

# The impact of economic growth, FDI and Tourism on CO2 emissions in Saudi Arabia

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#### Abstract:

This paper examines the impact of economic growth, foreign direct investment (FDI), and tourism on (CO2) emissions by utilizing data from Saudi Arabia spanning from 1970 to 2022. The study employed autoregressive distributed lag (ARDL) models to compute the variables pertaining to the stationarity of the time series. Through the estimation of the ARDL model, it was determined that CO2 emissions at (t-1), foreign direct investment, GDP per capita, electricity production from renewable sources, international tourism, and total natural resources rents at (t-1) have a substantial long-term impact on CO2 emissions. Conversely, domestic credit to the private sector by banks, foreign direct investment at (t-1), natural gas rents, and oil rents do not exhibit any long-term influence on CO2 emissions. Regarding the short-term scenario, it can be concluded that CO2 emissions at a lag of one period, electricity production from renewable sources, inflow of FDI, FDI at (t-1), GDP per capita, electricity production from renewable sources, international tourism, total rents derived from natural resources at (t-1), rents derived from natural gas, and rents derived from oil possess a significant influence on CO2 emissions in the case of Saudi Arabia.

keywords: identity, belonging, faith, postmigration, transculturality.



تأثير النمو الاقتصادي والاستثمار الأجنبي المباشر والسياحة على انبعاثات ثاني أكسيد الكربون في المملكة العربية السعودية د. لمياء محمد جمال قسم المالية والاقتصاد، كلية إدارة الأعمال، جامعة طيبة ملخص الدراسة:

تبحث هذه الورقة في تأثير النمو الاقتصادي والاستثمار الأجنبي المباشر والسياحة على انبعاثات ثاني أكسيد الكربون، من خلال الاستفادة من البيانات من الملكة العربية السعودية الممتدة من عام 1970 إلى عام 2022. استخدمت الدراسة نماذج الانحدار الذاتي الموزع (ARDL) لحساب المتغيرات المتعلقة بثبات السلسلة الزمنية. ومن خلال تقدير نموذج أردل، تم تحديد أن انبعاثات ثاني أكسيد الكربون عند (ت-1)، والاستثمار الأجنبي المباشر، والناتج المحلى الإجمالي للفرد، وإنتاج الكهرباء من مصادر متجددة، والسياحة الدولية، وإجمالي إيجارات الموارد الطبيعية عند (ت-1) لها تأثير كبير طويل الأجل على انبعاثات ثابي أكسيد الكربون. وعلى العكس من ذلك، فإن الائتمان المحلى للقطاع الخاص من قبل البنوك، والاستثمار الأجنبي المباشر عند (ت-1)، وإيجارات الغاز الطبيعي، وإيجارات النفط لا تظهر أي تأثير طويل الأجل على انبعاثات ثاني أكسميد الكربون. وفيما يتعلق بالسميناريو القصمير الأجل، يمكن استنتاج أن انبعاثات ثاني أكسيد الكربون عند تأخر فترة واحدة، وإنتاج الكهرباء من مصادر متجددة، وتدفق الاستثمار الأجنبي المباشر، والاستثمار الأجنبي المباشر عند (ت-1)، والناتج المحلى الإجمالي للفرد، وإنتاج الكهرباء من مصادر متجددة، والسياحة الدولية، وإجمالي الإيجارات المستمدة من الموارد الطبيعية عند (ت-1)، والإيجارات المستمدة من الغاز الطبيعي، والإيجارات المستمدة من النفط تمتلك تأثيرًا كبيرًا على انبعاثات ثابي أكسيد الكربون في حالة المملكة العربية السعودية الكلمات المفتاحية: انبعاثات ثاني أكسيد الكربون، النمو الاقتصادي، الاستثمار الأجنبي

المباشر، إيجارات الغاز الطبيعي، السياحة، ARDL

### 1. Introduction

In recent years, there have been increasing increases in traditional energy prices and fears of unstable and near-effective supply, on the one hand, and its adverse effects on the environment, on the other. Energy is the driver of economic sectors. Energy in all aspects of life is applied differently. Global interest in renewable energy has recently increased in terms of consumption and is sustainable and contributing to driving development, with the amount of energy consumed per capita in a country becoming a measure of economic growth and a reflection of that country's level of development. The Kingdom of Saudi Arabia is among the countries that have endeavored to promote the development of renewable energies by establishing the High Governorate of Renewable Energies to develop research in this area, through the development of a number of strategies and policies aimed at achieving economic and social gains to improve its economy on the one hand, and the gradual transition towards a green economy on the other.

Renewable energy is also the primary alternative energy that can respond to fossil fuel depletion because it is more sustainable and environmentally friendly than fossil fuels and the use and development of renewable energy has become a major theme in global energy demand, In recent years, many countries have insisted on developing and deploying renewable energy for the face of the global environmental crisis, such as fossil energy depletion and the Climate Convention for the Control of Carbon Dioxide Emissions (Kim et al., 2014).

Climate change has been viewed as an emerging global issue, and there are clear conclusions about the significant impact of global pollution reduction on economic growth (Saad and Taleb, 2017), so policymakers have recently turned to encouraging renewable energy generation and use through economic activities to ensure a lowcarbon economy (Paramati et al., 2017).

For tourist destinations, the circular economy can achieve a high degree of competitiveness, not only in terms of opportunities for

excellence and diversification of income sources, but also in the view of governments and investors towards environmental conservation policy, social responsibility, and governance, as adopted by the Kingdom's Vision 2030 in the development of tourism destinations and the development of cities. The circular economy also provides an opportunity to enhance the impacts of sustainable tourism development, generating the well-being of the local population through the creation of new jobs and the development of small and medium investment opportunities owned by the local population. The circular economy thus creates a spiral circle between the environment, society, culture, tourism activity, businesses, and areas adjacent to the tourist destination within the value chain.

Arriving visitors tend to increase a nation's GDP growth, but they also use a lot of energy that comes from fossil fuels, which is considered to harm the environment (Tsui et al. 2018; Gössling and Peeters 2015: Asayesh, 2021; Korotkih, 2023). The increasing amount of tourism has a negative impact on the environment because it uses a lot of energy for things like transportation, lodging for visitors, building, wood burning, and other tourist activities (Becken et al. 2001; Ramezani Gourab and Foroughe, 2010; Scott et al. 2010; Tsui et al. 2018).

According to research by the World Tourism Organization (UNWTO 2018), there is expected to be a rise in the overall number of tourists arriving worldwide in the upcoming years. There were 25 million visitors in 1950; by 2017, that figure had risen to 1326 million, of which 323.1 million were from Asia. The UNWTO also found that, by 2017, the yearly growth rate of tourists arriving was 4.2%, with 6.4% of those tourists being from the Asian area. The national revenue of rising developing nations is significantly impacted by the growing growth rate of foreign tourists.

Using Saudi Arabia as an example, the relationship between economic growth, tourism, and CO2 emissions may be utilized to investigate the effects of economic and tourism-related activities on environmental quality.

مجلة العلوم الإنسانية والاجتماعية

Sustainable economic growth presents a complex issue in Saudi Arabia. The economy of Saudi Arabia heavily relies on oil and gas exports, thus exposing it to fluctuations in global oil prices. The Saudi government is cognizant of this challenge and has implemented strategies to diversify the economy; however, many unresolved issues persist.

One of the primary obstacles to achieving sustainable economic growth in Saudi Arabia lies in the imperative to diminish the nation's reliance on oil and gas exports. The Saudi government has established an ambitious target of reducing oil dependency to 50% by 2030. While this goal is ambitious, it is plausible if the government continues to allocate resources to non-oil sectors such as tourism, manufacturing, and technology.

The challenge of climate change is also being confronted by the Saudi government. The adverse effects of climate change are currently being felt on the Saudi economy, with projections indicating a further exacerbation in the future. An imperative for the Saudi government is to allocate resources towards renewable energy and other environmentally friendly technologies in order to mitigate the nation's carbon footprint and enhance economic resilience against climate change impacts. Despite the obstacles, there exist limited prospects for sustainable economic advancement within Saudi Arabia. This is attributed to factors such as a youthful and expanding populace, a highly educated labor force, and plentiful natural resources. Moreover, the Saudi government has demonstrated a commitment to broadening the economic base and fostering investments in non-oil industries.

The objective of this paper is to examine the impact of economic growth, foreign direct investment (FDI), and tourism on carbon dioxide (CO2) emissions through the utilization of data from Saudi Arabia spanning the years 1970 to 2022. The study employed autoregressive distributed lag (ARDL) models to calculate the variables pertaining to the stationarity of the time series. This subject holds significant importance for scholarly examination due to the



prominent role of Saudi Arabia as a leading oil-producing nation, with a substantial dependence on the oil and gas industry for its economic stability. Nevertheless, the nation encounters several hurdles including population expansion, environmental shifts, enhancement of tourism, and the imperative to broaden its economic base.

The remainder of this paper is structured as follows: Section 2 provides a literature review. Section 3 discusses the data. Section 4 presents the methodology. Section 5 presents descriptive statistics. Section 6 summarizes the empirical findings. Section 7 presents the robustness test of the empirical results. Finally, Section 8 concludes.

# 2. Literature review

Many studies have tested the causal link between energy consumption and economic growth in a primary way, and then between energy consumption and economic growth and emissions of CO2 and Tourism. Evaluating the relationship between renewable energy (REC) use and GDP growth in the US, Usman et al., (2020) found that REC has a negative impact on environmental degradation due to its negative association with the "ecological footprint". However, the study also found that GDP and BC have an increase while TP has a decrease on EF. Hussain et al., (2019) examine the environmental impact of energy use in Malaysia on GDP growth. The study found a positive and significant correlation between the EC and GDP growth. The results of the study were further confirmed through the application of the Granger (Causality) test.

Hammami and Saidi (2015) show that CEs have a positive effect on EC at a global level. GDP (gross domestic product) has a positive correlation with EC but a positive and significant correlation at a regional level. The relationship between GDP, CE, and EC is complementary. Omri et al. (2014) show that FDI (foreign direct investment) and GDP are inversely related. FDI and CE are inversely related across the world, except for North Asia. The study also finds that across a broad reverse causal relationship between CE and GDP, the higher the GDP growth rate, the higher the CE level will be. The

use of cleaner technology and more efficient energy sources are essential for maintaining higher economic growth rates and reducing CE levels.

The relationship among tourism and economic growth has been examined in the literature from two angles: when it comes to the tourist industry, the theory of endogenous growth is applied from the perspective of the Keynesian theory of the multiplier. Among the earliest studies on this topic are those by Lanza and Pigliaru (2000a, 2000b), who discovered that tiny nations were the ones with the highest levels of tourist specialization, and by Balaguer and Cantavella-Jorda (2002), who studied the tourism-led growth theory for the first time.

When it comes to the metrics employed to measure both economic growth and tourism, a comparatively large number of articles analyze economic growth using metrics like GDP per capita, real GDP, change in GDP, industrial production, and the Human Development Index (Antonakakis et al., 2015; Cárdenas-García et al., 2015). On the other hand, terms like arrivals and receipts from foreign tourists are used to analyze tourism expansion. Regarding the indicators utilized or their applicability, there is still debate, nevertheless. Four hypotheses have been identified following a comprehensive study of the empirical literature on the relationship among tourist and economic growth: the tourism-led growth hypothesis, the growth-led tourism hypothesis, the bidirectional causality hypothesis, and the no causality hypothesis (Balaguer and Cantavella-Jorda, 2002).

Furthermore, there are many studies revealing similar results, such as Munir and Khan (2014), Lean and Smyth (2010), Halicioglu (2009), and Ang (2007). In this subsection, it can be summarized that the available EM-BIP-CE literature has significant problems in the choice of methodology. Furthermore, the methods used for panel estimation do not account for heterogeneous effects across countries, and cross-sectional dependence can lead to biased results that suffer from forecast errors.

Dogan and Aslan (2017) use existing and future European Union (EU) pooled datasets to explore the relationship between carbon emissions (CE), production (GDP), energy consumption (EC), and tourism. The authors claim to use a unique method of "heterogeneous panel estimation with cross-sectional dependence." This study confirms long-term relationships between key variables. Furthermore, this study found that while there is a direct relationship between EC, energy consumption, and KE, there is an inverse relationship between real GDP, tourism, and KE.

Zaman et al. (2017) investigate how tourism transport can contribute to economic growth (GDP), energy consumption (EC), and carbon emissions (CE). This study shows that the greater the GDP per capita, the greater the environmental pollution and destruction. Additionally, the study found that both income and payments from international travel increase CE and countries' per capita GDP. Furthermore, this study establishes a causal relationship between tourist payments and receipts, GDP per capita, and foreign direct investment between countries.

The existence of a connection among tourism and the CO2 emissions is self-evident. Nature has provided tourists with some of the most significant magnetisms and at the same time tourism companies have transformed the environment by building hotels, restaurants, ski slopes and wellness centers. We can therefore speak of a one-to-one link among them.

The first research on this topic dates back to the CO2 emissions movement of the 1980s and 1990s (Jacobson and Robles, 1992; Milne, 1992). After several countries experienced a significant increase in the number of international tourists, authors and researchers have attempted to measure the negative influence. For example, Milne (1992) focuses on the microstates of the South Pacific.

At the same time, Meyer (1993) was interested in alpine soils in Austria.'s research absorbed on several topics. The negative influences of tourists, such as litter (Havlikova and Sobotkova,

مجلة العلوم الإنسانية والاجتماعية

العدد الرابع والسبعون شوال 1446ه (الجزء الأول)

211



2018), the terrestrial and aquatic CO2 emissions (Lui, 2019), erosion of monuments and memorials (Wójtowicz, 2018), have been the subject of numerous research. Other authors have absorbed on the negative influences of hotels and other accommodation facilities on the natural environment, predominantly in rural and remote areas (Yusoff et al., 2021; Cioancă, 2015). On a macro level, tourism activities are linked to climate change. This issue became more significant after 2010, when the debate about international warming intensified significantly (Weir, 2017).

Shafaki et al. (2024) examine sustainable tourism in the countries and cities situated in the Middle East and North Africa (MENA) region. The study commences by presenting an overview of the region, which encompasses 20 countries from Morocco in the west to Iran in the east. Following this, a broad discussion on sustainable development and sustainable tourism in the region is provided, along with an analysis of the associated challenges, notably natural resources. and geopolitical instability. Α comprehensive examination of tourism and tourism patterns in the MENA region is presented. Subsequently, attention is directed towards individual countries and cities within MENA and their respective sustainable tourism endeavors. Noteworthy destinations such as Egypt, Jordan, Morocco, Oman, Türkiye, and the UAE (including Abu Dhabi and Dubai) are recognized as frontrunners in sustainable tourism practices. These countries exhibit significant discrepancies in terms of international visitor numbers. The narrative includes a portrayal of the emerging sustainable or eco cities in various nations. The outlook for sustainable tourism in MENA is deliberated upon, acknowledging the persistence of geopolitical challenges and natural calamities while highlighting the ambitious tourism expansion plans implemented by several countries. The chapter concludes with a series of deductions and suggestions.

Wijerathna and Dharmarathna (2023) conduct an analysis on the impact of financial development on global Carbon (CO2) emissions. They utilized newly introduced comprehensive financial development indexes from the International Monetary Fund (IMF), such as the financial development index, financial market index, and

financial institutions index, alongside metric tons per capita of CO2 emission from the World Development Indicators (WDI) to assess financial development and CO2 emission levels, respectively. The researchers applied panel cointegration tests followed by panel unit root tests to uncover the long-term relationship between the variables. Furthermore, FMOLS and DOLS estimators were utilized to explore the enduring effects. The study confirmed a significant positive long-term association between financial development and CO2 emissions on a global scale. Particularly, financial institutions exhibited notably higher long-term coefficients compared to the financial market index. The impact of the financial institutions index on emissions was significant, playing a crucial role in the positive and significant impact of the overall financial development index. Consequently, transitioning towards environmentally friendly products, services, and technologies while reducing carbon footprints is imperative for financial institutions.

Nguyen and Nguyến (2022) investigate the influence of the existing information and communication technology (ICT) infrastructure and the evolution of the destination's ICT on the demand for tourism from international visitors in an emerging economy, Vietnam. Employing time-series data spanning from 1995 to 2019, this study utilizes a vector error correction model to scrutinize the impact of ICT infrastructure in both the short and long run. The findings of the analysis indicate that while ICT infrastructure does not have an immediate effect on the volume of international tourists, it does make a favorable contribution to the advancement of tourism in the prolonged duration. Furthermore, the results reveal that consumer prices exhibit a negative influence on tourist arrivals in the short term but demonstrate a beneficial impact in the long term. This inquiry solely focuses on the influence of ICT infrastructure as a whole entity without delving into individual factors that represent diverse facets of the ICT infrastructure. Furthermore, this investigation concludes at the pre-pandemic era, hence failing to illustrate the role of ICT infrastructure in shaping travel and tourism demand amidst severe pandemic periods.

Eusébio et al. (2023) investigated the correlation between individuals' perceptions of air quality and their engagement in proenvironmental actions during their visits. The study categorized participants according to their self-disclosed pro-environmental behaviors. A survey was conducted among 602 individuals in Portugal. The analysis revealed three distinct clusters characterized by varying degrees of pro-environmental engagement: individuals seeking eco-friendly transportation options, visitors with strong environmental dedication, and individuals showing little concern for environmental issues. Discrepancies were noted across the clusters in terms of pro-environmental practices in domestic settings, environmental attitudes, assessments of air quality at the destination, perceptions of the impact of air quality on health, as well as sociodemographic and travel-related factors.

Anser et al. (2022) investigate the relationship between services trade and ICT on sustainable tourism in Asia. Utilizing an unbalanced panel dataset encompassing 44 countries in East Asia, the Pacific, and South Asia from 2010 to 2019, the study examines the impact using variables such as tourism receipts, services trade, and four ICT indicators (mobile phones, Internet users, fixed broadband, and secured internet servers). This research, in a broader context, seeks to address two main inquiries: the individual effects of ICT usage and services trade on tourism, and whether the interaction between ICT and services trade enhances or diminishes the influence on tourism. By employing the PSCC-LSDV and MM-QR robustness techniques, the results indicate that (1) both services trade and ICT have a positive impact on tourism; (2) the negative interaction between services trade and ICT does not negate the positive effect of services trade; (3) the effects of services trade and ICT usage, as well as their interaction, vary significantly across different sub-regions; and (4) the effects of services trade and ICT usage exhibit heterogeneity across various quantiles. The study concludes with a discussion on policy recommendations.

## 3. Data

This paper aims to examine the impact of economic growth, FDI and Tourism on CO2 emissions in Saudi Arabia during the period of study from 1970 to 2022. Table 1 presents all applicable variables and data assembly with their sources. All variables are collected from World Bank database.

Variables	Description	Source	Symbols
CO2 emissions	CO2 emissions (kg per 2017 PPP \$ of GDP)	World Bank database	CO2
Oil rents	Oil rents (% of GDP)	World Bank database	OILR
Foreign direct investment	Foreign direct investment, net inflows (% of GDP)	World Bank database	FDI
Natural gas rents	Natural gas rents (% of GDP)	World Bank database	NGASR
International tourism	International tourism, number of arrivals	World Bank database	NITA
Electricity production from renewable sources	Electricity production from renewable sources, excluding hydroelectric (% of total)	World Bank database	EPNS
Total natural resources rents	Total natural resources rents (% of GDP)	World Bank database	TNSR
GDP per capita	GDP per capita (constant LCU)	World Bank database	GDP
Domestic credit to private sector by banks	Domestic credit to private sector by banks (% of GDP)	World Bank database	DCPS

TABLE 1. Variables, description, sources and symbols

Source: Owen elaboration

# 4. Methodology

In this paper, we use LnCO2 which measures log of CO2 emissions, LnDCPS which measures log of Domestic credit to private sector by banks, LnEPNS which measures log of Electricity production from renewable sources, LnFDI which measures log of, LnGDP which measures log of GDP per capita, LnNGASR which measures log of Natural gas rents, LnNITA which measures log of International tourism, LnOILR which measures log of Oil rents, and LnTNSR which measures log of Total natural resources rents as a time series indicators to examine the impact of economic growth, FDI and Tourism on CO2 emissions in Saudi Arabia during the period of study from 1970 to 2022.

The present study integrates the EKC and IPAT financial models in order to establish an original model that stands on its own merits.

مجلة العلوم الإنسانية والاجتماعية

العدد الرابع والسبعون شوال 1446ه (الجزء الأول)

This investigation explores the disruptive U-shaped EKC phenomenon utilizing the EKC model. In the following equal, the model is shown.

$$LnEC_t = \vartheta GDP_t + \theta LnGDP_t^2 + u_1 \tag{1}$$

GDP<sup>1</sup> is measured as a GDP in the early stages of improvement, GDP<sup>2</sup> as a GDP in the latter stages of development, and v as the wrong term,  $\phi$  and  $\emptyset$  are parameters, such that  $\phi > 0$  and  $\emptyset < 0$ . An additional model utilized in this paper is named the IPAT model; it is presented as follows:

$$I = f(P, A, T) \tag{2}$$

The IPAT and EKC models have been employed in examining the impact of energy consumption and economic development on carbon dioxide emissions. This investigation centers on the domains of energy, flammable gas, petroleum, and tourism, featuring the subsequent model specifications:

$$LnCO_{2t} = \alpha_0 + \alpha_1 LnDCPS_t + \alpha_2 LnEPNS_t + \alpha_3 LnFDI_t + \alpha_4 LnGDP_t + \alpha_5 LnNGASR_t + \alpha_6 LnNITA_t + \alpha_7 LnOILR_t + \alpha_8 LnTNSR_t + \varepsilon_1$$
(3)

Where,  $\alpha_0$  present the constant,  $\alpha_i$  present the coefficients of explicative indicators (LnDCPS, LnEPNS, LnFDI, LnGDP, LnNGASR, LnNITA, LnOILR, and LnTNSR) where i = 1, ..., 8, presents the error term, and t indicates the time (t = 1, ..., 53)

The ARDL method offers superior benefits compared to other models, such as the Johansen approach and Engle-Granger strategies. By delving into a deeper understanding of the model's mechanics, we can evaluate its performance relative to models utilizing stationary (I(0)) and non-stationary (I(1)) components. Consequently, the Expanded Dickey-Fuller (ADF) test is employed to ascertain the presence of a unit root in a given time-series dataset.

## 5. Descriptive analysis

The descriptive statistics for all of the variables employed in this paper are presented in Table 2. LnCO2, LnDCPS, LnEPNS, LnFDI, LnGDP, LnNGASR, LnNITA, LnOILR, and LnTNSR are all incorporated in the Table 2 which provides the Mean, Median, Maximum, Minimum, Std. Dev., Skewness, Kurtosis, and Jarque-Bera Probability values. From the results presented in Table 2, each indicators have a considerable variance mainly LnDCPS, LnEPNS, LnFDI, LnNGASR and LnNITA.

For the two statistics of skewness (asymmetry) and kurtosis (leptokurtic), we can show that the variables used in our study are characterized by non-normal distribution. The positive sign of the skewness coefficients indicates that the variables LnCO2, LnGDP, LnNITA, LnOILR, and LnTNSR are skewed to the right, and it is far from being symmetric for all indicators. However, the negative sign of the skewness coefficients indicates that the variables LnDCPS, LnEPNS, LnFDI, and LnNGASR are skewed to the left, and it is far from being symmetric for all indicators. Also, the Kurtosis coefficients prove that the leptokurtic for all variables used in this study find the presence of a high peak or a fat-tailed in their volatilities.

Based on the estimate Jarque-Bera coefficients, we can reject the null hypothesis of normal distribution of the variables used in our study. Then, the elevated value of Jarque-Bera coefficients indicates that the series is not normally distributed at the level of 1%.

Finally, and Based on the three statistics; skewness, kurtosis and Jarque-Bera, we can assume that all indicators utilized in this study are not normally distributed at the level of 1%.



					-				
	LnCO2	LnDCPS.	LnEPNS	LuFDI	LuGDP	LaNGASR	LUNITA	LuQILR	LaTNSR
Mean	-1.258048	2.964463	-1.677675	0.135454	11.28709	-0.644410	15.91657	3.563642	3.587742
Median	-1.330472	3.108711	0.000000	0.000000	11.19995	-0.172428	16.15895	3.531361	3.553480
Maximum	-0.999991	4.030276	0.000000	2.139637	11.83793	0.539908	16.95144	4.466887	4.469174
Minimum	-1.418236	1.011817	-8.126625	-4.540700	11.00781	-3.301780	15.29666	2.771270	2.851771
Std. Dev.	0.130107	0.846569	3.309765	1.151568	0.245024	0.994703	0.647055	0.348562	0.335718
Skewness	0.526208	-0.699561	-1.442668	-1.179176	1.181493	-1.128836	0.249884	0.262463	0.306914
Kurtosis	1.699782	2.340458	3.081963	6.820508	3.049556	2.894810	1.372555	2.732100	2.715412
Jarque-Bera	86.179237	95.283522	18.39956	44.51581	12.33611	11.28049	99.400512	92.766995	101.010921
Probability	0.000000	0.000000	0.000101	0.000000	0.002095	0.003552	0.000000	0.000000	0.000000
Observations	53	53	53	53	53	53	53	53	53

#### **TABLE 2.** Descriptive statistics

Source: Owen elaboration

Using the unit root test, you can see the results in Table 3. We find that all components are not fixed at the level with no pattern. The results also reveal that all parameters are fixed at 1% at the main difference with almost no pattern. In terms of a pattern, all the variables are set at 1%, and before evaluating the long-run coefficients, the bound test was run.

TABLE 5. The unit root lest						
Intercept Intercept and trend						
X7. • 11	AD	F stat	ADI	ADF stat		
variable	Level	1st difference	Level	1st difference		
LnCO2	-33.6441***	-36.8454***	-31.6221***	-33.6374***		
LnDCPS	-28.3564***	-30.4853***	-28.4345***	-31.5394***		
LnEPNS	-31.5678***	-34.5906***	-30.0498***	-33.3894***		
LnFDI	-34.0586***	-37.0045***	-33.5432***	-36.0373***		
LnGDP	-27.6443***	-29.4851***	-28.9560***	-31.4682***		
LnNGASR	-31.9405***	-38.0453***	-32.3284***	-35.7489***		
LnNITA	-25.1002***	-29.1530***	-26.5786***	-29.3647***		
LnOILR	-23.6784***	-28.7432***	-24.7684***	-27.1903***		
LnTNSR	-25.5096***	-27.4095***	-26.0956***	-29.0374***		
Note: *** denotes significant at the 1% level.						

TABLE 3. The unit root test

Source: Owen elaboration

#### **6.** Empirical findings

As demonstrated in Table 4, the bounded examination has been conducted and yields a result surpassing the fundamental threshold of significance at the 5% level, as dictated by the F-value. The research endeavor has the potential to employ the approach of assessing the influence of energy consumption, foreign direct investment, the tourism sector, gross domestic product, and petroleum utilization on carbon dioxide emissions within the Saudi Arabia

<b>TABLE 4.</b> The results of the bound test					
F-statistic	6.6749**				
Lag Model	1, 0, 0, 1, 0, 0, 0, 0, 1				
R2	0.8205				
Adjusted R2	0.8340				
Acute Rate	Minor Certain	Advanced Certain			
1%	-4.72	-7.41			
5%	-3.47	-6.09			
10%	-4.26	-6.46			
Note: ** indicates the signi-	ficance level of 5%, respectively				
Sou	rce: Owen elaboration				

Using the ARDL technique outlined in Table 5, an examination of the long-term effects of various factors on CO2 emissions has been conducted. These factors include CO2 emissions at (t-1), Foreign direct investment, GDP per capita, Electricity production from renewable sources, international tourism (number of arrivals), and Total natural resources rents at (t-1) have a significant impact on CO2 emissions. The findings indicate that Foreign direct investment can exert a significant long-term impact on CO2 emissions, which holds great importance at a 1% level of significance. Similarly, GDP per capita has demonstrated a robust long-term association with CO2 emissions, also significant at a 1% level of significance. Furthermore, when GDP reaches its later stages, it exhibits a positive and substantial relationship with CO2 emissions.

Based on the results, it can be concluded that Electricity production from renewable sources is negatively linked to CO2 emissions, a finding of utmost importance at a 1% level of significance. Additionally, International tourism (number of arrivals) has the

potential to exert a long-term influence, specifically a positive impact, on CO2 emissions, which holds great significance at a 1% level of significance. Moreover, Total natural resources rents at (t-1) are positively associated with CO2 emissions, a finding that is highly significant at a 10% level of significance.

In contrast, the study reveals that increased Domestic credit to the private sector by banks, Foreign direct investment at (t-1), Natural gas rents, and Oil rents do not have any long-term influence on CO2 emissions. Furthermore, there is no long-term correlation between CO2 emissions and Total natural resources rents when employing the ARDL technique.

	, <u> </u>		0	
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LnCO2(-1)	0.788672	0.089987	8.764298	0.0000***
LnDCPS	0.005641	0.028493	0.197973	0.8441
LnEPNS	-0.002810	0.002516	-5.116981	0.0000***
LnFDI	0.004779	0.004109	4.162952	0.0000***
LnFDI(-1)	-0.005431	0.003805	-1.427308	0.1613
LnGDP	-0.067217	0.051412	-5.307424	0.0000***
LnNGASR	-0.019485	0.020605	-0.945667	0.3500
LnNITA	0.049906	0.018349	2.719825	0.0096***
LnOILR	-0.561126	0.590888	-0.949631	0.3480
LnTNSR	0.566324	0.607151	0.932756	0.3565
LnTNSR(-1)	0.034236	0.018522	1.848463	0.0719*
С	-0.477889	0.669855	-0.713422	0.4797
<b>R</b> -squared	0.966874	Mean dep	endent var	-1.255887
Adjusted R-squared	0.957765	S.D. depe	endent var	0.130412
S.E. of regression	0.026801	Akaike inf	fo criterion	-4.201550
Sum squared resid	0.028733	Schwarz	criterion	-3.751263
Log likelihood	121.2403	Hannan-Q	uinn criter.	-4.028921
F-statistic	106.1377	Prob(F-	statistic)	0.000000
<b>NT</b>		1.100		

TABLE 5. The long-term impacts of employing the ARDL method

Note: \*\*\* and \* indicate significance levels of 1% and 10%, respectively.

Source: Owen elaboration

Using the ARDL technique as delineated in Table 5, an investigation has been conducted to analyze the immediate ramifications of various factors on the emissions of CO2. These factors encompass CO2 emissions at the time lag of one period, the production of electricity from renewable sources, the influx of foreign direct

investment, foreign direct investment at the time lag of one period, GDP per capita, the production of electricity from renewable sources, international tourism measured by the number of arrivals, the total rents derived from natural resources at the time lag of one period, rents derived from natural gas, and rents derived from oil. The findings suggest that CO2 emissions at the time lag of one period and the production of electricity from renewable sources possess the capacity to exert a notable immediate impact on CO2 emissions, a phenomenon of considerable significance at a 10% level of significance.

Similarly, foreign direct investment, international tourism measured by the number of arrivals, and the total rents derived from natural resources at the time lag of one period have been able to manifest a robust immediate association with CO2 emissions, also possessing significance at a 5% level of significance.

On the basis of the results, it can be inferred that foreign direct investment at the time lag of one period and GDP per capita are negatively correlated with CO2 emissions, a finding of paramount importance at a 5% level of significance. Furthermore, rents derived from natural gas and rents derived from oil bear the potential to exert a short-term influence, specifically a negative influence, on CO2 emissions, a notion of great significance at a 10% level of significance. Conversely, the study divulges that an elevated provision of domestic credit to the private sector by banks does not exert any immediate influence on CO2 emissions.

			1	
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LnCO2(-1)	2.649511	1.134001	2.336426	0.0247*
LnDCPS	0.033727	0.032707	1.031166	0.3088
LnEPNS	0.011462	0.005805	1.974428	0.0554*
LnFDI	0.015276	0.007541	2.025690	0.0497**
LnFDI(-1)	-0.020577	0.009928	-2.072661	0.0449**
LnGDP	-0.260605	0.127827	-2.038721	0.0483**
LnNGASR	-0.084355	0.044277	-1.905148	0.0642*
LnNITA	0.198046	0.091780	2.157829	0.0372**
LnOILR	-2.426290	1.272393	-1.906871	0.0639*

**TABLE 6.** The results of the ARDL short-term impact method

LnTNSR	2.464605	1.297565	1.899407	0.0649*	
LnTNSR(-1)	0.121619	0.056103	2.167775	0.0363**	
С	-0.522341	0.656543	-0.795592	0.4311	
<b>R-squared</b>	0.969026	Mean dep	Mean dependent var		
Adjusted R-squared	0.959495	S.D. depe	S.D. dependent var		
S.E. of regression	0.026247	Akaike info criterion		-4.230246	
Sum squared resid	0.026866	Schwarz	criterion	-3.742435	
Log likelihood	122.9864	Hannan-Q	uinn criter.	-4.043231	
F-statistic	101.6757	Prob(F	-statistic)	0.000000	
Note: ** and * indicate significance levels of 5% and 10%, respectively.					

Source: Owen elaboration

The diagnostic testing results are succinctly presented in Table 7. encompassing LM, Ramsey RESET stability, and Heteroscedasticity (Breusch-Godfrey Serial Correlation). The aforementioned outcomes demonstrate that the model is devoid of any diagnostic concerns, suggesting its capability to elucidate the impact of energy consumption, oil and gas revenue, economic advancement, inflows of foreign direct investment, and the growth of the tourism industry on carbon dioxide emissions.

TABLE 7. The results of	of several diagnostic p	procedures
Stat	F-Stat./Jarque-Bera	Prob
Correlation Breusch-Godfrey-Serial	0.5871	0.6420
LM		
Ramsey re-establishes order	0.0253	0.9473
Heteroscedasticity	0.4182	0.6640

0.0392

0.7527

Source: Owen elaboration

Regularity

Therefore, and based on our empirical findings presented in Table 5, we confirm the results of Shang et al. (2022) on the relationship between electricity and CO2 emissions, we admit the findings of Omri et al. (2014), Shang et al. (2022) and Wijerathna and Dharmarathna (2023) on the nexus between Foreign direct investment and CO2 emissions, we also confirm the outcomes of Shafaki et al. (2024), Zaman et al. (2017), Eusébio et al. (2023), Yusoff et al. (2021) and Cioancă (2015) on the impact of GDP and natural resources rents on tourism in the case of Saudi Arabia. However, the results of this paper are not in conformity with the findings of Dong et al (2017a; 2017b) which find that electricity has any impact on CO2 emissions.

## 7. Robustness Test

Table 8 presents the elasticity estimates derived from the robustness analysis. To validate the long-term findings, the augmented mean group (AMG) and common correlated effects (CCE) estimators are also employed for forecasting long-run elasticities. The technological long-run elasticities associated with GDP growth, population growth (LnPOP), innovation in electrical generation capacity, and technical innovation (LnTEC) are consistent across all regression estimators.

However, the technological elasticity parameters related to GDP and population growth are considered irrelevant in the context of the augmented mean group (AMG) and common correlated effects (CCE) analysis. These findings provide valuable insights for deciding whether to utilize the ARDL technique to address crosssectional dependency and heterogeneity concerns in the data. Subsequent to the regression examinations, a comprehensive causality investigation is conducted. The results indicate that financial restructuring has the potential to significantly increase the level of cloudiness contamination, both in the short and long term.

	AMG			CCE			
Variables	Coefficient	Standard error	p Value	Coefficient	Standard error	p Value	
LnGDP	-0.253122**	0.112834	0.0193	-0.253904	0.092021	0.0282	
LnFDI	0.027738*	0.005348	0.0832	0.032972	0.004632	0.0562	
LnNITA	0.172293*	0.083304	0.0641	0.163524	0.083932	0.0745	
LnOILR	-0.253940**	0.130937	0.0304	-0.239024	0.143623	0.0200	
LnPOP	0.182633	0.083465	0.5449	0.173632	0.083742	0.8940	
LnTEC	0.243394***	0.140394	0.0000	-0.235209	0.130384	0.0000	
Note: ***, *:	Note: ***, ** and * indicate significance levels of 1%, 5% and 10%, respectively.						

<b>TABLE 8.</b> The results of the Robustness te	st
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Source: Owen elaboration

#### 8. Conclusion

The present study conducted an examination of the impact of economic growth, foreign direct investment (FDI), and tourism on carbon dioxide (CO2) emissions by utilizing data from Saudi Arabia spanning from 1970 to 2022. The study employed autoregressive

distributed lag (ARDL) models to compute the variables pertaining to the stationarity of the time series. A set of explanatory variables including oil rents, FDI, natural gas rents, international tourism, electricity production from renewable sources, total natural resources rents, GDP per capita, and domestic credit to the private sector by banks were utilized, as they possess the potential to exert a significant influence on CO2 emissions. Through the estimation of the ARDL model, it was determined that CO2 emissions at time point (t-1), foreign direct investment, GDP per capita, electricity production from renewable sources, international tourism (measured by the number of arrivals), and total natural resources rents at time point (t-1) have a substantial long-term impact on CO2 emissions. Conversely, domestic credit to the private sector by banks, foreign direct investment at time point (t-1), natural gas rents, and oil rents do not exhibit any long-term influence on CO2 emissions.

Regarding the short-term scenario, it can be concluded that CO2 emissions at a lag of one period, electricity production from renewable sources, inflow of foreign direct investment, foreign direct investment at a lag of one period, GDP per capita, electricity production from renewable sources, international tourism quantified by the number of arrivals, total rents derived from natural resources at a lag of one period, rents derived from natural gas, and rents derived from oil possess a significant influence on CO2 emissions in the case of Saudi Arabia.

As a policy implication, these findings are of great assistance to policymakers in selecting the appropriate course of action, as FDI, the tourism industry, and the utilization of electricity production from renewable sources can contribute to increased GDP growth, which in turn directly contributes to the environmental degradation of Saudi Arabia. While the country may exhibit a higher frequency of gasoline and diesel usage, the consumption of gas leads to a substantial release of CO2 emissions. In order to ensure the preservation of the ecosystem, Saudi Arabia has the potential to attract a greater number of tourists. Nevertheless, the study presents certain limitations, such as the empirical segment which fails to account for all factors that could potentially influence the economic growth in Saudi Arabia, and it neglects to address the potential endogeneity of certain variables. Furthermore, this manuscript puts forth various avenues for future research, including conducting a similar study over an extended timeframe. Additionally, there is a necessity to incorporate additional variables in the analysis, such as the quality of governance and the extent of corruption, and it is imperative to employ more advanced econometric methodologies to tackle the potential endogeneity of certain variables.

As a recommendation for future research, delving into the "black box" of technological impact can elucidate the specific reasons why TA detrimentally impacts the growth of Saudi Arabia. Further investigation is required. Is it due to disparities in abilities, employee displacement, or insufficient infrastructure? Moreover, it is crucial to understand how growth impacts different profit groups and sectors.

# **Conflict of Interest**

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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مجلة العلوم الإنسانية والاجتماعية

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