Effect of Logistics Performance Index on Human Development Index: An Application to Logistics Sector

Alper Kılıç, Emrah Akdamar, Maruf Göğebakan, Sedat Bastug

Human Development Index (HDI) has been subject to a lot of criticism over time, with the idea that it does not fully reflect human development, and has been complemented with different indicators in various studies. Despite its importance, especially considering the requirements of the era, logistics has not been considered with HDI and, although there are many synthetic indices that combine different methods (i.e. DEA, MCDM etc.) with HDI, these indices are far from reaching logical results. Logistics is a fundamental activity in meeting all human needs, and therefore should be considered as a measure of countries' human development. Therefore, this study offers a revision of the HDI with special consideration to the logistics performances of countries. It is observed that infrastructure and timeliness indicators from these sub-indicators of Logistics Performance Index (LPI) have a significant effect on the HDI. Using the United Nations' HDI calculation method with the statistically significant indicators, Logistics-HDI (L-HDI) is developed and proposed as a new index. This study argues that L-HDI reflects the human development of countries more appropriately. The L-HDI will also offer better benchmarking than other synthetic indices in its scientifical field.

KEY WORDS
~ Human development index
~ Logistics performance index
~ Multiple regression analysis
~ Logistics
~ Maritime

Bandırma Onyedi Eylül University, Balikesir, Türkiye
e-mail: sbastug@bandirma.edu.tr

doi: 10.7225/toms.v12.n01.w06

Received on: Oct 30, 2022 / Revised: Feb 8, 2023 / Accepted: Feb 20, 2023 / Published online: Feb 27, 2023

1. INTRODUCTION

Income per capita has for a long time been accepted as the primary indicator of the development of countries. However, it is not sufficient to define development only by means of economic indicators (Le Caous & Huarng, 2021). Indeed, in the first human development report published by the United Nations in 1990, development was defined as expanding people's options rather than increasing income and wealth. In this report, the fundamental development elements were determined as people living a long and healthy life, easy access to information, and attaining a certain level of living standards (Sagar & Najam, 1998).

The United Nations has developed the Human Development Index (the HDI) to determine the human development levels of countries by taking these fundamental factors into account. The HDI is a measure of average achievement in key dimensions of human development. Four sub-indicators represent the key dimensions in the index. The health dimension is measured by life expectancy at birth, education by the length of schooling for adults aged 25 and over, the expected period of study for children at schooling age, and finally, the standards of living by income per capita (UNDP, 2021).

The HDI was introduced in 1990 as an alternative to income per capita as a measure of success in development.

Until 2010, the index was calculated as the equally-weighted average of three dimensions: health, education, and income. However, a new version of the Human Development Report (HDR) was created in the 2010 revision, and the geometric mean of the three components replaced the arithmetic mean as a new calculation standard. The main reason for this change is to weaken the assumption of perfect substitutability between the three components of the HDI (Ravallion, 2012).

Previous literature has analysed the HDI from a variety of angles. Some of these studies examine HDI in relation to issues such as environment and energy, economy, cultural differences, education, health, infrastructure, working and living conditions, and transportation, while others create alternative indices to the HDI. These studies show that the three dimensions presented by the United Nations in their first report are not sufficient to fully reflect human development today, and that different dimensions should be taken into account.

In environmental studies, against the claim that there is a positive relationship between the HDI and environmental quality (Kirkman, Baliwe, Nhleko, & Pfaff, 2020; Sumargo, Nuriza, Mulyono, & Rohimah, 2021), various studies argue that the HDI score and economic growth are in direct proportion to increased CO2 emission (Mohmmed et al., 2019), and that increased CO2 emissions improve the HDI score, while increased renewable energy use reduces it (Wang, Danish, Zhang, & Wang, 2018). It has been stated that reducing the ecological footprint while increasing the HDI will ensure sustainable urbanisation (Long et al., 2020). Since a complete switch to renewable energy is not possible because of constraints on certain elements used in renewable energy technologies, the HDI may be a more appropriate target for a sustainable renewable energy system as an alternative (Mauleón, 2020).

On the other hand, The Sustainable Human Development Index (SHDI) was proposed as a more suitable alternative to the HDI (Assa, 2021). Considering the relationship between the HDI and the environment and energy, it is seen that there are different relationships according to the geography and scope in which the study is carried out. However, in general, it may be observed that the use of renewable energy sources in particular negatively affect the HDI, which is why alternative HDIs are recommended in terms of sustainability. It can therefore be argued that the HDI in its current form is insufficient in terms of environment, which represents one of the crucial global problems today, and this requires the creation of an alternative option.

Current studies have also shed light on the relationship between societies' socio-economic structure and the HDI. For example, income inequality reduces the HDI. Therefore, it is necessary to implement social protection policies that reduce poverty (Sarkodie & Adams, 2020). Although the HDI contains economic variables, some studies reveal fascinating results about the relationship between the economy and the HDI. For example, according to a study conducted in the context of Pakistan, economic growth has a significant negative effect on HDI and an increased CO2 emission improves the HDI score: there is bidirectional causality between CO2 emissions and the HDI, therefore the use of renewable energy has no role in improving the human development process, and commercial activities actually hinder the human development process (Wang, Danish, Zhang, & Wang, 2018). As can be seen here, the HDI index, which is related to economic growth, yields results contrary to expectations in different regions; therefore, consistent and robust alternatives that may be valid worldwide should be created.

Some studies relate the HDI not only to the economy but also to culture, living, and working conditions. A recent study shows that cultural diversity is very significant in explaining human development in the Caribbean region (McGowan, 2021). Another study shows that family planning has an impact on the three dimensions of the HDI in low-income countries. However, it is noted that such analyses may lack the depth necessary to provide meaningful results; therefore, an alternative HDI related to this issue should be created to include inequality, poverty, and gender inequality indicators (Ramdén & Swartling, 2021). Furthermore, it is determined that birth rates among young parents are higher in regions with low human development index values (Martinez & da Roza, 2020).

Various infrastructures that determine living conditions also have significant effects on the HDI (Novitasari, Drestalita, & Maryati, 2020). Moreover, the increase in school participation rates also predominantly affects the HDI (Sudirman & Hapsara, 2021). Another study on living conditions developed the Municipal Human Development Index (MHDI) adapted from the HDI (Yero, Sacco, & Nicoletti, 2021).

There is a relationship between the health conditions of the communities and the HDI as well. There is a statistically significant relationship between the HDI and childhood diarrhea mortalities (Riahi, Mohammadi, Moghadam, Robati, & Bidkhori, 2018). While there is a statistically significant correlation between MHDI and severe cases due to the current global catastrophe caused by the COVID-19 pandemic (Silva, Holanda, Abreu, & Freitas, 2020), infection and death rates are also correlated with the HDI (Liu, He, Zhuang, He, & Li, 2020).

Regarding working hours, it is observed that there is an inverse relationship between long working hours and the HDI, and GDP and the HDI increase as people's leisure time increases (Dinçer & Kalkan, 2021; Werneck, ve diğerleri, 2020). This is not surprising, since the decrease in labour-intensive work is also an indicator of human development.

Studies have been carried out to determine the relationship between the HDI and transportation systems that are part of logistics activities. For example, residents living in low MHDI areas are the main public transport users (Slovic, Tomasiello, Giannotti, Andrade, & Nardocci, 2019), whereas motorcycle use

increases as countries' HDIs increase (Bastos, Gama, Assis, & Milosz, 2020). A statistically significant relationship is found even between the passenger count on airplanes and GDP and the HDI (İnan & Gökmen, 2021).

The HDI has been constantly criticised since its initial development, as well as many different modifications have been proposed in the studies (Noorbakhsh, 1998). Many indices have been developed by deriving the HDI for different purposes.

Various methods are preferred in the formation of these new indices. For example, a valid and reliable regression model across countries is created by using the HDI components (Yakunina & Bychkov, 2015). Another study proposes a weighting scheme based on Shannon entropy to create composite indicators. The advantage of the method is that it offers a set of common weights that are easy to apply and allow complete comparison and rating between decision units. Since it provides a higher separation in terms of performance, it is suggested that it should be preferred to the equal weighting currently used in constituting the HDI (Karagiannis & Karagiannis, 2020).

Another study develops a new method combining data envelopment analysis (DEA) and multi-criteria decision making (MCDM) in two steps, without violating the principles of UNDP, the concept of the HDI is revised, and then GHDI, which is a generalised model of the HDI, is created. Then, a year-specific GHDIR index, which is a relative measure of GHDI, is created; and the HDI, GHDI, and GHDIR are compared in terms of country data presented in the HDR and, as may be seen, these two models are strongly related to the HDI (Mangaraj & Aparajita, 2020).

The HDI, proposed to provide managers with a better understanding of the development level of their society, is the geometric mean of the normalised indices for health, education, and standard of living. A study conducted to weigh the dimensions of the HDI uses multi-criteria decision-making techniques (Omrani, Alizadeh, & Amini, 2020).

A new indicator called "Sustainable Total Factor Productivity" is proposed for sustainable growth by using Data Envelopment Analysis-Malmquist (DEA-Malmquist) (Yue, Shen, & Yuan, 2019).

In a study in which life expectancy and literacy rate variables are used instead of the GDP per capita indicator in the HDI, the HDIF is proposed as an alternative to the HDI. It shows that this new index provides better human development performance in terms of health and education as compared to the HDI (Hou, Walsh, & Zhang, 2015).

There are some debates regarding the math of the HDI, as any composite index will entail potentially uncomfortable trade-offs. However, the 2010 HDI is more complex and problematic in terms of trade-offs between key dimensions. Therefore, an alternative index is proposed by modifying the current HDI formulation to allow perfect substitution with less problematic trade-offs (Ravallion, 2012).

With the increasing needs and expectations of people, quality perceptions are developing, and shopping habits are changing. On the other hand, production capacity of countries is developing day by day with Industry 4.0, artificial intelligence, and advancing production technologies. In this new state of affairs, which is formed by the changes in the lifestyles of the masses with the conditions brought by the COVID-19 pandemic, countries' logistics performance is critical in terms of their ability to be a part of global trade. Under these circumstances, a country's perception of development in the eyes of the consumers has become dependent on that country's effective and timely delivery of logistics services. In other words, the three dimensions of the HDI do not fully reflect current living conditions. It is a crucial deficiency that environmental problems and logistics processes, radically changing living conditions, are not taken into account in measuring human development. At this point, approaching logistics as a new dimension, and as one of the dimensions of human development, is a basic necessity, rather than a mere recommendation.

Based on this essential requirement, the study aims at determining the logistics indicators that are effective on the HDI, also adding the indicators that significantly affect the HDI as the logistics dimension of human development. In order to do so, we add a fourth dimension to the three-dimensional structure of the HDI, and propose a new human development index, which we call L-HDI. In new index proposals, whose variables will be included in the index, the weights of these variables represent important problems. In this study, the variables included in the HDI index are determined by multiple regression analysis, and the weight of these variables is obtained in accordance with the HDI calculation method recommended by the UN. Finally, the study examines how the L-HDI scores of the countries differ according to the economic regions in which they are located.

2. DATA

In this study, the HDI is used as an indicator of countries' human development, and LPI is used as an indicator of countries' logistics performance. The HDI, published by the United Nations, is a kind of a summary of achievement in key dimensions of human development. These key dimensions are health, education, and standard of living. The HDI is calculated based on four sub-indicators representing these three dimensions. Accordingly, while there is only one indicator for the health dimension, namely, Life Expectancy at Birth, the two indicators for the education dimension are Mean Years of Schooling and Expected Years of Schooling. The standard of living dimension is represented by the GNI per capita indicator. The geometric mean of the three different normalised indices calculated for all three dimensions gives the countries' HDI scores. Figure 1 shows the calculation model of the HDI (UNDP, 2021).

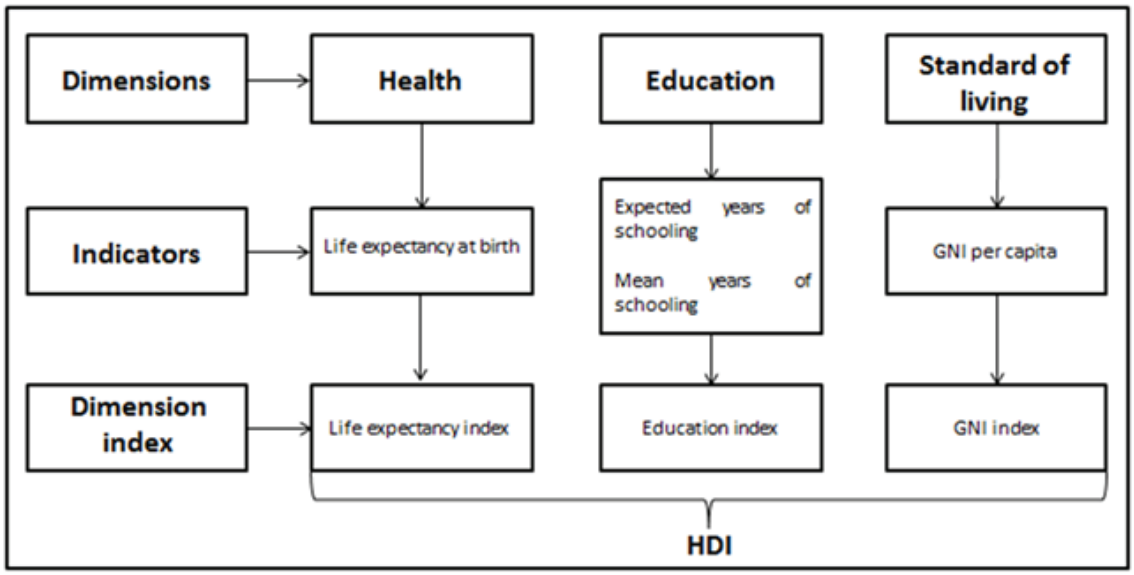

Figure 1.
The HDI calculation model.

In this model, the real values of the indicators are standardised between 0-1 as in equation (1), and the dimension index is obtained. In the education dimension, consisting of two indicators, both indicators are similarly standardised, and the education index is calculated by taking the arithmetic average. When obtaining the GNI index, the natural logarithm of the data (ln) is used for calculation convenience (UNDP, HDR Technical Notes, 2020).

$$Dimension\ index = \frac{Actual\ value - Minimum\ value}{Maximum\ value - Minimum\ value} \quad (1)$$

The HDI values are calculated for each country by taking the geometric mean of the Life expectancy index (I_health), Education index (I_education), and GNI index (I_income) values, as in equation (2).

$$HDI = (I_{health} \cdot I_{education} \cdot I_{income})^{1/3} \quad (2)$$

In this study, the HDI is the dependent variable in the multiple regression analysis used to determine the logistic indicators that affect the countries' HDI scores. The HDI data for 2019 is obtained from the United Nations human development report web-site (UNDP, 2021).

LPI published by the World Bank is used as an indicator of the countries' logistics performance in this study. This index, first published in 2007, was last published in 2018, as every two years since 2010 (World Bank, 2021). LPI is the equally-weighted average of six sub-indicators: Customs, Infrastructure, International Shipments, Logistics Competence, Tracking&Tracing, and Timeliness (Jhawar, Garg, & Khera, 2014). These sub-indicators are determined as a result of large-scale research, involving companies operating in the logistics sector. In this study, companies score the countries in which they operate in logistics activities. The data obtained is reduced to six sub-indicators by principal component analysis, which is a statistical dimension reduction method. Each of the six sub-indicators is scored between 1 and 5. Higher scores hereby indicated refer to performance (Martí, Martín, & Puertas, 2017). In this study, six sub-indicators of LPI are used as independent variables in the multiple regression model. The last published LPI data for 2018 is obtained from the World Bank (World Bank, 2021). Table 1 shows definitions of the dependent variable, the HDI, and the six sub-indicators of the independent variable LPI in the multiple regression model.

Table 1.
Definitions of the variables used in the study.

Indicators	Description
The HDI (Dependent Variable)	It is a measure of average achievement in three key dimensions of human development.
Customs (Independent Variable)	It refers to the efficiency of customs procedures.
Infrastructure (Independent Variable)	It refers to the quality of the infrastructure required for trade and transportation.
International Shipments (Independent Variable)	It is an indicator of the ease of creating shipments at prices that are competitive with the market.
Logistics Competence (Independent Variable)	It shows the adequacy and quality of logistics services offered in the country.
Tracing & Tracking (Independent Variable)	It reflects the performance of tracking and tracing of the shipments.
Timeliness (Independent Variable)	It refers to the frequency with which shipments reach recipients within expected delivery times.

The HDI is calculated by the United Nations for 189 countries, while LPI is calculated for 160 countries. The dataset is created for 154 countries that are common in both indices. As can be understood from Equation (1), the HDI value of a country varies according to the country that gets the minimum and maximum values in the dataset. Therefore, the HDI values for the 154-unit dataset are recalculated using the equations in (1) and (2). These newly calculated values are used in the analysis.

3. MULTIPLE REGRESSION ANALYSIS

Regression models in which the dependent variable is explained (estimated) by more than one independent variable are called multiple regression models. In the multiple regression model, the independent variables try to explain the change of the dependent variable in the model (Gunst & Mason, 1980). The mathematical notation of the multiple linear regression model for the sample is defined as follows:

$$\gamma_i = \beta_0 + \sum_{j=1}^{k} \beta_j x_{i,j} + \varepsilon_i \quad (3)$$

Here i=1,…,n and j=1,…,k are the indices of the multiple regression model, y_i shows the observation value of the dependent variable i. and x_{ij} shows the observation value of the j. independent variable i. in the multiple regression model, the coefficient of the j. independent variable is represented by β_j, i. the error term is represented by ε_i.

The β_j coefficients of the multiple linear regression model are estimated by the method of least squares (LSE) (Montgomery, Peck, & Vining, 2001). By using the coefficients estimated by LSE, the multiple regression model is created as follows:

$$\gamma_i = \beta_0 + \beta_j x_{i,j} + \ldots + \beta_k x_{i,k} \quad (4)$$

The multiple specificity coefficient and the adjusted multiple specificity coefficient are used as the eligibility criteria of the regression model. The multiple specificity coefficient is represented by R^2, and the adjusted multiple specificity coefficient is represented by R_p^2 (Montgomery, Peck, & Vining, 2001). To avoid difficulties in interpreting R^2 in creating the best regression model, the one using R_p^2 value produces more effective results (Haitovski, 1969). The relationship between the multiple specificity and the adjusted multiple specificity coefficients is as follows:

$$R_p^2 = 1 - \left(\frac{n-1}{n-p}\right)\left(1 - R_p^2\right) \quad (5)$$

Here, n shows the number of observations, while p shows the number of independent variables (size) in the model.

4. FINDINGS OF THE RESEARCH

With reference to the suggestion in the literature to support the HDI with different indicators, the effect of logistics on the HDI is investigated in this study. The logistics performances of countries are measured with LPI. Considering the countries' LPI and HDI scores, it is observed that there is a strong relationship between the two variables (r=.775, p<.01). Therefore, it is predicted that there may be a direct relationship between logistics and human development on the basis of particular countries.

Multiple regression analysis is performed to determine the logistic indicators that are effective on the HDI. In this analysis, the HDI is used as the dependent variable and the six sub-indicators of LPI, Customs, Infrastructure, International Shipments, Logistics Competence, Tracking & Tracing, and Timeliness, are used. In the multiple regression analysis conducted by the backward method, first, all independent variables are added to the model, and then the variables that are found to be statistically insignificant are removed from the model, respectively. The findings related to the analysis are given in Table 2.

The results obtained from Table 2. show that infrastructure and timeliness indicators have a statistically significant and positive effect on the HDI. With these two indicators, approximately 63% of the changes in the HDI can be explained. It is seen that a 1-unit increase in the infrastructure indicator increases the HDI by 0.136 units, and a 1-unit increase in the timeliness indicator increases the HDI by 0.166 units. Thus, the positive impact of countries' performances on infrastructure and timeliness on human development is revealed.

Table 2.
Multiple Linear Regression Analysis Findings.

	Model 1		Model 2		Model 3		Model 4		Model 5	
	β	t	β	t	β	t	B	t	β	t
Constant	.312**	-4.079	.135**	-4.065	-.308**	-4.049	-.296**	-3.916	-.339*	-4.705
Cus	.100	1.653	.065	1.610	.071	1.268	-	-	-	-
Inf	.153*	2.390	.096*	2.456	.121*	2.209	.163**	3.729	.136**	3.306
Intship	-.072	-1.327	-.049	-1.504	-.095	-1.866	-.088	-1.734	-	-
Logcom	-.037	-.464	-	-	-	-	-	-	-	-
Tr&Tr	-0.060	-.978	-0.069	-1.211	-	-	-	-	-	-
Time	.209**	3.734	.205**	3.718	.193**	3.553	.206**	3.866	.166**	3.433
Adj. R^2	.633		.635		.634		.632		.628	
Mean Square	.876		1.050		1.305		1.730		2.566	
F	45.006		54.252		67.237		88.754		129,902	
p- value	.000		.000		.000		.000		.000	

***Parameter is significant at the 0.01 level*
**Parameter is significant at the 0.05 level*
Cus: Customs, Inf: Infrastructure
Intship: International Shipment, Logcom: Logistics Competence
Tr&Tr: Tracking&Tracing, Time: Timeliness

Protecting public health, raising the level of education, and improving the standard of living is only possible by providing the necessary logistics for these indicators. Meeting the needs in the fields of health, education, and economy requires a just-in-time approach, which is fashionable today, and timely provision of logistics is only possible with logistics infrastructure. Therefore, these two indicators, which are naturally seen to be among the determinants of human development, should be taken into account in the human development ranking and classification of countries.

Based on the findings shown in Table 1, the logistics dimension is added to the health, education, and standard of living dimensions in view to creating the HDI. This dimension consists of infrastructure and timeliness indicators, which have a significant effect on the HDI as a result of multiple regression analysis. Figure 2. shows the new model formed by adding the proposed new dimension to the HDI calculation model.

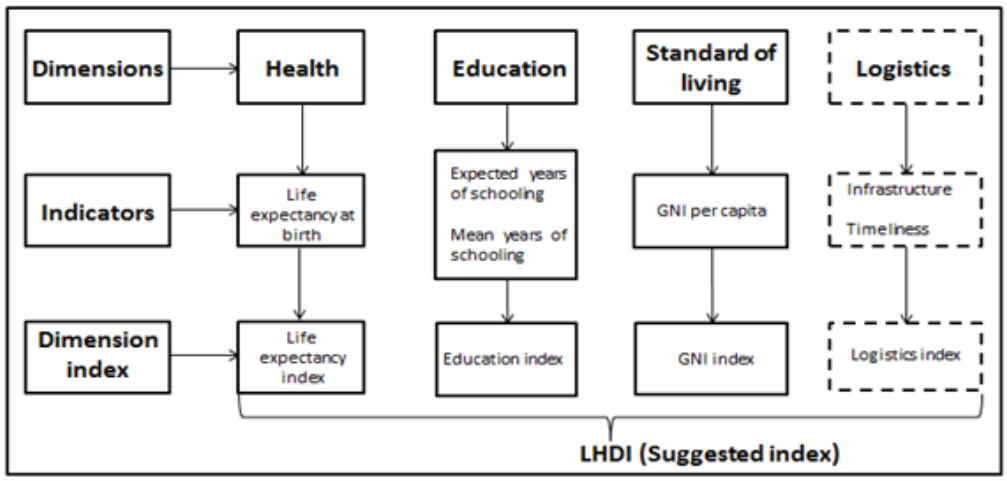

Figure 2.
Calculation model of the proposed L-HDI index.

In the proposed L-HDI calculation model, unlike the model described in Figure 1., the Logistics dimension is added based on the findings of multiple regression analysis, and this dimension is represented by Infrastructure and timeliness indicators, which are found significant as a result of the analysis. In the Logistics dimension, which has two indicators, just as in the education dimension, it is standardized as the Infrastructure and timeliness indicators (1), and the arithmetic average of the two indicators forms the Logistics index (I_logistics). Equation (2), used for calculating the HDI, is adapted to calculate L-HDI, as illustrated below:

$$L\text{-}HDI = (I_{health} \cdot I_{education} \cdot I_{income} \cdot I_{logistic})^{1/4} \quad (6)$$

According to this new index (L-HDI), the countries are reordered, and an L-HDI rank is obtained for each country. The relationship between the obtained L-HDI rank and the original HDI rank calculated for 154 countries is examined with Spearman's rho correlation. Accordingly, it is observed that there is a positive and powerful relationship between the HDI and L-HDI rankings of countries (r=.984, p<.01). At the same time, the Pearson correlation, calculated between the two indices, also shows a strong relationship between them (r=.979, p<.01). These findings reveal that the new index created is consistent. In other words, it is seen that the logistics dimension added to the index is compatible with the other three variables according to the calculation method of the UN. The descriptive statistics calculated for both indices are as shown in Table 3.

Table 3.
Descriptive Statistics for the HDI and L-HDI.

		The HDI	L-HDI
Number of Countries		154	154
Mean		.5707	.5350
Median		.6193	.5542
Std. Deviation		.23030	.22703
Quartiles	1	.3660	.3515
	2	.6193	.5542
	3	.7492	.7014

Table 3 shows the mean of L-HDI to be lower than the HDI, and the variability of the two indices is almost the same. When we consider the logistics dimension in the human development of the countries, it is observed that the average performance decreases. From this point of view, it can be said that the logistics dimension has a lower average than the other three dimensions of human development: health, education, and standard of living, thereby lowering the average of the general index. Based on this finding, although it is known that logistics processes are essential today, it can be evaluated that countries do not perform adequately in this regard. According to the HDI and L-HDI, there are positive and negative changes for some countries in the overall ranking of countries. According to the L-HDI score, a positive change is observed in 80 countries according to the HDI ranking, while a negative change is observed in 65 countries. The ranking of nine countries, namely Sweden, New Zealand, Bulgaria, Kazakhstan, Russia, Comoros, Mauritania, Central African Republic, and Burundi, does not change according to either index. Table 4 shows the top ten countries experiencing positive and negative changes.

Table 4.
Top ten countries with positive and negative changes in the HDI and L-HDI.

10 positive change			
Country	The HDI Rank	L-HDI Rank	Positive Change ↑
China	73	46	27
South Africa	105	82	23
Vietnam	90	72	18
Indonesia	91	73	18
India	108	93	15
Thailand	64	50	14
Brazil	74	60	14
Mexico	69	57	12
Côte d'Ivoire	137	126	11
Colombia	75	64	11
10 negative change			
Country	The HDI Rank	L-HDI Rank	Negative Change ↓
Cuba	68	96	28
Trinidad and Tobago	63	86	23
Iceland	6	25	19
Bahamas	58	77	19
Uruguay	52	67	15
Brunei Darussalam	45	59	14
Ireland	5	19	14
Papua New Guinea	121	134	13
Sri Lanka	67	80	13
Malta	27	39	12

Table 4 demonstrates that using L-HDI instead of the HDI brings a significant positive change in the rankings of some countries, while the same degree of regression is observed in some countries. Considering the countries that show positive changes, it is understood that these countries are located on crucial transfer points in the world's transportation geography, especially in maritime transportation (Rodrigue, 2020). On the other hand, it is not a coincidence that the countries that show the negative change substantially are island countries. Because, in general, due to the lack of land connections of the islands,

it is possible to experience delays and disruptions in logistical activities.

Considering the quartile cutoff given in Table 3, the class memberships of the countries are determined as in the calculation method of the UN, and 154 countries are divided into four classes as Very High (VH), High (H), Medium (M), and Low (L) for both the HDI and L-HDI. (UNDP, HDR Technical Notes, 2020). Accordingly, the classes of some countries differ according to the HDI and L-HDI. Table 5 shows the countries with varying class memberships.

As seen in Table 6, Chile, Croatia, Latvia, Lebanon, Myanmar, and the Syrian Arab Republic have moved down to a lower class when their L-HDI scores are considered. The negative class change in these countries depends on the negative performance in infrastructure and timeliness indicators. On the other hand, although it is seen that some countries have climbed to the top

Table 5.
Change of the HDI and L-HDI class memberships of countries.

Country	Previous Class Membership (the HDI)	Next Class Membership (L-HDI)
Chile	VH	H
Croatia	VH	H
Latvia	VH	H
Lebanon	H	M
Myanmar	M	L
Syrian Arab Republic	M	L

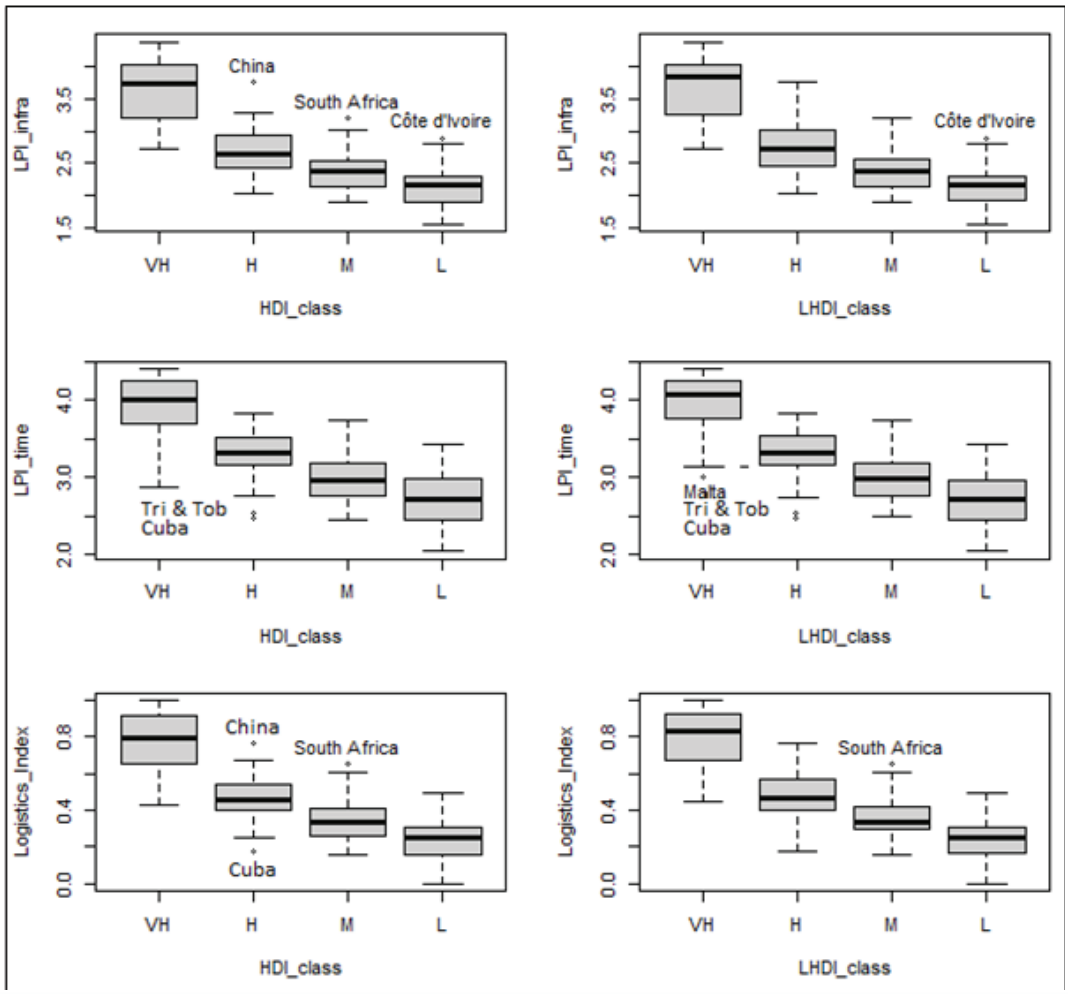

Figure 3.
Infrastructure, Timeliness and Logistics Index Boxplots according to the HDI and L-HDI classes.

when their L-HDI scores are considered, it is observed that no country is able to reach a higher class.

This situation actually shows how difficult a process logistics is, how effective it is at the level of human development, and how much effort should be spent in order to reach the upper class according to the L-HDI score, which also includes logistics. Class changes according to L-HDI suggest that the countries in Table 5 have a very fragile structure in terms of logistics. One of the most important factors that weaken logistics activities is the wars in the region. Thus, in the table, Myanmar, Lebanon, and Syria are the countries where civil wars occur today.

In Figure 3, box plots drawn to examine how the class characteristics of countries change when infrastructure, timeliness, and logistics indices are used instead of the HDI are shown.

When the infrastructure scores of the countries, divided into four classes according to the HDI, are examined, it is seen that the infrastructure of China, which is in the High class, is even higher than the average of the countries in the Very High class. Similarly, the infrastructure performance of South Africa, which is in the Medium class, is almost as high as the maximum infrastructure performance of High-class countries. Finally, the infrastructure score of Côte d'Ivoire, which is in the Low class according to the HDI, is close to the highest infrastructure score of the Medium class. When infrastructure is taken into account in determining the human development levels of these countries, and these countries are classified according to L-HDI, China and South Africa are no longer the outliers of their own classes. Because the infrastructure average in the new classes created according to L-HDI increases compared to the classes created according to the HDI, including China and South Africa. These countries are the first two countries that show the most positive change given in Table 4. Côte d'Ivoire is still seen as an outlier in its class in terms of infrastructure performance. This is because the average of infrastructure in the Low class, created according to L-HDI, is almost the same as the average of infrastructure in the Low class, created according to the HDI. In terms of timeliness, Trinidad & Tobago and Cuba are negatively differentiated according to the HDI, while Malta, an island country, is added to these countries according to L-HDI.

The examined regions are added to the data set as a categorical variable to investigate L-HDI differences according to the regions. Countries are divided into seven regions by the World Bank: Europe & Central Asia, Sub Saharan Africa, Latin American & Caribbean, Middle East & North Africa, East Asia & Pacific, South Asia, and North America. In Figure 4, the number of countries in each region is given, and Figure 5 shows the distribution of countries in the regions according to their L-HDI scores.

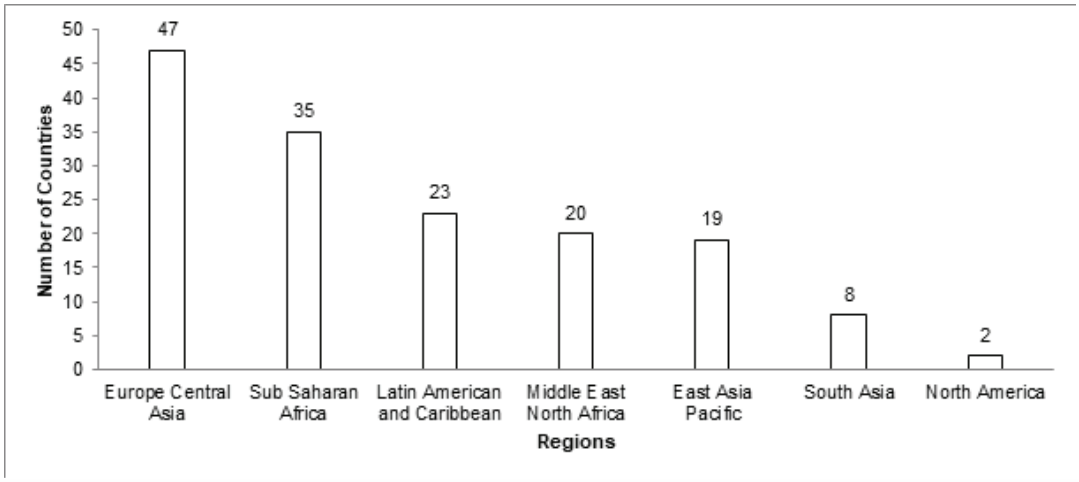

Figure 4.
Number of Countries by Regions.

When the distribution of countries according to their L-HDI scores is analysed in Figure 5, it is seen that the variability is high, especially in East Asia & Pacific and the Middle East & North Africa regions. On the other hand, countries in Europe & Central Asia and Sub-Saharan Africa regions are closer to each other regarding L-HDI scores. On the other hand, while there are no Low-class countries in Europe & Central Asia and North America regions, there are no Very High countries in Sub-Saharan Africa, Latin American & Caribbean, and South Asia regions. In the Middle East & North Africa, and East Asia & Pacific regions, a heterogeneous class structure with countries from all classes is observed. In this context, the regions exhibit three cluster structures with mostly Very High, Low, and Heterogeneous countries.

In all regions, the presence of one or more diverging countries attracts attention. To determine which countries are outliers, Figure 6 shows the box plots drawn for each region.

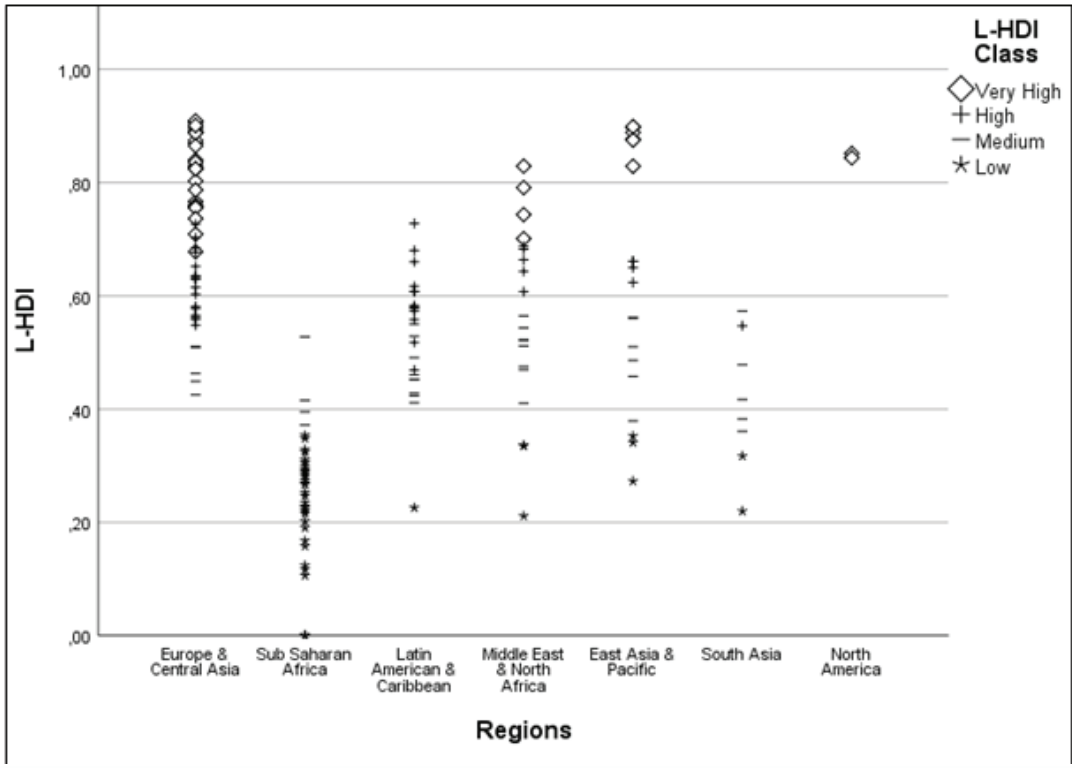

Figure 5.
Distribution of L-HDI scores of countries according to L-HDI classes and regions.

Accordingly, in the Sub-Saharan Africa region, South Africa diverges positively, while Guinea, Burundi and Central African Republic diverge negatively. In the Latin American & Caribbean region, Haiti differs negatively according to its L-HDI score.

One-way analysis of variance (ANOVA) is applied to determine whether L-HDI differs significantly between regions and thus investigate whether regions affect L-HDI. In the analysis, L-HDI is considered as a dependent continuous variable and regions as independent categorical variables. ANOVA requires the assumption of the normal distribution of data. As a result of the Kolmogorov Smirnov test performed to test this assumption, it is observed that the data is normally distributed ($p>0.05$). ANOVA findings show that L-HDI differs between regions; in other words, it is affected by regions ($F=39.812$, $p<0.05$). A multiple comparison test is applied to examine in which regions this difference exists, and the findings are provided in Table 6 below.

According to the multiple comparison findings of the seven regions, no significant difference has been found between the Europe & Central Asia region and the East Asia & Pacific regions in terms of L-HDI scores. Europe & Central Asia region differs significantly from the other five regions in terms of L-HDI score ($p<0.05$). There is no significant difference in L-HDI scores between the Sub-Saharan Africa region and South Asia regions. The Sub-Saharan Africa region differs significantly from the other four regions in terms of L-HDI score. There is a significant difference in L-HDI scores between Latin American & Caribbean and North America regions. There is no significant difference in L-HDI scores between the Latin American & Caribbean and the other three regions. There is a significant difference in L-HDI scores between the Middle East & North Africa and North America regions. There is no significant difference between the Middle East & North Africa regions and the other two regions regarding L-HDI score. There is a significant difference in L-HDI scores between East Asia & Pacific regions and North America regions. There is no significant difference between the East Asia & Pacific regions and the South Asia region regarding the L-HDI score. Finally, there is a significant difference in L-HDI scores between the South Asia and North America regions.

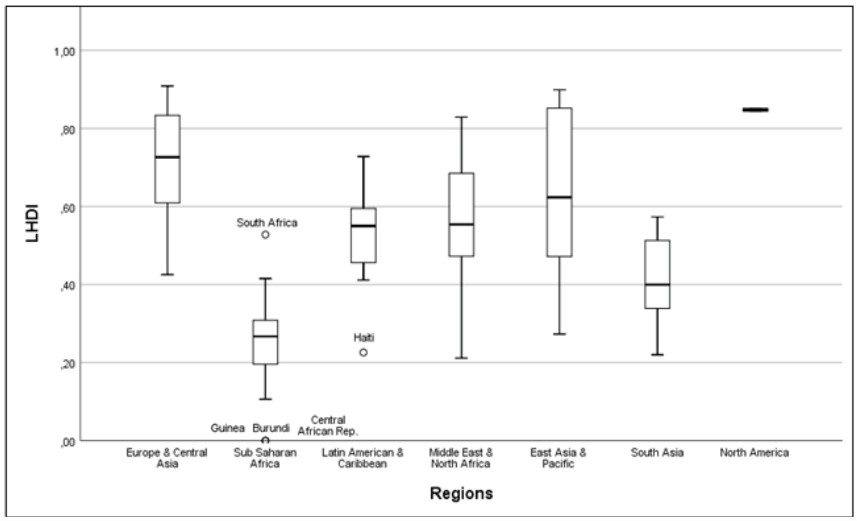

Figure 6.
L-HDI box plot according to regions.

Table 6.
Multiple Comparisons.

Region (I)	Region (J)	Mean Difference (I-J)
Europe & Central Asia	Sub-Saharan Africa	.46712*
	Latin American & Caribbean	.18426*
	The Middle East & North Africa	.15139*
	East Asia & Pacific	.09377
	South Asia	.30193*
	North America	-.13361*
Sub-Saharan Africa	Latin American & Caribbean	-.28286*
	The Middle East & North Africa	-.31573*
	East Asia & Pacific	-.37335*
	South Asia	-.16519
	North America	-.60073*
Latin American & Caribbean	The Middle East & North Africa	-.03287
	East Asia & Pacific	-.09050
	South Asia	.11767
	North America	-.31788*
The Middle East & North Africa	East Asia & Pacific	-.05763
	South Asia	.15054
	North America	-.28501*
East Asia & Pacific	South Asia	.20816
	North America	-.22738*
South Asia	North America	-.43555*

**The mean difference is significant at 0.05 level*

5. CONCLUSION

The HDI, representing a measure of human development for countries and published annually by the UN, has been criticised for various reasons. Previous literature shows that, apart from the criticism towards the calculation method of the HDI (Karagiannis & Karagiannis, 2020) (Mangaraj & Aparajita, 2020) (Omrani, Alizadeh, & Amini, 2020) (Ravallion, 2012), there is also criticism stating that the HDI does not fully reflect human development and should therefore be supplemented with new indicators (Assa, 2021) (Ramdén & Swartling, 2021) (Yero, Sacco, & Nicoletti, 2021) (Hou, Walsh, & Zhang, 2015). It is seen that inequality, poverty, life expectancy at birth, literacy, and sustainability indicators are included in the HDI in studies arguing that new dimensions, apart from health, education, and living standards, should be taken into account in measuring human development. Considering the competitive conditions, people's and organisations' needs and expectations, and the changing shopping habits, along with the COVID 19 pandemic, this study recommends a different index to alleviate the deficiency in the ability of the current HDI to represent human development with logistics indicators.

Logistics is the part of the value chain that plans, implements, and controls the efficient flow of goods, services, and information from resource to consumer (De Souza, Goh, Gupta, & Lei, 2007), thereby creating a strong relationship between logistics and development. The strong relationship found between the HDI and LPI (r=0.775) in the study confirms this, and it would seem to be beneficial to use a new human development index that considers logistics instead of the HDI.

Appropriate logistics indicators to be added to the HDI are determined by multi-linear regression analysis among the six sub-indicators of the LPI published by the World Bank. As a result of the analysis, it may be seen that the infrastructure and timeliness indicators, among the six sub-indicators, have a significant effect on the HDI. Significant indicators are integrated into the HDI using the UN's calculation method. The created new index with a logistics dimension is named L-HDI, and each country's performance is evaluated with the new index.

Countries are reordered and classified with L-HDI. Considering logistics in the human development of countries in terms of new rankings and classes, significant differences are observed compared to the current HDI. It is seen that the countries with a positive ranking according to L-HDI have a critical importance in terms of world transport geography, while the countries that change negatively are mostly island countries that are difficult to reach. However, it is noteworthy that although the class level of some countries decreases when switching from the HDI to L-HDI, no country sees an increase in their class level. Since logistics activities have complex processes, moving up to a class is considered difficult even if the ranking changes.

According to the HDI, China, South Africa, and Ivory Coast are far above the H, M, and L class averages, respectively, in terms of logistics infrastructures, while China and South Africa are no longer outliers when the classes are created according to L-HDI. According to the HDI, while Trinidad & Tobago and Cuba are well below the class average in H class, Malta, an island country in VH class, is added to these countries when classes are created according to L-HDI. When logistics in human development is taken into account, it may be observed that countries with positive infrastructure and timeliness scores are no longer an outlier in their own classes due to the increase in class averages, while countries with low scores turn into negative outliers.

In terms of L-HDI score averages, there are statistically significant differences between the seven economic regions determined by the World Bank. This reveals that some parts of the world are more successful than other regions in terms of logistics-based human development.

Marti et al. (2017) examine the difference in LPI between economic regions. According to this study, while Europe&Central Asia and North America do not differ in terms of LPI, these two regions differ according to L-HDI. In the same study, while there is no difference in LPI between Sub-Saharan Africa, the Middle East & North Africa and Latin American & Caribbean regions, a difference is found between these regions in terms of L-HDI. This shows that logistics is only one dimension of the L-HDI index, i.e. L-HDI is not a logistics index but a human development index with a logistics dimension.

While Europe &Central Asia countries and Sub-Saharan Africa countries have a more homogeneous class among themselves compared to L-HDI, the Middle East & North Africa, and East Asia & Pacific regions display a rather heterogeneous class structure. While Europe & Central Asia countries have achieved stability in a positive sense, Sub-Saharan Africa consists of countries that are similar to each other in a negative sense due to the handicaps of the region.

This study argues that the human development of countries better reflects today's conditions by considering logistics as a dimension of HDI. With the new index we have introduced for the first time, countries that do not perform well enough in terms of education, health, and living standards but play an important role in world trade with their performance in the field of logistics, are better represented. On the other hand, countries that perform well in terms of education, health and living standards, but are insufficient in logistics and cannot be adequately integrated into world trade, are also more accurately represented by L-HDI.

There are some limitations to this research inherited from an original logistics performance index. First, the service level of various freight forwarders in different countries may vary regarding their interactions with government agencies. Second, the small-islands states and landlocked countries have transit difficulties that cause the difficulties in assessing their trade

facilitation efforts. Third, L-HDI cannot be generalised in terms of transition economies. In the future studies, authors may expand the analysis by utilising the fuzzy methodology in L-HDI evaluation. Additionally, this analysis could be enlarged country wise, considering the rest of the countries in every continent with using L-HDI values over time.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Assa, J., 2021. Less is more: The implicit sustainability content of the human development index. Ecological Economics, 185. Available at: https://doi.org/10.1016/j.ecolecon.2021.107045.

Bastos, S. et al., 2020. Is there a relationship between the use of motorcycles and the level of development of countries? Bulletin of Geography. Socio-economic Series, 50, 43-53. Available at: https://doi.org/10.2478/bog-2020-0031.

De Souza, R. et al., 2007. An investigation into the measures affecting the integration of ASEAN's priority sectors: Phase 2: the case of logistics. Manila: Association of Southeast Asian Nations.

Dinçer, M. & Kalkan, S., 2021. The effect of long work hours on human development. BMIJ, 9(1), 186-199. Available at: https://doi.org/10.15295/bmij.v9i1.1746.

Gunst, R. F. & Mason, R. L., 1980. Regression analysis and its applications. New York: Marcel Dekker.

Haitovski, Y., 1969. A note on the maximization of R2. Am. Statist., 23(1), 20-21.

Hou, J. et al., 2015. The dynamics of Human Development Index. The Social Science Journal, 52(3), 331-347. Available at: https://doi.org/10.1016/j.soscij.2014.07.003.

İnan, A. et al., 2021. The determination of the factors affecting air transportation passenger numbers. International Journal of Aviation, Aeronautics, and Aerospace, 8(1), 4. Available at: https://doi.org/10.15394/ijaaa.2021.1553.

Jhawar, A. et al., 2014. Analysis of the skilled work force effect on the logistics performance index case study from India. Logist. Res., 7(117), 1-10. Available at: https://doi.org/10.1007/s12159-014-0117-9.

Karagiannis, R. & Karagiannis, G., 2020. Constructing composite indicators with Shannon entropy: The case of Human Development Index. Socio-Economic Planning Sciences, 70. Available at: https://doi.org/10.1016/j.seps.2019.03.007.

Kirkman, S. P. et al., 2020. Ecosystem health and human wealth – A comparison of sub-Saharan African Large Marine Ecosystems. Environmental Development, 36.

Le Caous, E. & Huarng, F., 2021. Economic Complexity and Human Development: Moderated by Logistics and International Migration. Sustainability, 13. Available at: https://doi.org/10.3390/su13041867.

Liu, K. et al., 2020. Unexpected positive correlation between human development index and risk of infections and deaths of COVID-19 in Italy. One Health, 10. Available at: https://doi.org/10.1016/j.onehlt.2020.100174.

Long, X. et al., 2020. Sustainability evaluation based on the Three-dimensional Ecological Footprint and Human Development Index: A case study on the four island regions in China. Journal of Environmental Management, 265. Available at: https://doi.org/10.1016/j.jenvman.2020.110509.

Mangaraj, B. & Aparajita, U., 2020. Constructing a generalized model of the human development index. Socio-Economic Planning Sciences, 70. Available at: https://doi.org/10.1016/j.seps.2019.100778.

Martí, L. et al., 2017. A DEA-logistics performance index. Journal of applied economics, 20(1), 169-192. Available at: https://doi.org/10.1016/S1514-0326(17)30008-9.

Martinez, E. Z. & da Roza, M. D., 2020. Ecological analysis of adolescent birth rates in Brazil: Association with Human Development Index. Women and Birth, 33, 191-198. Available at: https://doi.org/10.1016/j.wombi.2019.04.002.

Mauleón, I., 2020. Economic Issues in Deep Low-Carbon Energy Systems. Energies, 13. Available at: https://doi.org/10.3390/en13164151.

McGowan, I. S., 2021. Education, Globalization, Cultural Diversity and a Revised Human Development Index for the Caribbean Region: Findings & Policy Implications. 3rd International Conference on Future of Social Sciences. Berlin.

Mohmmed, A. et al., 2019. Driving factors of CO2 emissions and nexus with economic growth, development and human health in the Top Ten emitting countries. Resources, Conservation & Recycling, 148, 157-169. Available at: https://doi.org/10.1016/j.resconrec.2019.03.048.

Montgomery, D. C. et al., 2001. Introduction to Linear Regression Analysis, 3rd Edition. New York: John Wiley & Sons.

Noorbakhsh, F., 1998. A Modified Human Development Index. World Development, 26(3), 517-528.

Novitasari, F. et al., 2020. The impacts of infrastructure development on economic growth (case study: DKI Jakarta, Banten Province and West Java Province). IOP Conference Series: Earth and Environmental Science, 592, 1-10.

Omrani, H. et al., 2020. A new approach based on BWM and MULTIMOORA methods for calculating semi-human development index: An application for provinces of Iran. Socio-Economic Planning Sciences, 70. Available at: https://doi.org/10.1016/j.seps.2019.02.004.

Ramdén, V. & Swartling, J., 2021. The effect of family planning on human development. Lund University Department of Economics.

Ravallion, M., 2012. Troubling tradeoffs in the Human Development Index. Journal of Development Economics, 99(2), 201-209. Available at: https://doi.org/10.1016/j.jdeveco.2012.01.003.

Riahi, M. et al., 2018. Diarrhea deaths in children among countries with different levels of the human development index. Data in Brief, 17, 954-960. Available at: https://doi.org/10.1016/j.dib.2018.02.019.

Rodrigue, J. P., 2020. The Geography of Transport Systems (Fifth Edition b.). New York: Routledge.

Sagar, A. D. & Najam, A., 1998. The human development index: a critical review. Ecological Economics, 25, 249-264. Available at: https://doi.org/10.1016/S0921-8009(97)00168-7.

Sarkodie, S. A. & Adams, S., 2020. Electricity access, human development index, governance and income inequality in Sub-Saharan Africa. Energy Reports, 6, 455-466. Available at: https://doi.org/10.1016/j.egyr.2020.02.009.

Silva, A. et al., 2020. COVID-19 in children in the state of Pernambuco: Spatial analysis of confirmed severe cases and the Human Development Index. Journal of the Brazilian Society of Tropical Medicine, 54, 1-9. Available at: https://doi.org/10.1590/0037-8682-0782-2020.

Slovic, A. et al., 2019. The long road to achieving equity: Job accessibility restrictions and overlapping inequalities in the city of São Paulo. Journal of Transport Geography, 78, 181-193. Available at: https://doi.org/10.1016/j.jtrangeo.2019.06.003.

Sudirman & Hapsara, O., 2021. Analysis of the Human Development Index in Jambi City. Advances in Economics, Business and Management Research, 168, 264-268. Available at: https://doi.org/10.2991/aebmr.k.210305.048.

Sumargo, B. et al., 2021. The Two-Stage Least Squares Simultaneous Equation Model for Panel Data on Human Development, Economics, and Environmental Quality. AIP Conference Proceedings, 2331.

UNDP, 2020. HDR Technical Notes. Available at: http://hdr.undp.org/sites/default/files/ hdr2020_technical_notes.pdf, accessed on: 31.10.2022.

UNDP, 2021a. Human Development Index (HDI). United Nations Development Programme Human Development Reports. Available at: http://hdr.undp.org/en/content/human-development-index-hdi, accessed on: 31.10.2022.

UNDP, 2021b. United Nations Development Programme Human Development Reports. Human Development Index (HDI). Available at: http://hdr.undp.org/en/content/human-development-index-hdi, accessed on: 31.10.2022.

Wang, Z. et al., 2018. Renewable energy consumption, economic growth and human development index in Pakistan: Evidence form simultaneous equation model. Journal of Cleaner Production, 184, 1081-1090. Available at: https://doi.org/10.1016/j.jclepro.2018.02.260.

Werneck, A. et al., 2020. Macroeconomic, demographic and human developmental correlates of physical activity and sitting time among South American adults. International Journal of Behavioral Nutrition and Physical Activity, 17, 163. Available at: https://doi.org/10.1186/s12966-020-01068-6.

World Bank. 2021. World Bank. Available at: https://lpi.worldbank.org/international/global, accessed on: 31.10.2022.

Yakunina, R. & Bychkov, G., 2015. Correlation Analysis of the Components of the Human Development Index Across Countries. Procedia Economics and Finance, 24, 766-771. Available at: https://doi.org/10.1016/S2212-5671(15)00692-9.

Yero, E. et al., 2021. Effect of the Municipal Human Development Index on the results of the 2018 Brazilian presidential elections. Expert Systems with Applications, 168. Available at: https://doi.org/10.1016/j.eswa.2020.114305.

Yue, S. et al., 2019. Sustainable total factor productivity growth for 55 states: An application of the new malmquist index considering ecological footprint and human development index. Resources, Conservation & Recycling, 146, 475-483. Available at: https://doi.org/10.1016/j.resconrec.2019.03.035.