economies

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The Nexus between Oil Consumption, Economic Growth, and Crude Oil Prices in Saudi Arabia

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Abstract: The energy revolution in Saudi Arabia has accelerated significantly since 2016, driven by the National Vision 2030. Significant changes to energy subsidies took place, and the renewable energy sector has seen rapid growth. The paper presents an empirical analysis of the Saudi energy transition by emphasizing the drivers of fuel consumption in KSA. It primarily attempts to explore the long-run (LR) connection between oil consumption and several economic variables such as economic growth, crude oil prices, investment, and the labor force in Saudi Arabia (KSA) from 1991 up to 2021. The paper implemented the vector error correction model (VECM) and performed different diagnostic tests to provide more evidence about the validity and robustness of the tests. The empirical findings highlighted how important the labor force, savings, GDP, and crude oil price are in determining oil consumption for KSA. The law of demand is significantly present, which negatively affects oil consumption for KSA as an oil exporting country. The results also supported the existence of a long-term direct correlation between the variables and oil consumption. Furthermore, the short-term estimation highlighted that only saving has a negative impact on oil consumption for a single lagged period. Our findings provide governments and regulators with further incentive to slow the expansion in oil consumption, as a larger labor force is demanding more oil to attain the target, faster economic growth, and increased savings are all contributing factors. Our findings are significant because they can assist policymakers, investors, and regulators in generating more efficient oil substitutes and making them affordable for the economy.

Keywords: fuel energy consumption; oil exporter country; renewable energy; crude oil price; energy transition

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Citation: Alkofahi, Kolthoom, and Jihen Bousrih. 2024. The Nexus between Oil Consumption, Economic Growth, and Crude Oil Prices in Saudi Arabia. *Economies* 12: 105. https://doi.org/10.3390/economies12050105

Academic Editor: Brantley T. Liddle

Received: 22 March 2024
Revised: 17 April 2024
Accepted: 24 April 2024
Published: 29 April 2024

1. Introduction

The energy shift is already well underway and picking up speed (Xiao et al. 2021). In most of the world, wind and solar energy are the most affordable sources of electricity; renewable energy is responsible for almost all increases in electrical capacity worldwide; the use of electric vehicles (EVs) is growing quickly; and manufacturers are shifting to all-electric vehicles. The advancement of technology and the implementation of policies like China's most recent Five-Year Initiative for Renewable Energy Development, the European REPowerEU initiative, and the US Inflation Reduction Act are going to reinforce these trends. The transition has also been further accelerated by the rise in fossil energy prices since Russia's invasion of Ukraine.

Conventional oil and gas businesses are facing a difficult situation as they attempt to adjust their business models to the new realities of the energy industry while defending the significance of their operations. The world will continue to rely on fossil fuels for some time to come. Today, many nations believe that geothermal, tidal, solar, and wind energy will dominate our energy supplies in the future (Abban et al. 2023). We currently rely excessively on energy sources that will inevitably run out. Our houses, workplaces, educational institutions, public structures, and manufacturing facilities are all powered by fossil fuels. While these types of energy provide these sectors with a dependable and cost-effective means of operation, they also contribute to daily emissions of damaging CO_2 into the atmosphere. To slow down and eventually reverse the harm done to the world, we hope that renewable energy will completely replace fossil fuels one day. While renewable energy offers an excellent way to counteract the negative consequences of fossil fuels, other reasons need to be considered as well. A more sustainable system must be adopted to combat climate change, as fossil fuels are the primary cause of this issue. Beyond that, it is also essential if we want to supply the growing market with affordable and easily available energy (De La Peña et al. 2022).

Growing environmental concerns have been penetrating both public policy discussions and business activities. International and national legal actions have tightened environmental regulations, while rapid advancements in energy conservation and green energy have accelerated innovation in these fields (Nuţă et al. 2024). Despite these concerns, the fossil fuel market continues to be altered in more and more obvious ways. In 2023[1], fossil fuels accounted for more than 60% of the world's electricity generated to date. This is true even if every major economy is actively implementing renewable energy sources.

When examining the macroeconomic effects of the energy transition, it is convenient to concentrate on exporters of fossil fuels, as they would see a significant erosion of their primary source of export and fiscal revenue, necessitating a change to a new growth model. Therefore, the goal of the paper is to further the discussion by exploring the main drivers of the fossil fuel industry for one of the most important oil exporters in the world, which is Saudi Arabia. This paper will investigate the relationship in the short run and the long run of some main components of energy consumption for the Saudi economy.

The capacity of the oil sector in the Kingdom of Saudi Arabia (KSA) has been growing due to technical advancements. The output of traditional oil reserves has been increasing both in volume and productivity, and it has been supported by the shale oil industry, which is expanding quickly. It is expected that global pressure to reduce the use of fossil fuels will never stop. Although conventional energy sources are scarce, their negative effects outweigh their positive effects in terms of economic growth (Zhao et al. 2022). Nevertheless, conventional energy is vital to achieving output levels that support economic growth. Furthermore, the widespread use and high consumption rates of fossil fuels are contributing factors to the present worries about their depletion (Madaleno and Nogueira 2023).

Oil energy continues to play a crucial role for most countries, despite the debate surrounding the usage of substitute renewable energy resources like water, solar, and nuclear power, which is becoming increasingly heated. So, changes in the price of oil could have a significant macroeconomic impact on nations that export as well as those that import (Bouri et al. 2020). Oil is a key factor in determining production costs for the first group, and it is the second main source of government revenue. Oil price fluctuations have differing effects on exporting and importing nations. Exporting nations rely heavily on income from oil. Therefore, the money to finance development projects will increase as oil prices rise.

Academics and policymakers have long debated domestic fuel prices in oil-exporting nations, and it continues to be a crucial factor in these nations' public policy decisions (Coady et al. 2018; Atalla et al. 2018; Aune et al. 2017). Although governments may reduce the price of domestic gasoline for some social and commercial reasons, this practice is sometimes criticized because it encourages excessive and inefficient domestic energy usage and costs governments money by reducing oil exports. However, this approach may be less effective than pricing domestic fuels according to the worldwide market. Hence, the effectiveness of fiscal and monetary policies is greatly impacted by fluctuations in oil prices (Siddiqui et al. 2022). Yet, the negative influence increases the uncertainty of the financial and real aggregates because of the oil price volatility, particularly when there are imperfect capital markets (Kitous et al. 2016). Governments, on the other hand, cannot abruptly reduce their spending and then confront a significant budget deficit.

In the last 10 years, KSA's domestic oil consumption has increased nine times, on average by 16% a year, to around 4 million barrels daily. Only the US, China, India, Japan, and Russia consume more oil than KSA, which is currently the world's sixth-largest oil consumer. More than one-fourth of KSA's production is now consumed domestically. If this rise persists, which we anticipate will be the case, it will significantly affect KSA's oil exports and production.

The main purpose of this research is to explore the factors that impact the consumption of oil and, therefore, formulate strategies to reduce the dependence on fuel energy, as the consumption of oil is the primary energy source in the region, and we expect that it will decline in the future owing to the widespread use of renewable energy supplies. In fact, in the short term, there are several possible directions for the changeover. Investment restrictions on fossil fuels might cause energy prices to spike rapidly for a lengthy period, and obstacles in the markets for metals and minerals could cause the transition's costs to increase or slow down. The long-term scenario could look like this: Most of the world, especially East and South Asia, should benefit from switching to more affordable, locally derived energy sources in place of costly, environmentally damaging fossil fuels. The decrease in current energy supplies is likely to outweigh the economic benefits of clean energy for major fossil fuel producers, particularly those in the Middle East and North Africa (Pearce 2023). This paper is an attempt to explore the impact in the short run and long run of economic growth, saving, and the labor force on crude oil consumption. By far, this work represents the opening attempt to examine this relationship for the Kingdom of Saudi Arabia to better understand the transition toward green energies. The other parts of the paper will appear as follows: Section 2 will investigate the theoretical background and the review of the literature. We present the data and techniques that are implemented in the next section. Section 4 shows the results, and the final section will include recommendations and a conclusion.

2. Theoretical Background and Literature Review

Energy is a necessary component of economic growth (Liu and Hao 2018). Concurrently, the primary cause of greenhouse gas emissions, which contribute to climate change, is energy consumption (Chang 2012; Alshehry and Belloumi 2015). One of the main issues facing the coming years will be how to simultaneously accomplish energy sustainability, economic development, and climate change mitigation. Decoupling rising energy consumption from economic growth and other macroeconomic variables means it is crucial to know the underlying causes of this trend (Wang et al. 2014).

According to the theory, Uri (1982) and Beenstock and Dalziel (1986) demonstrate that, under certain assumptions, an expression for energy demand is constructed using the production equation and includes income and energy costs as explanatory variables. However, depending on the topic being investigated, the typical function of energy demand may not be an appropriate paradigm in a variety of scenarios, according to Bhattacharyya and Timilsina (2010) and others. The energy demand equation was reworked and presented as follows: Nordhaus (1975), followed by Beenstock and Willcocks (1981), and Beenstock and Dalziel (1986).

$$Q = F(K, L, E) \tag{1}$$

where Q represents the production output, K represents capital, L represents Labor, E represents Energy and F is a function that indicates the innovation or manufacturing procedure that converts inputs to output.

The Taylor expansion can be used to state Equation (1). The following equation represents the Cobb-Douglas production function (Cobb and Douglas 1928; Nordhaus 1975):

$$Q = AK^{\alpha}L^{\beta}E^{\gamma} \tag{2}$$

where A is the overall factor of productivity and, α, β, and γ, respectively, are the production elasticities for capital, labor, and energy.

Numerous studies have been conducted on the earlier connection between labor, capital, and energy, utilizing various data frequencies, methodologies, countries, and periods. The results have varied widely. Many scholars have investigated the connection between the use of energy and economic growth since Apergis and Payne (2010). But no conclusion has been reached. This undoubtedly reveals that further energy research is still required. This results from the fact that the causal chain's orientation has important policy ramifications. Energy conservation implies that lower energy consumption could hurt real GDP if energy plays a major role in economic growth (Eggoh et al. 2011).

Several temporal and spatial scales have been used to investigate the factors that influence energy use. Using structural decomposition analysis (SDA), Lan et al. (2016) broke down the global energy footprint from 1990 to 2010 and discovered that GDP per capita contributed significantly to the rise in global energy consumption during this time. Omri et al. offered a thorough investigation of the factors influencing the use of renewable energy for a global panel of 64 countries and subgroups between 1990 and 2011 based on income levels (Shahbaz et al. 2015).

Bilgen (2014) studied the worldwide energy consumption of various fuel types, industry sectors, and their effects on the environment. He recommended increasing energy efficiency and implementing related innovations to lower energy consumption.

Ramanathan (2006) examined the relationship between energy consumption and economic growth using data from 1980 to 2001. Based on the assumption of a fixed GDP in 2025, he projected the association between non-fossil energy consumption and GDP growth.

A wider range of studies examine the energy use of a particular nation, while others focus on regions like the OECD and the European Union. Between 1995 and 2000, the energy intensity trend that affected Lithuania's various industries as well as the country was examined by Baležentis et al. (2011). The biggest influence on the decline in energy intensity came from energy savings in the residential and service sectors. However, this study did not examine different types of energy; rather, it concentrated solely on sectors. Furthermore, studies conducted in developing nations primarily concentrate on China and India, in contrast to studies conducted on energy use in developed countries.

Gorus (2017) looked at the connection between KSA's economic growth and oil production between 1970 and 2013. It also uses the Bootstrap Granger causality test and the ARDL Bound test to explore the causal association between oil consumption and economic growth. Results show the long-run sensitivity of economic growth to oil consumption and the cointegration of variables. However, the Bootstrap Granger Causality Test results demonstrate the absence of a causal connection between rising economic activity and oil consumption. We also find that (Osiobe 2019) used VECM techniques to examine the connection between energy consumption and GDP growth in Malaysia from 1970 to 2014. Their results show that an increase in GDP increases CO2 emissions through a surge in energy use.

Wang and Li's comparative study in 2016 revealed the most important variables influencing China and India's changes in energy consumption between 1970 and 2012. Wang et al. (2020) analyzed China, India, and the US and revealed that, whereas income and oil intensity were the main drivers in the US, coal intensity was a driving factor in China and India for rising energy consumption. Numerous academics have conducted in-depth examinations of the factors that influence the energy consumption of specific industries in China, such as transportation (Zhang et al. 2011), logistics (Dai and Gao 2016), and nonferrous metals (Wang and Feng 2018). Nonetheless, it is uncommon to find an in-depth look that addresses the energy consumption of multiple nations.

According to research by Pao and Tsai (2011), FDI and energy use are causally related in both directions. Zeng et al. (2020) conclude that whereas FDI influx stimulates energy consumption, it stimulates FDI inflow. Through energy consumption, FDI indirectly supports economic growth. Wahyudi and Palupi (2023) reveal a bidirectional connection between FDI and energy consumption, as well as a two-way relationship between FDI and labor force participation rate (LFR). While LFR has a negligible inverse impact on energy consumption over the LR, FDI has a considerable beneficial impact on energy consumption. LFR and FDI, however, have no bearing in the near run. This study aids in the making of decisions about energy, foreign direct investment, and increasing the number and caliber of workers in OECD nations.

Typically, market efficiency and energy market volatility are taken into consideration when analyzing energy pricing for fossil fuels, such as coal, natural gas, and crude oil (Khan et al. 2022; Olubusoye et al. 2021; Wang et al. 2022). As fossil fuels are mostly used upfront in the supply chain as intermediate inputs, rising energy prices have a knock-on impact that raises costs throughout the whole global supply chain. Such supply-chain disruptions are the subject of numerous published studies (Durugbo et al. 2020).

Another essential component of the economy is labor, along with capital and inputs like energy. According to Çetin (2019), the labor force participation rate is thought to be a better indicator of the labor market. (Kusairi et al. 2023) study claims that automation is currently taking over from technology, which has an impact on the structure of the labor market. Consequently, it can lead to a drop in the function of the workforce, which might cause a change in investment that turns an industry into one that is more capital-intensive than labor-intensive. Therefore, a rise in income and consequently an increase in energy consumption have an impact on a decrease in labor force participation. The findings of Kalantzis and Niczyporuk's research in 2022 indicate a causal relationship between labor productivity and energy efficiency. The authors demonstrate how an increase in energy efficiency, induced by a decrease in energy consumption, will lead to an increase in labor productivity. Rising productivity is influenced by increased labor force participation, and rising productivity can increase energy demand. A policy including the public and private sectors is required to address this problem and raise the standard of industrial inputs that employ renewable energy sources to boost energy efficiency.

3. Methodology

This section is designed to demonstrate the econometric model the study will implement and elaborate on the databases used to extract the statistics. It also reveals the empirical model used in the analysis, and hence, it attempts to assess the empirical results for the LR connection amongst energy consumption and the chosen economic variables. Energy consumption remains a crucial source of energy in KSA, as it is one of the world's top oil-extracting and distributing nations. However, with the widespread use of green energy and other energy substitutes, we need to research if the usage of oil as the key source of energy will diminish in the future with the rise of other energy substitutes.

3.1. Data and Descriptive Statistics

This study has chosen some economic indicators based on the expected relative importance of these indicators to KSA's use of energy. The data were selected from two different sources: the "Statistical Review of World Energy", where the energy consumption (OilC) and crude oil prices (Pcrude) data were obtained, and the WBT (World Bank Tables) to retrieve the data of GDP, the gross domestic saving (S), and the labor force (L). Refer to Table 1.

To gain a better understanding of the transition from fossil fuel consumption to clean energy consumption, and as the KSA announced numerous reforms to reduce its dependence on oil or fossil fuels as well as introduce new clean energy sources, a longer time span was selected. However, the period was chosen based on the availability of the data for all the indicators. As the labor force for KSA has only been available from 1991 until 2021, the data were collected over that period. For the estimation, we used data on annual frequency. The estimation is performed using EViews 12. An analysis of transforming the logs was employed for the indicators (taking natural logarithms) to stabilize the variance of the series and reduce potential heteroskedasticity. The log transformation not only induces stationarity in the matrix of variance-covariance, but it is also helpful as the growth rate for the variable is represented by taking the log difference of the variable (Tang and Tan 2013).

In addition, it should be noted that the period was selected because it is restricted by the overparameterization problem, which refers to the problem that exists when the number of observations used is fewer than the number of estimated parameters. If it persists, the estimation technique will be inadequate, and the used model will not be compatible (Hapsari et al. 2021).

Table 1. Variable definitions and sources.

Factor	Abbreviation	Description	Source
Dependent Variable			
Oil Consumption	lOilC	Oil Consumption in thousands barrel per day	Statistical Review of World Energy (2023)
Independent Variables			
GDP	lGDP	GDP per capita (current USD)	World Bank (2023)
Crude oil prices	lPcrude	Global crude oil prices, are measured in current US dollars per barrel.	Statistical Review of World Energy (2023)
Gross domestic savings (% GDP)	lS	Calculated by subtracting the expenditure on financial consumption from GDP.	World Bank (2023)
Labor Force participation rate	lL	Labor force participation rate, male (% of male population ages 15–64)	World Bank (2023)

3.2. Model

This study examines the determinants of energy consumption at the SR and LR for KSA. Theoretically, the energy consumption function relates crude oil prices to the total output of the economy. Therefore, the energy consumption equation could be modeled as in Equation (3):

$$OilC_t = F(Pcrude_t, GDP_t) \tag{3}$$

where OilC, Pcrude, and GDP are explained in Table 1. In line with the purpose of the current analysis, more variables were added, such as savings and labor force. Based on the research techniques of Tang and Tan (2013) and Shahbaz and Rahman (2010), the suggested research model can now be written as follows:

$$lOilC_t = \theta_0 + \theta_1 lGDP_t + \theta_2 lPcrude_t + \theta_3 lS_{it} + \theta_4 lL_t + \varepsilon_t \tag{4}$$

where θ_i is the coefficient to be estimated; $i = 0, \ldots, 4$. And subscripts t denote year; $t = 1, 2, \ldots, 24$.

The first model to estimate the joint dynamic behavior of a system of time series equations is vector autoregression analysis (VAR). However, for the results to be legitimate, this model requires all the series to satisfy the stationarity condition in level in addition to the first difference. Unfortunately, there is a possibility of losing important insight into the interrelation among these series, especially for the LR stochastic trend, mostly known as the cointegration between the levels, caused by differencing the data. An alternative method initiated by Johansen (1995) is VECM, which is widely used to assess the credibility of level regressions and whether LR relationships (cointegration) amongst these indicators occur (Indrajaya 2021). If estimation shows at least one cointegration relationship, then VECM is a better estimate than the VAR, as it was created to predict the LR association and to adjust to SR variation from LR stability. In the VECM, all the variables are treated as endogenous, including the levels of the variables as well as the first differences. Therefore, estimation using VECM was created to function well with nonstationary data that has some cointegration relationship (Enders 2008); as a result, it will outpace the VAR estimation.

Before we move on, some diagnostic tests must be checked and conducted to ensure the legitimacy of the variables used and the appropriate model that could be employed.

In the coming subsections, several important tests and their outcomes are stated in the subsequence tables.

3.2.1. Descriptive Statistics and Correlation Matrix

More information about the statistics used in this study can be obtained through the analysis of the descriptive statistics. It summarizes the features of the time series used in this study and gives insight about how far the observation of each data point is from the mean. Referring to Table 2, it is reported that the descriptive statistics' output comprises three main categories: measuring the sample's mean, the median, and the standard deviation from the mean. It also reveals if the data are distributed normally or not through the Jarque-Bera test.

Table 2. Descriptive statistics.

Variable	$loilC_t$	$lGDP_t$	$lPcrude_t$	lS_t	lL_t
Mean	7.7275	9.4975	3.9880	3.6080	3.4565
Median	7.6914	9.6057	3.9594	3.5912	3.4015
Max	8.2846	10.099	4.8521	4.0148	3.8988
Min	7.0522	8.8776	3.0052	3.0866	3.2108
S.D.	0.4298	0.4761	0.5255	0.2568	0.1901
Jarque-Bera	2.9072	3.8072	1.7036	1.387	6.3488
Probability	0.2337	0.1490	0.4266	0.5103	0.2700
Obs.	31	31	31	31	31

As can be seen, the standard deviation of all the variables under investigation ranges from 0.1901 to 0.5255. The results of the Jarque-Bera diagnostic test failed to reject the hypothesis that the variables are normally distributed (probability is greater than 0.05).

Another important test that is used to check the pair correlation between the variables is the correlation test (correlation matrix), represented in Table 3 below. According to the data, the highest correlation coefficient is observed between energy consumption and the GDP, and a strong and positive correlation can be predicted between savings and crude oil prices.

Table 3. Correlation Matrix.

Variable	*loilC*	*lGDP*	*lPcrude*	*lS*	*lL*
loilC	1.0000				
lGDP	0.9589	1.0000			
lPcrude	0.7275	0.8432	1.0000		
lS	0.4508	0.5097	0.8022	1.0000	
lL	−0.7517	−0.6497	−0.6267	−0.7053	1.0000

3.2.2. Unit Root Tests

The unit root test is very important, and we cannot proceed with the study without providing enough evidence that the series is appropriate for the study. The test is designed to test if the series used in the model are stationary in level (integrated of order 0; $I(0)$), or whether they are stationary in the first difference; $I(1)$, but the series must not be stationary in the second difference $I(2)$. The ADF test (Dickey and Fuller 1979) and the PP test (Phillips and Perron 1988) are used to test stationarity. The results for the unit root test are only reported for the first difference of the variables, as the unit root test for all the series in level was found not to be stationary and is suggested to be integrated of order one $I(1)$, see Table 4.

Table 4. Unit root test for the variables (in first-difference).

Variable	ADF Test (*t*-Test)	*p*-Value	Phillips-Perron Test	*p*-Value
loilC	−4.6779 ***	0.0008	−4.7186 ***	0.0007
lGDP	−5.0423 ***	0.0003	−5.0201 ***	0.0003
lPcrude	−4.8148 ***	0.0006	−4.7380 ***	0.0007
lS	−5.4401 ***	0.0001	−5.5340 ***	0.0001
lL	−4.2273 ***	0.0026	−4.4171 ***	0.0016

Note: *** denote 1%, 5%, and 10% significant levels. The intercept and trend are included in the estimation.

3.2.3. Lag Length Selection Criterion

The outcomes of the three lag-length selection criteria are reported in Table 5: the Akaike (AIC), Schwarz (SIC), and Hannan Quinn tests (HQ). As can be seen, all three selected criteria indicated a one-lag length for the use of the analysis (VECM).

Table 5. Lag Length Selection Test.

Lag Length Test	Akaik Information Criterion	Schwarz Information Criterion	Hannan-Quinn Information Criterion
0	−4.9429	−4.7072	−4.8691
1	−13.7286 *	−12.3142 *	−13.2856 *

Note: * denote 1% significant level.

3.2.4. Cointegration Test and Long-Run (LR) Stability

The cointegration test is a statistical method that every study must conduct as it examines the possible presence of a LR correlation amongst the non-stationary variables over the given period of the study. This test helps in identifying the LR parameters or equilibrium, and it sure helps in examining whether two of the series are cointegrated or not and therefore cannot depart from LR stationarity. Table 6 below reports the results of the Johansen Cointegration test.

Table 6. Results of the Cointegration test.

Hypothesized No. of Cointegration Equations	Trace Test	
	Statistic	Critical Value
None *	88.6059 ***	69.8189
At most 1 *	58.2548 ***	47.8651
At most 2 *	34.7753 **	29.7971
At most 3 *	16.0911 **	15.4947
At most 4 *	5.9697 **	3.8415

Note: *** and ** denote the rejection of the null hypothesis of no cointegration at 1% and 5% significant levels, respectively. * denote 1% significant level.

As can be seen in Table 6, the results indicate the presence of four cointegration equations among the variables at a 5% level of significance. This validates the existence of a LR relationship between oil consumption, economic growth, crude oil prices, savings, and the labor force in the suggested research model.

We have previously stated that if the data shows a LR association amongst the selected indicators, then VAR is not the legitimate model to use. Referring to the empirical output in Tables 2–6, as the data are cointegrated of order one, I(1), and that a LR association amongst the selected variables does exist, then the VECM is an appropriate model to use in investigating the SR and the LR effect of the used economic variables and the oil consumption.

To describe the VECM, it is important to highlight that this model is an SR model, and the deviation of the SR model is subject to LR adjustment (stationarity).

The common formula of VECM (p-1) is described below (p is the endogenous variable lag with cointegration rank ≤r):

$$\begin{aligned}\Delta loil_t = \alpha_1 \quad &+ \sum_{k=1}^{p} \alpha_{11}\Delta loilC_{t-k} + \sum_{k=1}^{p} \alpha_{12}\Delta lGDP_{t-k} + \sum_{k=1}^{p} \alpha_{13}\Delta lPcrude_{t-k} + \sum_{k=1}^{p} \alpha_{14}\Delta lS_{t-k} + \sum_{k=1}^{p} \alpha_{15}\Delta lL_{t-k} \\ &+ \gamma_1 ECT_{t-1} + \varepsilon_{1t}\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta lGDP_t = \alpha_2 \quad &+ \sum_{k=1}^{p} \alpha_{21}\Delta loilC_{t-k} + \sum_{k=1}^{p} \alpha_{22}\Delta lGDP_{t-k} + \sum_{k=1}^{p} \alpha_{23}\Delta lPcrude_{t-k} + \sum_{k=1}^{p} \alpha_{24}\Delta lS_{t-k} + \sum_{k=1}^{p} \alpha_{25}\Delta lL_{t-k} \\ &+ \gamma_2 ECT_{t-1} + \varepsilon_{2t}\end{aligned} \tag{6}$$

$$\begin{aligned}\Delta lPcrude_t = \alpha_3 \quad &+ \sum_{k=1}^{p} \alpha_{31}\Delta loilC_{t-k} + \sum_{k=1}^{p} \alpha_{32}\Delta lGDP_{t-k} + \sum_{k=1}^{p} \alpha_{33}\Delta lPcrude_{t-k} + \sum_{k=1}^{p} \alpha_{34}\Delta lS_{t-k} + \sum_{k=1}^{p} \alpha_{35}\Delta lL_{t-k} \\ &+ \gamma_3 ECT_{t-1} + \varepsilon_{3t}\end{aligned} \tag{7}$$

$$\begin{aligned}\Delta lS_t = \alpha_4 \quad &+ \sum_{k=1}^{p} \alpha_{41}\Delta loilC_{t-k} + \sum_{k=1}^{p} \alpha_{42}\Delta lGDP_{t-k} + \sum_{k=1}^{p} \alpha_{43}\Delta lPcrude_{t-k} + \sum_{k=1}^{p} \alpha_{44}\Delta lS_{t-k} + \sum_{k=1}^{p} \alpha_{45}\Delta lL_{t-k} \\ &+ \gamma_4 ECT_{t-1} + \varepsilon_{4t}\end{aligned} \tag{8}$$

$$\begin{aligned}\Delta lL_t = \alpha_5 \quad &+ \sum_{k=1}^{p} \alpha_{51}\Delta loilC_{t-k} + \sum_{k=1}^{p} \alpha_{52}\Delta lGDP_{t-k} + \sum_{k=1}^{p} \alpha_{53}\Delta lPcrude_{t-k} + \sum_{k=1}^{p} \alpha_{54}\Delta lS_{t-k} + \sum_{k=1}^{p} \alpha_{55}\Delta lL_{t-k} \\ &+ \gamma_5 ECT_{t-1} + \varepsilon_{5t}\end{aligned} \tag{9}$$

where Δ refers to the first difference of the series, ε_{it}, $i = 1, \ldots, 5$, are error terms that are presumed to be distributed normally and to have white noise disturbances. p it the ideal lag length that is suggested by employing the AIC statistics. α_{1i} is a 5×1 column vector that explains the SR association between the consumption of energy and the other indicators of the study. The sign and significance of the α_{1i} determines the nature of how these variables are connected to oil consumption. γ_i denotes the adjustment error correction term coefficient, ECT_{t-1}, and is assumed to be negative for convergence to hold. The ECT_{t-1} (lagged error correction term of one period) is drawn from a normalized cointegrating equation and is usually utilized to investigate the LR causation analysis and the rate of convergence to equilibrium in the LR. ECT_{t-1} can be written as:

$$ECT_{t-1} = [loilC_{t-1} - \omega\, lGDP_{t-1} - \gamma\, lPcrude_{t-1} - \mu\, lS_{t-1} - \tau\, lL_{t-1} - \vartheta] \tag{10}$$

More characteristics were delivered in Banerjee et al. (1998). If the ECT is significantly negative, then the presence of an LR association among the variables is proven. Moreover, Narayan (2005) stated that the negative ECT is effective in balancing investment disparities. Their influential work suggested that the ECT is essential to constructing a LR association amongst the indicators used in the study.

4. Results

This study aims at finding the SR and LR relationship determinants of energy consumption in KSA using the VECM. The estimation results are reported in Table 7 below.

Table 7. VECM Results.

Cointegrating Eq:	CointEq1
$loilC(-1)$	1.000000
$lGDP(-1)$	2.4366 ***
	[3.4921]
$lPcrude(-1)$	−3.0300 ***
	[−4.1076]
$lS(-1)$	6.2943 ***
	[4.6969]
$lL(-1)$	3.1359 ***
	[3.2131]
C	−52.3975
Error Correction:	D(loilC)
CointEq1 (ECT(−1))	−0.0500 **
	[−2.1550]
$\Delta LoilC(-1)$	0.0546
	[0.2915]
$\Delta LGDP(-1)$	0.1846
	[0.7048]
$\Delta lPcrude(-1)$	0.1534
	[1.3671]
$\Delta lS(-1)$	−0.3601 **
	[−2.4129]
$\Delta lL(-1)$	−0.0185
	[−0.1016]
C	0.0331 ***
	[2.6359]

Note: *** and ** denote 1%, and 5% significance levels, respectively. t statistics are reported in brackets.

As can be seen, Table 7 is designed by reporting the LR association at the top and the SR relationship at the bottom. The empirical findings in the top section suggest that there is a long-term trend toward convergence of the variables (the variables are cointegrated). The cointegration equation (ECT) can be written as:

$$ECT_{t-1} = [1.00\ loilC_{t-1} - 2.4366\ lGDP_{t-1} + 3.0300 lPcrude_{t-1} - 6.2943 lS_{t-1} - 3.1359 lL_{t-1} + 52.3975] \quad (11)$$

ECT coefficient, as reported by Table 7, is negative and statistically significant. According to Narayan (2005), if ECT is found to be significantly negative, the feedback mechanism is vital in stabilizing the LR deviation of oil consumption. It could also indicate the length and phase it needs for the system to adjust to the LR stability of energy consumption after the exogenous impulses take place. This also implies that GDP, prices for crude oil, savings, and the labor force in the KSA are important variables in determining the level of energy consumption in the LR. The estimation coefficient reveals that GDP, saving, and the labor force are positively and significantly affecting the consumption of energy. The results also show that the law of demand is significantly proven to be accurate for KSA, with a negative and significant relationship between prices and energy consumption. These results are supported by the findings of Zaghdoudi et al. (2023), who found that the demand law exhibits a negative relationship for the oil exporting countries. As can be seen from Table 7, as the price of oil increases by 1%, the consumption of oil decreases by 3.0300%. A similar result was found by De Michelis et al. (2019).

The estimation coefficient reveals that a 1% increase in economic growth will increase the consumption of oil by 2.4366%. This finding was also reported by Osiobe (2019) and Zhou (2023). Gorus (2017) also confirmed the positive impact of GDP on energy consumption in KSA. Moreover, as savings increase by 1%, the consumption of oil increases by 6.2943%. This result is confirmed by Zeng et al. (2020), who conclude that saving stimulates energy consumption through the increase in FDI inflows Wahyudi and Palupi (2023). Furthermore, when the labor force increases by 1%, oil consumption increases by 3.1359%, similar results were represented by Kalantzis and Niczyporuk (2022). However, Wahyudi and Palupi (2023) found that the labor force has no influence on oil consumption in both time spans.

The short-term association between energy consumption and the variables is reported in the lower table. As can be seen, the one-lag period of saving is negatively and significantly affecting the growth rate of SR energy consumption. However, a one-lagged period of the other estimators is all insignificantly affecting the current energy consumption in the short run.

4.1. Diagnostic Test for VECM

To ensure the robustness of the VECM model in Table 7, it is a must to conduct several diagnostic tests, such as the LM test for the normality of the residual and the residual heteroskedasticity test.

4.1.1. The LM test

The serial correlation across error terms was presented in Table 8. The null hypothesis refutes the presence of a serial correlation up to lag 2, and the alternative hypothesis states the presence of a serial correlation. The focal part of this assessment is the initial segment that exhibits the F-measurement and R-squared tests and their likelihoods. Based on the reported results, the test fails to reject the null hypothesis as the likelihoods of F-statistics decline to reject the null hypothesis; therefore, error terms' serial association is not observed.

Table 8. VECM Residual serial correlation LM test.

			Null Hypothesis: No Serial Correlation at lag h			
lag	**LRE × Stat**	**df**	***p*-Value**	**Rao F-stat**	**df**	***p*-Value**
1	17.6005	25	0.8589	0.6625	(25,49.8)	0.8668
2	16.4386	25	0.7564	0.6126	(25,8.9)	0.9070
			Null Hypothesis: No Serial Correlation at lag1 to h			
lag	**LRE × Stat**	**df**	***p*-Value**	**Rao F-stat**	**df**	***p*-Value**
1	17.6005	25	0.8589	0.6625	(25,49.8)	0.8061
2	45.1639	50	0.6674	0.8198	(50,39.8)	0.7490

4.1.2. The Residual Normality Test

Numerous scholars trust that several regressions indicate normality. Luckily, we can assess this statement by employing normality screening to check if the residuals follow a normal distribution or not. Referring to Table 8, the *p*-value reveals the normality assumption.

4.1.3. Residual Heteroskedasticity Test

The diagnostic tests are performed by the error-term heteroscedasticity test. Heteroscedasticity appears when the variance is not the same for the set of observations in the data. The test assumes that the residuals are homoscedastic (homoscedastic); otherwise, they are heteroscedastic.

As with the rest of the investigative tests, the likelihood of F-statistic cannot support the presence of heteroscedasticity in favor of homoscedastic residuals. See Table 9 below.

Table 9. VECM Normality test.

Component	Skewness	Chi-sq	df	Prob.
1	−0.6664	2.0721	1	0.1500
2	−0.2889	0.3895	1	0.5326
3	−1.1112	5.7689	1	0.0163
4	0.2459	0.2822	1	0.5953
5	−0.2076	0.2011	1	0.6538
joint		7.3831	5	0.1210
Component	**Jarque-B.**	**Chi-sq**	**df**	**Prob**
1	3.2707	0.0855	1	0.7700
2	2.8623	0.0221	1	0.8817
3	4.7773	3.6851	1	0.0549
4	2.2925	0.5840	1	0.4447
5	2.5064	0.2843	1	0.5939
joint		4.6610	5	0.4586

To wrap it up, all the results of the three previous assessments validate the adequacy of the VECM, and the results that are stated in Tables 7–10 prove the stability of the estimation; therefore, these are enough evidence that the model is perfect and well-fitted at a 95% confidence level.

Table 10. VECM Residual Heteroskedasticity Test.

Chi-Squared	df	Prop
176.7605	180	0.5543

5. Conclusions

The energy transition is at a key turning point with a succession of shocks with compounding consequences. The Russia-Ukraine war has exposed the weaknesses in the energy security architecture globally by heavily employing energy supply and infrastructure. To guarantee a sufficient supply of energy, nations with advanced supply chains and well-developed energy infrastructure felt obligated to take emergency action.

The KSA, one of the main producers of fuel energy, is experiencing considerable economic and social change due to the 2030 Vision, which involves more regulations of energy consumption and a promise to move toward a clean energy and environment defiance with innovative resolutions such as a progressively assorted energy mix, in which, by 2030, around half of all energy sources will be derived from renewable energy. However, as the economy of KSA is growing and flourishing, it sure depends largely on oil consumption. KSA is an oil extractor-exporter country, and more economic growth is vital to boosting the need for oil, especially in the production process. For this reason, with the widespread use of green energy and other energy substitutes, we need to research whether the energy provided primarily by oil will diminish in the future with the rise of other energy substitutes. This study aimed to investigate the short- and long-term association amongst oil consumption, economic growth, price of crude oil, saving, and labor force participation rate. The data were selected from two different sources, and different assessments of VECM legitimacy were implemented. The empirical results emphasized that GDP, price for crude oil, saving, and labor force are integrated in KSA. A 1% increase in economic growth will increase the consumption of oil by 2.4366%. As saving increases by 1% the consumption of oil increases by 6.2943%. When the labor force increases by 1%, oil consumption increases by 3.1359%. Our findings support the law of demand; as the price of oil increases by 1%, the consumption of oil decreases by 3.0300%. This study also revealed that all the indicators are significantly vital in determining the level of oil consumption. In the long term, a direct association exists between the variables and oil consumption, except for crude oil prices, which emphasize the law of demand for oil consumption. However, the one-lag period of the other estimators is all insignificantly affecting the current energy consumption in the short run.

6. Implications and Limitations

Exporters of fossil fuels can put in place the appropriate safety measures and structural changes to handle the eventual long-term downfall of their main.

The government of Saudi Arabia still needs to make large investments to support the country's energy transition. KSA may speed up its transformation by emphasizing economic development, strengthening its institutional and fiscal frameworks, and doing careful planning. The government could identify new low-carbon energy solutions based on lessons from other nations, prioritize innovation in the development of new energy infrastructure, increase small and medium-sized businesses' energy efficiency, investigate the efficient use of domestic funding, and harmonize various energy policy frameworks. To speed up the shift to renewable energy, the KSA reform plans require reducing those associated investment barriers and providing viable methods to overcome them.

Overall, if the government is planning to curb the growth of oil consumption, faster economic growth, more saving, and a larger labor force are demanding more oil to achieve the target; saving and investment require more energy use in carrying out and finalizing the production process. As a result, more economic growth leads to more consumption of oil. The government also needs to efficiently use all resources at full capacity (including environmental resources), which can be achieved through enhancing KSA'a infrastructure and achieving more diversification of the economy. This will lead to a flow of investment and provide more labor force to the private corporations (Abid and Alotaibi 2020). On the other hand, if policymakers are planning to achieve lower oil consumption by increasing energy prices, as the study suggests, it must be done away from increasing crude oil prices, as a hint to the policymakers to generate more efficient oil substitutes and make them affordable for the economy. Another hint for policymakers is to improve the quality of the labor force through investing in human capital and involving the workforce in more training workshops and career development. Finally, using labor-intensive techniques in the production process not only lowers the unemployment rate but also reduces energy consumption and moves the economy toward a green economy.

Regarding the limitations of the paper, technically speaking, many factors affect the consumption of energy, especially when it comes to the resources that a country is endowed with. Therefore, choosing the appropriate factors was somehow challenging as some of the indicators were not available over time, which in turn minimized the selection of the most important factors on the one hand and the need to rely on a data set that is consistent and free of war crises on the other.

Working on this paper opened our research zone to different angles. It is so important to expand the research to explore more factors and their influences on enhancing KSA's economy. We also believe that by examining the drivers of fossil energy consumption in Saudi Arabia, this article can serve as a springboard for future research that focuses more intently on the components of the energy transition that scholars, politicians, and investors usually focus on.

Future research will take into consideration different econometric models and countries hoping to find a new factor that could accelerate and enhance the current economic performance and care more about the natural resources and the environment of KSA.

Author Contributions: Conceptualization, K.A. and J.B.; methodology, K.A.; software, K.A.; validation, J.B. and K.A.; formal analysis, K.A.; investigation, J.B.; resources, K.A.; data curation, K.A.; writing—original draft preparation, K.A. and J.B.; writing—review and editing, J.B.; visualization, J.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Not applicable.

Data Availability Statement: All the data used has public access.

Conflicts of Interest: The authors declare no conflicts of interest.

Note

1 https://ember-climate.org/ (last accessed on 10 January 2024).

References

Abban, Olivier Joseph, Yao Hong Xing, Alina Cristina Nuţă, Florian Marcel Nuţă, Prasad Siba Borah, Charles Ofori, and Yao Jing Jing. 2023. Policies for carbon-zero targets: Examining the spillover effects of renewable energy and patent applications on environmental quality in Europe. *Energy Economics* 126: 106954. [CrossRef]

Abid, Mehdi, and Mohammed Naif Alotaibi. 2020. Crude oil price and private sector of Saudi Arabia: Do globalization and financial development matter? New evidence from combined cointegration test. *Resources Policy* 69: 101774. [CrossRef]

Alshehry, Atef Saad, and Mounir Belloumi. 2015. Energy consumption, carbon dioxide emissions and economic growth: The case of Saudi Arabia. *Renewable and Sustainable Energy Reviews* 41: 237–47. [CrossRef]

Apergis, Nicholas, and James E. Payne. 2010. Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy* 38: 656–60. [CrossRef]

Atalla, Tarek N., Anwar A. Gasim, and Lester C. Hunt. 2018. Gasoline demand, pricing policy, and social welfare in Saudi Arabia: A quantitative analysis. *Energy Policy* 114: 123–33. [CrossRef]

Aune, Finn Roar, Kristine Grimsrud, Lars Lindholt, Knut Einar Rosendahl, and Halvor Briseid Storrøsten. 2017. Energy consumption subsidy removal in OPEC and other non OECD countries: Oil market impacts and welfare effects. *Energy Economics* 68: 395–409. [CrossRef]

Baležentis, Alvydas, Tomas Baležentis, and Dalia Streimikiene. 2011. The energy intensity in Lithuania during 1995–2009: A LMDI approach. *Energy Policy* 39: 7322–34. [CrossRef]

Banerjee, Anindya, Juan Dolado, and Ricardo Mestre. 1998. Error-correction Mechanism Tests for Cointegration in a Single-equation Framework. *Journal of Time Series Analysis* 19: 267–83. [CrossRef]

Beenstock, Michael, and Alan Dalziel. 1986. The demand for energy in the UK: A general equilibrium analysis. *Energy Economics* 8: 90–98. [CrossRef]

Beenstock, Michael, and Patrick Willcocks. 1981. Energy consumption and economic activity in industrialized countries: The dynamic aggregate time series relationship. *Energy Economics* 3: 225–32. [CrossRef]

Bhattacharyya, Subhes C., and Govinda R. Timilsina. 2010. A review of energy system models. *International Journal of Energy Sector Management* 4: 494–518. [CrossRef]

Bilgen, Selçuk. 2014. Structure and environmental impact of global energy consumption. *Renewable and Sustainable Energy Reviews* 38: 890–902. [CrossRef]

Bouri, Elie, Imad Kachacha, and David Roubaud. 2020. Oil market conditions and sovereign risk in MENA oil exporters and importers. *Energy Policy* 137: 111073. [CrossRef]

Chang, Ching-Chih. 2012. Marine energy consumption, national economic activity, and greenhouse gas emissions from international shipping. *Energy Policy* 41: 843–48. [CrossRef]

Coady, D., I. Parry, and B. Shang. 2018. Energy Price reform: Lessons for policymakers. *Review of Environmental Economics and Policy* 12: 197–219. [CrossRef]

Cobb, C. W., and P. H. Douglas. 1928. A Theory of Production. *American Economic Review* 18: 139–65.

Çetin, Mümin Atalay. 2019. The Role of Foreign Direct Investment on Female Labor Force Participation: Evidence from Emerging Markets. Paper presented at the 5th International Congress of Economics and Business: New Economic Trends and Business Opportunities, Bursa, Turkey, April 10–13.

Dai, Ying, and H. Oliver Gao. 2016. Energy consumption in China's logistics industry: A decomposition analysis using the LMDI approach. *Transportation Research Part D* 46: 69–80. [CrossRef]

De La Peña, Lizette, Ru Guo, Xiaojing Cao, Xiaojing Ni, and Wei Zhang. 2022. Accelerating the energy transition to achieve carbon neutrality. *Resources, Conservation and Recycling* 177: 105957. [CrossRef]

De Michelis, Andrea, Thiago RT Ferreira, and Matteo Iacoviello. 2019. Oil Prices and Consumption Across Countries and U.S. States. International Finance Discussion Papers 1263. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3494187 (accessed on 20 April 2024). [CrossRef]

Dickey, David A., and Wayne A. Fuller. 1979. Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association* 74: 427–31.

Durugbo, Christopher M., Abdel Latef Anouze, Omar Amoudi, and Zainab Al-Balushi. 2020. Competitive priorities for regional operations: A Delphi study. *Production Planning and Control* 32: 1295–312. [CrossRef]

Eggoh, Jude C., Chrysost Bangake, and Rault Christophe. 2011. Energy consumption and economic growth revisited in African countries. *Energy Policy* 39: 7408–421. [CrossRef]

Enders, W. 2008. *Applied Econometric Time Series*. Hoboken: John Wiley & Sons.

Gorus, M. S. 2017. Oil production-economic growth nexus in Saudi Arabia: ARDL bound and bootstrap causality test. *The Empirical Economics Letters* 16: 889–97.

Hapsari, M., S. Astutik, and L. Soehono. 2021. VECM and Bayesian VECM for Overparameterization Problem. *Journal of Physics: Conference Series* 1811: 012086. [CrossRef]

Indrajaya, D. 2021. Analysis of cointegration and VECM of FDI, labor force, government expenditure and GDP in Indonesia (2005–2019). *International Journal of Economics Development Research* 2: 65–77. [CrossRef]

Johansen, S. 1995. *Likelihood Based Inference in Cointegrated Vector Autoregressive Models*. Oxford: Oxford University Press, vol. 10.

Kalantzis, F., and H. Niczyporuk. 2022. Labour productivity improvements from energy efficiency investments: The experience of European firms. *Energy* 252: 123878. [CrossRef]

Khan, K., C.-W. Su, and M. N. Zhu. 2022. Examining the behavior of energy prices to COVID-19 uncertainty: A quantile on quantile approach. *Energy* 239: 122430. [CrossRef]

Kitous, A., B. Saveyn, K. Keramidas, T. Vandyck, L. Rey Los Santos, and K. Wojtowicz. 2016. *Impact of Low Oil Prices on Oil Exporting Countries*. EUR 27909. Luxembourg: Publications Office of the European Union, JRC101562.

Kusairi, S., Z. Y. Wong, R. Wahyuningtyas, and M. Sukemi. 2023. Impact of digitalization and foreign direct investment on economic growth: Learning from developed countries. *Journal of International Studies* 16: 98–111. [CrossRef]

Lan, J., A. Malik, M. Lenzen, D. McBain, and K. Kanemoto. 2016. A structural decomposition analysis of global energy footprints. *Applied Energy* 163: 436–51. [CrossRef]

Liu, Y., and Y. Hao. 2018. The dynamic links between CO_2 emissions, energy consumption and economic development in the countries along "the Belt and Road". *Science of the Total Environment* 645: 674–83. [CrossRef]

Madaleno, Mara, and Manuel Carlos Nogueira. 2023. How Renewable Energy and CO_2 Emissions Contribute to Economic Growth, and Sustainability—An Extensive Analysis. *Sustainability* 15: 4089. [CrossRef]

Narayan, P. K. 2005. The Saving and Investment Nexus for China: Evidence from Cointegration Tests. *Applied Economics* 37: 1979–90. [CrossRef]

Nordhaus, W. 1975. The Political Business Cycle. *Review of Economic Studies* 42: 169–90. [CrossRef]

Nuţă, F., A. Sharafat, O. Abban, I. Khan, M. Irfan, A. Nuţă, A. Dankyi, and M. Asghar. 2024. The relationship among urbanization, economic growth, renewable energy consumption, and environmental degradation: A comparative view of European and Asian emerging economies. *Gondwana Research* 128: 325–39. [CrossRef]

Olubusoye, O. E., O. J. Akintande, O. S.Yaya, A. E. Ogbonna, and A. F. Adenikinju. 2021. Energy pricing during the COVID-19 pandemic: Predictive information-based uncertainty indexes with machine learning algorithm. *Intelligent Systems with Applications* 12: 200050. [CrossRef]

Osiobe, E. 2019. A Cointegration Analysis of Economic Growth and CO_2 Emissions: A Case Study of Malaysia. *Environmental Management and Sustainable Development* 9: 1–29. [CrossRef]

Pao, H. T., and C. M. Tsai. 2011. Multivariate Granger causality between CO_2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy* 36: 685–93. [CrossRef]

Pearce, F. 2023. In Scramble for Clean Energy, Europe Is Turning to North Africa. YaleEnvironment360. February 16. Available online: https://e360.yale.edu/features/africa-europe-solar-wind-power (accessed on 20 April 2024).

Phillips, P. C. B., and P. Perron. 1988. Testing for a Unit Root in Time Series Regression. *Biometrika* 75: 335–46. [CrossRef]

Ramanathan, R. 2006. A multi-factor efficiency perspective to the relationships among world GDP, energy consumption and carbon dioxide emissions. *Technological Forecasting and Social Change* 73: 483–94. [CrossRef]

Shahbaz, Muhammad, and Mohammad Mafizur Rahman. 2010. Foreign Capital Inflows-Growth Nexus and Role of Domestic Financial Sector: An ARDL Co-integration Approach for Pakistan. *Journal of Economic Research* 15: 207–31.

Shahbaz, Muhammad, Samia Nasreen, Faisal Abbas, and Omri Anis. 2015. Does Foreign Direct Investment Impede Environmental Quality in High, Middle, and Low-income Countries? *Energy Economics* 51: 275–87. [CrossRef]

Siddiqui, A., A. Kautish, P. Sharma, and A. Sinha. 2022. Evolving a policy framework discovering the dynamic association between determinants of energy consumption in India. *Energy Policy* 169: 113179. [CrossRef]

Tang, C. F., and C. E. Tan. 2013. Exploring the nexus of electricity consumption, economic growth, energy prices and technology innovation in Malaysia. *Applied Energy* 104: 297–305. [CrossRef]

Uri, N. 1982. The demand for energy in the United Kingdom. *Bulletin of Economic Research* 34: 43–56. [CrossRef]

Wahyudi, H., and W. Palupi. 2023. Relationship between Energy Consumption, Foreign Direct Investment, and Labor Force Participation Using the VECM Model: Empirical Study in OECD Countries. *International Journal of Energy Economics and Policy* 13: 157–65. [CrossRef]

Wang, Hailin, Xi Yang, and Xunmin Ou. 2014. A Study on Future Energy Consumption and Carbon Emissions of China's Transportation Sector. *Low Carbon Economy* 5: 133–8. [CrossRef]

Wang, M., and C. Feng. 2018. Decomposing the change in energy consumption in China's nonferrous metal industry: An empirical analysis based on the LMDI method. *Renewable and Sustainable Energy Reviews* 82: 2652–63. [CrossRef]

Wang, Q., X. Jiang, X. Yang, and S. Ge. 2020. Comparative analysis of drivers of energy consumption in China, the USA and India—A perspective from stratified heterogeneity. *Science of the Total Environment* 698: 134117. [CrossRef]

Wang, Q., X. Yang, and R. Li. 2022. The impact of the COVID-19 pandemic on the energy market—A comparative relationship between oil and coal. *Energy Strategy Reviews* 39: 100761. [CrossRef]

Xiao, M., T. Junne, J. Haas, and M. Klein. 2021. Plummeting costs of renewables—Are energy scenarios lagging? *Energy Strategy Reviews* 35: 100636. [CrossRef]

Zaghdoudi, Taha, Kais Tissaoui, Mohamed Hédi Maaloul, Younès Bahou, and Niazi Kammoun. 2023. Asymmetric connectedness between oil price, coal and renewable energy consumption in China: Evidence from Fourier NARDL approach. *Energy* 285: 129416. [CrossRef]

Zeng, S., L. Yiqun, J. Ding, and D. Xu. 2020. An Empirical Analysis of Energy Consumption, FDI and High-Quality Development Based on Time Series Data of Zhejiang Province. *International Journal of Environmental Research and Public Health* 17: 3321. [CrossRef]

Zhang, M., H. Li, M. Zhou, and H. Mu. 2011. Decomposition analysis of energy consumption in Chinese transportation sector. *Applied Energy* 88: 2279–85. [CrossRef]

Zhao, X., M. Ramzan, T. Sengupta, G. Deep Sharma, U. Shahzad, and L. Cui. 2022. Impacts of bilateral trade on energy affordability and accessibility across Europe: Does economic globalization reduce energy poverty? *Energy Building* 262: 112023. [CrossRef]

Zhou, R. 2023. Economic growth, energy consumption and CO2 emissions—An empirical study based on the Yangtze River economic belt of China. *Heliyon* 9: e19865. [CrossRef]