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Research article

The Impact of CO_2 Emissions on Human Development: The Saudi Context

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Abstract: Over the last few decades, humans have been facing numerous challenges of environmental degradation, including CO_2 emissions. The relevance of CO_2 emissions to improvement of human development cannot be overlooked in this modern world. Based on this standpoint, the primary aim of this study is to empirically examine the impact of CO_2 emissions on the human development index over the years (1990-2021) in the Saudi economy using the (ARDL) model. The findings of the empirical investigation revealed a positive significant relationship between CO_2 with the human development index (with the t-value of 3.046123, and level of significance of 0.0051). In addition, the value of R-squared adjusted of 0.995064 indicates that the CO_2 is a very good explanatory variable in the model. The study commends for the presence of the environmental indicators, namely, the CO_2 emissions, when crafting policies for the human development in the Saudi Arabia.

Keywords: HDI, CO emissions, ARDL, SAUDI.

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1.Introduction

Climate change, environmental degradation and global warming are attracting worldwide attention. Over the past few decades, humans have confronted numerous challenges related to environmental degradation, including CO_2 emissions. In addition, the increasing levels of carbon dioxide (CO_2) and other greenhouse gases in the atmosphere are considered one of the world's most environmental threats. Among the greenhouse gases, CO_2 shows a critical role in increasing the greenhouse effect and is responsible for more than 60% of this effect (Acaravci and Ozturk 2010). Several studies have focused on the link between human development indicators, such as economic growth and CO_2 emissions. It is documented that higher economic growth has led to environmental degradation and is unsustainable. In particular, it is contended that higher economic growth requires higher energy consumption and is therefore believed to be responsible for higher CO_2 emissions. For example, Dincer (2000) explored that there is a direct link between sustainable development and renewable energy.

On the other hand, energy is essential for all types of economic activity. The rising usage of energy which leads to increases in per capita energy consumption, have characterized industrialization and economic development over the past century. Therefore, it is estimated that a country with high energy

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consumption is also likely to score high economic growth and have a high standard of living. In addition, high energy consumption leads to increased CO_2 emissions, which is damaging to the environment. Through this recognized connection, studies have widely observed the impact of global warming and climate change on the global economy (Alkhathlan and Javid, 2013).

However, such an economic growth does not always take into account central factors of social well-being that are not directly related to economic production, such as life expectancy, health, and education (Ouedraogo 2013, p. 29). This is why in recent years there has been a focus on human development indicators, for example (Niu et al. 2013, Martinez and Ebenhack 2008, Steinberger and Roberts 2010) investigated on this issue. Few literature have been conducted, therefore, this study investigates the relationship between the Human Development Index (HDI) and CO_2emissions at an individual country's level, namely, the Saudi Arabia. Most studies in the literature use Gross Domestic Product (GDP) as a growth index for example (Kraft and Kraft 1978, Mehrara 2007, Acaravci and Ozturk 2010). However, this study uses the HDI as a growth index, so welfare and not just monetary wealth is taken into account.

According to the first Human Development Report (HDR) published by the United Nations Development Program (UNDP) in 1990, “people are the real asset of any country". The fundamental goal of development is to create a conducive environment for individuals to live long, healthy, and creative lives. However, it is often a forgotten in the immediate concern of accumulating assets and financial wealth. Indeed, economic growth is an important factor in reducing poverty and generating the resources necessary for human well-being and environmental protection, but it is not limited to ensuring enhanced standard of living.

The Human Development Index links three well-known dimensions: a long, healthy life, education, and standard of living. Energy emissions accelerate all these dimensions, directly or indirectly. Therefore, all countries directly strive, without affecting human development, reducing greenhouse gas emissions from energy consumption and improve energy efficiency practices. Based on this perspective, the objective of this study is to empirically examine the relationship between CO_2 emissions and the human development index over the years (1990-2021) in the Saudi Arabian economy using a model. This study attempts to present a specific approach by addressing the limitations of the previous literature through a comprehensive index (HDI) of community welfare, instead of taking GDPP as a measure of living standards. This analysis is therefore novel in determining the relationship between short- and long-term CO_2 emissions and the HDI as a measure of human well-being in the Saudi Arabian economy.

The issue of the causal relationship between energy consumption and macroeconomics variables has been discussed in numerous studies. different studies have investigated the causal relationship between energy consumption and some independent variables such as economic growth, employment. However, few researches have been conducted to examine the impact of the co2 emissions on human development, particularly, for oil producing countries in the MENA region, such as the Saudi economy. Furthermore, the following study is different from the existing literature on the impact of CO_2 emissions on human development. We do not use the panel unit root and the panel cointegration approaches, as it is in the literature today. We rather use a dynamic ARDL model, which shows that there is a strong theoretical foundation for the empirical analysis. Therefore, this study is intended to fill in this research gap.

The remainder of the study is structured as follows. Section 2 presents the theoretical framework and recent empirical literature on this topic. Section 3 provides the data, methods, and discussion.

Finally, section 4 illustrates the conclusions and policy implications.

2.Theoretical framework and literature review

2.1 Theoretical framework

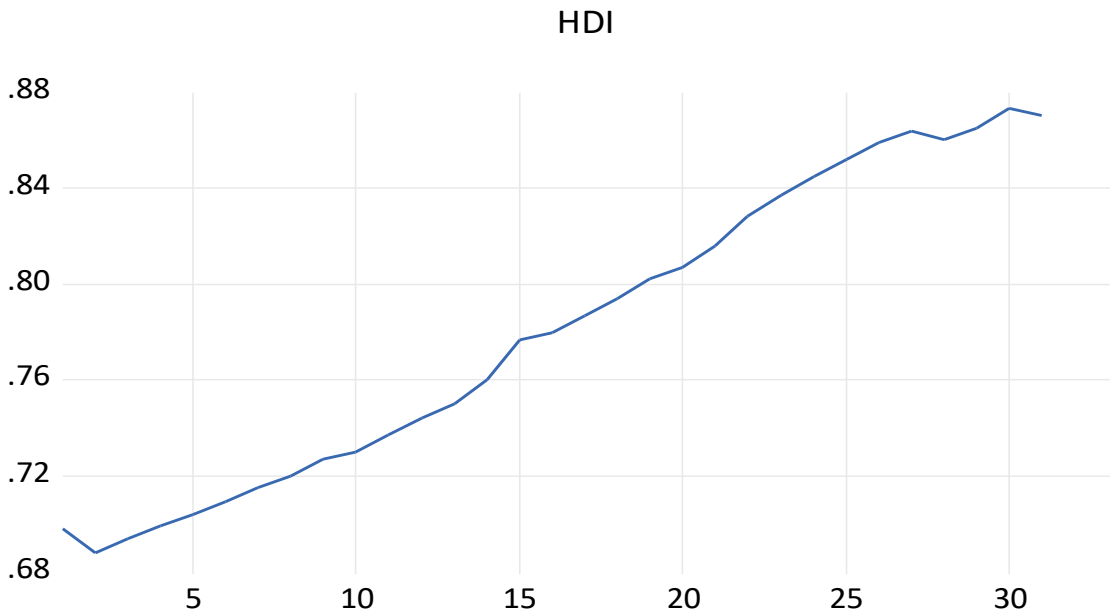
The environmental Kuznets curve hypothesis suggested a relationship between economic growth and the environment. Grossman and Krueger (1995) argued that those economic activities cause environmental pollution during a country's development phase. That added that as income per capita stabilizes, people demand a better living environment. Moreover, Barić, Zovak, and Periša (2013) argued that economic development contributes to human development by expanding access to knowledge, education, and community activities. Furthermore, Liu, Hong, and Sohail (2022) added that better human development means an improved understanding of environmental pollution and how to tackle it by reducing CO_2 emissions. Therefore, environmental protection activities have led to a reduction in environmental pollution.

The Human Development Index (HDI) is a statistic developed and compiled by the United Nations since 1990 to measure various countries' levels of social, environmental, and economic development. It is composed of four principal areas of interest: mean years of schooling, expected years of schooling, life expectancy at birth at birth, and gross domestic product (GDP) per capita. The human development index is the geometric mean of normalized indices for each one of the three dimensions (UNDP, 2020c). It ranges from 0 to 1, where 0 is the lowest level of human development while 1 is the highest one (UNDP, 2020c).

The first component of the HDI is a long and healthy life, measured by longevity. Life expectancy is considered the main measure to evaluate people's health (UNDP report). The second component of the HDI is access to education, measured by the expected years of schooling for school-age children and the average years of schooling for adults. Education is one of the most important drivers and outcomes of global development. The third component of the HDI is reflected in a good standard of living measured by gross national income per capita. The final HDI score for each country is calculated as the geometric mean of the three components by taking the cube root of the product of the normalized component scores.

Those dimensions of HDI are closely interrelated; For instance, according to the human capital theory, education is considered as an engine of growth through its impact on productivity (Becker, 2010). Education also enhances human skills and capacity, influencing effectiveness and efficiency (Mirowsky & Ross, 2017). Similarly, education is taken as a basic factor for health improvement (Link & Phelan, 2005). Another example of the interrelationships between the variables, (Eren et al., 2014) shows that increasing GNI may improve the quality of education and health. It has generally been well accepted that populations in countries with higher levels of GDP will have better health and longer life expectancy, as higher living standards lead to enhanced prevention and treatment of diseases and healthcare spending (Swift, 2011).

Figure 1 illustrates the performance of HDI in the Saudi Arabian economy over the period (1990-2021). The chart shows that the index has increased from 0.68 in 1990 to above 0.88 in 2021.



Source: Output using Eviews 11.0 Software

Figure 1: the performance of HDI in the Saudi economy (1990-2021)

On the other hand, carbon emissions are emissions that exist around us. It is one of the forms of air pollution and the main cause of global warming. Carbon dioxide emissions into the atmosphere are the most widespread type of pollution due to its ease of transmission from one region to another. The carbon dioxide emissions variable is considered an independent variable in this study. It is symbolized by the symbol CO_2, and it is expected that there will be a negative relationship between it and the dependent variable represented by the Human Development Index.

The share of total greenhouse gas emissions in 1991 was relatively low but increased gradually until 1996, then fluctuated between 1997 and 2000. Carbon emissions in Saudi Arabia were 193 million tons and increased sharply in 2021 reaching 220 million tons. Figure 2 reflects CO_2 emissions in Saudi Arabia during the period (1990-2021). Overall, greenhouse gas emissions have increased sharply in Saudi Arabia over the previous two decades. However, Saudi Arabia has committed to reducing greenhouse gas emissions by 2060. Saudi Arabia's heavy dependence on oil energy poses a challenge but the country is taking steps to produce clean energy. Therefore, product affordability and per capita emissions from burning fossil fuels were the main sources of CO_2emissions during this period.

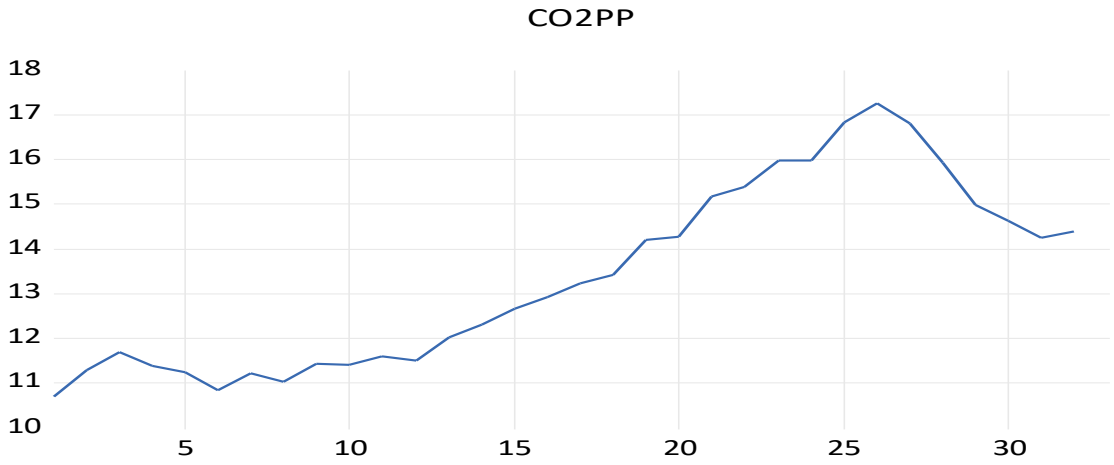


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Figure 2 the CO_2 emissions over the period (1990-2021)

Theoretically, carbon emissions could affect human development in many different ways. For example, energy is considered one of the fundamental factors linking economic growth, social justice, and environmental sustainability (Sandra, 2021). In this context, energy use also strengthens the relationship between CO_2 emissions and human development. In some ways, the level of human development depends on the satisfaction of one's own needs, and energy consumption is often the main supporting factor.

2.2 Literature Review

The correlation between the CO_2 emissions, and the human development index (HDI) has been the subject of intense studies. Although numerous empirical studies are examining the "emissions of Carbone dioxide", and "HDI growth," relationship separately, few studies are empirically investigating these links together. Sallam (2022) intended to examine the impact of carbon dioxide emissions coupled with energy consumption on the human development index in the MENA Countries over the period (1990- 2018) using the Random-effects models and the difference-generalized method of moment (DIF-GMM) estimators. The empirical results revealed that carbon dioxide emissions have a positive impact on HDI in the MENA region.

Maye, R. (2021) intended to examine the impact of CO_2 on economic growth in the Saudi economy during the period (1980-2018) using the ARDL method. The findings revealed the existence of an integration and balance relationship between CO_2 emissions, fossil fuel energy consumption, electrical energy consumption, and agricultural production with GDP in the long term. In addition, to an inverse relationship between CO_2 emissions and GDP in the short term. Nur Ekasari (2020) examined the impact of the CO_2 emission levels and poverty on the human development index in Indonesia during (2012-2016) using the panel data regressions analysis method. The result revealed that the emissions level in Indonesia affected positively and significantly towards the human development index. While, the poverty level had a negative and significantly impact upon the human development index.

Amer, H. (2020). Examined the link between energy and human development in selected countries

over the period 1990-2015 using the PVAR analysis. The findings of the study revealed that the impact of renewable energy consumption in reducing CO_2 emissions is insignificant. In addition, the results reflected that the effect of the CO_2 emissions on the HDI was also insignificant. Lawson (2020) explored the relationship between greenhouse gas emissions, fossil energy use, and economic development in certain African countries over the period (1990-2013) using causal analysis. The study argued that human development is not responsible for carbon dioxide emissions. The results revealed that greenhouse gas emissions were direct consequences of fossil energy use, and economic growth was not the primary cause for carbon dioxide emissions.

Hitam (2012) aimed at investigating the impact of foreign direct investment (FDI) in Malaysia on the environmental degradation using the non-linear model during (1965 – 2010). The results indicated that environmental Kuznets curve exists and foreign direct investment increases environmental degradation.

Table 1 summarized the most recent previous literature that examined the impact of CO_2 emissions and the human development in different economies of the world. Reviewing previous studies, as shown in Table1, some studies found a significant impact of CO_2 on economic growth or on human development, for example, (Sallam (2022, Nur Ekasari, 2020). Other studies found an insignificant relation, for example (Amer, H. 2020)

3. Data, Methodology, and Discussion

3.1Data and Methodology

Given that this research paper's main goal is to objectively examine the effect of the CO_2 emissions per capita on the human development index over the years (1990-2021) in the Saudi economy. Human development index is taken as the dependent variable, and the CO_2 emissions per capita is taken as the explanatory variable. Data was collected over the period (1990- 2021) from official UNDP and Saudi sources such as UNDP Human Development Reports, and the Saudi General Authority for Statistics.

This study uses the Autoregressive Distributed Lag (ARDL) test for several reasons. First, the ARDL was proposed by Pesaran et al. (2011) can examine long-term relationships that exist in series. Second, the ARDL method provides unbiased estimates and valid t-statistics, regardless of the endogeneity of some regressors (Jalil and Ma 2008). Third, the ARDL method can tolerate different changes in different variables, which makes it very attractive, adaptable, and flexible. The ability to accommodate sufficient deviation allows to best capture the mechanics of the data generation process.

Therefore, the ARDL approach has recently become better used in a number of empirical studies aimed at exploring the relationship between economic growth and other sustainable development factors in a number of countries and economies. For instance, the BRICS (Adriage, 2022), in Asian economies (Mallick, 2016) and selected European economies (Tampakoudis, 2014, Ziolkowska, 2010). Since the ARDL model is proposed to be as the most suitable econometric method compared to others in a case when the variables are stationary at I(0) or integrated of order I(1). The ARDL, is therefore chosen as the appropriate model to catch both short-term and long-term impact of explanatory variables on economic growth for the Saudi economy during the period of the study.

Table 1: Summary of the Literature CO_2 and HDI Nexus

Author(s)	Study area	Period	Methodology	Results
Yaofei Liu, et al.	China	1990 – 2021	quantile regression	infrastructure has positive and statistically significant relationships with HDI, CO_2 emissions, and GDP in all quantiles.
Serap Bedir, et al.	OECD countries	1992–2011	panel data approach	
Sallam	MENA countries	1990-2018	Random-effects models	carbon dioxide emissions have a positive impact on HDI in MENA region.
Amer, H. (2020)	Selected countries	1990-2015	PVAR Models	the impact of renewable energy consumption in reducing the CO_2 emissions is insignificant. In addition, the resulted reflected that the effect of the CO_2 emissions on the HDI were also insignificant
Lawson (2020)	African economies	(1990-2013)	Granger causality	greenhouse gas emissions were direct consequences of fossil energy use, and economic growth was not the primary cause for carbon dioxide emissions.
Nur Ekasari (2020)	Indonesia	(2012-2016)	panel data regressions	the emissions level affected positively and significantly towards the human development index. While, the poverty level had a negative and significantly impact upon the human development index.
Hitam (2012)	Malaysia	1965-2020	the non-linear model	The results indicated that environmental Kuznets curve exists and foreign direct investment increases environmental degradation.
Maye, R. (2021)	Saudi Arabia	(1980-2018)	The ARDL	the existence of an integration and balance relationship between CO_2 emissions, with GDP in the long term. In addition, to an inverse relationship between CO_2 emissions and GDP in the short term.

The variables used in this study include per capita CO_2 emissions, measured in millions of metric tons per capita, and the HDI over the annual period (1990–2021) for the Saudi economy. The dependent variable is the human development index as a proxy for human development. To examine the impact of CO_2 emissions on the HDI, the study used the empirical specifications by (Poumanyvong & Kaneko, 2010) and (Paliova et al., 2019) with some modifications, as reflected in equation (1).

The study set out the following empirical model In Equation 1 to determine how the CO_2 significantly affects the HDI in the Saudi economy:

$$HDIt = \beta 0 + \beta 2CO2Emt + \varepsilon t \quad (1)$$

By converting all variables of Equation (1) into the natural log, the model is designed below:

$$LnHDIt = \beta 0 + \beta 1LnHDIt - 1 + \beta 2LnCO2Emt - 1 + \varepsilon t \quad (2)$$

Where:

ln(HDI): represents the human development index in logs;

HDIt-1: represents the human development index in previous lags, and in logs

ln (CO_2): represents carbon emissions per capita in logs,

β0 is the fixed intercept, β1 and β2 represent the slope of the model, and εit is the error term.

The study proposes the following hypothesis:

H1: The level of gas emissions is positively impacted the HDI in the Saudi economy.

3.2 Discussion

3.2.1Descriptive Statistics

This section provides the results and discussion. Before analysis, the first step is to analyze the detailed descriptive statistics. A comprehensive summary of the variables included in the model is provided in Table 2 with mean, variation (standard deviation), and bounds (minimum and maximum).

Table 2: descriptive statistics

	CO_2 Emissions	HDI
Mean	22.05921	0.780355
Median	22.18413	0.780000
Maximum	23.15740	0.873000
Minimum	19.32432	0.688000
Std. Dev.	0.869703	0.062964
Skewness	-1.105941	0.057314
Kurtosis	4.345493	1.554027
Jarque-Bera	8.657745	2.717639
Probability	0.013182	0.256964
Sum	683.8354	24.19100
Sum Sq. Dev.	22.69149	0.118933
Observations	31	31

Source: Output using Eviews 11.0 Software

CO_2 has both a high mean value and variation, compared with the HDI. In addition, the descriptive statistics of the selected variables stated in Table 2 specified that the Jarque–Bera test for entire variables used in the study is insignificant, which implies that all the selected variables are normally

distributed.

3.2.2Unit Root Tests

Next, it is necessary to check the integration order of the studied variables. Thus, the primary goal of using a unit root test is to determine whether data contain a unit root. This study used three-unit root tests to analyze the stationarity of the variables. The results of the unit root tests are illustrated in Table 3, including (Maddala and Wu, 1999; Im et al., 2003; Levin et al., 2002) variables that display that variables comprise a unit root at their levels, denoting that the variables are not stationary. All the coefficients of the variables' first difference are significant at the 1% level, indicating that all variables are stationary at their first difference. The unit root test results presented in Table 3 show that all variables are stationary, either in levels or in terms of the first difference. Thus, the results of Table 3 are consistent with the hypothesis that the variables are integrated first order I (0) and I (1).

Table 3: Unit Root for CO_2 (At level with intercept) Augmented Dickey-Fuller
Null Hypothesis: (HDI, and CO2) have a unit root

Variable	Test Critical Value		t- tatistics	Prob.*
D(HDI)	1%	-3.670170		
	5%	-2.963972	-3.552352	0.0133
	10%	-2.621007		
D(CO_2)	1%	-3.6793222		
	5%	-2.967767	-5.753903	0.0000
	10%	-2.622989		

*MacKinnon (1996) one-sided p-values
Source: Output using Eviews 11.0 Software

3.2.3 Selection of Lag Order

Choosing the lag order is the next stage. This stage aims to find the VAR model's optimal lag order, which is based on the following selection criteria: LR-sequential modified LR test statistics, FPE, AIC, SIC, and Hannan–Quinn information criterion. This process is required because if the lag length is chosen incorrectly, the results will be skewed (Hdom and Fuinhas, 2020). Table 4 shows that the result of the appropriate lag length is 1.

Table 4: Optimal Lags: VAR Lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	13.65793	NA	0.001534	-0.803996	-0.709699	0.774463
1	95.85998	147.3968*	6.99e-06*	-.197240*	-.914351*	-6.108643*
2	97.46074	2.649634	8.29e-06	-6.031775	-5.560294	-5.884113

*Includes lag order selected by the criterion
LR: Sequential modified LR test statistic (each at 5% level)

FPE: Final Prediction Error
AIC: Akiake Information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Source: Output using Eviews 11.0 Software

3.2.4ARDL Estimates

Table 5 data displays the ARDL outcomes of the analysis using Equation 1. Table 5's overall findings show that the model has a very high explanatory power of R-squared (0.995), which showed that independent variable (the CO_2 emissions) accounted for more than 99% of fluctuations in human development index in the Saudi economy across the study's years. In addition, the results revealed that CO_2 emissions per capita have positive and statistically significant effects on HDI at a 5% significance level. The coefficient of per capita CO_2 is approximately .01 implying that a 1% increase in the per capita CO_2 emissions increases HDI by approximately 0.01% for Saudi economy.

Table 5: Dependent Variable (Log (HDI) using ARDL

Variable	Coefficient	Std. Error	t-statistics	Prob.*
LOG(HDI-1)	1.004510	0.013196	76.12279	0.0000
LOG(CO_2Em)	0.080897	0.026558	3.046123	0.0051
C	-0.241883	0.081816	-2.956440	0.0064
R-squared	0.995404	Mean Dep. Var	-0.247550	
Adjusted R-squared	0.995064	S.D. Dep. Var	0.079596	
S.E. of regression	0.005592	Akaike info Criterion	-7.440185	
Sum squared residuals	0.000844	Schwarz criterion	-7.300066	
Log Likelihood	114.6028	Hannan-Quin Criter.	-7.395360	
F-statistics	2923.837	Durbin-Waston Stat	1.757166	
Prob(F-statistics)	0.00000		1.757166	

*Note: p-values and any subsequent tests do not account for model selection
Source: Output using Eviews 11.0 Software

3.2.4ARDL Cointegration Test

The ARDL-bound test cointegration put out by Pesaran, Shin, and Smith (2001) is presented in this study. Table 6 provides an overview of the cointegration of the ARDL bound test. A cointegration correlation between CO_2Emt, and the HDIt is established using the bound F-test. The coefficient of the lagged Error Correction Term should be substantial with a negative sign in order to support the results of the bound tests for cointegration for long-term analysis. That means the series in question are related and therefore can be combined in a linear fashion. This implies that, even if there are shocks in the short run, which may affect movement in the individual series, they would converge

with time (in the long run).

To ascertain the dynamic relationship, the investigation would be based on ARDL's short- and long-term analyses. The ARDL model's ECM is effective at identifying the long-term relationship between the variables. There is ample evidence to conclude that there is a long-term relationship between CO_2 and the HDI in Saudi Arabia when considering the critical value bounds shown in Table 6.

Table 6: Coefficient diagnostic: ARDL Long-run and Bounds Test

F-Bounds tests	Null Hypothesis: No levels of relationship			
Test Statistics	Value	Sign.	1(0)	1(1)
F-statistic	20.33275	10%	3.02	3.51
K	1	5%	3.62	4.16
		2.5%	4.18	4.79
		1%	4.98	5.58
EC=LOG(HDI)-(-17.9373*LOG(CO_2 EM)+53.6323				

Source: Output using Eviews 11.0 Software

The results from Table 6 based on the ARDL bound tests show that the F-statistic is value is 20.33275 above the critical values of the upper bound of 10%, 5%, and 1%, indicating that the null hypothesis of no cointegration nexus between CO_2Em, and the HDI is rejected at 10%, 5%, and 1% significance levels So, the investigation can go on to the ARDL Error Correction Model.

3.2.5Heteroscedasticity Test

Table 7: Heteroscedasticity Test (Breusch-Pagan-Godfrey)

Null Hypothesis: Homoscedasticity

F-statistic	2.741682	Prob. F(2,27)	0.0824
Obs*R-Squared	5.064159	Prob. Chi-Square(2)	0.0795
Scaled Explained SS	8.829229	Prob.Chi-Square (2)	0.0121

Source: Output using Eviews 11.0 Software

Table 7 shows that the probability of the observed R-R square (0.0795) is greater than 0.05 and is therefore acceptable. Therefore, the null hypothesis of the absence of homogeneity is not rejected. In this case, both the F- and $\chi 2$ ('LM') versions of the test statistic give the same conclusion that there is no evidence for the presence of heteroscedasticity, since the p-values are considerably in excess of 0.05.

3.2.6 Post Estimation Test

This will require verifying whether the estimates from the error correction model are reliable. The most relevant post-estimation tests for dynamic model include: linearity test (using Ramsy Reset test), serial correlation tests (using the LM test), normality test (using Jack-Bera test), and stability test (using

CUSUM test). These tests are residual based and they are performed on the preferred model.

3.2.7 Linearity Test (Ramsey Reset Test)

The essence is to find out if there is a linear relationship between the dependent variable (HDI) and the independent variables (CO_2). The null hypothesis is that the model under consideration is linear or correctly specified. The null hypothesis for linearity is rejected since the test statistics (t-statistic, f-statistic and likelihood ratio statistic) are statistically significant.

Table 8: Stability diagnostic: Ramsey RESET Test

	Value	df	Probability
t-statistic	2.764219	26	0.0103
F-statistic	7.640909	(1,26)	0.0103
Likelihood ratio	7.729389	1	0.0054

Source: Output using Eviews 11.0 Software

3.2.8 Autocorrelation Test (LM test)

To find out if our specification exhibits autocorrelation problem, Eviews provides us with several methods of testing for the presence of serial correlation. The Breusch-Godfrey LM test is one of the prominent tests. The null hypothesis is that there is no serial correlation. Table 8 shows that the probability of the observed R-squared is greater than 0.05 and is reasonable. Both statistics indicate that there is no presence of serial correlation in the model. Therefore, the null hypothesis of no serially correlated residuals (i.e., autocorrelation) is not rejected).

Table 9: Breusch-Godfrey Serial Correlation LM Test

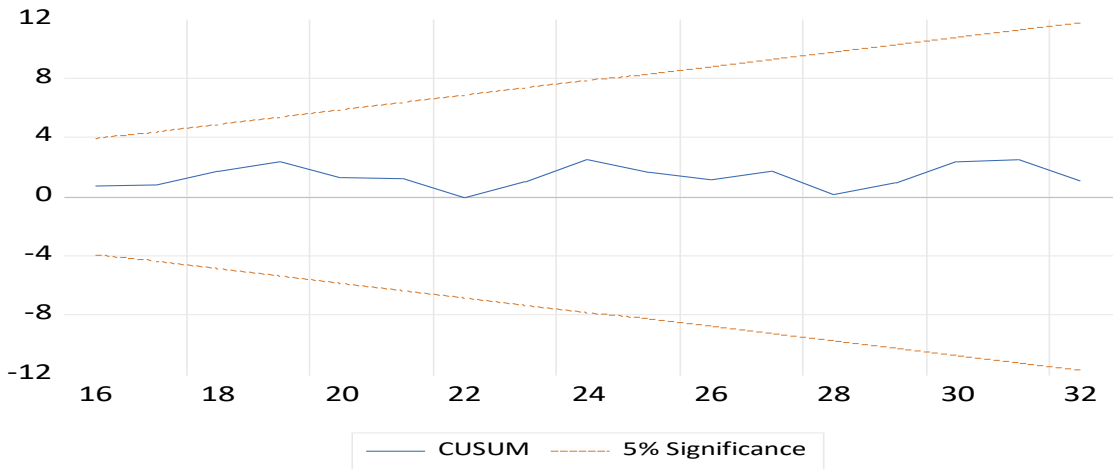
Null Hypothesis: No Serial Correlation at up to 2lags

F-statistic	0.212182	Prob. F(2,25)	0.8103
Obs*R-squared	0.500736	Prob.Chi-Squared (2)	0.7785

Source: Output using Eviews 11.0 Software

3.2.9 Stability Test (CUSUM Residual Test)

The CUSUM test for stability is meant to determine the appropriateness and the stability of the model. Put differently, the CUSUM test is used to show whether the model is stable and is suitable for making long run decision. The long-run coefficient stability was tested using short-run dynamics. To assess the stability of the estimations, the cumulative sum of the recursive residuals (CUSUM) was used. At a 5% level of significance, the plot of CUSUM is within critical boundaries, indicating that our regression model specification is stable and accurate as illustrated in Figure 3. The diagnostic tests confirmed the model's validity. It suggests that researchers, policymakers, and decision-makers can have confidence in the model. The figure below shows that the plot of CUSUM for the model under consideration is within the five per cent critical bound. This by implication suggests that the parameters of the model do not suffer from any structural instability over the period of study. That is, all the coefficients in the error correction model are stable.



Source: Output using Eviews 11.0 Software

Figure 3: CUSUM at 5% Significance level

3.2.10 The Dynamic Response Analysis

Further study is necessary using both the impulse response function and variance decomposition based on the ARDL, and the findings for consideration for 10 periods, to investigate the dynamic effects of the model reacting to specific shocks as well as how the effects are among the three variables.

3.2.11 The Variance Decompositions

The term "variance decomposition" refers to the breakdown of mean square error into the individual contributions of each variable. This technique can be used to examine how each variable's update affects the other variables and to show the relative effects. Table 10 shows that the variance in the HDI projections is not accurate, and that part of it may be due to arbitrary innovation shocks to CO_2, including itself. The study's findings suggest that there are two co-integration relationships existing between the two variables. Co2 has a low effect in the long run. Future studies on the subject are recommended by the study, and they should take additional variables into account that could have an impact.

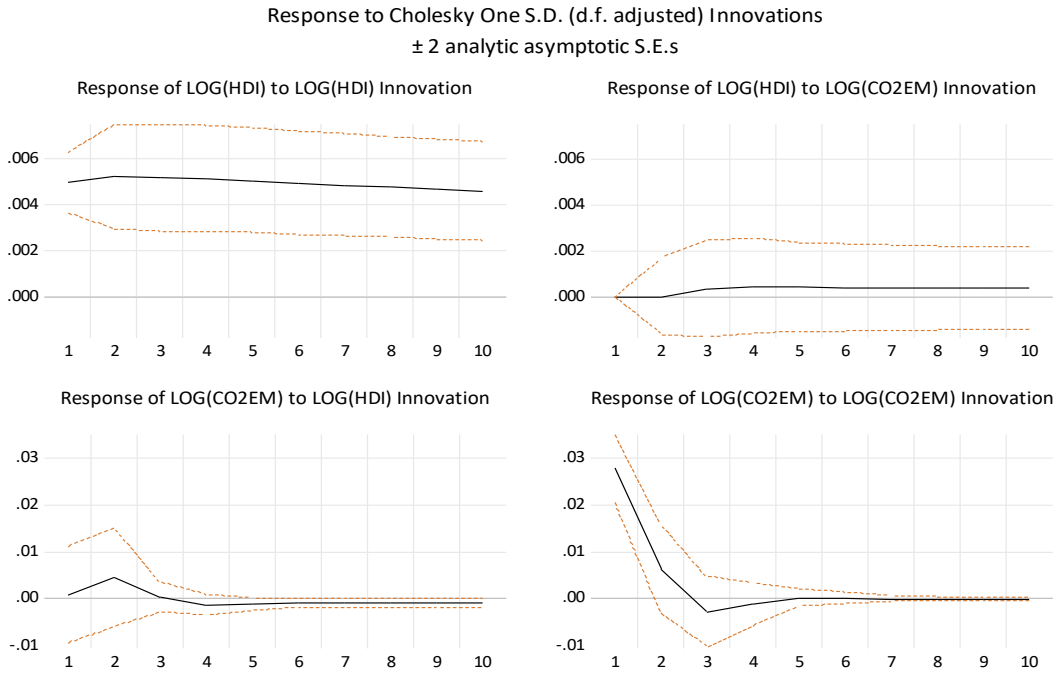
Table 10: Variance Decomposition of Log (HDI)

Period	S.E.	Log(HDI)	Log(CO_2 Emissions)
1	0.004964	100.0000	0.000000
2	0.007201	99.99904	0.000962
3	0.008871	99.82540	0.174605
4	0.010261	99.66683	0.333171
5	0.011448	99.59388	0.406119
6	0.012481	99.55484	0.445164
7	0.013399	99.52652	0.473476
8	0.014225	99.50458	0.495415
9	0.014977	99.48769	0.512315
10	0.015666	99.47440	0.525604

Source: Output using Eviews 11.0 Software

3.2.12 The Impulse response analysis

The impulse response analysis of the ARDL is shown in Figure 6. The effects of D (CO_2) on D(HDI),) are displayed in the first two rows. These details are shown in Figure 6: First, it is discovered that positive shock has a significant impact after examination of the impacts of CO_2 shock. After a positive shock, HDI subsequently stabilizes. This shows that CO_2 's positive shock has a little impact on the HDI index's increase. Figure 4 reveals the impulse response analysis between the HDI and the CO_2 emissions.



Source: Output using Eviews 11.0 Software

Figure 4: Impulse response function

4. Conclusion and policy implications

Since the last four decades the world has been facing different challenges of environmental degradation, namely, the CO_2 emissions. The impact of CO_2 emissions on all humans, and human development cannot be ignored in this contemporary world. Based on this background, this study was conducted to empirically examine the impact of CO_2 emissions on the human development index over the years (1990-2021) in the Saudi economy using the (ARDL) model. The findings of the empirical investigation revealed a significant relationship between CO_2 with the human development index. The study recommends for the inclusion of the environmental indicators, namely, the CO_2 emissions, when designing policies for the human development in the Saudi Arabia. Furthermore, the study calls for adopting alternatives and other sources of renewable energy rather than the CO_2 emissions. Finally, the study is highly raised the community awareness and cooperation in the field of lessening the CO_2 emissions in their daily practices and activities. The study has potential limitations. For example, when conducting this type of study, it is important to have a sufficient sample size in order to draw valid conclusions. The larger the sample, the more precise the results will be. Therefore, the present study calls for further time series data of the variables. In addition, the study recommends further and future research for panel data and cross-section studies.

References

Acaravci, A., & Ozturk, I. (2010). Electricity consumption-growth nexus: Evidence from panel data for transition countries. Energy Economics, 32, 604–608. https://econpapers.repec.org/scripts/redir.pf?u=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS0140-9883%2809%2900199-6;h=repec:eee:eneeco:v:32:y:2010:i:3:p:604-608

Adrangi, B.; Kerr, L. (2022). Sustainable Development Indicators and Their Relationship to GDP: Evidence from Emerging Economies. Sustainability. 14, 658. https://doi.org/10.3390/su14020658.

Alkhathlan, K., & Javid, M. (2013). Energy consumption, carbon emissions and economic growth in Saudi Arabia: An aggregate and disaggregate analysis. Energy Policy, 62, 1525–1532. http://www.sciencedirect.com/science/article/pii/S0301421513007118.

Amer, H. (2020). The Impact of Renewable Energy Consumption on the Human Development Index in Selected Countries: Panel Analysis (1990-2015). Int. J. Economy, Energ. Environ. 5(47). https://doi.org/10.11648/j.ijeee.20200504.12

Barić, D., Zovak, G., and Periša, M. (2013), Effects of eco-drive education on the reduction of fuel consumption and CO2 emissions, Promet-Traffic&Transportation, 25(3), 265–272.

Dincer, I., 2000. Renewable energy and sustainable development: a crucial review. Renewable and sustainable energy reviews, 4 (2), 157-175. https://doi.org/10.1016/S1364-0321(99)00011-8

Eren, M., Çelik, A. K., & Kubat, A. (2014). Determinants of the levels of development based on the Human Development Index: A comparison of regression models for limited dependent variables. Rev. Eur. Stud., (6)10, 9-23.. file:///C:/Users/hp140/Downloads/32501-113661-1-PB.pdf

Grossman, G. M. and Krueger, A. B. (1995), Economic growth and the environment, Q. J. Econ., 110(2), 353–377, doi: 10.2307/2118443.

Hitam, M. Bin, & Borhan, H. B. (2012). FDI, Growth and the Environment: Impact on Quality of Life in Malaysia. Procedia - Social and Behavioral Sciences. 50, 333-342. https://doi.org/10.1016/j.sbspro.2012.08.038.

Hdom, H. A. D., and Fuinhas, J. A. (2020). Energy Production and Trade Openness: Assessing Economic Growth, CO2 Emissions and the Applicability of the Cointegration Analysis. Energ. Strategy Rev. 30, 100488. https://doi.org/10.1016/j.esr.2020.100488.

Im, K. S., Hashem Pesaran, M., and Shin, Y. (2003). Testing for Unit Roots in Heterogeneous Panels. J. Econom. 115, 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7

John Mirowsky, et al. (2005). Education, learned effectiveness and health. London Review of Education 3(3):205-220. DOI:10.1080/14748460500372366

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. Journal of Energy and Development, (3), 401–403. https://www.jstor.org/stable/24806805.

Laté Ayao Lawson. GHG emissions and fossil energy use as consequences of efforts of improving human well-being in Africa. 2020. J Environ Manage. https://doi.org/10.1016/j.jenvman.2020.111136

Levin, A., Lin, C. F., and Chu, C. S. J. (2002). Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties. J. Econom. 108, 1–24. https://doi.org/10.1016/S0304-4076(01)00098-7

Liu, N., Hong, C., and Sohail, M. T. (2022), Does financial inclusion and education limit CO2

emissions in China? A new perspective, Environ. Sci. Pollut. Res., 29(13), 18452–18459.
Maddala, G. S., and Wu., S. (1999). A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. Oxford Bull. Econ. Stat. (61), 631–652. https://doi.org/10.1111/1468-0084.0610s1631
Martinez, D. M., & Ebenhack, B. W. (2008). Understanding the role of energy consumption in human development through the use of saturation phenomena. Energy Policy, (36), 1430–1435. https://www.researchgate.net/publication/223021198_Understanding_the_role_of_energy_consumption_in_human_development_through_the_use_of_saturation_phenomena
Maye, Rajeh, et al (2021). The impact of CO2 emissions on economic growth in the Kingdom of Saudi Arabia from 1980-2018. Ru'a Economic Review. Volume (11) 2, 93-111. https://www.asjp.cerist.dz/en/article/175470
Mehrara, M. (2007). Energy consumption and economic growth: The case of oil Energy consumption and economic growth: The case of oil exporting countries. Energy Policy, (35), 2939–2945. https://doi.org/10.1016/j.enpol.2006.10.018
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. Electrical Power and Energy Systems, (53), 338–347. https://doi.org/10.1016/j.ijepes.2013.05.024
Ouedraogo, N. (2013). Energy consumption and human development: evidence from a panel. Energy, (63), 28–41. https://doi.org/10.1016/j.energy.2013.09.067
Paliova I., McNown R., Nülle G. (2019). Multiple dimensions of human development index and public social spending for sustainable development. IMF, WP/19/204, 1–42. file:///C:/Users/hp140/Downloads/wpiea2019204-print-pdf.pdf.
Pesaran, M. H. (2003). A Simple Panel Unit Root Test in the Presence of Cross Section Dependence. Cambridge Working Papers in Economics. 0346, University of Cambridge. https://ideas.repec.org/p/cam/camdae/0346.html
Phelan Jo C, Link Bruce G. (2005). Controlling Disease and Creating Disparities: A Fundamental Cause Perspective. Journals of Gerontology: SERIES B. ;(60), 27–33. https://doi.org/10.1093/geronb/60.special_issue_2.s27
Phetkeo Poumanyvong and Shinji Kaneko, (2010), Does urbanization lead to less energy use and lower CO2 emissions? A cross-country analysis, Ecological Economics, 70, (2), 434-444.
.
https://econpapers.repec.org/scripts/redir.pf?u=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS0921-8009%2810%2900388-5;h=repec:eee:ecolec:v:70:y:2010:i:2:p:434-444
Sandra Chukwudumebi Obiora, Yong Zeng, Qiang Li, Emelia Asiedu-Ayeh, Grace Ugochi Nneji & Olusola Bamisile (2021).The economic growth and environmental sustainability nexus: a metanalysis of three economic types. Journal of Environmental Planning and Management. (65)14: 2556-2586. https://doi.org/10.1080/09640568.2021.1973974
Steinberger, J. K., & Roberts, J. (2010). From constraint to sufficiency: The decoupling of energy and carbon from human needs, 1975–2005. Ecological Economics, (70), 425–433. https://econpapers.repec.org/scripts/redir.pf?u=http%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS0921-8009%2810%2900373-3;h=repec:eee:ecolec:v:70:y:2010:i:2:p:425-433
Swift, R. (2011). The relationship between health and GDP in OECD countries in the very long run.

Health economics, 20(3), 306-322. https://doi.org/10.1002/hec.1590
Tampakoudis, I.A.; Fylantzopoulou, D.; Nikandrou, K. (2014). Examining the Linkages between GDP Growth and Sustainable Development in the Eurozone. J. Econ. Bus. 17, 15–27.
https://www.u-picardie.fr/eastwest/fichiers/art183.pdf.
The United Nations Development Programme, Human Development Reports. "Technical Notes: Calculating the Human Development Indices—Graphical Presentation,".
Ziolkowska, J. and Ziolkowski, B., (2010). Sustainable Development in the European Union: Tools for policy evaluation, Annals of the University of Petroşani, Economics, 10 (3): 373-382.
http://upet.ro/annals/economics/pdf/2010/20100340.pdf

تأثير انبعاثات ثاني أكسيد الكربون على التنمية البشرية: حالة السعودية

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ملخص: على مدى العقود القليلة الماضية، واجه البشر العديد من تحديات التدهور البيئي، بما في ذلك انبعاثات ثاني أكسيد الكربون. ولا يمكن التغاضي عن أهمية انبعاثات ثاني أكسيد الكربون في تحسين التنمية البشرية في هذا العالم الحديث. ومن هذا المنطلق فإن الهدف الأساسي لهذه الدراسة هو إجراء دراسة بحثية لأثر انبعاثات ثاني أكسيد الكربون على مؤشر التنمية البشرية للأعوام (1990-2021) في الاقتصاد السعودي باستخدام نموذج (الانحدار الذاتي ذو الفجوات المبطأة). حيث كشفت نتائج البحث عن وجود علاقة إيجابية معنوية بين ثاني أكسيد الكربون ومؤشر التنمية البشرية (بقيمة T= 3.046123، ومستوى أهمية(0.0051). بالإضافة إلى ذلك، تشير قيمة R-squared المعدلة البالغة 0.995064 إلى أن ثاني أكسيد الكربون هو متغير تفسيري جيد جدًا في النموذج. وأثنت الدراسة على وجود المؤشرات البيئية، وهي انبعاثات ثاني أكسيد الكربون، عند صياغة سياسات التنمية البشرية في المملكة العربية السعودية.

كلمات مفتاحية: مؤشر التنمية البشرية، الانحدار الذاتي ذو الفجوات المبطأة، ثاني أكسيد الكربون، السعودية.