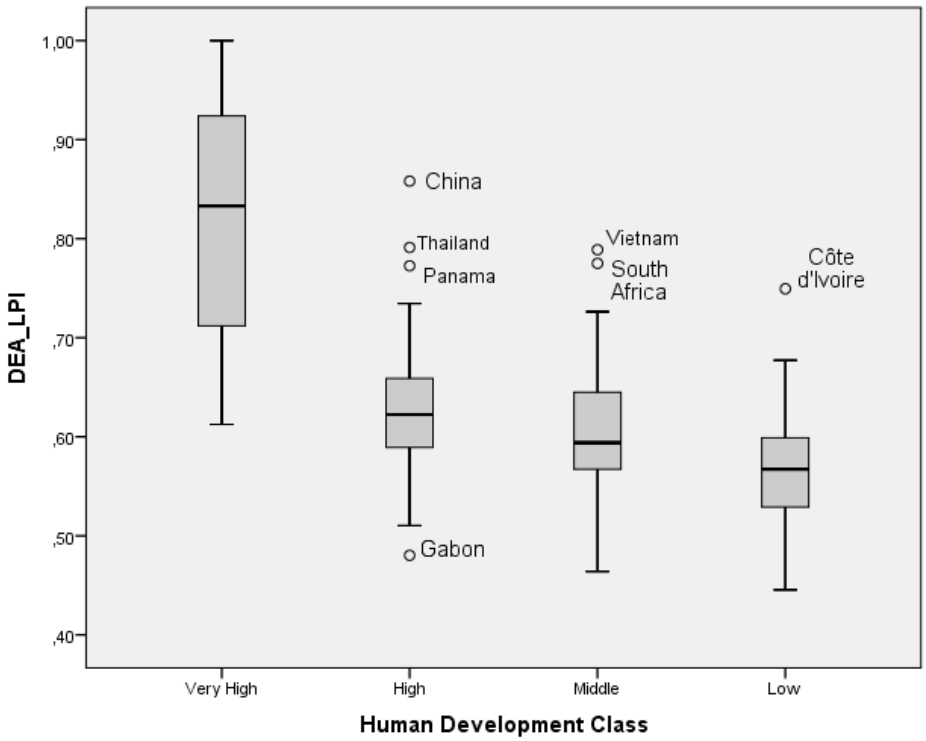
Table 7. Comparison of Logistics Efficiency Between Different Human Development Classes

Comparision	p- value
Very High Human Development - High Human Development	.000
Very High Human Development - Medium Human Development	.000
Very High Human Development - Low Human Development	.000
High Human Development - Medium Human Development	1.000
High Human Development - Low Human Development	0.068
Medium Human Development - Low Human Development	0.838

As seen in Table 7, the logistics efficiencies of the countries in the very high human development class according to HDI differ significantly from the countries in the other class ($p < 0.05$). Countries in the High, Medium and Low class according to HDI are not different in terms of logistics efficiencies ($p > 0.05$). In other words, countries divided into four classes in terms of human development are divided into two classes in terms of logistics efficiency.

In Figure 2, the descriptive statistics obtained regarding logistics efficiency scores in different human development classes are shown with a box plot. The three countries in the High class in terms of human development (China, Thailand, and Panama) differ from their group in terms of logistics efficiency. Although these countries are not in the very high class, their logistics efficiency scores are as high as the countries in the very high class. Especially China's efficiency score is above the mean logistics efficiency of the Very high class (0.86). Similarly, Vietnam and South Africa from the Medium class and Côte d'Ivoire from the Low class are among the countries with a high logistic efficiency score, although they are behind in terms of human development. Although Gabon is in the High class in terms of human development, it has a very low score (0.48) in terms of logistics efficiency. These countries can be considered as outliers in a positive and negative sense within their class. Countries that differentiate positively from their HDI class in terms of logistics efficiency (China, Thailand, Panama, Vietnam, South Africa, and Cote d'Ivoire) can be considered to achieve high logistics efficiency with geographical, political, and cultural advantages.

Figure 2. Box Plot for Logistics Efficiency Scores in Different Human Development Classes



The positive developments in health, economy, and education, which enable countries to be in the top class in terms of human development, also enable countries to operate more effectively in the field of logistics. However, the findings show that unless the HDI sub-indicators are sufficient to raise a country's human development class to the Very High level, improvements in these indicators will not lead to significant improvements in logistics efficiency. This finding shows that the impact of improvements in health, education, and the economy will only be felt in the field of logistics in the long run.

To deepen this finding and create a more solid basis, the effect of HDI's four sub-indicators on the logistics efficiency of countries was investigated by multiple linear regression. In the model created, the logistics efficiency score of the countries (DEA_LPI) was used as the dependent variable. The independent variables of the model are Life Expectancy at Birth (LEAB), Expected Years of Schooling (EYOS), Mean Years of Schooling (MYOS), and GNI Per Capita (GNIPC), which are four sub-indicators of HDI. In the analysis performed with the backward method, all independent variables were included in the model firstly, and then variables found to be statistically insignificant were excluded from the model, respectively. The findings of the three models are given in Table 8.

Table 8. Multiple Linear Regression Analysis Findings

	Model 1		**Model 2**		**Model 3**	
	β	t	β	t	β	t
Constant	0.289**	.261	0.303**	.591	0.398**	1.519
GNIPC	3.768E-006**	.762	3.718E-006**	.823	3.949E-006**	.024
EYOS	0.013**	.158	0.012**	.304	0.015**	.912
LEAB	0.002	.335	0.002	.238	-	
MYOS	-0.002	0.537	-		-	
Adj. R^2	0.687		0.688		0.687	
Mean Square	0.532		0.709		1.059	
F	84.866		113.597		169.035	
p- value	0.000		0.000		0.000	

The findings show that the variables GNI Per Capita and EYOS have a significant effect on the logistics efficiency of countries. However, the $ 1 increase in GNI per capita has a very low impact on the country's efficiency score. This finding supports the finding that we put forward with the Kruskal Wallis H test. Accordingly, although national income affects the logistics efficiency of countries, to achieve a significant improvement in the logistics efficiency score, per capita national income increase must also be at a significant level. In other words, the positive developments in the economy can only be felt in the field of logistics in the long run.

Another important finding is the significant relationship between the EYOS variable and logistic efficiency. Accordingly, an increase in the expected schooling time in a country by 1 year increases the logistics efficiency by 0.015 units. However, education is an area where the return on investments made is delayed. Therefore, it may take a serious amount of time to increase the expected duration of education

by 1 year. Nevertheless, it is seen that an investment in a country's trained manpower will bring that country to the top in logistics.

It has been observed that both variables can explain approximately 69% of the variability in a country's logistics efficiency. This finding reveals how important the investments be made in the economy and education are in the logistics sector, which is one of the main elements of the country's trade. Therefore, it is clear that countries with developed economies and education systems are very advantageous in this regard.

5. CONCLUSION AND DISCUSSION

This study has been designed for two main purposes, which are detailed in Figure 1. The first aim of the study is to determine the efficiency scores of the countries in the field of logistics. For this purpose, based on the sub-indicators of LPI, which is an important quantitative measurement tool in the field of logistics, the efficiency score of 160 countries was measured by DEA. The second aim of the study is to investigate the effects of human development classes and sub-indicators that determine human development levels on the logistics efficiencies of countries. For this purpose, the first model, in which human development classes of countries are considered as independent variables and logistic efficiency scores as dependent variables, was analyzed with the Kruskal Wallis H test. The second model, in which the sub-indicators determining the human development classes of the countries are considered as independent variables and logistic efficiency scores as dependent variables, is examined by multiple linear regression. HDI has been used as the human development indicator of the countries.

The constraints of this study are as follows. The logistics efficiency of the countries was only measured based on the indicators in the LPI. Again, only the indicators in HDI were adhered to in representing the human development of countries. Research units are determined as 160 countries where both indices are calculated jointly. The most recent version of both indices was used in the study. The inputs and outputs used in measuring the logistics efficiency of the countries were determined subjectively by looking at the common applications in the literature.

The findings obtained as a result of DEA reveal that the competitiveness of the European continent countries and OECD member countries are high, while the countries in the African continent are in the last ranks in terms of efficiency scores. These findings are consistent with similar studies in the literature (Yu & Hsiao, 2016; Lu et al., 2019; Martí et al., 2017). The low-efficiency scores are thought to be due to the unsafe environment in the region such as piracy, smuggling, and drug activities. For example; The logistics infrastructure in Afghanistan, which ranks last in terms of logistics efficiency, is used for illegal activities, especially drug supply (UNODC, 2020). On the other hand, the literature and the findings of this study show that countries with high logistics efficiency are at high-income levels.

For the second purpose of the study, the effect of HDI, which measures the performance of countries not only in the economic field but also in the fields of education and health, on the logistic efficiency score was investigated. Findings show that countries' human development classes have a significant effect on logistics efficiency. Accordingly, it has been determined that the countries in the Very High Human Development class show more efficient logistics performance compared to the countries in the High, Medium, and Low Human Development classes. No significant difference was found between the three classes except Very High Human Development in terms of logistics efficiency. These findings show that countries should be promoted to the top class in terms of human development to significantly increase logistics efficiency. Transitions between other subclasses of human development will not provide a meaningful change in the logistic efficiency score.

At this point, four sub-indicators of HDI, which is the determinant of human development classes, namely Life Expectancy at Birth, Expected Years of Schooling, Mean Years of Schooling, and GNI Per Capita, were taken as independent variables and their effect on the logistic efficiency score was investigated.

The findings given in Table 8 show that GNI per capita and expected years of schooling variables have a significant effect on logistics efficiency. These findings are consistent with (Başar & Bozma, 2017; Wong & Tang, 2018; Jhawar et al., 2014) which determines the effect of the economy, education, and qualified workforce on LPI.

Although the effects determined as a result of the analysis are significant, it is time-consuming to realize an increase in the independent variables that will significantly increase the logistic efficiency. Increasing the expected education period by 1 year for countries is a very long-term process. The expected time to spend in education worldwide was 9.1 years in 1980, 12.5 years in 2012, and 12.7 years in 2019 (Novak et al., 2016). As can be seen, the expected time in education has increased by only 3.6 years in the past 40 years. Especially countries with developed technology and economic power have more advantages than backward countries in increasing the expected time in education.

On the other hand, it has been observed that the effect of a 1 dollar increase in GNI per capita on logistic efficiency score is quite low. Therefore, to achieve meaningful development in the field of logistics, economic activities that will create leaps in GNI per capita should be carried out. Studies (Erkan, 2014; Çemberci et al., 2015; Civelek et al., 2015) show that this development is possible with R&D, innovation, and technology investments and that logistics performance is related to these concepts support this idea.

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