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EMPIRICAL ANALYSIS OF RENEWABLE ENERGY CONSUMPTION, ENVIRONMENTAL POLLUTION AND OFFICIAL DEVELOPMENT ASSISTANCE IMPACT ON HUMAN DEVELOPMENT: EVIDENCE FROM OECD COUNTRIES

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ABSTRACT

This study is aimed at establishing some of the key factors that have affected Human Development from 1990 to 2017. The Human Development Index was used as a dependent variable while renewable energy consumption, total CO2 emission, official development assistance, mean years of schooling, life expectancy at birth, employment to population ratio and population were used as the independent variables. Panel Data Analysis and panel causality were used to analyze the data. The conclusion show that renewable energy consumption, CO2, official development assistance, mean years of schooling, life expectancy at birth, and employment to population ratio affect the Human Development Index (HDI) positively, while population affects the HDI negatively. Also, there is a bidirectional causality running from renewable energy consumption to HDI, from official development assistance, to HDI, from mean years of schooling to HDI and from employment to population ratio to HDI for the whole panel. Therefore, it was established that all independent variables in the study model are among the key determinants of human development.

JEL Classification: Q41, D12, C31

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1. INTRODUCTION

Over the last two decades, countries worldwide have emphasized how to increase renewable energy consumption, reduce environmental pollution and ensure human development. Understanding these issues have helped to shed light on how development concept differs from economic growth and should not be confused; because while economic growth refers to an increase in national income (Samuelson and William, 1989), development refers to a broader concept than growth. The conceptual distinction between economic development and economic growth emerges in terms of structure, form and process (Brinkman, 1995). The growth process refers to increased production in the production system through more and more duplication of the same structure. Development, on the other hand, indicates economic structure transformation with more production. Economic growth is the increased output resulting from increase in one or more factors of production (such as natural resources, labor, capital, and technology). In economic growth, there is no economic structural change but an increase in total production in a certain period. In other words, economic growth expresses a quantitative change and its ultimate goal is to generate more output per capita. Development refers to social and economic progress with an increase in per capita output, and it refers to qualitative change in society. Finally, economic growth provides resources needed in the human development process.

Nowadays, no consensus is apparent among economists on the measurement and indicator of development, and discussions continue on the content of development. Such discussions on how to measure development have helped the UNDP (United Nations Development Program) to improve the Human Development Index (HDI). This index is basically calculated by income, education and health dimensions. It is built on the human welfare capability-capacity[1] approach based on the concept of human development (Sen 1985, 1982). The HDI that builds on the capability-capacity approach is promoted as a measure of a quality living standard of people (UNDP, 1990). Therefore, increasing income level is not enough and the freedom that will contribute to economic, social, health, environment and cultural development should be increased to realize a human-oriented development.

Environmental pollution can reduce human development by causing scarce resources in the world to deteriorate and to diminish, thereby negatively affecting human health. In general, environmental pollution is represented by CO2 emissions. While many types of environmental pollution exist, namely CO2, water, groundwater, soil, air, noise, and so forth, CO2 is an accepted environmental pollution proxy (Haseeb et al. 2019; Shakouri, Yazdi, and Ghorchebigi 2017; Al-Mulali, Sheau-Ting and Ozturk 2015; Albiman, Suleiman, and Baka 2015). Ensuring sustainable economic development is based on effective control of CO2 emissions (Wang and Chang, 2014). Therefore, it is crucial to better understand how CO2 emissions and renewable energy consumption (REC) affect economic development. CO2 from combustion of fossil fuels, biomass and industrial processes determines the trend of global greenhouse gases. CO2 represents about 70% of global greenhouse gas emissions, and this rate reaches 98% with CH4 and N2O (IEA- International Energy Agency 2019a). According to an OECD (The Organization for Economic Co-operation and Development) report, OECD countries emit more CO2 emissions per capita than other countries, and their carbon footprint is generally higher than for domestic emissions (Environment at a Glance, 2020). In OECD countries, while the renewable energy rate in total primary energy supply was 6% in 1990, this increased to 10.5% in 2018 (IEA, 2019b). This shows that OECD countries have turned to renewable energy production over time. Many empirical studies have confirmed that REC is a factor in reducing environmental degradation (Salim et al. 2019; Vo et al., 2019; Baek 2016). Therefore, REC effect on the environment can positively affect human development by ensuring that scarce resources are not depleted and destroyed. In addition, conserving scarce resources should be considered as a method of alleviating poverty.

Because energy resources are scarce and existing resources are unevenly distributed over the world, energy resources also impact on use of other scarce resources (resources providing nutrition, shelter, and health). Greenhouse gases arising from excessive use of fossil energy destabilize the world climate and further reduce existing resources through global climate change (Alola, Bekun, and Sarkodie 2019; Crentsil, Derek, and Fenny, 2019) thus exposing more people to poverty. Academics suggest increasing REC as way to eliminate this negative effect (Shafiei and Salim, 2014; Dong et al. 2020; Baloch et al. 2020). Reducing poverty is the most important agenda item among sustainable development goals (Baloch et al. 2020). Many studies have empirically demonstrated that renewable energy use is one of the best solutions for reducing negative climate change impact on human health by reducing CO2 emissions (Wang et al. 2020; Destek and Aslan, 2019; Shafiei and Salim, 2014).

Since human development is not spontaneous and is often a long-running process that should be planned with programs, countries try to find resources specific to this process. The development resources can be provided both domestically and from abroad; resources accessed from abroad (ODA- Official development assistance)[2] are expressed in the literature as net development assistance and are mostly based on foreign assistance. The ODA consists of development aid sent to the countries and are included in the aid receiving list of the Development Assistance Committee (DAC). This aid comes from donations by many countries. Recently, these resources have been given more for welfare that can enhance quality of life and individual ability, such as health and education, which are components of human development. A general consensus is that the main purpose of external development assistance should be human development (Human Development Report 2005).

Some studies prove the positive effects of ODA on education, life expectancy and human development (Shon et al. 2018; Shirazi, Ngwenyama, and Morawczynski, 2010; Ranis, Stewart and Ramirez, 2000). An increase in a country's employment increases its production capacity and provides economic growth and per capita income increase. This process can contribute to economic development. High level employment in a country also indicates effective resource use. Consequently, production capacity and national income will increase, thereby improving general welfare. Thus, employment emerges as an important factor both for human development and is a representative of the development geared toward economic growth.

Most of the studies carried out within the scope of the energy economy have focused on the relationship between renewable energy consumption and economic growth, and few studies have examined the impact of REC on HDI, which is an indicator of human well-being and quality of life. Besides that, only a limited number of studies have assessed the environmental pollution effect on human development (Asongu and Odhiambo 2019; Spierre, Seager and Selinger, 2013). It is also important to empirically explain how development aid impacts on human development, which positively affects dimensions such as health and education. This study helps to fill the gap in the literature by empirically analyzing human development with a multivariate approach, considering REC, environmental pollution, and other important variables affecting economic development.

In this context, the study will contribute to the current literature in several ways: i) Primarily, very few studies investigate the relationship between renewable energy consumption and environmental pollution with human development (Soukiazis Proença, and Cerqueira, 2019). ii) studies that examine the combined impact of external development assistance and renewable energy consumption on human development are also very limited. iii) It is important to explain human development, which has many dimensions, with a multivariate approach and using a new and large data set. iv) Multiple factors affecting human development can be explained more accurately through OECD countries where renewable energy consumption and human development are relatively higher than in other countries. Also, the subject of the study is analyzed by current analysis methods. The main aim of this study is to reveal whether REC, environmental pollution and development aid impact on the human development index, which is an indicator of a quality life.

The remainder of the paper is structured as follows: Section 2 provides a summary of the literature. Section 3 deals with the methodology. The empirical results are tendered in Section 4 and Section 5 gives the conclusion, inferences, and future research directions.

2. LITERATURE REVIEW

Numerous studies have taken into account the causal relationship between renewable and non-renewable energy sources and economic growth. Given the studies on renewable energy in general, although there is no clear consensus, most of these studies provide the following evidence: i) use of renewable energy positively affects economic growth, ii) causality between renewable energy consumption (REC) and economic growth is generally bi-directional, iii) renewable energy resources support creation of new employment opportunities through direct and indirect effects, iv) renewable energy contributes to technology development, and v) REC prevents environmental destruction.

For the literature in general, empirical studies focus intensively on the relationship between renewable energy consumption and per capita income and measured economic growth.

Studies focus on the REC-human development relationship are very limited. Therefore, as a result of the literature review conducted in this study, and by using the variables of mean years of schooling, life expectancy at birth, employment to population ratio and population as well as REC, total CO2 emissions and official development assistance, it was observed that many variables could be effective on human development. For this reason, the following literature review is discussed in the context of sampling and analysis method over these variables that are related to HDI.

As mentioned before, the literature concerning the energy economy generally tends to focus on analyzing the relationships between energy consumption and economic growth (Brini et al. 2017; Narayan and Doytch 2017; Koçak and Şarkgüneşi 2017; Aneja et al. 2017; Paul and Bhattacharya 2004; Hossain 2011; Pao and Fu 2013; Apergis and Payne 2011, 2012; Kraft and Kraft 1978).

Among these studies, the results of studies conducted by Brini et al. (2017), Narayan and Doytch (2017), Koçak and Şarkgüneşi (2017), Aneja et al. (2017), Apergis and Payne (2011, 2012), and Pao and Fu (2013), suggest that renewable energy consumption (REC) is an essential determinant of economic growth. HDI has been considered as the representative of sustainable development in some studies and its relationship with REC has also been examined. For example, Soukıazıs, Proença, and Cerqueira (2017) using analysis on panel data for 28 OECD countries for the period 2004 to 2015, revealed that alongside human and physical capital, REC is an important factor explaining the sustainable development level. Sasmaz et al. (2020) examined the relationship between REC and human development for the period 1990-2017 using structural break panel cointegration test and causality test. They found that renewable energy has a positive effect on human development and that a bidirectional causality relationship exists between renewable energy and human development. Also, Wang et al. (2021) used different panel analysis methods to reveal the relationship between REC and human development of BRICS countries in the period 1990-2016. They showed that human development is promoted by renewable energy use and that bidirectional causality occurs between human development and REC. This result is also confirmed by Omri and Belaïd (2021).

Studies on the CO2 and HDI relationship mostly addressed it in the climate change context. For example, according to Akanbi et al. (2014), climate change effects such as increase in natural disaster frequency and intensity can be stopped or reversed in poor countries without HDI improvements. In contrast, according to Brooks et al. (2005), improving HDI reduces vulnerability to climate change effects. Berg and Botzen (2018), found in their analysis on countries with data for the period 2015 to 2050, that a 2 °C limitation to global temperature increase offers opportunities and space for welfare increase in poor countries. Asongu and Odhiambo (2020) analyzed the effect of management quality with generalized method of moments in alleviating negative impact of environmental impairment on human development for the period between 2000 to 2012 in 44 Sub-Saharan African countries. They showed that effective corporate governance can adjust CO2 emissions to have a net negative impact on development. Jha and Bhanu (2003) found an inverted N-shaped curve between the environmental pollution index and HDI in their study using the cross-sectional data of 174 countries. Serkan (2009), according to the results of his analysis for 15 countries in the Mediterranean region for the years 1970-2006, determined that human development reduces regional pollution emissions. Some studies have also shown a positive and time-dependent relationship between the HDI and CO2 emissions per capita resulting from fossil fuel burning (Costa et al. 2011; Asongu and Odhiambo 2019).

Recently, possible relations between ODA and HDI have been investigated in country-based econometric studies. For instance, Lee et al. (2019) examined the ODA impact on human development across 15 Asian countries using the Panel Regression and Fuzzy Set Approaches. They observed that the ODA economic and social effects on the basis of panel data were significant and that in the instrumental variable method, ODA had a statistically significant effect on total HDI. In another empirical study, the ODA impact on HDI in Pakistan was examined for the period 1975 to 2006. The result of causality analysis conducted showed there is only one-way Granger causality from ODA to Education index, Human development index and life expectancy index (Shirazi et al. 2009). Ustubici and Irdam (2012) used the total indicators of the HDI in their study on the period 1990 to 2005, stating that ODA was significant and negatively related to HDI. According to the authors, this can be attributed to the countries receiving the highest ODA having the lowest HDI level. In contrast to these studies, a country-based study where the data were analyzed by panel quantile regression technique found a positive relationship between ODA and economic growth per capita, whereas the aid-human development link was negative (Asongu 2014).

Also, HDI depends not only on REC, CO2 and ODA, but on many other factors as shown by studies done on this issue. In an empirical study, Shah (2016), determined that GDP, life expectancy rate and literacy rate positively affect HDI, whereas Gini index, fertility rate and CO2 emissions negatively affect HDI. Another study, showed population and per capita income growth rate affected HDI in ASEAN countries, whereas inflation rate and unemployment rate did not (Arisman 2018). Other studies have found that life expectancy has a significant positive effect on human development (Tudorache, 2020; Soukiazis et al., 2019; Sabyasachi, 2019; Sangaji, 2016; Khodabakhshi, 2011).

Education can provide individuals with better opportunities to access information quickly, find a job fast, change jobs, and thus increase their earnings. Bhowmik (2019) found that a long-term causality exists from education spending, health spending and per capita GDP to HDI, but there is no short-term causality among these variables. Soukazis et al. (2019) found in their empirical study that the average year of schooling, which they consider as representing human capital, significantly affects human development. Similarly, the education variable has a positive impact on human development both in the short and long run. Keskin (2011) analyzed the relationship between human capital and economic development data from 177 UN member countries using the regression method. The results, showed the literacy rate, education level, public health expenditures, and R&D expenditures have a positive effect on economic development. Other studies also confirm that education positively affects human development (Adenutsi, 2010; Azizi, 2018; Asongu, 2020).

Depending on the country level of development and workforce education level, employment can contribute positively to human development with its anti-poverty effect (Karnani, 2011). In this context, Mihci et al. (2012) found that the workforce has a significant and positive effect on HDI. In a study to analyze employment effect and economic growth rate on HDI in Indonesia, panel data for the period 2006-2013 was used (Feriyanto, 2016). The study showed that employment has a positive and significant impact on the HDI in Indonesia. In another study on Indonesia, the relationship of HDI on unemployment rate was analyzed for the period 2010-2019 (Sumaryoto, Herawati, and Hapsari, 2020) using time series analysis methods. The results showed that HDI has a significant and negative effect on the unemployment rate at the 5% level. Similar to this study, Bingl and Ayhan (2020) researched the

EU-28 countries during the 2004-2018 period by using panel data analysis and analyzed the impact of education, unemployment, and non-educational employment on human development. As a result of the analysis, it was found that the unemployment variable had a negative effect on HDI, and the education variable had a significant positive effect on HDI.

Grubaugh (2015) used data from 83 countries for the period 1980-2010 in his study. The analyzes performed found that population, population growth, and baseline GDP were significantly correlated with growth in HDI. In contrast, Soukiazis et al. (2019) found an inverse relationship between population and economic development. Another study examined the effect of urbanization on the HDI value by using the Panel Tobit Model with Random Effect method for the period 1990 to 2017; it was found that urbanization had a positive effect on HDI (Sabyasachi 2019). Zgheib et al. (2006) determined the relationship between population and HDI in 16 Middle Eastern countries; data for the period 1991-2000 were analyzed by regression method. It was determined that no significant relationship existed between the HDI and the population.

When these studies were evaluated in general, it was observed that more studies are needed to determine how the effects of REC, environmental pollution and ODA programs on human development have changed country-wide and what strategies are effective in this regard.

3. METHODOLOGY

3.1 MODEL AND DATA

In this study, to analyze factors affecting human development we used annual data from 22 OECD countries for the period 1990-2017. The Human Development Index has been calculated since 1990. For this study, the sample starting year was determined as 1990. Study estimates cover 22 countries over a 28-year period (1990-2017). Countries with missing data in the analysis period were excluded from the sample and only 22 countries with complete data were included in the analysis. The fact that the independent variables used in the study do not have data for some countries in some years reduces the sample size, but we have a total data set that includes 616 years of observations from 22 countries. The symbols, definitions and data sources of the variables we used are given in the following Table 1.

TABLE 1
Variables Used in Empirical Study and Their Descriptions

Variables	Symbols	Descriptions of Variables	Sources
Dependent Variable	HDI[3]	Human Development Index	UNDP
Independent Variables	REC	Renewable Energy Consumption (kilotonne of oil equivalent)	IEA
	CO2	Total CO2 emissions - Fuel Combustion (Mt of CO2)	IEA
	ODA	Official development assistance - Total, % of gross national income	OECD
	MYS	Mean years of schooling (years)	UNDP
	LE	Life expectancy at birth	UNDP
	EMP	Employment to population ratio, 15+, total (%)	World Bank Database
	POP	Population, Total, 1000 persons	World Bank Database

After determining the dependent variable and independent variables, the model established to examine the factors affecting human development is given in Equation 1.

$$(1) \quad HDI_{it} = \alpha_0 + \alpha_1 \ln REC_{it} + \alpha_2 \ln CO2_{it} + \alpha_3 ODA_{it} + \alpha_4 \ln MYS_{it} + \alpha_5 \ln LE_{it} + \alpha_6 EMP_{it} + \alpha_7 \ln POP_{it} + u_{it}$$

As shown in Equation 1, we expect the impact of REC, which is known to have an important role in sustainable economic development and whose use is encouraged to reduce negative impact of global warming on economic development to be positive ($\alpha_1 > 0$). We expect α_2 to be negative as CO2 commonly causes scarce resources to decrease and negatively affects the quality of life, due to its negative environmental impact.

ODA are funds given to support economic development and welfare of countries. If an increase in ODA is used efficiently, it is expected to positively affect HDI (Berhane and Chou 2017). Therefore, we expect a positive impact of ODA on economic development ($\alpha_3 > 0$). We also expect, α_4, α_5 and α_6 to be positive, while $\alpha_7$is expected to be negative, as larger populations are likely to induce decrease in the HDI. High population growth can reduce the quality of health and education and reduce per capita income. Therefore, population is expected to have negative impact on HDI.

Furthermore, according to the results of empirical studies in the literature, mean years of schooling representing education, life expectancy from birth representing health, and employment rate representing labor factor have a positive effect on human development. Hence, these independent variables are expected to have a positive effect on human development.

Graphical representation of HDI values of OECD countries by years is presented in Figure 1. It can be observed in Figure 1 that HDI values of OECD countries increased continuously over the years. This upward trend suggests that OECD countries are constantly striving to improve the quality of human development.

FIGURE 1
Human Development Index in OECD (2010-2018)

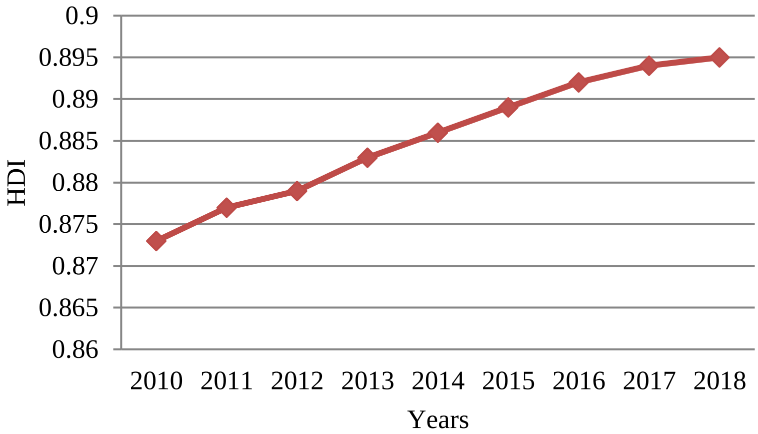
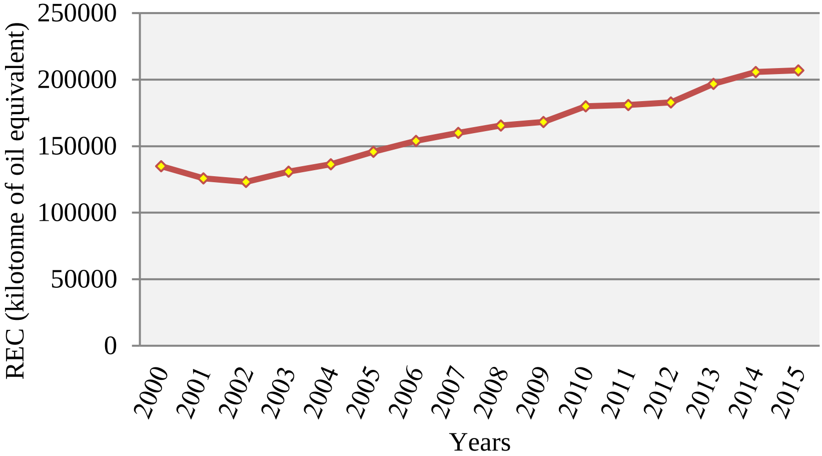


Figure 2 gives the renewable energy consumption values of OECD countries, which are included in the empirical analysis of the study. According to Figure 2, the total REC of OECD countries exhibited an upward trend except from 2001 to 2002. This trend reveals that countries attach importance to REC over time.

FIGURE 2
Total Renewable Energy Consumption in OECD (2000-2015)



3.2 SPECIFICATION OF EMPIRICAL MODEL

In this subsection, the model selection process for factors affecting human development is discussed and empirical tests are presented for heteroscedasticity and correlations within and between groups on a panel group basis. In addition, the analysis method to be used to examine the causality among these variables is included.

3.2.1 MODEL SELECTION

The analytical method used in this study is based on panel data analysis. Panel data analysis models are indicated in Equation 2 (Tatoglu, 2013).

$$(2) \qquad Y_{it} = \beta_{0it} + \sum_{k=1}^{K} \beta_{kit} X_{kit} + \varepsilon_{it} \quad i=1,\ldots\ldots, N \text{ and } t=1,\ldots..T$$

where, i is the cross section, t is the time, β_{0it} is the constant term; β_{kit} is the Kx1 dimensional vector of coefficients, $X_{kit}$is the value of k, the independent variable for unit i at time t, Y_{it} is the value of the dependent variable for unit i at time t and ε_{it} is the random error terms assumed to be i.i.d. .$(0, \sigma^2)$. Before predicting equation 1, the stationarity of the variables in the equation must be investigated.

In addition, it is likely that economic shock in any one country is affecting other countries differently. For this reason, since the results obtained in the analysis without considering the cross section dependency will be deviated and inconsistent, it is necessary to test whether cross-section dependence exists among the countries before starting the analysis. If there is no cross-section dependence, first generation unit root tests are used. On the other hand, if there is cross-section dependence, second generation unit root tests should be used. In this way more consistent results are obtained. Therefore, before performing unit root tests, Breusch and Pagan (1980) (CD_{BP}), Pesaran (2004) (CD_P) and Pesaran et al. (2008) (bias-adjusted Lagrange multiplier-LM test, LM_{Adj}) cross-section dependence tests were executed.

Cross-section Augmented Dickey-Fuller (CADF) and CIPS second-generation unit root test were employed to designate whether the variables were stationary due to the existence of cross-section dependence (Pesaran 2007). These findings showed that the series were stationary. According to these results, the estimates of the study were made using the panel least squares method. Three methods are used for estimating the pooled regression for both cross-section and time series, which are the classic model, fixed effects model and random effects model. Classical Model was not used because it assumes that all observations in the panel are homogeneous, that is, they do not have unit and / or time effects. However, although the fixed effects and random effects models assume certain unit and time effects that are not observed, autocorrelation and inter-unit correlation and heteroscedasticity within the unit and by units cannot capture the possible presence. Therefore, it is preferred to analyze the data using the feasible generalized least squares (FGLS) method for effective and consistent estimates.

The Parks-Kmenta FGLS model (Parks 1967; Kmenta 1986) was used to analyze the data, as it allows heteroscedasticity on a group basis (country level) with a correlation between the country and between countries. The Parks-Kmenta method is based on generalized least squares and can temporarily correct associated errors and contemporaneous correlations between units as well as panel heteroscedasticity.

A brief description of the Parks-Kmenta methodology is provided below. This model takes into account the first-order autoregressive model of random errors ε_{it}, which has the following three stochastic properties.

1. $E\left(\varepsilon_{it}^2\right) = \sigma_{it}$ (heteroscedasticity across panels);
2. $E\left(\varepsilon_{it}\varepsilon_{jt}\right) = \sigma_{ij}$ (a covariance specification allowing for contemporaneous correlation among the disturbances)
3. $\varepsilon_{it} = \rho_i \varepsilon_{i,t-1} + \nu_{\text{it}}$ (AR (1) autocorrelation within panels)

Where $E(\nu_{\text{it}}) = 0$, $E(\varepsilon_{it}\nu_{\text{it}}) = 0$, $E(\upsilon_{it}\nu_{\text{jt}}) = \theta_{ij}$, $E(\upsilon_{it}\nu_{\text{js}}) = 0\ (s \neq t)$, $E(\varepsilon_{i0}) = 0$, $E(\varepsilon_{i0}\varepsilon_{j0}) = \sigma_{ij} = \theta_{ij}/(1-\rho_i\rho_j)$. In this method the covariance matrix $E(\varepsilon\varepsilon')$ or $\Psi$of random errors ε can be showed as follows (Greene, 2003):

(3) $$E(\varepsilon\varepsilon') = \Psi = \begin{bmatrix} \sigma_{11}P_{11} & \sigma_{12}P_{12} & \cdots & \sigma_{1N}P_{1N} \\ \sigma_{21}P_{21} & \sigma_{22}P_{22} & \cdots & \sigma_{2N}P_{2N} \\ \cdots & \cdots & \cdots & \cdots \\ \sigma_{N1}P_{N1} & \sigma_{N2_{N2}} & \cdots & \sigma_{NN}P_{NN} \end{bmatrix} \text{ where}$$

(4) $$H_{ij} = \begin{bmatrix} 1 & \rho_j & \rho_j^2 & \cdots & \rho_j^{T-1} \\ \rho_i & 1 & \rho_j & \cdots & \rho_j^{T-2} \\ \rho_i^2 & \rho_i & 1 & \cdots & \rho_j^{T-3} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \rho_i^{T-1} & \rho_i^{T-2} & \rho_i^{T-3} & \cdots & 1 \end{bmatrix}$$

FGLS is done by following the two steps given below.

i) In the first place, a two-stage covariance matrix (Ψ) is estimated. Then, model coefficients $\beta_k, k = 1,2,3,...,p$ are estimated by FGSL. The first step to estimate Ψ involves estimating $\beta_k$with ordinary least squares (OLS) and obtained fitted residuals. A consistent estimator of first order autoregressive parameter with fitted residuals $\hat{\varepsilon}_{it} = y_{it} - \sum_{k=}^{p} X_{itk}\hat{\beta}_k$is obtained as follows.

(5) $$\hat{\rho}_i = \left(\sum_{t=2}^{T} \hat{\varepsilon}_{it}\hat{\varepsilon}_{i,t-2}\right) \Big/ \left(\sum_{t=2}^{T} \hat{\varepsilon}_{i,t-1}^2\right)$$

for i =1, 2, . . . , N and t=2, . . . , T. It is then performed for Prais - Winsten's transformation to asymptotically remove the autoregressive properties of the data. Namely,

(6) $$y_{i1} - \hat{\rho}_i y_{i,t-1} = \sum_{k=1}^{p} (x_{i1k}\beta_k \hat{\rho}_i X_{i,t-1,k})\, \beta_k + \varepsilon_{it-}\hat{\rho}_i \varepsilon_{i,t-1}$$

while for i=1, 2, . . . , N and t = 1.

(7) $$y_{i1}\sqrt{1-\hat{\rho}_i^2} = \sum_{k=1}^{p} X_{i1k}\beta_k \sqrt{1-\hat{\rho}_i^2} + \varepsilon_{i1}\sqrt{1-\hat{\rho}_i^2})$$

Equation 7 can be briefly rewritten from as follows:

(8) $$y_{it}^* = \sum_{k=1}^{p} X_{i1k}^* \beta_k + \varepsilon_{it}^*$$

Where, p shows the number of independent variables.
ii) In the second stage, the covariance matrix Ω is estimated by applying OLS to the preceding transformed model. Acquiring $\hat{\varepsilon}^* = y^* - X^* \hat{\beta}_{OLS}^*$ from which the consistent estimator of σ_{ij} is worked out as $m_{ij} = \hat{\varphi}_{ij}/(1-\hat{\rho}_i\hat{\rho}_j)$, where $\hat{\varphi}_{ij} = 1/(T-p)\sum_{t=1}^{T} \hat{\varepsilon}_{it}^* \hat{\varepsilon}_{ij}^*$. In the end, the FGLS estimator can be written in substantial matrix notation

(9) $$\hat{\beta}_{FGLS} = (X' \hat{\Psi}^{-1} X)^{-1} X' \hat{\Psi}^{-1} y$$

In this study, Greene (2012) Lagrange Multiplier (LM_G) test was applied to determine for heteroscedasticity, while Baltagi and Lee (1995) (LM_{BL}) and Born and Breitung's (2011) (LM_{BB}) tests were used to test for autocorrelation.

Besides, Emirmahmutoglu-Kose’s (2011) causality test was performed to specify the causal relationship between the variables. In this test, Equations (10) and (11) which have causality relationship based on the two-variable VAR model can be constituted as follows (Emirmahmutoglu and Kose, 2011:872). This test considers the level VAR model with $k_i + d\max_i$ lags in heterogeneous mixed panels:

(10) $$x_{i,t} = \mu_i^x + \sum_{j-1}^{k_i+d\,max_i} B_{11,ij}\, x_{i,t-j} + \sum_{j-1}^{k_i+d\,max_i} B_{12,ij}\, y_{i,t-j} + \varepsilon_{i,t}^x$$

$$(11) \quad y_{i,t} = \mu_i^y + \sum_{j-1}^{k_i+d\,max_i} B_{21,ij}\, x_{i,t-j} + \sum_{j-1}^{k_i+d\,max_i} B_{22,ij}\, y_{i,t-j} + \varepsilon_{i,t}^y$$

i=1, 2, ..., N and j=1, 2 , ..., k

where the variables x_i and y_i illustrate the error terms, in return ε_i, a constant effects matrix, k_i delay, $d\max_i$ the maximum integration value for each cross-section, i cross-sections, t time period, Equation (10) testing causality from x to y, Equation (11) testing causality from y to x. B is the fixed matrices of coefficients that permits to vary across countries.

4. EMPIRICAL RESULTS

Since OECD member countries have similar economic conditions, there is a possibility of cross-sectional dependence between members, so the cross-sectional dependence between units in the variables needs to be tested. The results of the CD_{BP}, CD_P, and LM_{Adj} tests, which were used to test for a cross-sectional dependence in series are shown in Table 2. According to these tests results, there is cross-section dependence in all variables for constant and constant and trend models. For this reason, the stationarity of the series should be tested with second-generation unit root tests.

TABLE 2
Tests Results for Cross-Section Dependence of Variables

Variables	CD_{BP}		CD_P		LM_{Adj}	
	With constant only	With constant and trend	With constant only	With constant and trend	With constant only	With constant and trend
HDI	1682.6***	1679.8***	67.4***	28.8***	39.2***	27.3***
REC	1860.1***	983.9***	75.8***	81.5***	56.8***	25.0***
CO2	1410.4***	1427.2***	54.8***	55.6***	49.5***	29.2
ODA	1274.5***	1285.8***	48.5***	49.1***	45.4***	22.2***
MYS	1957.2***	1973.8***	80.3***	81.1***	39.5***	30.6***

TABLE 2 *(continued)*

Variables	CD_{BP}		CD_P		LM_{Adj}	
	With constant only	With constant and trend	With constant only	With constant and trend	With constant only	With constant and trend
LE	1383.6***	1344.6***	53.6***	51.8***	38.9***	35.2***
EMP	1293.1***	1291.6***	49.4***	49.3***	49.6***	25.6***
POP	1982.2***	1618.1***	81.4***	64.5***	73.4***	27.7***

Note 1: ***Statistical significance at 1%. Optimal lag length is assumed to be 1.

Therefore, Cross-section Augmented Dickey-Fuller (CADF) and CIPS tests, which are the second-generation unit root tests, were applied for testing the unit root in the series (Pesaran 2007). The results obtained from these three tests are shown in Table 3.

In stationary tests results in Table 3, it has been designated that all variables are stationary at the 1% significance level according to CADF and CIPS test. For this reason, the panel OLS method was employed to estimate the model.

TABLE 3
Unit Root Test Results

Variables	CADF and CIPS			
	With constant only		With constant and trend	
	Level	1st Difference	Level	1st Difference
HDI	-4.722***	-	-4.672***	-
REC	-4.353***	-	-4.469***	-
CO2	-3.061***	-	-3.409***	-
ODA	-3.067***	-	-3.103***	-
MYS	-4.393***	-	-4.339***	-
LE	-4.578***	-	-4.604***	-
EMP	-3.998***	-	-4.037***	-
POP	-3.781***	-	-4,816***	-
CADF Critical Values	%1: -2.30 %5: -2.15 %10: -2.07		%1: -2.81 %5: -2.66 %10: -2.58	

Note: *** $p < 0.01$. Schwarz information criterion was used as information criterion. Lag length was determined as 1. CADF-CIPS critical values were obtained from the Peseran (2007) study.

The following Table 4 indicates the conclusions of the FGLS estimation of Equation (1). Namely, Table 4 describes the FGLS estimates propped up the Parks-Kmenta method. Clearly, in Table 4 we permit for both group-wise heteroscedasticity and serial correlation of order 1 with usual AR(1) parameter for all panels (variance $\varepsilon_{it}^2 = \sigma_{it}$ and $\varepsilon_{i,t} = \rho_i \varepsilon_{i,t-1} + \nu_{\text{it}}$)

LM_G, LM_{BL} and LM_{BB} tests were hence performed to specify heteroscedasticity and autocorrelation in the models. The consequences are given in Table 4. In accordance with result of LM_G test, heteroscedasticity problem is i specified at 1% significance level. Also, the LM_{BL} and LM_{GL} tests indicate that the autocorrelation problem exists at the 0.001 significance level. These tests results show justification for using the FGLS method, because Park's (1967) and Kmenta's (1986) resistant estimators were adjusted to both the heteroscedasticity and autocorrelation problems.

In Table 4, the Wald chi2 statistic tests the null hypothesis that all of the model coefficients, except the constant term, are zero. The Wald chi2 statistic (df=7) is significant, allowing rejection of the null hypothesis that all of the coefficients, excluding the intercept term, are zero.

TABLE 4
Estimation Results of the FGLS model

Variables	Coefficients	Standard Error	*t*-Statistics	*p*-Values
REC	0.0010563*	0.000184	5.72	0.000
CO2	0.006324*	0.000394	15.84	0.000
ODA	0.005669*	0.000524	10.85	0.000
MYS	0.112355*	0.001244	93.34	0.000
LE	0.708877*	0.006632	106.95	0.000
EMP	0.000783*	0.000003	28.05	0.000
POP	-0.01069*	0.000402	-26.54	0.000
C	0.006324*	0.00039	15.84	0.000
	Wald $chi^2(7)$: 75735.21*			
	LM_G: 245.991*			
	LM_{BL}: 384.227*			
	LM_{BB}: 422,124*			

Note: $^*p < 0.001$

The results of the analysis show that REC, CO2, ODA, MYS, LE and EMP affect HDI in a positive and statistically significant way, while POP affects HDI in a negative and statistically significant way (Table 4). The estimation results show that REC affects the HDI positively at the 1% significance level. An increase of 1% in the REC increases the HDI by approximately 0.00001 unit. The same result for REC is found by Soukiazis et al. (2017), for OECD countries.

A positive relationship also exists between CO2 and HDI at the 1% significance level. An increase of 1% in the rate of CO2 emission increases the HDI by about 0.00006 units. This result is inconsistent with economic expectations. The positive relationship between HDI and CO2 emissions can be explained through the link between desire to increase economic growth and energy use. Desire to increase economic growth increased energy demand in sectors such as residential, industrial, transportation, and goods and services, in turn leading to increased energy consumption. A study conducted to reveal HDI effect and economic growth on agricultural CO2 emissions determined that both the HDI and economic growth had positive and statistically significant effects on agricultural CO2 emissions (Mohmmed et al. 2019). The same study determined that economic growth has a significant effect on energy, industrial processes, other fuel combustion, manufacturing and CO2 waste emissions. These results support the findings of this study. Another study that confirmed the positive relationship between CO2 and HDI was performed by Costa et al. (2011).

Similarly, it has been concluded that ODA has a strong positive effect on HDI at the 1% significance level. An increase of one unit in ODA increases HDI by about 0.006. This result is coherent with economic expectations. It is consistent with those of Lee et al. (2019), Asongu (2014) and Moe (2008). Development assistance, used for social and economic development can improve human health and educational development of individuals, thereby increasing the degree of human development.

It was determined that mean year of schooling (MYS) significantly and positively affected the HDI at the 1% significance level. An increase of 1% in MYS increases HDI by approximately 0.00112 units. Similar results were found by Suri et al. (2011); Bundala (2012) and Soukiazis et al. (2017). The coefficient for life expectancy at birth is positive and statistically significant at the 1% level. An increase of 1% in the rate of LE increases the HDI by approximately 0.0071 units. A positive relationship also exists between employment (EMP) and HDI at the 1% significance level. The population coefficient was found to be -0.011, which is negative and significant. An increase by 1% in the population decreases the

HDI by 0.00011% (p < 0.01). This consequence both meets economic expectations and is consistent with the findings of several studies that examined the HDI and LE relationship (e.g., Suri et al. 2011; Bundala 2012; Soukiazis et al., 2017).

Finally, the causal relationship between the variables was investigated using Emirmahmutoglu-Kose's (2011) causality test and the relevant results are presented in the following Table 5. Table 5 shows the results of the bivariate pair wise Emirmahmutoglu and Kose's Causality test between HDI, REC, CO2, ODA, MYS, LE, EMP and POP for the entire OECD countries panel.

TABLE 5
Emirmahmutoglu and Kose's (2011) Panel Causality Test Result

Hypothesis	Wald	Conclusion
$REC \neq\rightarrow HDI$	119.74***	Two way Causality from HDI to REC
$HDI \neq\rightarrow REC$	85.940***	
$CO2 \neq\rightarrow HDI$	71.28***	One way Causality from CO2 to HDI
$HDI \neq\rightarrow CO2$	42.96	
$ODA \neq\rightarrow HDI$	80.44***	Two way Causality from HDI to ODA
$HDI \neq\rightarrow ODA$	86.50***	
$MYS \neq\rightarrow HDI$	115.054***	Two way Causality from HDI to MYS
$HDI \neq\rightarrow MYS$	61.379**	
$LE \neq\rightarrow HDI$	43.576	No Causality
$HDI \neq\rightarrow LE$	46.646	
$EMP \neq\rightarrow HDI$	79.458***	Two way Causality from HDI to ODA
$HDI \neq\rightarrow EMP$	66.333**	
$POP \neq\rightarrow HDI$	79.647*	One way Causality from POP to HDI
$HDI \neq\rightarrow POP$	39.876	

Note: The maximum lag length is 2. ***, ** illustrates 0.01 and 0.05 statistical significance, respectively.

The results display that there is no causality except from HDI to LE; while all the other hypotheses could be rejected for the entire OECD panel. In other words, there is a bidirectional causality running from REC to HDI, from ODA to HDI, from MYS to HDI and from EMP to HDI for the entire OECD panel (Table 5).

5. DISCUSSION AND CONCLUSION

The aim of this study is to research the relationship existing among renewable energy consumption, environmental degradation and external development assistance and human development in 22 OECD countries.

Main reasons behind researching the relationship between energy consumption, environmental degradation and external development aid and human development are the lack of studies investigating the relationships in this issue and the necessity to explain the phenomenon of development with many dimensions. In addition, it is important to investigate the factors affecting human development with a multivariate model because human development is a multidimensional indicator and it is important to examine the multiple effects of this indicator. Also, this study stands out by examining the existence and direction of causal dynamics between human development and independent variables of the study for OECD countries. To realize the purpose of this study, a multivariate panel HDI model involving data produced between 1990 and 2017 was estimated.

Thus, several factors affecting HDI were analyzed in this study by using panel data analysis. HDI was used as the dependent variable, while renewable energy consumption, total CO2 emissions, Official development assistance, Mean years of schooling, Life expectancy, employment and population were used as independent variables. Analysis was carried out with panel data from 22 OECD countries for the period 1990-2017. The model of the study was estimated with the Parks-Kmenta feasible generalized least squares method.

The results indicate that REC, Total CO2 emissions, Official development assistance, Mean years of schooling, Life expectancy and Employment affect human development positively, while population affects Human development negatively. Life expectancy appeared to be the variable affecting human development most strongly. Also, for selected OECD countries, there is bidirectional causality from REC to HDI, from ODA to HDI, from MYS to HDI and from EMP to HDI. This means REC, ODA, MYS and EMP are promising factors for HDI in future.

These outcomes have some substantial policy implications. Improving human development will be possible if governments of these countries rely on the following: (i) Launch an incentive system to support renewable energy consumption and create renewable energy generation and supply infrastructure, (ii) Develop cooperation policies for using development based foreign resources and allocate planned domestic resources based on development; (iii) Make cooperation agreements for accessing renewable energy-based technologies; (iv) Allocate resources for health and education and use them effectively, and finally, (vi) Establish an environmentally friendly production system as much as possible to ensure sustainable development.

Although we tried to explain human development by using multivariate and current econometric methods in this study, some dimensions still need to be explained because different dimensions influence human development. Therefore, the issue should continue to be investigated with different samples, approaches and variables.

The data used in this study is limited to 22 OECD countries and the period 1990 to 2017. In this context, the data set can be extended regarding the time, the number of countries and sample. These limitations in the study should be considered before making any generalizations. As stated before, different econometric methods are used in empirical studies to determine the effects of variables. Because the nature of human needs changes over time, human development has a multidimensional feature and may differ according to time and place. Considering that some variables may have time or space effects in future, a dynamic model can be created to measure alteration in human development in time and space. Explanatory power and policy implications of the studies will increase even more.

ENDNOTES

1. Capability-capacity approach is the potential to do something or gain functionality. In this context, the increase in the capabilities of a person throughout his or her life means a human-oriented development.
2. ODA is described as government assistance planned to support the economic development and welfare of countries. ODA is also expressed as fund flows provided for countries and regions. According to the United Nations, developed countries must allocate 0.7% of their gross national income to ODA.
3. The human development index, regarded as an indicator of economic development has been calculated by UNDP since 1990. The index is calculated from three dimensional perspectives which are, a long and healthy life, accessibility to information and a decent living standard.

First, the life expectancy index, education index and income index, which represent 3 dimensions, are calculated, and then the human development index is calculated by taking the geometric average of the three indices. The HDI ranges from 0 to 1. An index close to one indicates that economic development, prosperity and a quality of life level have increased

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