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The Role of Energy Consumption and Economic Growth on Human Development in Emerging (E-7) Countries: Fresh Evidence from Second-Generation Panel Data Analyses

Symbioza kreatywności i zrównoważonego rozwoju: modelowanie dynamicznych relacji pomiędzy zrównoważonym rozwojem a kulturą i przemysłem kreatywnym w krajach UE, Wielkiej Brytanii i Ukrainie

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Abstract
This study aims to examine the impacts of energy consumption and economic growth on the human development index of seven emerging countries (E-7) with high economic performance for yearly observations from 1992 to 2021. The analyses were carried out with second-generation panel data analyses: (i) Panel cointegration test with structural breaks proposed by Westerlund (2006), (ii) augmented mean group estimator recommended by Eberhardt and Bond (2009), and (iii) Dumitrescu and Hurlin (2012) panel causality test. The empirical model also included trade openness and urbanization parameters as control variables. The panel cointegration test outcomes reveal the presence of a long-run relation among the human development index and energy consumption, economic growth, urbanization, and trade openness for all countries. Augmented mean group test outcomes signify that energy consumption, economic growth, and trade openness have positive and statistically significant impacts on the human development index, whereas urbanization does not have any statistically significant impact in the long-run. Finally, panel causality test results signify that there is a bidirectional relation between the human development index and energy consumption, economic growth, and trade openness and also a unidirectional relation from urbanization to the human development index in E-7 countries. All these findings indicate that the main macroeconomic indicators have an important role on the human development index in E-7 countries. In this context, these countries should implement a more effective and innovative economic policy for Sustainable development goals.

Key words: human development index, economic growth, energy consumption, E-7 countries, panel data estimations

Streszczenie
Niniejsze badanie ma na celu zbadanie wpływu zużycia energii i wzrostu gospodarczego na wskaźnik rozwoju społecznego siedmiu krajów wschodzących (E-7) o wysokich wynikach gospodarczych w rocznych obserwacjach

od 1992 do 2021 r. Analizy przeprowadzono z wykorzystaniem danych panelowych drugiej generacji analizy: (i) panelowy test kointegracji z przerwami strukturalnymi zaproponowany przez Westerlunda (2006), (ii) rozszerzony estymator grupy średniej zalecany przez Eberhardta i Bonda (2009) oraz (iii) panelowy test przyczynowości Dumitrescu i Hurlina (2012). W modelu empirycznym jako zmienne kontrolne uwzględniono także parametry otwartości handlu i urbanizacji. Wyniki panelowego testu kointegracji ujawniają istnienie długoterminowego związku pomiędzy wskaźnikiem rozwoju społecznego a zużyciem energii, wzrostem gospodarczym, urbanizacją i otwartością handlową dla wszystkich krajów. Zwiększone średnie wyniki testów grupowych oznaczają, że zużycie energii, wzrost gospodarczy i otwartość handlu mają pozytywny i statystycznie istotny wpływ na wskaźnik rozwoju społecznego, podczas gdy urbanizacja nie ma statystycznie istotnego wpływu w dłuższej perspektywie. Wreszcie, wyniki panelowego testu przyczynowości wskazują, że istnieje dwukierunkowa zależność pomiędzy wskaźnikiem rozwoju społecznego a zużyciem energii, wzrostem gospodarczym i otwartością handlową, a także jednokierunkowa zależność pomiędzy urbanizacją a wskaźnikiem rozwoju społecznego w krajach E-7. Wszystkie te ustalenia wskazują, że główne wskaźniki makroekonomiczne odgrywają ważną rolę we wskaźniku rozwoju społecznego w krajach E-7. W tym kontekście kraje te powinny wdrożyć bardziej efektywną i innowacyjną politykę gospodarczą na rzecz Celów zrównoważonego rozwoju.

Słowa kluczowe: wskaźnik rozwoju społecznego, wzrost gospodarczy, zużycie energii, kraje E-7, szacunki danych panelowych

1. Introduction

The United Nations has been developing comprehensive policies to increase international cooperation in combating economic, social, and environmental problems experienced on a global scale since the 1990s. In particular, the negotiations held in 2015 are the most important turning point of these efforts. At this meeting, joint negotiations among 193 countries determined some valuable Sustainable development goals (SDGs) and reached a consensus to achieve these targets by the end of 2030. SDGs include the solutions of some fundamental problems that directly affect human life and well-being in developing and underdeveloped countries. Poverty, quality education, sustainable cities, climate change, economic growth and clean energy are some of the most important of these targets (United Nations, 2023).

As an important engagement of development, *energy* is an indispensable input of production processes that directly affects human welfare. Especially in the field of sustainable development, researchers are widely investigating how increasing energy consumption will enable a healthier and higher standard of living without harming environmental quality. In other words, they are trying to explain to what extent energy use/consumption will affect the economic growth and development processes of countries (and, therefore, human well-being) without causing environmental damage. It is widely accepted that energy consumption plays a key role in economic growth (Warr & Ayres, 2010). It leads to high levels of economic activity and improved living standards (Hussein & Filho, 2012). In addition, it contributes to solving many social problems such as reducing poverty, increasing human development, and improving the quality of life (Karekezi et al., 2012).

Energy usage/consumption has a close relation with both economic growth and development. First, in economic literature, the relation among energy consumption and economic growth is commonly examined through the *energy-growth nexus* (Inglesi-Lotz, 2015; Ben Mbarek et al., 2016; Kahia et al., 2016; Bildirici & Gökmenoğlu, 2017; Koçak & Şarkgüneşi, 2017; Gozgor et al., 2018; Stoenoiu, 2018; Chovancová & Vavrek, 2019). Energy is considered the main driver of economic growth in traditional production processes (Stern, 2011), and its demand is rapidly increasing due to social and economic developments in recent years (Koçak & Şarkgüneşi, 2017). According to the International Energy Agency (IEA, 2020), final energy consumption in the world was 4,667 million tons of oil equivalent (mtoe) in 1973, and this demand reached 9,938 (almost doubled) mtoe in 2018. More specifically, the share of fossil fuels in total energy consumption in 2018 was at a high level of 67%, including oil at 40.8%, natural gas at 16.2%, and coal at 10%. This indicates that fossil fuels have significantly maintained (and even increased) their important share in energy consumption in the last half century. Conversely, economic growth also affects energy consumption patterns. Governments tend to prefer renewable energy sources rather than traditional energy derivatives such as coal, natural gas, and oil to prevent possible negative consequences of energy consumption in the future (Wang et al., 2018). The IEA reports have emphasized that governments need to triple their global renewable energy capacity by 2030. In this way, there will be a 39% increase in electricity production from renewable energy by 2050 (Koçak & Şarkgüneşi, 2017).

Second, the relation among energy consumption and development is mostly examined through the *energy–human development nexus*. The human development index is considered one of the most important indicators of social welfare and is defined as a composite measure of countries' income, health, and education levels (United Nations Development Programme [UNDP], 1990). The increase in the human development index means that individuals live a long, healthy, and quality of life (Akar et al., 2021). Undoubtedly, access to reliable and clean energy has direct and positive effects on human welfare. It is important to have access to low-cost and reliable energy services to meet basic human needs such as lighting and heating (Alstone et al., 2015). In contrast, energy poverty, which is a significant obstacle to human development, is defined as the lack of access to modern energy services (Casillas & Kammen, 2010). It can hinder education, health, and economic opportunities, particularly in developing and underdeveloped countries. Therefore, increases in energy consumption can contribute to human development by improving living conditions and ensuring socio-economic progress (Sadiq et al., 2022a). However, millions of people around the world are still left without the most basic and reliable services despite an increase in energy production capacity (Alstone et al., 2015). The IEA (2022) estimated that the number of people living without electricity rose by nearly 20 million in 2022, reaching nearly 775 million. This increase is expected to occur mostly in sub-Saharan African countries, where the number of people without access to energy is almost back to its 2013 peak.

Finally, the relation among economic growth and human development is commonly examined through the *growth–human development nexus*. In empirical studies, human development is considered both an input and an output of economic growth (Boozer et al., 2003; Suri et al., 2011). Undoubtedly, economic growth contributes to the improvement of human development by increasing national income. However, economic growth alone cannot explain the basic features of human development because it does not reflect the improvement in people's education and living conditions. Instead, the human development index is a more realistic parameter for assessing the development of a society and is the ultimate goal of economic development (Van Tran et al., 2019). In addition, the improvement in the quality of labour is likely to contribute to economic growth by increasing productivity in production. Ranis and Stewart (2005) stated that a high level of human development positively affects production activities by increasing people's creativity and productivity.

All countries severely need energy resources within the framework of their sustainable economic growth and development policy targets. In literature, the economic and environmental effects of energy supply and demand are discussed extensively by researchers. However, the impacts of energy consumption and economic growth on human development have received relatively little attention. The aim of this study is to analyze this relationship for seven emerging market economies (E-7) with high economic performance and to contribute to the literature gap on development economics.

E-7 economies are the countries with high energy consumption as a result of increasing population and rapid urbanization (Tong et al., 2020). The lack of capital and technology investment in these countries causes environmental regulations to not be implemented effectively, resulting in intense environmental destruction (Han et al., 2023). Research reveals that E-7 countries have had a significant share in carbon emissions since the 1850s. In particular, China, Russia, Brazil, and Indonesia are among the top 10 countries that cause the most carbon emissions, with their shares of 11%, 7%, 5%, and 4%, respectively (Carbon Brief, 2021). In addition, these countries also make significant contributions to the world production level. Hussain et al. (2022) predicted that E-7 countries will produce more than 25% of world production by 2032, thus leaving G-7 countries behind. Similarly, these countries are expected to grow at an average annual rate of 3.5% between 2016 and 2050. Hussain et al. (2022) also estimated this rate will be limited to an average level of 1.6% for G-7 economies. In contrast, the UNDP (2022) report revealed that E-7 countries do not have good levels in human development rankings as of 2021. Among 191 countries, Türkiye and Russia rank 48th and 52nd, respectively, and are among the countries with high levels of human development. China, Mexico, and Brazil are characterized as countries with high levels of human development, with rankings of 79th, 86th, and 87th, respectively. Finally, India is among the countries with medium human development, with its rank of 132nd.

The concept of sustainability has a complex structure. Accordingly, sustainability is not the maintenance of a system in a stable state, but the adaptation of the system to change and the preservation of renewal resources for this purpose. The important factor for sustainability here is the improvement of social and ecological capacity. Therefore, sustainable development does not mean the continuation of existing conditions (Gallopin, 2003). In this context, in 1987, the World Commission on Environment and Development tried to resolve the conflict between environment and development goals by defining the boundaries of the concept of sustainable development (WCED, 1987). Since then, as a result of extensive discussion of the concept, the three pillars of sustainable development – economic, environmental and social - have become more widely used. These three aspects of sustainability cause the objectives of economic development to be multidimensional (Harris, 2003). Especially in recent years, the rapid urbanization process experienced worldwide has led to the emergence of economic benefits and problems. Therefore, urban sustainability has become important for achieving Sustainable development goals (Shen et al., 2012). Because although urbanization has been identified as an important development strategy, especially for developing countries, it also carries concerns such as air pollution and loss of arable land (Shen et al., 2016). However, countries' trade policy can also be a facilitating force for sustainable development, as it has the ability to influence the economy, culture and environment in both directions (Sheikh et al., 2020). Another factor that is important for sustainability today is energy. In this context, the gradual replacement of fossil fuels highlights different energy sources that can sustainably meet the amount of energy needed in the long term. One of these energy sources is nuclear fission technology (Brook et al., 2014). However, there are opposing views on the role of nuclear energy in sustainable development. Accordingly, it is argued that it should be phased out because it is a dangerous energy technology. Moreover, nuclear energy is not among the clean energy options in the UN discussions on sustainable development (Mourogov, 2000). However, the advancement of renewable energy technologies is emphasized for the success of sustainable energy production worldwide (Elliott, 2000). Therefore, there is a global need to harmonize the education system for the deployment of renewable energy sources, mitigation of the nuclear energy process and identification of new strategies for sustainable energy development (Afgan et al., 1998). In this context, in terms of sustainable development, the common view is that it is important to increase the level of human capital for the effective use of renewable energy resources (Yumashev et al., 2020).

Based on above information, we analyzed the impacts of energy consumption and economic growth on the human development index for E-7 countries, controlling variables such as trade openness and urbanization. This study makes three main contributions to the literature. First, it is one of the pioneering studies that investigated the impact of energy consumption and economic growth on human development specifically for E-7 countries. Second, it applies powerful and up-to-date econometrics testing methods such as Westerlund (2006) cointegration test, augmented mean group (AMG) estimator provided by Eberhardt and Bond (2009), and Dumitrescu and Hurlin (2012) panel causality method. Thus, it aims to contribute to the existing literature by providing more robust and unbiased empirical evidence. Finally, it provides practical and political implications based on empirical evidence for E-7 countries within the framework of the SDGs and guides decision-makers to achieve higher human development.

The rest of the study is organized as follows. Section 2 reveals the theoretical relationship between sustainable development and human development. Section 3 provides detailed information about the empirical literature on the relationships among economic growth, energy consumption, and human development. Section 4 includes the data and Section 5 explains the econometric method. Section 6 discusses the empirical findings. Finally, Section 7 provides conclusions and policy recommendations for future research.

2. The Nexus between Sustainable Development and Human Development

Sustainable development represents progress in enhancing human well-being while staying within the ecological limits of the biosphere. Because the necessary condition for sustainability is that resource use remains within the limits of nature's capacity to renew itself (Moran et al., 2008). It is also important to consider development as a process that diversifies people's options and increases their capabilities, and to ensure this for future generations. In other words, development should be sustainable. There is strong evidence that sustainable development should take into account all components in a balanced way to meet the needs of the environment and the economy (Jepson, 2004). Sustainable development should take into account economic growth and social development to improve the quality of life of current generations while balancing intergenerational well-being (Jin et al., 2020). Moreover, in terms of environmental sustainability, the complex system of linkages between human activities and nature conservation allows for a strong relationship between human development and sustainable development (Vasquez Roldan and Henao, 2017). For this reason, it is not correct to see human development and sustainable development as alternatives to choose between (Griffin et al., 1994). In this context, the sustainability dimension of human development has been analyzed in many studies (Estoque and Murayama, 2014; Bravo, 2014; Berryman and Sauve, 2016; Biggeri and Mauro, 2018).

The main objective of human development is to create an environment in which individuals can enjoy a healthy and higher quality of life. Accordingly, in a sustainable development approach integrated with human development, which is a dynamic process, targets for expanding human capacity to improve welfare should be such as to guarantee a minimum quality of life for future generations. Improving health and education will contribute to human capital stock and lay the foundation for higher living standards for future generations (Costantini and Monni, 2005). Education that results in improved well-being of individuals can be seen as an important transformative factor in improving the environment for sustainable human development and ensuring future sustainability (Landorf et al., 2008). Accordingly, given the low stock of human capital, especially in developing countries, governments need to increase investment in human capital if they want to promote ecological conservation (Costantini and Monni, 2008). In a study confirming this, Moyer and Bohl (2019) emphasized that improving human development is important, especially for many developing countries to achieve their Sustainable development goals. This is because the achievement of some development goals requires prior success in other factors, such as achieving a certain level of education. In this context, especially in recent years, it is stated that sustainable development emphasizes the welfare and happiness of people as well as the sustainability of natural resources and ecological sustainability (Yan et al., 2018). The aim here is to achieve environmental sustainability along with human development. This is now recognized as a process reflected in Sustainable development goals (Hickel, 2020). Because there is a strong relationship between achieving sustainable development and welfare indicators (De Neve and Sachs, 2020). In a different approach, human development enables the identification of the appropriate route to achieve Sustainable development goals (Conceıcao, 2019). In this respect, human development offers a process that promotes a contextual framework for sustainable development that not only focuses on economic growth, but also advocates for a more equitable distribution and regeneration rather than destruction of the environment (Mosteanu et al., 2014).

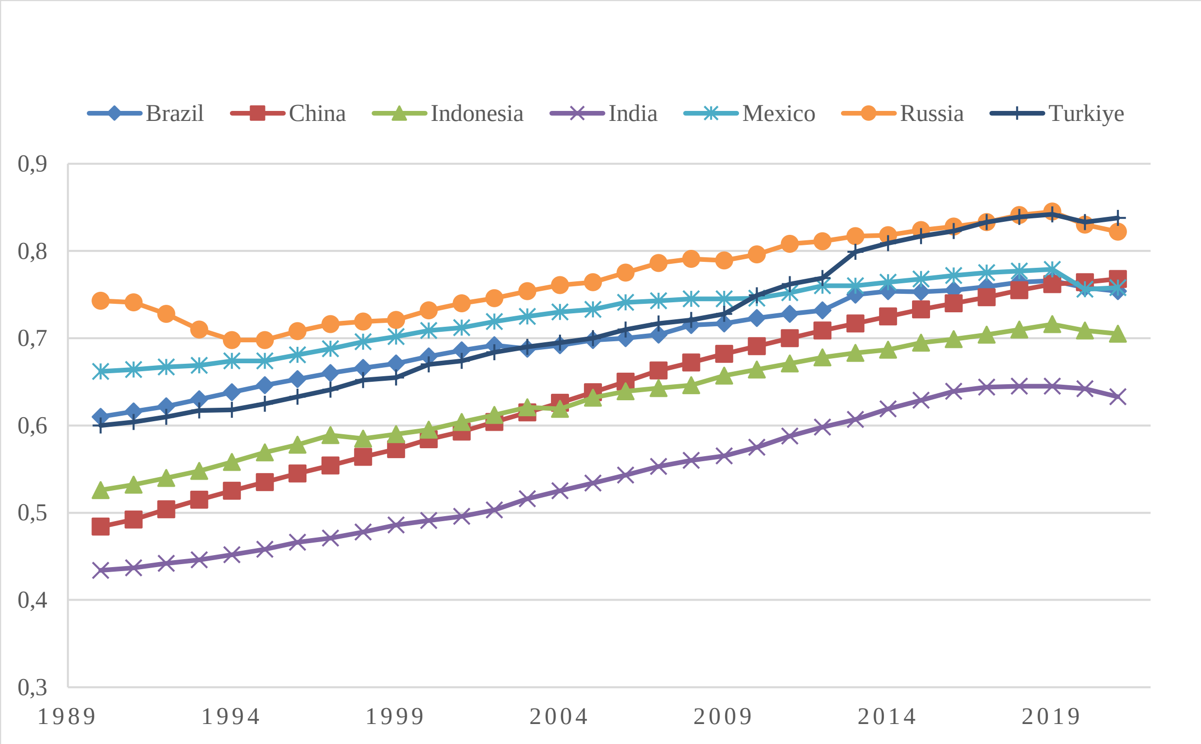

Figure 1. Trends in the Human Development Index of E-7 Countries

Figure 1 indicates the human development trends of E-7 countries from 1990 to 2021. As can be seen, the human development index shows an uptrend in all E-7 countries in this period. India is the country with the lowest human development index in the period 1990-2021. However, Türkiye and China have the highest growth rate in the human development index, especially in recent years.

3. Literature Review

In recent years, a large and important research area has emerged specifically in the energy economics literature. The basis of this development is undoubtedly the direct impacts of energy usage on both economic activities and social welfare. Many of the studies in the energy-related literature are commonly shaped around several main approaches. The first of these are studies investigating the relations among energy use and human development. A large body of research has stated that energy consumption contributes to the human development process. Accordingly, Kanagawa and Nakata (2008) revealed that access to energy has significant impacts on education, economy, and health in rural areas of India. Martinez and Ebenhack (2008) analyzed the relation among energy consumption and human development for 120 countries and discovered that there is a strong correlation among these two variables, especially in energy-poor countries. Pasten and Santamarina (2012) stated that energy consumption is a necessity to sustain life and is also directly linked to the quality of life. Roy et al. (2015) found that energy consumption increases the human development index. Njiru and Letema (2018) revealed that energy poverty affects the development of life expectancy, nutrition, and education in Kenya. They also found that access to energy affects health and the ability to be successful. Murillo-Alvarado and Ponce-Ortega (2022) indicated that biogas energy allows the improvement of the human development process in Mexico. Adekoya et al. (2021) examined yearly observations of 126 countries from 2000 to 2014 and concluded that renewable energy positively affects human development. Satrovic (2018) obtained similar results for Türkiye using annual data from 1992 to 2015. Acheampong et al. (2021) examined 79 energy-poor countries using the ordinary least squares procedure for the period 1990–2018 and concluded that access to electricity and clean energy is important for human development. Banday and Kocoglu (2022) investigated a sample of emerging economies using a panel quantile regression approach for the period 1990–2014 and found that energy use has positive impacts on the human development process. Sadiq et al. (2022b) researched BRICS countries from 1990 to 2019 and found that the renewable and nuclear energy usage improves human development in these countries. Using data from the same period, Sadiq et al. (2022a) also concluded that nuclear energy consumption increases human development for a sample of 16 selected OECD countries.

Conversely, some studies focused on the causal relation among energy use and human development. Niu et al. (2013) examined 50 countries using the panel data estimation for the period 1990 to 2009 and found there is bidirectional causality among electricity consumption and human development in the long run. They also concluded that electricity consumption and human development increase if the countries have a high income level. Ouedraogo (2013) investigated 15 selected developing countries from 1988 to 2008 and revealed that human development has a negative relation with energy consumption and also a positive relation with electricity consumption in the long run. The outcomes also showed that there is no causal relation among the series in the short run. Wang et al. (2020) analyzed BRICS countries from 1990 to 2015 and revealed that biomass energy provides an improvement in the human development index. Sasmaz et al. (2020) researched a sample of 28 OECD countries from 1990 to 2017 and found that renewable energy positively affects human development in these countries. Wang et al. (2021) obtained similar results for BRICS countries using similar variables for the period 1990–2016. Similarly, Azam et al. (2021) found the same results for 30 developing countries in the period 1990–2017. Hashemizadeh et al. (2022) revealed bidirectional causal relations between non-renewable and renewable energy and human development for the period 1990–2015 in the sample of G7 countries.

Several studies have found that energy consumption has negative impacts on human development. Pirlogea (2012) indicated that high energy intensity harms human development in European Union countries. Huskic and Satrovic (2020) examined the 10 countries with the highest energy consumption using the vector autoregressive model from 1990 to 2015 and concluded that renewable energy usage negatively impacts the human development process in these countries. Ibrahim et al. (2021) analyzed 43 sub-Saharan African countries using OLS and SYS-GMM models from 1990 to 2017 and found that non-renewable energy has negative impacts on the human development index and average life expectancy. Finally, a small number of studies found that energy does not contribute to human development. Gohlke et al. (2011) found that electricity consumption does not provide more health benefits in some countries with a certain level of birth rates. Mazur (2011) indicated that there is no relationship between the increase in energy use and the improvement in quality of life. Wang et al. (2018) examined Pakistan using two-stage least squares estimation method for the period 1990–2014 and concluded that renewable energy does not contribute to human development.

The second part of the studies commonly focused on the relation among economic growth and human development. Increase in per capita income will contribute to the improvement of education and health quality because of the increase in purchasing power. A high level of human development is expected to contribute to the development process (Sofilda et al., 2015). Additionally, human development can also have an important role in sustainable economic growth (Suri et al., 2011). Ranis and Stewart (2005) found that the human development process is directly linked to economic growth. Arisman (2018) revealed that per capita income affects human development for ASEAN countries. Khan et al. (2019) indicated that economic growth and communication technologies support human development for Pakistan. In another study using data from 1990 to 2016 for the same sample, Fatima et al. (2019) found causality relation among economic growth and human capital.

The third part of the studies focused on the relations between international trade and human development. International trade increases the income levels of countries and thus contributes to the improvement of development indicators such as health and education as well as human development. For this reason, recent research has tended to examine the impacts of international trade on human development as well as its stimulating feature of economic growth. Accordingly, Hamid and Amin (2013) indicated that trade is related to the human development process only through the income channel. Kabadayı (2013) revealed that an increase in trade openness improves the standard of living. Tahir and Khan (2014) found that trade openness positively affects economic growth by using the two-stage least squares procedure for developing countries in the Asian region. Kumar (2017) found that there is a significant relation among trade openness and human development for seven ASEAN member countries. Mbabazi (2017) examined for sub-Saharan African countries using the GMM procedure from 2004 to 2014 and found that the increase in trade has positive impacts on the improvement of social welfare. For the same sample, Tsokalida and Yang (2019) and Behailu (2023) found that trade openness positively affects the level of human development. Mustafa et al. (2017) revealed that trade liberalization policies contribute to the human development process for a sample of Asian economies. Fankem and Oumarou (2020) revealed that an increase in trade openness promotes economic growth for a sample of sub-Saharan African countries.

Finally, the fourth part of the studies focused on the relations between urbanization and human development. It is possible to explain the relation between human development and urbanization through economic growth (Nguea, 2023). Accordingly, some studies have found that urbanization has a close relationship with economic growth (Solarin & Shahbaz, 2013; Tamang, 2013; Hong et al., 2021). Urbanization has positive effects on human life such as safe nutrition and easy access to health services. Conversely, it also has many harmful effects such as urban congestion, crime, and the emergence of stress-related diseases. In addition, unplanned urban growth and population increases negatively affect human health by causing environmental degradation (Moore et al., 2003). Uche (2022) indicated that urbanization negatively affects environmental quality. Li et al. (2012) stated that urbanization in China causes health problems by causing changes in the environment and lifestyle. In contrast, Kongkuah et al. (2022) found that urbanization reduces environmental pollution caused by carbon emissions in the long term. There are many studies in the literature investigating the relation among environmental pollution and human development (Nazeer et al., 2016; Smith, 2016; Van Tran et al., 2019; Wang et al., 2019; Amer, 2020; Omri &

Belaid, 2021; Dumor et al., 2022; Opoku et al., 2022; Saqip et al., 2022). Nathaniel (2021) found that the interaction among human capital and urbanization contributes to the reduction of environmental degradation. Opuku et al. (2022) concluded that improvement in human development has an important role in ensuring environmental sustainability. Chankrajang and Muttarak (2017) revealed that increasing the duration of education increases the possibility of environmentally friendly activities for Thailand. In this context, urbanization has significant potential to promote human capital accumulation (Bertinelli & Black, 2004).

Urbanization contributes to human development by providing improvements in income, health, and education. However, these improvements may not always be possible. Daneshm Naruee et al. (2022) examined a sample of developing countries using regression analysis from 1990 to 2017 and revealed that urbanization has a negative impact on human development. Njoh (2003) indicated urbanization and development were positively related to the sub-Saharan African region. Anisujjaman (2015) found that there is a positive relation among urbanization and the level of human development for the state of West Bengal in India. In same region, Bhattacharya (1998) concluded that the human development level is higher in regions with higher urbanization. Huang and Jiang (2017) found that the human development index was higher in urban areas than in rural areas in China. Maiti (2017) stated that urbanization is an important factor in increasing the human development index for China and India. Tripathi (2021) analyzed a sample of 187 countries with different income levels by using Tobit model and concluded that urbanization is necessary for a higher human development index for these countries. Nipo et al. (2021) examined 33 low- to middle-income countries for the period 2000–2019 and found that the increase in urban population increased the level of human development. Nguea (2023) researched 33 African countries for the period 1990–2019 and concluded that the increase in urbanization led to an improvement in the level of human development.

As a summary of this section, most of the studies emphasized the important relations between energy consumption, economic growth, urbanization, and human development. However, the results showed a mix character due to the differences of data range, selected country and/or country groups, and estimation method. Accordingly, increases in energy use supports human development. Moreover, the human development index is likely to be high because of better living standards in urban areas. As we know from the above literature, there is no study examining the relation among energy consumption, economic growth, urbanization, and the human development index in E7 countries together. The aim of this research is to enrich the literature by analyzing the relationships among the relevant variables in more detail.

4. Data

This study examined the impacts of energy consumption and economic growth on human development by controlling trade openness and urbanization in E-7 countries for the period 1992–2021. The countries in question are Brazil, China, Indonesia, India, Mexico, Russia, and Türkiye, respectively. Following Wang et al. (2018) and Pham et al. (2024), we construct the model given by Equation (1):

$$hdi_{it} = a_0 + \beta_1 ec_{it} + \beta_2 eg_{it} + \beta_3 trade_{it} + \beta_4 urb_{it} + \varepsilon_{it} \quad (1)$$

In the equation, hdi is the human development index, ec is the total primary energy consumption, eg is the level of real gross domestic product per capita, $trade$ is trade openness, and finally, urb is the level of urbanization. i and t are the cross-section (country) and the time (year) subscript, respectively. a_0 is the constant term, and ε_{it} is the error term. Error term demonstrates the impact of other determinants on human development in E-7 countries. β_1, β_2, β_3, and β_4 express the coefficients of energy consumption, economic growth, trade openness, and urbanization parameters, respectively.

Table 1. Variable Definitions

Variables	**Indicators**	**Measurements**	**Sources**
Human Development	*hdi*	Human Development Index	UNDP
Energy Consumption	*ec*	Primary Energy Consumption (Exajoules)	British Petroleum (2022)
Economic Growth	*eg*	GDP per capita (constant 2015 US$)	World Bank (2023)
Trade Openness	*trade*	Trade (% of GDP)	World Bank (2023)
Urbanization	*urb*	Urban Population Growth	World Bank (2023)

Definitions of the variable used in the study are given in Table 1. To reduce the effect of outliers and heterogeneity, the human development index, energy consumption, GDP per capita, and trade openness series have been transformed into natural logarithm form. Because of the presence of negative values, natural logarithm transformation was not applied to the urbanization series. Pairwise correlation outcomes are included in Table 2.

The correlation analysis outcomes given in Table 2 demonstrate that there is a positive and statistically significant relation between economic growth, trade openness, and urbanization and the human development index. In addition, the correlation coefficient showing the relation among energy consumption and the human development index is statistically insignificant.

Table 2. Pairwise Correlations

Variable(s)	*hdi*	*ec*	*eg*	*trade*	*urb*
hdi	1				
ec	0.065	1			
eg	0.917*	-0.064	1		
trade	0.369*	-0.010	0.200*	1	
urb	-0.659*	-0.119***	-0.553*	-0.123***	1

Note: *, ** and *** demonstrate statistical significance at the 1%, 5% and 10% level, respectively.

5. Econometric Methodology

Examination of the relations among the variables included in the study was carried out using panel data analyses. Before investigating the presence of cointegration relationship, cross sectional dependency and unit root analyses were performed. The cross-sectionally augmented Im-Pesaran-Shin (CIPS) test recommended by Pesaran (2007) was applied to examine the stationarity of the series. Then the structural breaks panel cointegration method (Westerlund, 2006) was performed to investigate the presence of the cointegration relation. Long-run coefficients were obtained using the AMG estimator provided by Eberhardt and Bond (2009). Finally, Dumitrescu and Hurlin (2012) procedure was applied to check the causality relation among variables.

5.1. Cross-Sectional Dependency and Slope Homogeneity Tests

An economic shock in one country can impact the economic activities of other countries directly and indirectly. In this context, it is imperative to investigate cross-sectional dependence in order to choose the suitable method in econometric analysis. Pesaran (2006) stated that ignoring cross-sectional dependence will result in significant biases and size distortions. Conversely, Breitung (2005) specified that the assumption of homogeneity for the panel data does not capture the heterogeneity because of country-specific characteristics. For this reason, the study will first check the cross-sectional dependence and slope homogeneity. In this study, the presence of cross-sectional dependence was investigated using the bias-adjusted Lagrange Multiplier (LM) test recommended by Pesaran et al., (2008). The LM_{adj} test statistics is given in Equation (2).

$$LM_{adj} = \left(\frac{2}{N(N-1)}\right)^{1/2} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \frac{(T-k)\hat{\rho}_{ij}^2 - \mu_{Tij}}{\upsilon_{Tij}} \right) \quad (2)$$

Here, k is the number of regressors and μ_{Tij} and υ_{Tij} express the exact mean and variance of $(T-k)\hat{\rho}_{ij}^2$, respectively. The null hypothesis of this test states that there is no cross-sectional dependence. It is also important to take into account heterogeneity in the estimated parameters for each panel. Swamy (1970) proposed the slope homogeneity test given in Equation (3) to determine cross-country heterogeneity.

$$\tilde{S} = \sum_{i=1}^{N} \left(\hat{\beta}_i - \tilde{\beta}_{WFE}\right)' \frac{x_i' M_T x_i}{\tilde{\sigma}_i^2} \left(\hat{\beta}_i - \tilde{\beta}_{WFE}\right) \quad (3)$$

In Equation (3), $\hat{\beta}_i$ is the pooled least squares estimator and $\tilde{\beta}_{WFE}$ is the weighted fixed effects pooled estimator. M_T indicates the identity matrix, and $\tilde{\sigma}_i^2$ represents the estimator of σ_i^2. Pesaran and Yamagata (2008) recommended the following standardized distribution statistics:

$$\hat{\Delta} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - k}{\sqrt{2k}}\right) \quad (4)$$

The small sample properties of the $\hat{\Delta}$ test can be improved by using the following bias-adjusted version under normally distributed errors:

$$\hat{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - E(\tilde{z}_{it})}{\sqrt{var(\tilde{z}_{it})}}\right) \quad (5)$$

where $E(\tilde{z}_{it}) = k$ and $var(\tilde{z}_{it}) = 2k(T-k-1)/(T+1)$.

5.2. Panel Unit Root Test

Second-generation unit root tests consider cross sectional dependence and provide consistent and reliable outcomes for balanced panel data. In this study, the second generation CIPS unit root test developed by Pesaran (2007) was employed. The CIPS test statistic is calculated using cross-sectionally augmented Dickey-Fuller (CADF) statistics. CADF test statistics are obtained by the following equation:

$$\Delta y_{i,t} = \alpha_i + \beta_i y_{i,t-1} + \delta_i \bar{y}_{t-1} + \sum_{j=0}^{t} \theta_{ij} \Delta \bar{y}_{t-j} + \sum_{j=1}^{p} \mu_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \quad (6)$$

Here, Δ states the difference operator and $\bar{y}_{t-j}$ is the average of the lagged level of each cross-section. The CIPS statistics is presented in Equation (7) as follows:

$$CIPS = N^{-1}\sum_{i=1}^{N} CADF_i \tag{7}$$

where $CADF_i$ represents the CADF test statistics for the ith cross-sectional unit in Equation (6). Although the null hypothesis of the test ($H_0: \beta_i = 0\ for\ all\ i$) signifies the existence of unit root in the panel, the alternative hypothesis signifies stationarity.

5.3. Panel Cointegration Test

Westerlund (2006) recommended a cointegration procedure based on the McCoskey and Kao (1998) study that allows for multiple structural breaks. The Westerlund (2006) cointegration test takes cross-sectional dependency into consideration. This method allows different numbers and different dates of breaks for each individual. The data generation process in the Westerlund (2006) test is defined as follows:

$$y_{it} = \gamma_{ij} z'_{it} + \beta_i x'_{it} + e_{it} \tag{8}$$

$$e_{it} = r_{it} + u_{it}\ ,\ r_{it} = r_{it-1} + \emptyset_i u_{it} \tag{9}$$

where $x_{it} = x_{it-1} + v_{it}$ is a dimensional vector of explanatory variables; z_{it} denotes a vector of deterministic components. The null hypothesis ($H_0: \emptyset_i = 0\ for\ all\ i = 1, \ldots N$) is tested against the alternative hypothesis ($H_1: \emptyset_i \neq 0\ for\ all\ i = 1, \ldots N_1$ and $\emptyset_i = 0\ for\ all\ i = N_1 + 1, N_1 + 2, \ldots N$) for all countries of the panel under multiple structural breaks. Here, the null hypothesis states that all individuals forming the panel are cointegrated. In the Westerlund (2006) panel cointegration test, the LM statistics is obtained as follows:

$$Z(M) = \sum_{i=1}^{N}\sum_{j=1}^{M_i+1}\sum_{t=T_{ij-1}+1}^{T_{ij}} \frac{S_{it}^2}{(T_{ij} - T_{ij-1})^2 \widehat{\omega}_i^2} \tag{10}$$

In Equation (10), $j = 1, \ldots, M_i + 1$ signifies structural breaks; T_{ij} is the jth break date of country i; $S_{it} = \sum_{k=T_{ij-1}+1}^{t} \hat{e}_{ik}^*$ and $\hat{e}_{ik}^*$ are any efficient estimates of e_{ik}; and $\widehat{\omega}_i^2$ represents a consistent estimate of the long run variance of e_{it}. Within the framework of this test, the procedure developed by Bai and Perron (2003) was used to determine structural break dates endogenously.

5.4. Panel Causality Test

The Granger (1969) causality procedure assumes that the slopes are homogeneous across the cross section. The Dumitrescu-Hurlin (D-H, 2012) causality technique allows heterogeneity across the cross-sectional units. Because of the existence of heterogeneity and cross sectional dependence in our panel data, the D-H causality analysis was employed. The D-H test procedure is based on the Granger procedure. Dumitrescu and Hurlin (2012) suggested the model given in Equation (11):

$$y_{i,t} = a_i + \sum_{k=1}^{K} \delta_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \theta_i^{(k)} x_{i,t-k} + \varepsilon_{it} \tag{11}$$

where i is the cross-sections and t is the time period. a_i denote fixed individual effects. $\delta_i^{(k)}$ and $\theta_i^{(k)}$ are autoregressive parameters and regression coefficients, respectively. In the D-H causality test, the null hypothesis of no causality is tested. D-H test statistics are given below:

$$W_{N,T}^{HNC} = N^{-1}\sum_{i=1}^{N} W_{i,T} \tag{12}$$

$$Z_{N,T}^{HNC} = \sqrt{\frac{N}{2M}}\left(W_{N,T}^{HNC} - M\right) \rightarrow N(0,1) \tag{13}$$

where $W_{i,T}$ shows the individual Wald statistical values; $W_{N,T}^{HNC}$ and $Z_{N,T}^{HNC}$ are the average and standardized test statistics, respectively; and N signifies the number of cross sections and M is the appropriate lag length.

6. Findings

6.1. Cross-Sectional Dependency and Slope Homogeneity Tests Results

The first stage of the econometric analysis involves examining cross-section dependence (CD) and slope homogeneity. Findings from the CD test help decide among first and second generation estimation approaches. In this study, we used LM (Breusch & Pagan, 1980), CD_{LM} (Pesaran, 2004), CD (Pesaran, 2004), and LM_{adj} (Pesaran et al., 2008) methods. The findings obtained from the cross-section dependency and slope homogeneity tests are presented in Table 3.

Table 3. Cross-Sectional Dependence and Slope Homogeneity Results

Panel A: Cross-Section Dependency Tests						
	hdi	*ec*	*gdp*	*trade*	*urb*	*Model residuals*
LM *(BP,1980)*	48.622* (0.001)	29.981*** (0.092)	37.012** (0.012)	46.007* (0.001)	187.335* (0.000)	45.405* (0.002)
CD_{LM} *(Pesaran, 2004)*	4.262* (0.000)	1.386*** (0.083)	2.471* (0.007)	3.859* (0.000)	25.666* (0.000)	3.766* (0.000)
CD *(Pesaran, 2004)*	-3.140* (0.001)	-2.774* (0.003)	-3.099* (0.001)	-2.572* (0.005)	-2.557* (0.005)	3.772* (0.000)
LM_{adj} *(PUY, 2008)*	65.853* (0.000)	68.699* (0.000)	66.053* (0.000)	35.197* (0.000)	62.367* (0.000)	6.001* (0.000)
Panel B: Slope Homogeneity Tests						
	Statistics	*p-value*				
$\hat{\Delta}$	11.575*	0.000				
$\hat{\Delta}_{adj}$	12.890*	0.000				

Note: *, ** and *** demonstrate statistical significance at the 1%, 5% and 10% level, respectively.

According to the cross-sectional dependence outcomes, the null hypothesis of no cross sectional dependence for the variables and model residues is strongly rejected. These results signify that there is cross sectional dependence among panel members. In other words, any shock that occurs in one of the countries considered also impacts other countries. As can be seen in Table 3, the null of homogeneity is rejected for two homogeneity tests ($\hat{\Delta}$ and $\hat{\Delta}_{\mathrm{adj}}$). This outcome reveals the presence of slope heterogeneity. The presence of slope heterogeneity means that slope coefficients vary across countries.

6.2. Unit Root Analysis

In testing the stationarity of the variables, panel data methods that take cross-sectional dependence into consideration should be employed. In this regard, the stationarity properties of the series were examined using the CIPS unit root test. Panel unit root test findings are given in Table 4.

Table 4. CIPS Unit Root Test Results

	Levels		**First Differences**	
Variable(s)	*Constant*	*Constant and Trend*	*Constant*	*Constant and Trend*
hdi	-2.276***	-2.368	-3.427*	-3.512*
ec	-2.171	-2.420	-2.842*	-2.775***
gdp	-1.749	-1.666	-2.871*	-2.895**
trade	-2.001	-2.450	-3.782*	-3.067**
urb	-2.318***	-2.382	-2.932*	-3.014**

Note: *, ** and *** demonstrate statistical significance at the 1%, 5% and 10% level, respectively.

Table 4 signifies that the null hypothesis of unit root for the human development index, energy consumption, economic growth, trade openness, and urbanization variables cannot be rejected. In other words, all series have unit roots. When the first differences of these variables are taken, it is seen that they become stationary. Unit root test outcomes display that all series are I(1) and that the necessary prerequisite for examining the cointegration relationship is met.

6.3. Cointegration Analysis

After we performed unit root analysis, the cointegration approach should be applied in the next step. The cointegration approach is used to solve the problem of building models with non-stationary variables. If there is a cointegration in the model, it means there is a long-run equilibrium relation among the variables. In this study, the Westerlund (2006) panel cointegration method, which considers multiple structural breaks, was employed. In this cointegration test, to determine whether there is a cointegration relation, the asymptotic p-value is employed in cases where there is no cross-sectional dependence, and the bootstrap p-value is employed in cases where there is cross-sectional dependence. Because there is cross-sectional dependence in this study, bootstrap p-values were taken into account. The results of the cointegration method presented in Table 5.

Failure to reject the null hypothesis in the Westerlund (2006) procedure indicated the presence of a cointegration relationship. As seen in Table 5, the null hypothesis cannot be rejected for all models. The panel cointegration test outcomes indicated evidence of the presence of a long-run relation among the human development index, energy consumption, economic growth, urbanization, and trade openness. Table 5 also shows the number of breaks and break dates. Accordingly, it is seen that countries generally have two structural breaks.

Table 5. Westerlund (2006) Cointegration Test Results

	Description	LM	Asymptotic p-values	Bootstrap p-values
Model 1	No break in constant	-0.627	0.735	0.999
Model 2	No break in constant and trend	-0.129	0.551	0.987
Model 3	Break in constant	-66.517	0.999	0.871
Model 4	Break in constant and trend	-1006.432	0.999	0.979

Breaks

	Model 3			*Model 4*		
	Break Number	*Break Dates*		*Break Number*	*Break Dates*	
Brazil	2	1997	2005	2	2002	2012
China	2	2009	2015	2	2006	2013
Indonesia	0	-	-	2	1998	2014
India	1	2000	-	1	2004	-
Mexico	2	1998	2013	2	2007	2014
Russia	1	2005	-	2	1999	2008
Türkiye	2	1999	2010	1	2012	-

Note: The structural breaks are estimated using the Bai-Perron (2003) methodology.

6.4. Estimating Long-Run Cointegration Coefficients

In this part of the study, after determining the cointegration relation among the series, long run coefficients were estimated using the AMG estimator method provided by Eberhardt and Bond (2009). The AMG method estimates long-run parameters by taking cross sectional dependence into account in the analysis. This method also allows for heterogeneous slope coefficients among panel members. AMG estimation findings are shown in Table 6.

Table 6. AMG Estimation Results

Countries	*ec*	*gdp*	*trade*	*urb*
Brazil	0.077** (0.042)	-0.004 (0.909)	0.009 (0.327)	0.011 (0.199)
China	-0.010 (0.458)	0.139* (0.000)	0.035* (0.000)	-0.004 (0.402)
Indonesia	0.092* (0.000)	0.063* (0.000)	0.003 (0.656)	0.001 (0.765)
India	0.113 (0.212)	0.126*** (0.097)	0.016 (0.129)	0.036 (0.163)
Mexico	0.122* (0.000)	0.051** (0.049)	-0.009 (0.193)	-0.015** (0.020)
Russia	0.030 (0.250)	0.067* (0.000)	0.021* (0.006)	0.014* (0.009)
Türkiye	-0.087 (0.123)	0.252* (0.000)	0.001 (0.987)	0.005 (0.357)
Panel	0.048*** (0.092)	0.099* (0.001)	0.011** (0.049)	0.007 (0.247)

Note: *, ** and *** demonstrate statistical significance at the 1%, 5% and 10% level, respectively. The p-values are reported within the parentheses.

As can be seen in Table 6, energy consumption has a statistically significant and positive effect on human development for Brazil, Indonesia, and Mexico, which indicates that increases in energy consumption tend to increase human development. Specifically, the energy consumption coefficient for Brazil, Indonesia, and Mexico was obtained as 0.077, 0.092, and 0.122, respectively. Accordingly, a 1% increase in the energy consumption in Brazil, Indonesia, and Mexico causes a 0.077%, 0.092%, and 0.122% increase in the human development index, respectively. The coefficients of energy consumption for China, India, Russia, and Türkiye are statistically insignificant. The economic growth is statistically significant and has a positive impact on human development in all E-7 countries except Brazil. Accordingly, increasing economic growth in these countries leads to increased human development. Specifically, the economic growth coefficient for China, Indonesia, India, Mexico, Russia, and Türkiye was obtained as 0.139, 0.063, 0.126, 0.051, 0.067, and 0.252, respectively. This result means that a 1% increase in economic growth in China, Indonesia, India, Mexico, Russia, and Türkiye causes a 0.139%, 0.063%, 0.126%, 0.051%, 0.067%, and 0.252% increase in the human development index, respectively. The trade openness has a statistically significant and positive impact on human development for China and Russia, which demonstrates that increases in trade openness tend to increase human development. Specifically, the trade openness coefficient for China and Russia was obtained as 0.035 and 0.021, respectively. Accordingly, a 1% increase in the trade openness in China and Russia causes a 0.035% and 0.021% increase in the human development index, respectively. The coefficients of trade openness for Brazil, Indonesia, India, Mexico, and Türkiye are statistically insignificant. Finally, the coefficient of urbanization is negative and statistically significant for Mexico, whereas it is positive and statistically significant for Russia. Accordingly, an increase of urbanization in Mexico leads to a decrease of human development. In addition, an increase in the rate of urbanization leads to an increase in human development for Russia.

The long run findings of the panel signify that the level of economic growth has positive and significant impact on human development at the 1% level. Accordingly, a 1% increase in economic growth increases the human development index by 0.099%. That the energy consumption coefficient is positively significant at the 10% level in the long run signifies that a 1% increase in energy consumption will cause the human development index to increase by 0.048% in the long run. The coefficient of the trade openness is positive and statistically significant at the 5% level. This means that a 1% increase in the level of trade openness increases the human development index by 0.011% in the long run. Finally, the coefficient of the urbanization variable is positive and statistically insignificant.

Overall, we can draw some important country-specific inferences from these results. First, economic growth has a vital importance on human development in E-7 countries because it shows increasing impacts on all emerging countries except for Brazil. Despite some global challenges such as economic, political, financial, and natural issues, these countries keep their priority on sustained and inclusive economic growth, and therefore they can contribute to human development standards by creating decent jobs and improving living conditions in their countries. Second, energy consumption has a second importance on human development in E-7 countries. Only three countries can benefit from the advantages of energy consumption on human development, namely Brazil, Indonesia, and Mexico. Energy usage is an indispensable input for both production and consumption processes across the world. The widespread use of fossil fuels, especially in crowded countries such as China and India, can cause environmental pollution and serious harm to human health. In contrast, the use of clean energy can contribute to human development by decreasing health damage and environmental degradation. These three emerging countries are more successful than others in terms of the contribution of energy consumption to human development thanks to clean energy and technology investments. Third, international trade (or trade openness) has limited impact on human development in only two countries. As is known, China is one of the most important trading countries in the world. Its comparative advantages in terms of the labor force and capital stocks in the production process make a significant contribution to its economic growth potential. This also contributes to the use of trade earnings on human development and to increase social welfare. Finally, urbanization is the only parameter that shows no impact on human development in E-7 countries in group estimation. Specifically, it decreases the human development process in Mexico because irregular and unplanned urbanization brings with it many social, economic and social problems. For Russia, urbanization has a positive but negligible impact on human development.

6.5. Causality Analysis

After investigating the presence of cointegration, the direction of the causality relations among the variables needs to be determined. Therefore, the D-H test was applied to investigate the pairwise causal dynamics. The findings of the causality analysis presented in Table 7.

Table 7. D-H Panel Causality Test Results

Causality path	**W-statistics**	**Z-statistics**	**p-values**
ec→hdi	6.621	8.970	0.000
gdp→hdi	9.644	13.868	0.000
trade→hdi	8.618	12.207	0.000
urb→hdi	9.520	13.667	0.000
hdi→ ec	5.952	7.888	0.000
hdi→ gdp	6.678	9.063	0.000
hdi→ trade	2.949	3.022	0.003
hdi→ urb	1.435	0.569	0.569

The outcomes of the causality analysis have displayed that there is a bidirectional causality relation between the human development index and energy consumption, economic growth, and trade openness in E-7 countries. Additionally, unidirectional causality relation is obtained from urbanization to the human development index.

7. Conclusion and Policy Recommendation

Developing countries need energy resources more and more each day as a result of increasing production capacities and rapid population growth. The lack of energy capacity creates a new obstacle to a sustainable economic growth policy for countries that currently have capital and technology deficits. Efforts to meet the energy demand of developing countries generally entail environmental costs, especially in terms of human health and climate crisis, and also lead to a conflicting relationship with the Sustainable development goals of the United Nations.

It is widely discussed in the literature that developing countries are moving away from their development goals while realizing their economic growth potential. However, there is no clear consensus on the dimensions of this relation. This study addresses this literature gap. In this context, the study examined the dimensions of the long-run relation among the human development index and energy consumption, economic growth, urbanization, and trade openness for the emerging seven (E-7) countries that show a high economic performance among the developing countries. In the empirical model, the human development index has been evaluated as a proxy of Sustainable development goals.

This study covers the annual observations from 1992 to 2021, and the analyses were carried out in five stages. First, a priori tests were used to determine the cross-sectional dependence and homogeneity relationship among the series. The results pointed to the existence of cross-sectional dependence and heterogeneity among the sections. Second, CIPS test was employed to determine the stationarity levels of the series. The outcomes revealed that all series show stationarity at the first difference. Third, we applied the cointegration test developed by Westerlund (2006) and that also considers the structural breaks. The results demonstrated the presence of long run relation among the human development index and energy consumption, economic growth, urbanization, and trade openness for all countries. Fourth, the AMG estimator was applied to reveal the long-run coefficients that were provided by Eberhardt and Bond (2009). The results in the panel indicated that energy consumption, economic growth, and trade openness have positive and statistically significant impacts on the human development index, whereas urbanization does not have any statistically significant effect on these countries. Finally, the panel causality method recommended by Dumitrescu and Hurlin (2012) was applied to robust check the cointegration test outcomes. The findings indicated the presence of a bidirectional causal relation between the human development index and energy consumption, economic growth, and trade openness and also unidirectional causality relation from urbanization to the human development index in E-7 countries.

Specifically, individual results from the AMG estimator indicated different findings. Accordingly, energy consumption has a positive effects on the human development index only for Brazil, Indonesia, and Mexico. Economic growth has a positive impacts on human development for all countries except Brazil. Trade openness has a positive effects on the human development index only for China and Russia. Finally, urbanization has a negative effect for Mexico and a positive effect for Russia.

Overall, these results have some important policy implications for E7 countries. First, the decisive role of economic growth on human development in E-7 countries is quite striking. In this context, sustainable and inclusive economic growth policies will contribute to the increase of human life and welfare in these countries. Second, energy consumption has a second importance on human development in E-7 countries. Advances in green energy and technology will contribute to human health and environmental quality, thereby contributing to human development in these countries. Finally, international trade and urbanization have limited and negligible impacts on human development relative to these two variables. In other words, trade openness and urbanization do not support human development in the majority of the relevant countries. As a result, we recommend that E-7 countries should increase the effectiveness of international trade and urban policies within the framework of their development policies.

For future studies, we mainly propose investigating the effects of some critical uncertainties such as economic policy uncertainty and geopolitical risks on the development processes of emerging market economies. For this purpose, it is of great importance to evaluate the Soviet invasion on Ukraine, which has occurred since 2022, in terms of development economics. Since our sample covers the years 1992-2021, we cannot detect the effects of this invasion, and we acknowledge that this is a significant shortcoming. Researchers' consideration of the effects of this war in future studies will allow more comprehensive results to be obtained in terms of development economics.

References

1. ACHEAMPONG A. O., ERDIAW-KWASIE M. O., ABUNYEWAH M., 2021, Does energy accessibility improve human development? Evidence from energy-poor regions, *Energy Economics*, 96: 105165.
2. ADEKOYA O. B., OLABODE J. K., RAFI S. K., 2021, Renewable energy consumption, carbon emissions and human development: Empirical comparison of the trajectories of world regions, *Renewable Energy*, 179: 1836-1848.
3. AFGAN N. H., AL GOBAISI D., CARVALHO M. G., CUMO M., 1998, Sustainable energy development, *Renewable and Sustainable Energy Reviews*, 2(3): 235-286.
4. AKAR G., SARITAS T. KIZILKAYA O., 2021, The Impact of Human Development on Economic Growth: An Application on Transition Economies, *Business and Economics Research Journal*, 12(2): 307-318.
5. ALSTONE P., GERSHENSON D., KAMMEN D. M., 2015, Decentralized energy systems for clean electricity access, *Nature climate change*, 5(4): 305-314.
6. AMER H., 2020, The impact of renewable energy consumption on the human development index in selected countries: panel analysis (1990–2015), *Int J Econ Energy Environ*, 5(4): 47.

7. ANISUJJAMAN M., 2015, Urbanisation and human development: a study of West Bengal, *International Journal of Humanities and Social Science Invention*, 4(7): 1-8.
8. ARISMAN A., 2018, Determinant of human development index in ASEAN countries, *Signifikan*, 7(1): 113-122.
9. AZAM A., RAFIQ M., SHAFIQUE M., YUAN J., SALEM S., 2021, Human development index, ICT, and renewable energy-growth nexus for sustainable development: a novel PVAR analysis, *Frontiers in Energy Research*, 9: 760758.
10. BAI J., PERRON P., 2003, Computation and analysis of multiple structural change models, *Journal of Applied Econometrics*, 18(1): 1-22.
11. BANDAY U. J., KOCOGLU M., 2022, Modelling simultaneous relationships between human development, energy, and environment: Fresh evidence from panel quantile regression, *Journal of the Knowledge Economy*, 14: 1559–1581.
12. BEHAILU A., 2023, The Impact of Trade Openness and Foreign Direct Investment on Human Development in Sub-Saharan African Countries: Evidence from Panel Data, *The Ethiopian Journal of Business and Economics*, 13(1): 1-33.
13. BEN MBAREK M., BOUKARRAA B., SAIDI K., 2016, Role of energy consumption and economic growth in the spread of greenhouse emissions: empirical evidence from Spain, *Environmental earth sciences*, 75(16): 1161.
14. BERTINELLI L., BLACK D., 2004, Urbanization and growth, *Journal of Urban Economics*, 56(1): 80-96.
15. BERRYMAN T., SAUVE L., 2016, Ruling relationships in sustainable development and education for sustainable development, *The Journal of Environmental Education*, 47(2): 104-117.
16. BHATTACHARYA B., 1998, Urbanisation and human development in West Bengal: A district level study and comparison with inter-state variation, *Economic and Political Weekly*, 33(47-48): 3027-3032.
17. BIGGERI M., Mauro V., 2018, Towards a more ‘sustainable’ human development index: Integrating the environment and freedom, *Ecological Indicators*, 91: 220-231.
18. BILDIRICI M. E., GOKMENOGLU S. M., 2017, Environmental pollution, hydropower energy consumption and economic growth: Evidence from G7 countries, *Renewable and Sustainable Energy Reviews*, 75: 68-85.
19. BOOZER M., RANIS G., STEWART F., SURI T., 2003, *Paths to success: the relationship between human development and economic growth*, SSRN 487469.
20. BRAVO G., 2014, The Human Sustainable Development Index: New calculations and a first critical analysis, *Ecological Indicators*, 37: 145-150.
21. BREITUNG J., 2005, A parametric approach to the estimation of cointegration vectors in panel data, *Econometric Reviews*, 24(2): 151-173.
22. BREUSCH T. S., PAGAN A. R., 1980, The Lagrange Multiplier Test and Its Applications to Model Specification Tests in Econometrics, *Review of Economic Studies*, 47(1): 239-53.
23. BROOK B. W., ALONSO A., MENELEY D. A., MISAK J., BLEES T., VAN ERP J. B., 2014, Why nuclear energy is sustainable and has to be part of the energy mix, *Sustainable Materials and Technologies*, 1: 8-16.
24. CARBON BRIEF, 2021, *Analysis: Which countries are historically responsible for climate change?*, https://www.carbonbrief.org/analysis-which-countries-are-historically-responsible-for-climate-change/.
25. CASILLAS C. E., KAMMEN D. M., 2010, The energy-poverty-climate nexus, *Science*, 330(6008): 1181-1182.
26. CHANKRAJANG T., MUTTARAK R., 2017, Green returns to education: Does schooling contribute to pro-environmental behaviours? Evidence from Thailand, *Ecological Economics*, 131: 434-448.
27. CHOVANCOVA J., VAVREK R., 2019, Decoupling analysis of energy consumption and economic growth of V4 countries, *Problemy Ekorozwoju/ Problems of Sustainable Development*, 14(1): 159-165.
28. CONCEICAO P., 2019, Human development and the SDGs, *Human Development Report. https://hdr.undp.org/content/human-development-and-sdgs*.
29. CONSTANTINI V., MONNI S., 2005, Sustainable human development for European countries, *Journal of Human Development*, 6(3): 329-351.
30. COSTANTINI V., MONNI S., 2008, Sustainability and human development, *Economia politica*, 25(1): 11-32.
31. DANENSHMAND NARUEE M., PAHLAVANI M., ESFANDIARINI M., 2022, The Impact of Urbanization on Human Development Index in the Provinces of Iran: Quantile Regression Method, *Journal of Iranian Economic Issues*, 9(1): 163-184.
32. DE NEVE J. E., SACHS J. D., 2020, Sustainable development and human well-being, *World Happiness Report:* 112-127.
33. DUMITRESCU E. I., HURLIN C., 2012, Testing for Granger non-causality in heterogeneous panels, *Economic modelling*, 29(4): 1450-1460.
34. DUMOR K., LI Y., AMOUZOU E. K., AMPAW E. M., KURSAH M. B., AKAKPO K., 2022, Modeling the dynamic nexus among CO_2 emissions, fossil energy usage, and human development in East Africa: new insight from the novel DARDL simulation embeddedness, *Environmental Science and Pollution Research*, 29(37): 56265-56280.
35. EBERHARDT M., BOND S., 2009, Cross-section Dependence in Nonstationary Panel Models: A Novel Estimator, MPRA (Munich Personal RePEc Archive), Paper No: 17692, https://mpra.ub.uni-muenchen.de/17692.
36. ELLIOT D., 2000, Renewable energy and sustainable futures, *Futures*, 32(3-4): 261-274.
37. ESTOQUE R. C., MURAYAMA Y., 2014, Social–ecological status index: A preliminary study of its structural composition and application, *Ecological Indicators*, 43: 183-194.
38. FANKEM G., OUMAROU M., 2020, Trade Openness and Economic Growth in Sub-Saharan Africa: Evidence from New Trade Openness Indicator, *Economics Bulletin*, 40(4): 2920-2931.
39. FATIMA N., LI, Y., AHMAD M., JABEEN G., LI X, 2019, Analyzing long-term empirical interactions between renewable energy generation, energy use, human capital, and economic performance in Pakistan, *Energy, Sustainability and Society*, 9(1): 1-14.
40. GALLOPIN G. C., 2003, *A systems approach to sustainability and sustainable development*, UN Publ., Santiago, Chile.
41. GOHLKE J. M., THOMAS R., WOODWARD A., CAMPBELL-LENDRUM D., PRRUSS-ÜSTUN A., HALES S., PORTIER C. J., 2011, Estimating the global public health implications of electricity and coal consumption, *Environmental health perspectives*, 119(6): 821-826.

42. GODFREY R., JULIEN M., 2005, Urbanisation and health, *Clinical Medicine*, 5(2): 137-141.
43. GOZGOR G., LAU C. K. M., LU Z., 2018, Energy consumption and economic growth: New evidence from the OECD countries, *Energy*, 153: 27-34.
44. GRIFFIN K., McKINLEY T., GRIFFIN K., McKINLEY T., 1994, *Human development and sustainable development, Implementing a Human Development Strategy:* 96-102, https://books.google.pl/books?hl=pl&lr=&id=fkauCwAAQBAJ&oi=fnd&pg=PR10&dq=McKINLEY+T.,+1994,+Human+development+and+sustainable+development,+Implementing+a+Human+Development+Strategy&ots=0pZur2d0Mi&sig=VnRw5cO4oGzRebsfV4DPVTl89Es&redir_esc=y#v=onepage&q&f=false.
45. HAN J., XIE D., AHMED Z., KHAN S. U., KIRIKKLELI D., 2023, Green technologies, government stability, and green energy transition in a globalized world: evidence from E-7 nations, Environmental Science and Pollution Research, 30: 92255–92266.
46. HAMDI H., HAKIMI A., 2022, Trade openness, foreign direct investment, and human development: a panel cointegration analysis for MENA countries, *The International Trade Journal*, 36(3): 219-238.
47. HARRIS J. M., 2003, Sustainability and sustainable development, *International Society for Ecological Economics*, 1(1): 1-12.
48. HASHEMIZADEH A., BUI Q., ZAIDI S. A. H., 2022, A blend of renewable and nonrenewable energy consumption in G-7 countries: The role of disaggregate energy in human development, *Energy*, 241: 122520.
49. HICKEL J., 2020, The sustainable development index: Measuring the ecological efficiency of human development in the Anthropocene, *Ecological Economics*, 167: 106331.
50. HONG T., YU N., MAO Z., ZHANG S., 2021, Government-driven urbanisation and its impact on regional economic growth in China, *Cities*, 117: 103299.
51. HUANG G., JIANG Y., 2017, Urbanization and socioeconomic development in inner Mongolia in 2000 and 2010: a GIS analysis, *Sustainability*, 9(2): 235.
52. HUSKIĆ M., SATROVIĆ E., 2020, Human development-renewable energy-growth nexus in the top 10 energy gluttons, *Uprava*, 11(1): 25-42.
53. HUSSAIN M., MIR G. M., USMAN M., YE C., MANSOOR S., 2022, Analysing the role of environment-related technologies and carbon emissions in emerging economies: a step towards sustainable development, Environmental Technology, 43(3): 367-375.
54. HUSSEIN M. A., LEAL FILHO W., 2012, Analysis of energy as a precondition for improvement of living conditions and poverty reduction in sub-Saharan Africa, *Scientific Research and Essays*, 7(30): 2656-2666.
55. IBRAHIM R. L., AJIDE K. B., OMOKANMI O. J., 2021, Non-renewable energy consumption and quality of life: Evidence from Sub-Saharan African economies, *Resources Policy*, 73: 102176.
56. IEA, 2020, *Key World Energy Statistics*, *World Energy Outlook*, https://www.iea.org/reports/world-energy-outlook-2020.
57. IEA, 2022, *World Energy Outlook*, https://www.iea.org/reports/world-energy-outlook-2022.
58. IEA, 2023, *World Energy Outlook*, https://www.iea.org/reports/world-energy-outlook-2023.
59. INGLESI-LOTZ R., 2016, The impact of renewable energy consumption to economic growth: A panel data application, *Energy economics*, 53: 58-63.
60. JEPSON Jr E. J., 2004, Human nature and sustainable development: A strategic challenge for planners, *Journal of Planning Literature*, 19(1): 3-15.
61. JIN H., QIAN X., CHIN T., ZHANG H., 2020, A global assessment of sustainable development based on modification of the human development index via the entropy method, *Sustainability*, 12(8): 3251.
62. KABADYAI B., 2013, Human development and trade openness: A case study on developing countries, *Advances in Management and Applied Economics*, 3(3): 193.
63. KAHIA M., AISSA M. S. B., CHARFEDDINE L. 2016, Impact of renewable and non-renewable energy consumption on economic growth: New evidence from the MENA Net Oil Exporting Countries (NOECs), *Energy*, 116: 102-115.
64. KANAGAWA M., NAKATA T., 2008, Assessment of access to electricity and the socio-economic impacts in rural areas of developing countries, *Energy policy*, 36(6): 2016-2029.
65. KAREKEZI S., McDADE S., BOARDMAN B., KIMANI J., LUSTIG N., 2012, *Global Energy Assessment (GEA): energy, poverty, and development*, https://previous.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/GEA_Chapter2_development_lowres.pdf.
66. KHAN N. H., JU Y., HASSAN S. T., 2019, Investigating the determinants of human development index in Pakistan: an empirical analysis, *Environmental Science and Pollution Research*, 26: 19294-19304.
67. KOCAK E., ŞARKGUNESI A., 2017, The renewable energy and economic growth nexus in Black Sea and Balkan countries, *Energy policy*, 100: 51-57.
68. KONGKUAH M., YAO H., YILANCI V., 2022, The relationship between energy consumption, economic growth, and CO_2 emissions in China: The role of urbanisation and international trade, *Environment, Development and Sustainability*, 24(4): 4684-4708.
69. KUMAR S., 2017, Trade and Human Development: Case of ASEAN, *Pacific Business Review International*, 12: 48-57.
70. LANDORF H., DOSCHER S., ROCCO T., 2008, Education for sustainable human development: Towards a definition, *Theory and Research in Education*, 6(2): 221-236.
71. LI X., WANG C., ZHANG G., XIAO L., DIXON J., 2012, Urbanisation and human health in China: spatial features and a systemic perspective, *Environmental Science and Pollution Research*, 19: 1375-1384.
72. MAITI M., 2017, Urbanisation and inequalities in China and India. Overview and comparative study, *Theoretical & Applied Economics*, 4(613): 121-136.
73. MARINEZ D. M., EBENHACK B. W., 2008, Understanding the role of energy consumption in human development through the use of saturation phenomena, *Energy Policy*, 36(4): 1430-1435.

74. MAZUR A., 2011, Does increasing energy or electricity consumption improve quality of life in industrial nations?, *Energy Policy*, 39(5): 2568-2572.
75. MBABAZI G., 2017, *The Impact of Trade on Human Development in Sub-Saharan Africa (SSA),* Master Thesis in Economics, Jönköping University International Business School, Sweden.
76. MOORE M., GOULD P., KEARY B. S., 2003, Global urbanization and impact on health, *International journal of hygiene and environmental health*, 206(4-5): 269-278.
77. MORAN D. D., WACKERNAGEL M., KITZES J. A., GOLDFINGER S. H., BOUTAUD A., 2008, Measuring sustainable development – Nation by nation, *Ecological economics*, 64(3): 470-474.
78. MOSTEANU D., MIHAILA-LICA G., HALMAGHI E. E., MOSTEANU R., 2014, The sustainable development-human development, *Land Forces Academy Review*, 19(1): 106.
79. MOUROGOV V. M., 2000, Role of nuclear energy for sustainable development, *Progress in Nuclear Energy*, 37(1-4): 19-24.
80. MURILLO-ALVARADO P. E., PONCE-ORTEGA J. M., 2022, An optimization approach to increase the human development index through a biogas supply chain in a developing region, *Renewable Energy*, 190: 347-357.
81. MUSTAFA G., RIZOV M., KERNOHAN D., 2017, Growth, human development, and trade: The Asian experience, *Economic Modelling*, 61: 93-101.
82. NATHANIEL S. P., 2021, Natural resources, urbanisation, economic growth and the ecological footprint in South Africa: The moderating role of human capital, *Quaestiones Geographicae*, 40(2): 63-76.
83. NAZEER M., TABASSUM U., ALAM S., 2016, Environmental pollution and sustainable development in developing countries, *The Pakistan Development Review:* 589-604.
84. NGUEA S. M., 2023, Improving human development through urbanization, demographic dividend and biomass energy consumption, *Sustainable Development*, 31(4): 2517-2535.
85. NIU S., JIA Y., WANG W., HE R., HU L., LIU Y., 2013, Electricity consumption and human development level: A comparative analysis based on panel data for 50 countries, *International Journal of Electrical Power & Energy Systems*, 53: 338-347.
86. NIPO D. T., LILY J., IDRIS S., PINJAMAN S., BUJANG I., 2021, Globalisation, Urbanisation and Human Development: Evidence from Lower-Middle Income Economies, *International Journal of Academic Research in Economics and Management and Sciences*, 10(3): 154–167.
87. NJIRU C. W., LETEMA S. C., 2018, Energy poverty and its implication on standard of living in Kirinyaga, Kenya, *Journal of Energy*, 2018(9): 1-12.
88. NJOH A. J., 2003, Urbanization and development in sub-Saharan Africa, *Cities*, 20(3): 167-174.
89. OMRI A., BELAID F., 2021, Does renewable energy modulate the negative effect of environmental issues on the socio-economic welfare? *Journal of Environmental Management*, 278: 111483.
90. OPOKU E. E. O., DOGAH K. E., ALUKO O. A., 2022, The contribution of human development towards environmental sustainability, *Energy Economics*, 106: 105782.
91. OUDEDRAOGO N. S., 2013, Energy consumption and human development: Evidence from a panel cointegration and error correction model, *Energy*, 63: 28-41.
92. PASTEN C., SANTAMARINA J. C., 2012, Energy and quality of life. *Energy Policy*, 49: 468-476.
93. PESARAN M. H., 2004, *General Diagnostic Tests for Cross Section Dependence in Panels*, Cambridge Working Papers in Economics No. 435.
94. PESARAN M. H., 2006, Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure, *Econometrica*, 74(4): 967-1012.
95. PESARAN M. H., 2007, A simple panel unit root test in the presence of cross-section dependence, *Journal of applied econometrics*, 22(2): 265-312.
96. PESARAN M. H., ULLAH A., YAMAGATA T., 2008, A Bias-Adjusted LM Test of Error Cross-Section Independence, *Econometrics Journal*, 11(1): 105-127.
97. PESARAN M.H., YAMAGATA T., 2008,, Testing Slope Homogeneity in Large Panels, *Journal of Econometrics*, 142(1): 50-93.
98. PHAM A., LI C., BUI Q., 2024, Assessing the heterogeneous impacts of energy consumption on human ,development of G7 by employing advanced quantile panel data estimation, *Gondwana Research*, 127: 211-225.
99. PIRLOGEA C., 2012, The human development relies on energy. Panel data evidence, *Procedia economics and Finance*, 3: 496-501.
100. RANIS G., STEWART F., 2005, *Dynamic links between the economy and human development,* Department for Economic and Social Affairs Working Paper No. 8, United Nations, New York.
101. RAY S., GHOSH B., BARDHAN S., BHATTACHARYYA B., 2016, Studies on the impact of energy quality on human development index, *Renewable energy*, 92: 117-126.
102. ROY H., GUPTA A., JAYARAJ R., 2015, Energy consumption and human development: global perspective, *Economics and policy of Energy and the Environment*, Franco Angeli Editore 2015(1): 111-131.
103. SADIQ M., WEN F., BASHIR M. F., AMIN A., 2022a, Does nuclear energy consumption contribute to human development? Modeling the effects of public debt and trade globalization in an OECD heterogeneous panel, *Journal of Cleaner Production*, 375: 133965.
104. SADIQ M., SHINWARI R., USMAN M., OZTURK I., MAGHYEREH A. I., 2022b, Linking nuclear energy, human development and carbon emission in BRICS region: Do external debt and financial globalization protect the environment?, *Nuclear Engineering and Technology*, 54(9): 3299-3309.
105. SAQIB N., USMAN M., RADULESCU M., SINISI C. I., SECARA C. G., TOLEA C., 2022, Revisiting EKC hypothesis in context of renewable energy, human development and moderating role of technological innovations in E-7 countries, *Front Environ Sci*, 10(2509): 10-3389.

106. SASMAZ M. U., SAKAR E., YAYLA Y. E., AKKUCUK U., 2020, The relationship between renewable energy and human development in OECD countries: A panel data analysis, *Sustainability*, 12(18): 7450.
107. SATROVIC E., 2018, The human development relies on renewable energy: evidence from Turkey, *Proceedings of the 3rd International Energy & Engineering*, Book of Proceedings, Gaziantep, Turkey: 19-27.
108. SMITH S., 2016, Determinants of human development index: A cross-country empirical analysis, *SSRG Int. J. Econ. Manag. Stud.*, 3: 40-43.
109. SOFILDA E., HERMIYANTI P., HAMZAH M., 2015, Determinant variable analysis of human development index in Indonesia (Case for high and low index at period 2004-2013), *OIDA International Journal of Sustainable Development*, 8(09): 11-28.
110. SOLARIN S. A., SHAHBAZ M., 2013, Trivariate causality between economic growth, urbanisation and electricity consumption in Angola: Cointegration and causality analysis, *Energy policy*, 60: 876-884.
111. STERN D. I., 2011, The role of energy in economic growth, *Annals of the New York Academy of Sciences*, 1219(1): 26-51.
112. STOENOIU C. E., 2018, Pattern of Energy Productivity and Gross Domestic Product Among European Countries, *Problemy Ekorozwoju/ Problems of Sustainable Development*, 13(2): 113-123.
113. SURI T., BOOZER M. A., RANIS G., STEWART F., 2011, Paths to success: The relationship between human development and economic growth, *World Development*, 39(4): 506-522.
114. SWAMY P.A.V.B., 1970, Efficient Inference in a Random Coefficient Regression Model, *Econometrica*, 38(2): 311-323.
115. TAHIR M., KHAN I., 2014, Trade openness and economic growth in the Asian region, *Journal of Chinese Economic and Foreign Trade Studies*, 7(3): 136-152.
116. TAMANG P., 2013, Urbanisation and economic growth: Investigating causality, *Econometrics*, 1(3): 41-47.
117. TONG T., ORTIZ J., XU C., LI F., 2020, Economic growth, energy consumption, and carbon dioxide emissions in the E7 countries: a bootstrap ARDL bound test, *Energy, Sustainability and Society*, 10(1): 1-17.
118. TRIPATHI S., 2021, How does urbanization affect the human development index? A cross-country analysis, *Asia-Pacific Journal of Regional Science*, 5(3): 1053-1080.
119. TSOKALIDA E. E., YANG J., 2019, Examining Trade by Destination, Innovation and Human Development in FOCAC, *Open Journal of Business and Management*, 7(03): 1225.
120. UCHE E., 2022, Strategic pathways to combating remittance-induced carbon emissions; the imperatives of renewable energy, structural transformations, urbanization and human development, *Energy Sources, Part B: Economics, Planning, and Policy*, 17(1): 2141375.
121. UNDP, 1990, *Human Development Report*, Oxford University Press, New York.
122. UNDP, 2022, *Human Development Index (HDI)*, https://hdr.undp.org/data-center/human-development-index#/indicies/HDI (16.11.2023).
123. UN, 2023, *Sustainable Development Goals*, https://sdgs.un.org/goals (16.11.2023).
124. VAN TRAN N., VAN TRAN Q., DO L. T. T., DINH L. H., DO H. T. T., 2019, Trade off between environment, energy consumption and human development: Do levels of economic development matter?, *Energy*, 173: 483-493.
125. WANG Z., ZHANG B., WANG B., 2018, Renewable energy consumption, economic growth and human development index in Pakistan: evidence form simultaneous equation model, *Journal of cleaner production*, 184: 1081-1090.
126. WANG Z., RASOOL Y., AASGHAR M. M., WANG B., 2019, Dynamic linkages among CO_2 emissions, human development, financial development, and globalization: empirical evidence based on PMG long-run panel estimation, *Environmental Science and Pollution Research*, 26: 36248-36263.
127. WANG Z., BUI Q., ZHANG B., 2020, The relationship between biomass energy consumption and human development: Empirical evidence from BRICS countries, *Energy*, 194: 116906.
128. WANG Z., BUI Q., ZHANG B., NAWARATHNA C. L. K., MOMBEUIL C., 2021, The nexus between renewable energy consumption and human development in BRICS countries: The moderating role of public debt, *Renewable Energy*, 165: 381-390.
129. WARR B. S., AYRES R. U., 2010, Evidence of causality between the quantity and quality of energy consumption and economic growth, *Energy*, 35(4): 1688-1693.
130. WESTERLUND J., 2006, Testing for panel cointegration with multiple structural breaks, *Oxford Bulletin of Economics and Statistics*, 68(1): 101-132.