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Testing the Effect of Oil Prices, Ecological Footprint, Banking Sector Development and Economic Growth on Energy Consumptions: Evidence from Bootstrap ARDL Approach

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Abstract: Energy generation from carbon fuels produces a major portion of the greenhouse gases that envelop the planet and trap the sun's heat. Fossil fuels, including coal, oil, and gas, account for approximately 75% of global greenhouse gas emissions and almost 90% of carbon dioxide emissions. Therefore, there is an urgent need to finance cleaner, efficient, low-cost, sustainable, and energy-reliable alternative fuels. Therefore, we investigated the effect of oil prices, ecological footprint, banking sector development, and economic growth on energy consumption in South Africa. We employed the newly developed bootstrap autoregressive distributed lag (ARDL) model to the link between explanatory antecedents and explained facets in the short and long term. The outcome of our study witnessed the positive and significant effect of economic growth and ecological footprint on energy consumption in the short and long run, in the case of South Africa. This suggests that a drastic boost in South African economic growth and environmental quality results in the increased use of energy. However, ARDL outcomes affirm that industrial structure has effects positively and significantly in the short run only. Moreover, oil price shocks have a negative and significant link with energy use in the short and long run, suggesting that in the case of South Africa, increased oil prices reduce the use of energy. Based on the evidence obtained from the results of our study, we proposed several policy suggestions and recommendations to the government authorities, policymakers, environmentalists, and other stakeholders in order to develop an energy strategy in line with sustainable economic growth and the environment.

Keywords: sustainability; South Africa; bootstrap ARDL; ecological footprint; banking sector development

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1. Introduction

Recent global attention has focused on how economic growth affects energy use. Energy consumption boosts industrialization, population growth, and transportation infrastructure. Demand for fossil fuels such as oil and coal accelerates ecological degradation, ecological footprint, and oil price volatility. Looking at the economy's growth in the 21st century, most countries, developed and developing, will need more energy to expand. Energy's role in manufacturing goods and services makes it crucial to a nation's economic development [1,2]. However, energy development pressure causes environmental hazards. Energy is needed to produce almost all goods and services, so developing countries need more energy as they grow [3]. At the same time, excessive energy consumption has disrupted energy supply and demand, hurting economic growth [4].

It is also crucial for managing future carbon dioxide CO_2 emissions from energy consumption and implementing energy policies [5]. The nexus between banking sector development, economic growth, industrial structure, and CO_2 emission on energy use has become more popular due to the necessity of energy consumption in daily life and its role in manufacturing sectors and economic growth. Additionally, "lower rates figure of economic growth in sub-Saharan Africa (SSA), from 3.8% in 2009 to 2.7% in 2017", arouse the need to perform more studies on how banking sector development (BSD), economic growth (EG), ecological footprint (EF) (used as a proxy for environment quality), shocks in oil prices (OP), and industrial structure (IND) and energy use (EUSE) can promote sustainable development, especially in Africa.

South African power utility (Eskom) failed to meet the 25% higher demand for 39,000 megavolts (MV) due to frequent power cuts in South Africa since 2020 [6]. Due to load shedding, South Africa's gross domestic product fell by 1.1%, raising concerns about energy supply reliability [6]. Additionally, the cabinet's failure to retrieve the capital cost of R9.9 billion in 2018 as a result of operational and financial mismanagement created a lot of anxiety in the country's energy system of operation [7]. Due to systemic failure and without additional capacity, Eskom (South African power utility) predicts a 4000–6000 megawatt electricity supply shortfall in five (5) years as the old coal-fired power stations' life has come to an end [8]. However, in previous studies, financial development was cited as a driver of energy use [9]. A strong financial development allows households, an individual, and businesses to use more energy, according to [10].

Development in the banking sector can improve energy use by boosting economic growth and the supply of funds to firms, households, and government at fair and not-too-high rates for consumer durables such as air conditioners, televisions, cars, computers, etc. [11]. Other studies, such as those of Stern [12] and Kakar [13], concur that energy consumption (EC) improves financial development. Bayer [14] postulates that investment boosts urbanization, industrialization, economic growth, and energy consumption. Energy use affects early financial development, and economic growth improves financial development as the country grows, according to other studies that support the opinion of Sadorsky [3]. Financial development and energy consumption are bidirectional, according to Gungor and Simon [15], Roubaud and Shabaz [16], and Sadrao et al. [17].

In contrast, other studies posit that there is no significant correlation between energy use and financial sector development. Yue et al. [18] examined the link between financial sector development and energy use in "Middle East and North Africa" (MENA) countries. The findings indicated that financial sector development and energy use were not significant.

Previous research cited that oil prices strongly affect economic variables. Depending on economic factors such as oil-importing vs. oil-exporting countries. Gorus et al. [19] found that oil prices affect economic indexes differently in developed and developing economies. The oil-importing nations suffer as oil prices rise. South Africa imports crude oil and refined fuels for liquid fuel. Additionally, 90% of domestic crude is imported into the country, according to the Energy Information Administration (EIA). Thus, oil is mostly imported by South Africa. As a matter of fact, in an oil-importing country such as South Africa, the rising oil price will affect economic growth, the current account balance, and other variables in the economy. In oil-importing nations such as South Africa, rising crude oil prices cause inflation, which raises interest rates [20]. Furthermore, rising interest rates reduce investments and energy use by increasing finance costs. Due to the oil price shocks following the 1973 oil price crisis worldwide, policymakers, businesspeople, and economists have been studying energy use and oil price fluctuation. Since oil is the main energy source, oil markets are often uncertain. However, terrorism and civil unrest such as war (Arab spring) and COVID-19, which hit China and other large economies at the end of 2019, also contributed to the uncertainties (as cited by the international energy agency (IEA) oil market report 2020 (https://www.iea.org/reports/oil-market-report-december-2022, accessed on 1 March 2023). Therefore, investment, stock markets, macroeconomic variables, and industrialization are affected by oil price volatility.

Energy use, which emits carbon dioxide (CO_2), contributes to global warming, as reported by "Intergovernmental Panel on Climate Change" (IPCC (https://www.ipcc.ch/2007/, accessed on 1 March 2023) in (2007) estimated that 76.7% of greenhouse gases are CO_2. Industrialization and openness reduce CO_2 emissions. Maruotti and Martínez Zarzoso [21] opined that trade openness and improved living standards have increased life expectancy and reduced child mortality, causing a massive global population increase. Thus, industrial growth increases energy use and pollution. It has been deduced that by 2050, the world's population will exceed 10 billion, growing 1.5% annually. Urban development varies by region, but developing economies are rapidly increasing in population, so a larger part of energy use comes from them, especially since CO_2 emissions in developing economies are rising and will continue to rise consistently [22]. Additionally, according to the opinion of Al-mulali et al. [23], in 30 years, these emerging economies may emit more CO_2 than developed nations. However, developing economies have been slow to take curative measures to reduce environmental degradation. They further argue that advanced economies should take action first, even though they are already working assiduously to reduce environmental hazards. Thus, there is a need for greater attention on developing nations to investigate the consequences of increasing energy use.

South Africa's status as one of Africa's largest economies influenced the choice. Over the years, immigration, especially from African countries, has been unprecedented. South Africa's non-renewable energy—mostly coal—has increased energy consumption, which may harm the environment. Few studies have examined how banking sector development, oil prices, and ecological footprint affect South African energy consumption. Most studies have ignored the environmental impact of human activity that can create environmental imbalance. It can also be explained as land space required for the balanced use of natural deposits. Thus, the human economy's ecological footprints (EFs) show its dependence on the stocks of natural wealth, which include soil, air, geology, and all living thing [24]. Therefore, in this study, we investigated the influence of the banking sector development, economic growth, oil prices, ecological footprint, and industrial structure on energy use to provide empirical evidence of their correlations in the case of South Africa.

This research advances knowledge. To our knowledge, this study is the first to examine how banking sector development, economic growth, oil prices, ecological footprint, industrial structure, and energy use in South Africa. Second, the literature added oil prices and ecological footprint. Most previous studies have focused on CO_2 emissions without putting into consideration the impact on individuals. This can also be described as the land space required for the balanced use of mineral deposits. Thus, we used the ecological footprint to gauge the effect of the environmental component on energy use. Oil prices were not included in the variables to determine the real impact on energy use in South Africa. Thus, the study results will enrich the literature. We used the McNown et al. [25] Bootstrap ARDL lag model is used to test co-integration. Finally, this study suggests evidence-based policies to revamp South African energy use strategies.

The rest of this research is as follows: The second portion discusses the literature, and the third section explains the process. The empirical findings were provided in Section 4, and the conclusions and suggested policies were offered in Section 5.

2. Literature Review

2.1. Banking Sector Development and Energy Use

A well-developed financial sector in a country changes a nation's economy. For instance, low borrowing costs in developed countries increase financial capital access and transparency between borrowers and creditors. These factors cause cross-border investment, which improves technology. A well-developed financial sector may not inspire the banking sector and private sectors to deliver more energy-efficient projects and investment credit. A regression analysis by Mielnik and Goldemberg [26] in twenty developing countries from 1987 to 1998 discovered a negative relationship between energy use and financial sector development. A similar result by Salman and Atya [27] found a negative relationship between energy use and financial sector development in Egypt.

Sadorsky [5] examined finance–energy linkages in twenty-two developing countries using bound test and dynamic panel estimation on annual panel data sets from 1990 to

2006. Financial development, economic growth, energy price, and energy consumption were studied. The finance–energy nexus is positive and significant. Sadorsky [3] cited that the developed banking sector also boosts consumer credit, encouraging them to buy more cars and appliances, which boosts energy demand. However, domestic credit to the private sector by banks assists companies in increasing liquidity assets and production inputs to make energy-saving tools and types of machinery. Ozili [28] employed the Pearson correlation analysis to determine the correlation and casualty between financial inclusion and sustainable development worldwide. The result showed a unidirectional inclusion between financial inclusion and sustainable development.

Moreover, Ma and Fu [10] examined energy consumption and financial development worldwide. Their findings show that financial development increases energy consumption. Financial development and energy consumption research were conducted in South Africa by [29]. Their findings depict that financial development and energy use are beneficial in the short and long run. Other studies say consumers feel secure and confident when their homes or investments appreciate [30]. Jabari et al. [31] tested the linkage between the financial sector development, external debt, and energy consumption. The study suggests a positive nexus between the financial sector growth and energy consumption.

In contrast, other scholars such as Odhiambo [32] for South Africa, Tamazian [33] for "Brazil, Russia, India, China, and South Africa" (BRICS) countries, Kim et al. [34] for global scale, and Hermes (2003) for Latin America and Asia, posit that financial development helps businesses update production technologies and equipment, which reduces energy consumption. Financial development could help companies invest in research and development (R&D) and create energy-efficient products. Thus, financial growth may not affect energy use [35].

2.2. Economic Growth and Energy Use

The global economy has grown significantly in the last 40 years. The first US study from 1947 to 1974 to examine the relationship between energy consumption, carbon emissions, and economic growth was [36]. The finding shows that causality is one-way from gross national product (GNP) growth to energy use, and that economic growth is achieved through extensive consumption-related energy that inspires CO_2 [37–41] for Malaysia, South Asia, "Gulf Cooperation Council" (GCC) countries, and Turkey.

One reason for unclear results is that the energy-growth literature can use different econometric tools and techniques, such as simple regression, panel unit root testing, the correlation approach, bivariate causal and multivariate co-integration, the "Vector Error Correction model" (VECM), and the "Autoregressive Distributed Lag model" (ARDL). In Salahudin et al.'s [42] Kuwaiti ADRL study using 1980–2013 ARDL data, they confirmed that long and short economic growth increases energy use. Mukhtarov et al. [43] used VECM to examine Kazakhstan's energy consumption, financial development, economic growth, and energy prices from 1993 to 2014. Estimation results showed that financial development and economic growth positively and statistically significantly affect energy consumption, while energy prices proxied by consumer price index (CPI) hurt energy consumption in the long run for Kazakhstan, which is consistent with expectations and theoretical findings.

Singh and Vashishtha [44] examined energy consumption and GDP per capita in India from 1970–1971 to 2014–2015. Results showed unidirectional causality from per capita GDP to energy consumption and no long-term equilibrium relationship between them in India. Krkošková [45] used "unit root, co-integration, and causality tests" to examine the "long-term relationship between energy consumption and real GDP for "Visegrád Four" V4 countries from 2005 to 2019". In "Slovakia, Hungary, and the Czech Republic", energy consumption drives GDP over time. Energy consumption did not correlate with GDP in Poland. AL-Bazali and Al-Zuhair [46] used fuzzy logic to calculate the impact of technical and non-technical factors on oil and gas sustainability and economic growth. They found that oil-revenue dependence, public debt, and institutional structure affect oil and gas sustainability and economic growth. Liu [47] gave analyses of the link between EC and EG in "China from 1982 to 2015 the ARDL model" was used. The conclusion suggested that utilizing all energy sources could improve the long-run economy.

Ahmed et al. [48] used ARDL methodology to analyze the dynamic relationship between renewable and non-renewable energies, CO_2 intensity, and economic growth in support of their conclusions. The "Panel dynamic ordinary least square" (DOLS) was utilized by Yorucu and Ertac Varoglu [49] to assess the energy-led growth hypothesis for 23 minor island republics from different continents from 1977 to 2017. Energy consumption was clearly the driving force behind the countries' growth. Additionally, Adebayo [50] examines the causative and long-run implications of energy consumption on Japanese economic growth from 1970 to 2015 using the ARDL model. The outcome indicated that energy consumption causes economic growth in one-way.

2.3. Oil Price and Energy Use

South Africa imports oil and depends on it for energy, rendering it susceptible to variations in the price of oil. The rising cost of oil affects consumption, government spending, investment, and economic output. Studies have examined how economies react to energy consumption and oil prices. Essama-Nssah et al. [51] studied the effects of oil price shocks on South Africa's economy using the computable general equilibrium model and microsimulation analysis of household surveys. The study finds that an increase in crude oil and refined petroleum lowers GDP, household consumption, employment, and oil prices relative to non-oil commodities. Oil security exchange returns were examined by Kang et al. [52]. Policy uncertainty shocks lower oil stock market returns, while oil demand shocks increase them. According to Ranjbar et al. [53], symmetric causality showed that energy utilization and economic development in South Africa from 1956 to 2012 were symmetric and asymmetric.

Frequency-domain test methods by Hatemi-J and Uddin [54] and Breitung and Candelon [55] showed that economic growth increases with negative energy consumption shocks. Energy reduction may slow economic growth, while economic growth does not increase energy consumption. From 1991Q1 to 2016Q3, Shin et al. [56] examined how oil price changes affected Korea's crude oil demand. Korea's oil demand responds more to price increases than decreases. Oil prices had only a long-term asymmetric effect. Rising oil prices and revenues are expected to boost income, economic activity, and consumption; [57,58] examined Saudi Arabia's utilization per capita and oil shock costs using an ARDL co-integration test. In South Arabia, a percentage increase in oil prices has a 0.563% positive effect on consumption per capita [57]. Gorus [19] examined Turkey's GDP's response to oil prices from 1996 to 2017. Turkey's GDP is strongly affected by oil prices.

In Turkey, Abumunsher et al. [20] examined oil prices, energy consumption, and CO_2 emissions (bootstrap). Oil prices negatively impacted CO_2 emissions over time, according to the ARDL coefficient. Over 50% of Turkey's energy comes from imports, proving its dependence on oil. Ali et al. [59] examined oil, gold, and energy prices in South Africa. The study found that a rise in oil prices pollutes South Africa.

2.4. Ecological Footprint and Energy Use

Human impact on the ocean, gracing land, carbon footprint, crops, built-up land, and forest products is measured by the ecological footprint (*EF*) globally. Recent studies developed the *EF* to measure anthropogenic activities in the natural environment [60,61]. The conflicts arise from energy consumption, economic growth, and ecological footprints. South Africa is Africa's largest CO_2 emitter and has an ecological deficit, but this development boosts welfare, employment, foreign direct investment, and exports (Global Footprint Network (https://www.footprintnetwork.org/, accessed on 1 March 2023). A country has an ecological deficit if its biocapacity is less than its *EF* [61]. South Africa had 3.35 gha *EF* and 1.46 gha biocapacity in 1990. Its *EF* was 3.05 gha, and biocapacity was 1.26 gha in 2000.

Both "increased to 3.60 gha and 1.08 gha in 2010, and in 2016, the *EF* was 3.15 gha and the biocapacity 0.95 gha (GFN 2019)".

According to Nathaniel [61], recent research has focused on urbanization and *EF*. However, energy consumption, urbanization, and economic growth affected Indonesia's *EF* from 1971 to 2014. Indonesia's *EF* increased with all the variables. In a Pakistani study, Hassan et al. [62] found similar environmental impacts from economic growth and energy consumption. Dogan et al. [63] first studied *EF* drivers in "Mexico, Indonesia, Nigeria, and Turkey" (MINT) countries. Urbanization in MINT countries' is the biggest environmental issue. Unlike previous studies, Belloumi et al. [64] found something. Urbanization in Malaysia does not harm the environment. Nathaniel et al. [65] used the AMG estimator without all variables to replicate Dogan et al. [63] for MENA. Urbanization, economic growth, and energy consumption hurt the *EF* and are supported by [66–69]. Kutlar et al. [70], for MINT countries using the Vector error correction model, found that in the long run, only the increase in energy flexibility increases the ecological footprint. Karsili et al. [62] investigated the ecological footprint–ecological regulation relationship of the five member countries of the union in the Mediterranean. The study determined that energy use and trade increased the environmental footprint.

2.5. Industrial Structure and Energy Use

A targeted policy to expand economic activity is the best way to sustain economic growth in this uncertain time. Industrial structure (*IND*) boosts productivity, job creation, innovation, and resource use, boosting economic growth. *IND* boosts GDP by increasing output, encouraging innovation, and optimizing resource use. However, manufacturing will increase energy use, which increases CO_2 emissions and indirectly affects economic growth. Many scholars have studied industrial structure and energy consumption (*EC*) [64,71–73]. Shahbaz and Lean [74] found that *IND* and *EC* Granger cause economic growth in Tunisia. Energy consumption, financial development, economic growth, industrialization, trade openness, and urbanization have been studied in other contexts [15,73,75,76].

Sahoo and Sethi [76] used the ARDL model to examine how "industrialization, urbanization, financial development, and economic growth affected energy consumption in India from 1980 to 2017". Industrialization, urbanization, and economic growth increased energy consumption, while financial development decreased it. Elfaki [73] examined Indonesia's economic growth from 1984 to 2018 based on "industrialization, trade openness, financial development, and energy consumption. They found that industrialization, energy consumption, and financial development (measured by domestic credit)" boosted economic growth.

Gungor and Simon [15] also found that financial development, industrialization, and urbanization increased energy consumption in South Africa. Poumanyvong and Kaneko [77] used panel data to estimate how "income, urbanization, industrialization, and population affect energy use in 99 countries from 1975 to 2005". They found that industrial activity increases energy consumption, but only for low- and middle-income groups.

This study examines how oil prices, economic growth, banking sector development, industrialization, and ecological footprint affect energy efficiency in South Africa.

Most studies in the literature ignored structural breaks in time series, but most time series had series fluctuations that needed to be taken into account. To determine a series' integration order in the presence of structural breaks, we used the structural break unit root test in this study. We used a unique econometric model developed by McNown et al. [25] known as the "Bootstrap Autoregressive Distributed lag (BARDL)" model to investigate the variables' effects using combined co-integrations, which is more robust than the traditional ARDL model. This test also solves the stability issue in standard co-integration findings.

3. Methodology

3.1. Data

This study examines South Africa's energy efficiency in relation to oil prices, economic growth, banking sector development, industrial structure, and ecological footprint (Supplementary Materials). Therefore, based on the research facets, the research model is developed as follows:

$$ln\ EUSE_{it} = \delta_0 + \delta_1 InOP_{it} + \delta_2 InEG_{it} + \delta_3 InBSD_{it} + \delta_4 InIND_{it} + \delta_5 InEF_{it}\ \varepsilon_t \quad (1)$$

In Equation (1), *lnEUSE* depicts the "logarithm of energy use", defined as total energy consumption per capita. Energy consumption is measured as a "kilogram of oil equivalent per capita" unit in South Africa and includes electricity, gas, oil, and coal consumption. *InOP* is described as the "logarithm of crude oil price", referred to as "the spot price of a barrel of benchmark core oil used as fuel and is measured in Brent, $/bbl (CB)." *InEG* depicts the "logarithm of economic growth", measured as GDP per capita. This explains how GDP changes from year to year. This study expects the variable to increase energy use as the economy grows, leading to high energy consumption. *InBSD* represents the "logarithm of banking sector development", referred to as domestic credit provided to the private sector by banks and is measured as the share of GDP. It fully intermediates in developing countries. Governments build economic infrastructure with financial market loans. Because consumers will buy more with easy credit, this study expects this variable to increase energy use. *InIND* represents the "logarithm of industrial structure", defined as manufacturing value added. Industrialization pollutes energy worldwide. This variable was expected to boost energy consumption as a percentage of GDP. *InEF* represents the "logarithm of ecological footprint", defined as the ecological footprint of consumption in our natural environment and measured as global hectares per capita. Table 1 shows the study variables.

Table 1. Variables description and sources of data.

Variables	Description and Measurement Unit	Source
$lnEUSE_{it}$	"Kilogram of oil equivalent per capita"	WB
$InEG_{it}$	Gross domestic product per capita	WB
$InOP_{it}$	The spot price of a barrel of benchmark cure oil used as fuel and is measured in Brent, $/bbl (CB)	WB
$InBSD_{it}$	Domestic credit to private sector by banks (% of GDP)	WB
$InIND_{it}$	Industry (including construction), value added (% of GDP)	WB
$InEF_{it}$	"Global hectares per capita"	GFN

Source: authors' compilation; data source: WB = World Bank (https://databank.worldbank.org/source/world-development-indicators, accessed on 14 December 2022) and *GFN* = global footprint (Home—Global Footprint Network). Note: *lnEUSE* = logarithm of energy use; *lnEG* = logarithm of economic growth; *lnEF* = logarithm of ecological footprint; *lnOP* = logarithm of oil prices; *lnBSD* = logarithm of banking sector development; *lnIND* = logarithm of industrial structure.

3.2. Stationary and Co-Integration Tests

To check the stationary of the variables used in this study, the "Augmented Ducky Fuller" test is used. The "ARDL-Bound" co-integration test was also used to test the long-term relationship between variables. The test can perform efficiently for small sample sizes in time series data. ARDL bounds test approach consists of three main steps: first is to evaluate the long-run co-integration among the variables in the equation. Second, to estimate the elasticity of the long-run relationship in order to evaluate their impact on the dependent variables. Third, the robustness of the ARDL bounds test of co-integration can be used to test the estimation sensitivity. Additionally, this study used the "Bootstrap Autoregressive Distributed lag (BARDL) model" suggested by McNown et al. [25] to investigate the effects of *OP*, *EG*, *BSD*, *IND*, and *EF* on energy use in South Africa. "F-test" ($Fstatistic_{ov}$) is used in the traditional ARDL model on all lagged variables of study ($H_0 = \pi_1 = \pi_2 = \pi_3 = \pi_4 = \pi_5 = \pi_6 = 0$). To explain the long-term relationship between the variables of interest, the "t test" is used on lagged dependent variable $H_0: \pi_1 = 0$. However, McNown et al. [25] improved traditional ARDL model by adding an additional "F-test" on the lagged independent variables ($H_0 = \pi_1 = \pi_2 = \pi_3 = \pi_4 = \pi_5 = \pi_6 = 0$). Thus, the improved ARDL model based on "F-test ($Fstatistic_{ov}$), t-test" ($tstatistic_{DV}$), and F-test ($Fstatistic_{IDV}$) on "the coefficient of all lagged levels of variables; dependent and independent variables", respectively, were used. These tests should also distinguish between co-integration, non-co-integration, and degenerate situations, according to McNown et al. [25]. Degeneracy occurs twice, indicating that the variables under study are not integrated properly. The first degenerate case occurs when the lagged level dependent variable is insignificant, and the second occurs when the lagged level independent variables are not significant. The "bootstrap ARDL critical values (CVs)" include the properties of the combined integration of each tested series using the ARDL bootstrap method. This method solves the stability problem in standard co-integration findings. The expanded ARDL test allows multiple variables to be endogenous, unlike the classic ARDL approach. Thus, empirical models with several variables should use this strategy. Therefore, the co-integration among oil prices, economic growth, banking sector development, industry, and ecological footprints on the energy consumption in South Africa will be established if the values of ($Fstatistic_{ov}$), ($tstatistic_{DV}$), and ($Fstatistic_{IDV}$) do not exceed the "CV" bootstrap model. The following is the formulation of the "ARDL" test:

$$\begin{aligned}\Delta lnEUSE_{it} = \theta_0 \quad & + \sum_{i=1}^{q} \delta_1 \Delta lnEUSE_{t-j} + \sum_{i=1}^{f} \delta_2 \Delta lnOP_{t-j} + \sum_{i=1}^{f} \delta_3 \Delta lnEG_{t-j} \\ & + \sum_{i=1}^{f} \delta_4 \Delta lnBSD_{t-j} + \sum_{i=1}^{f} \delta_5 \Delta lnIND_{t-j} + \sum_{i=1}^{f} \delta_6 \Delta lnEF_{t-j} \\ & + \pi_1 lnEUSE_{t-j} + \pi_2 lnOP_{t-1} + \pi_3 lnEG_{t-1} + \pi_4 lnBSD_{t-1} \\ & + \gamma_5 lnIND_{t-1} + \gamma_6 lnEF_{t-1} + \omega ECT_{t-1} + \in_{it}\end{aligned} \tag{2}$$

In Equation (2): $\in_{it}$ denotes white noise; Δ represents the first difference process operator; θ_0 denotes intercept; $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5$ and δ_6 denotes the coefficients' explanatory variables in short term; $\pi_1, \pi_2, \pi_3, \pi_4, \pi_5$ and π_6 denotes the explanatory variables' coefficients in long-run; q denotes the lags of explained variables; f denotes the lags of explanatory variables and ωECT_{t-1} denotes the error correction term representing the speed of the examined variables getting adjusted.

Additionally, this research employed the "Ramsey RESET test (X^{-Rrt}) to test model fit"; the ARCH test (X^{-Art})" and "Brush–Pagan–Godfrey heteroscedasticity test (X^{-Bpght})" to explore the heterogeneity; normality test (X^{-Nort}) to examine that data are normally distributed; and multicollinearity test M^{ct} to confirm the presence of multicollinearity in the variables.

Furthermore, the empirical model's validity and fit are checked in this research using the "CUSUM and CUSUM-square (CUSUMSQ) tests." This research also employs Granger causality to determine causation between variables. However, the econometric technique, "(EC^{Term})", shows the "speed of adjustment of variables from long-term equilibrium." The ECM were formulated in the following Equations (3)–(8):

$$\begin{aligned}&\Delta lnEUSE_t = \alpha + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \\ &\sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_1 ECT_{t-1} + \epsilon_{1t}\end{aligned} \tag{3}$$

$$\begin{aligned}&\Delta lnOP_t = \sigma + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \\ &\sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_2 ECT_{t-1} + \epsilon_{2t}\end{aligned} \tag{4}$$

$$\Delta lnEG_t = \rho + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_3 ECT_{t-1} + \epsilon_{3t} \tag{5}$$

$$\Delta lnBSD_t = \varphi + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_4 ECT_{t-1} + \epsilon_{4t} \tag{6}$$

$$\Delta lnIND_t = \phi + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_5 ECT_{t-1} + \epsilon_{5t} \tag{7}$$

$$\Delta lnEF_t = \delta + \sum_{i=1}^{p-1} \varsigma_i \Delta lnEUSE_{t-i} + \sum_{j=1}^{q-1} \omega_j \Delta lnOP_{t-j} + \sum_{m=1}^{q-1} \vartheta_m \Delta lnEG_{t-m} + \sum_{l=1}^{q-1} \Theta_l \Delta lnBSD_{t-l} + \sum_{r=1}^{q-1} \xi_r \Delta lnIND_{t-r} + \sum_{n=1}^{q-1} \pi_n \Delta lnEF_{t-n} + \lambda_6 ECT_{t-1} + \epsilon_{6t} \tag{8}$$

where Δ denotes the "first difference operator; $\in_{it}$ denotes the error term, and ωECT_{t-1} denotes lagged *ECT*. The F statistics provided by the Wald test are used in order to investigate the short-term causal link that exists between the variables that are being examined.

For robustness assessment, econometric methods such as "Canonical co-integration regression (CCR), fully modified least squares (FMOLS), Impulse response function (IRF), and variance decomposition factor (VDF) analysis" are used.

4. Results and Discussion

In Table 2, the outcomes show that the variables EUSE, EG, OP, BSD, and EF are stationary at the first difference I(1). However, IND is stationary at level I(0). Hence, there is a mixed order of stationary in the variables of interest. Second to the unit root test results, the ARDL bound test and Bootstrap ARDL co-integration test results are depicted in Table 3. The ARDL bound test results affirm that all variables (*EUSE*, *OP*, *EG*, *BSD*, *IND*, *EF*) of this study are co-integrated. Additionally, the BARDL co-integration results confirmed that the $F.Statistic_{OV}$, $F.Statistic_{DV}$, and $F.Statistic_{IDV}$ values are less than "bootstrap ARDL CVs". Thus, both test results affirmed that co-integration exists among the variables.

Table 2. Unit root test.

	At Level		At First Difference		
Variables	**T Statistic**	***p* Value**	**T Statistics**	***p* Value**	**Remarks**
lnEUSE	−1.831	0.358	−5.067 ***	0.000	I(1)
lnOP	−1.272	0.628	−4.809 ***	0.000	I(1)
lnEG	−1.249	0.638	−2.908 *	0.057	I(1)
lnBSD	−2.368	0.159	−6.109 ***	0.000	I(1)
lnIND	−3.199 **	0.030	—	—	I(0)
lnEF	−2.406	0.148	−7.043 ***	0.000	I(1)

Note: *, **, and *** refer to the level of significance at 10%, 5%, and 1%; I(0) refers to level and I(1) shows first difference. *lnEUSE* = logarithm of energy use; *lnEG* = logarithm of economic growth; *lnEF* = logarithm of ecological footprint; *lnOP* = logarithm of oil prices; *lnBSD* = logarithm of banking sector development; *lnIND* = logarithm of industrial structure.

Table 3. Bootstrap "ARDL" co-integration test.

"ARDL" Diagnostic Tests Findings						
Bootstrap "ARDL"	FS^{OV}	TS^{DV}	FS^{IDV}	X^{Rst}	X^{Norm}	X^{Bpgt}
(euse, op, eg, bsd, ind, ef)	3.192 ***	−3.035 ***	3.566 ***	0.62^{FS} 0.56^{PV}	0.97^{FS}	1.44^{FS}
Bootstrap-based table CV 1%	8.475	9.413	−5.511	0.38^{FS} 0.55^{PV}	0.46^{PV}	0.24^{PV}
ARDL bound test	F Stat	I(0) Bound	I(1) Bound		X^{Bgsct}	X^{Arch}
	5.555	3.06 ***	4.15 ***		0.51^{FS} 0.61^{PV}	0.43^{FS} 0.52^{PV}
	lnEUSE	*lnOP*	*lnEG*	*lnBSD*	*lnIND*	*lnEF*
Multicollinearity test VIF	1.51	2.22	1.72	1.36	1.29	1.41

Note: *** refer to the level of significance at 1%; I(0) refers to level and I(1) shows first difference. *lnEUSE* = logarithm of energy use; *lnEG* = logarithm of economic growth; *lnEF* = logarithm of ecological footprint; *lnOP* = logarithm of oil prices; *lnBSD* = logarithm of banking sector development; *lnIND* = logarithm of industrial structure. Moreover, FS^{OV} = F-statistic for overall variable; FS^{IDV} = F statistic for independent variable; TS^{DV} = t-statistic for depend variable; *VIF* = Variance Inflation Factor; X^{Rst} = Ramsey reset test; X^{Arch} = the ARCH test and X^{Bpgt}= Brush–Pagan–Godfrey heteroscedasticity test; X^{Norm} = Normality test; *CV* = critical value; *FS* = F-statistic; *PV* = *p*-Value.

The outcomes of the ARDL are shown in Table 4. The outcomes present that the coefficient of *EG* (0.719, 1.262) with EUSE are significant at 1% and 5% significance levels in the short and long run, respectively. This shows how boosts in economic growth lead to more energy consumption in the case of South Africa. A 1% increase in *EG* leads to a 0.719% and 1.262% increase in the *EUSE*. Moreover, it is interesting to report that magnitude of the *EG* to *EUSE* in South Africa is higher in the long term as compared to the short run. The outcomes of studies by Salahuddin et al. [42] in Kuwait, Wang and Zhang [78] in China, and Shahbaz et al. [79] in the case of China validate the outcomes of our study. Thus, it can be concluded that the economic development of a country demands more consumption of energy. The economy of South Africa is mostly dependent on gold mining as it is one of the world's top gold-producer countries. The country meets energy demands by using fossil fuels (known as a dirty source), whereas the proportion of renewable energy used in the country is not sufficient in the magnitude to meet the needs. Therefore, the country compromises on environmental quality, which is the biggest and trending issue in the world the present. Therefore, the top authorities of the country are required to strengthen the energy infrastructure, develop polices and invest in the R&D to minimize the energy use in the country. Additionally, South Africa must invest in the renewable energy sources as an alternative to get rid of dirty energy. This will result in the sustainable economic development of the country and the protection of the environment.

Table 4. ARDL model results.

Variable	Coefficient	t-Statistic	Prob.
$\Delta lnEG_t$	0.719 ***	3.297	0.003
$\Delta lnEF_t$	0.243 *	1.821	0.083
$\Delta lnOP_t$	−0.153 ***	−5.012	0.000
$\Delta lnBSD_t$	0.106	1.139	0.268
$\Delta lnIND_t$	0.418 **	2.368	0.028
$lnEG_t$	1.262 **	2.421	0.025
$lnEF_t$	0.426 *	1.830	0.082
$lnOP_t$	−0.269 ***	−3.850	0.001
$lnBSD_t$	−0.161	−0.938	0.359
$lnIND_t$	0.013	−0.053	0.958
ECT_{t-1}	−0.570 ***	−7.108	0.000

Note: *, **, and *** refer to the level of significance at 10%, 5%, and 1%; I(0) refers to level and I(1) shows first difference. *lnEUSE* = logarithm of energy use; *lnEG* = logarithm of economic growth; *lnEF* = logarithm of ecological footprint; *lnOP* = logarithm of oil prices; *lnBSD* = logarithm of banking sector development; *lnIND* = logarithm of industrial structure; ECT_{t-1} = Error Correction Term.

Moreover, the coefficients of *EF* (0.243, 0.426) with *EUSE* are positive and significant at 10% in the short and long run. This affirms that ecological degradation is directly associated with energy use in the context of South Africa. A 1% rise in ecological degradation results in a 0.243% and 0.426% rise in energy use. This suggests that energy consumption in South Africa is linked with ecological degradation, as witnessed by Osuntuyi and Lean [80]. According to Monfreda et al. [81], the ecological footprint is a measurement that compares the rates of resource consumption and waste creation by humans with the rates of resource regeneration and trash absorption by the biosphere. These rates are stated in terms of the area that is required to sustain these flows. As a result, South Africa is abundant in gold sources; yet, the mining of gold necessitates the use of energy, which comes at the expense of leaving an ecological impact. Hence, the stakeholders of South Africa, such as the government, economists, and environmentalists, should focus on ecological reduction by developing, implementing, and monitoring the policies to reduce ecological and environmental hazards. This could be possible through investing in technological innovation and enhancing clean and green energy sources. This will result in the country's energy efficiency, leading to less consumption of energy.

Furthermore, the outcomes reveal that the *OP* coefficients in the short run (−0.153) and in the long run (−0.269) are negative and significant at the 1% significance level. This affirms that 1% positive shocks in the OP lead to a decrease the energy consumption by −0.153% in the short term and −0.269 in the long term. A study by Ali et al. [59] in South Africa, Abumunsher et al. [20] in Turkey, and Apergis and Gangopadhyay [82] in Vietnam supports our results. The authors of these studies found that the *OP* positive shocks decrease and negative shocks increase energy use. As South Africa does not meet the demand for energy from domestic energy production sources, to meet the desired demand of the country for economic activities, the country imports oil. Therefore, South Africa imports oil from Nigeria, Saudi Arabia, Ghana, the United Arabs Emirates, and the United States. In just 2020, the country imported USD 5.09 billion dollars of oil to meet the required demand, and it became the 19th largest importing country around the globe (https://oec.world/en/profile/bilateral-product/crude-petroleum/reporter/zaf, accessed on 1 March 2023). Therefore, a little shift in the prices of oil in the international market impacts the country's energy consumption, as observed during the Russo-Ukraine conflict. Hence, it is recommended that the country explore cheaper, cleaner, more renewable, and more efficient energy sources, and reduce dependency on international imports of oil. This will benefit the country in terms of efficient use of energy, enhancement in the quality of the environment, and reduced impact on the current account in the balance of payment.

In addition, in the short period, *EUSE* and *BSD* have positive coefficients (0.106); however, in the long run, both variables have negative coefficients (−0.161), but in both cases, the coefficients are insignificant. The results are in contrast to Mielnik et al. [26], who established that financial development reduces energy consumption by helping firms update production technologies and equipment, which improves energy efficiency. Their study further suggests that financial sector development could help companies invest in R&D and design and manufacture energy-saving products, lowering energy consumption. However, our results are affirmed by [3,35,83–87]. From our results, it can be concluded that the banking sector of South Africa is not developed as per standards to support the energy infrastructure of the country and produce capital for investment into the industry and economy to explore more opportunities through R&D. Thus, it is endorsed to the South African government to build a sound banking sector, under the central bank, to raise standards and the capabilities of supporting the country's energy infrastructure.

Additionally, the estimations of ARDL depicts that *IND* and *EUSE* have positive and substantial coefficient (0.418), which is significant at a 5% significance level. In contrast, both variables have a positive but insignificant coefficient (0.013) in the long run. This reveals that the industrial structure of the South African industry sector consumes more energy in the short run. The effect may be the result of obsolete industrial infrastructure. The African industry requires the transition from obsolete to innovative and new infrastructure efficient to energy consumption. As witnessed by Liu [47,86], industrial activity uses more modern machinery than agriculture and basic manufacturing. Thus, these always increase energy consumption, which is needed in industrialized nations such as South Africa. Additionally, the industries in South Africa demand more energy to carry out smooth business and operational activities. The findings of Elfaki [73] will be applied to South Africa, which has high energy demand and rapid industrial growth.

Robustness Analysis and Assessment

The discussions from the "ARDL" estimator in Table 4 were evaluated by making use of the two substitute single equation estimators, these being the "CRR" and "FMOLS". Table 5 revealed the results of "CCR" and "FMOLS". The difference between the two applications is not very noted in terms of indication and statistical significance. For each application, the coefficients of *EG*, *EF*, and *IND* with *EUSE* are positive and significant; however, the coefficient of *OP* with *EUSE* is negative, whereas the coefficient of the *BSD* with *UESE* is positive and insignificant in the case of South Africa. The results of CCR and FMOLS are in line with outcomes obtained in ARDL.

Table 5. FMOLS and CCR results.

Canonical Co-integration Regression (CCR) Results				**Fully Modified Least Squares (FMOLS)**			
Variable	**Coefficient**	**t-Statistic**	***p*-Value**	**Variable**	**Coefficient**	**t-Statistic**	***p*-Value**
$lnEG_t$	0.692 ***	4.247	0.000	$lnEG_t$	1.487 ***	4.404	0.000
$lnEF_t$	0.240	1.465	0.159	$lnEF_t$	0.233 *	1.838	0.084
$lnOP_t$	−0.138 ***	−5.341	0.000	$lnOP_t$	−0.166 ***	−5.522	0.000
$lnBSD_t$	0.281	1.518	0.145	$lnBSD_t$	0.120	1.608	0.127
$lnIND_t$	0.428 **	1.302	0.028	$lnIND_t$	0.494 **	2.905	0.010

Note: *, **, and *** refer to the level of significance at 10%, 5%, and 1%; *lnEUSE* = logarithm of energy use; *lnEG* = logarithm of economic growth; *lnEF* = logarithm of ecological footprint; *lnOP* = logarithm of oil prices; *lnBSD* = logarithm of banking sector development; *lnIND* = logarithm of industrial structure.

Furthermore, the variance decomposition factor results are delivered in Table 6. According to the results, shocks account for 100% of energy use. The contribution of the energy use ratio declined slowly throughout the period from 1 to 10, with the energy use ratio in the 10th period contributing 49.63%. Moreover, the economic growth ratio to energy use increases up to the 9th period and declines very slowly in the 10th period. Additionally, ecological footprint, banking sector development, and industry ratio to energy use increased from the 1st period to the 10th period, such as 5.67%, 3.239%, and 7.497, respectively. However, the oil price contributes to energy use, and the ratio increases up to the 7th period and declines hereafter to the 10th period. Thus, South Africa's energy use changes are driven by economic growth, industrialization, banking sector development, oil prices, and ecological footprint.

Table 6. Outcome of variance decomposition factor analysis.

Model: *lnEUSE* = *f*(*lnOP, lnEG, lnBSD, lnIND, lnEF*)							
Period	***S.E.***	***EUSE***	***EG***	***EF***	***BSD***	***IND***	***OP***
1	9.053	100	0.000	0.000	0.000	0.000	0.000
2	11.276	94.023	1.715	0.514	0.079	1.288	2.378
3	12.607	81.683	7.229	0.497	0.696	2.493	7.400
4	13.857	68.332	14.381	1.998	2.032	3.490	9.763
5	14.839	59.594	20.167	3.225	2.890	5.351	8.771
6	15.525	54.723	23.928	4.094	2.866	6.326	8.060
7	15.956	51.934	25.814	5.089	2.714	6.774	7.672

Table 6. *Cont.*

Model: *lnEUSE* = *f*(*lnOP, lnEG, lnBSD, lnIND, lnEF*)							
Period	***S.E.***	***EUSE***	***EG***	***EF***	***BSD***	***IND***	***OP***
8	16.182	50.493	26.504	5.577	2.766	7.198	7.459
9	16.288	49.861	26.597	5.721	3.030	7.426	7.363
10	16.331	49.632	26.530	5.767	3.239	7.497	7.331

Note: *lnEUSE* = logarithm of energy use; *lnEG* = logarithm of economic growth; *lnEF* = logarithm of ecological footprint; *lnOP* = logarithm of oil prices; *lnBSD* = logarithm of banking sector development; *lnIND* = logarithm of industrial structure; *SE* = Standard Error.

Figure 1 displays impulse response function results. It can be observed from the figure that economic development has a positive effect on energy use. However, the ecological footprint has a negative effect on energy use in the short run, a positive effect in the medium term, and a declining effect in the long run. The banking sector development and oil price effect decreased in the short term but increased in the long term. In South Africa, the industry's impact on energy use has grown over time.

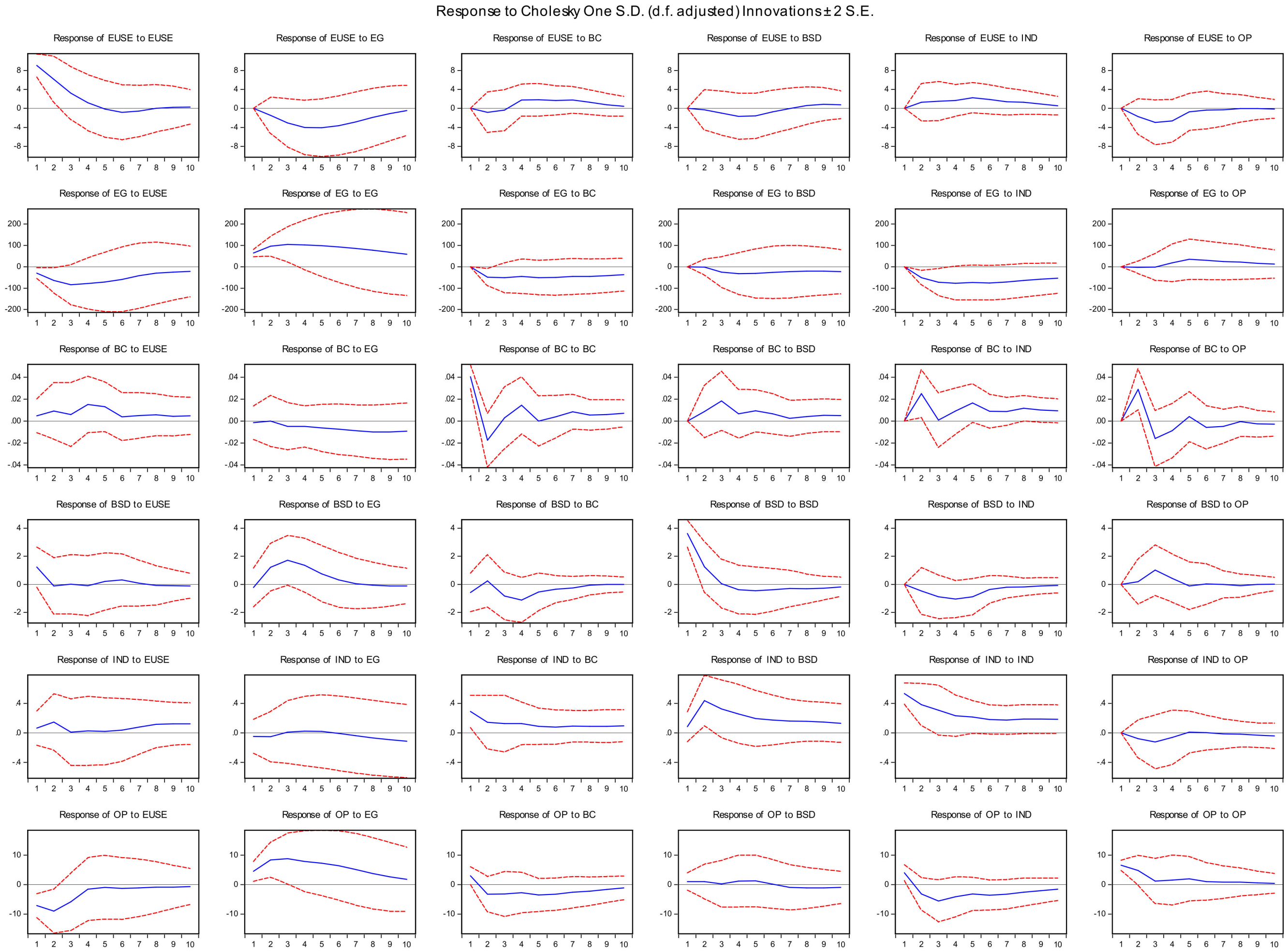

Figure 1. Impulse response function. Blue line is impact line and shows the impact, however upper and lower red doted lines are upper and lower bounds.

Figure 2 shows the "CUSUM and CUSUM of squares (CUSUMSQ) charts." The CUSUM chart affirmed that the model in this study is accurately specified, and the "CUSUM squares" indicates that there were no formational changes in the model over the evaluation period. Table 5 reveals the results of the diagnostic tests. The "Brush–Pagan–Godfrey of heteroscedasticity test (X^{-Bpgth}), and ARCH test (X^{-Art})" confirmed homoscedasticity in this article and gave no serial correlations in the model. However, the normality test (X^{-Nort}) assures that the model being examined is regularly distributed, while the Ramsey RESET test (X^{-Rrt}) affirmed that the model is suitable and reliable. The multicollinearity test, M^{cr}, confirmed the model had no multicollinearity issues.

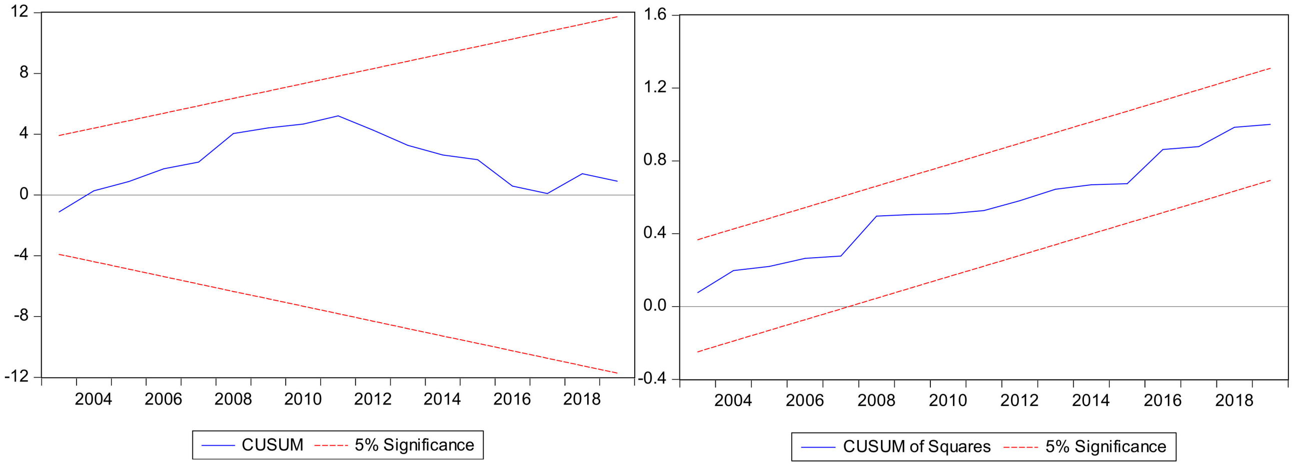

Figure 2. CUSUM and CUSUM square. Blue line is model line where as upper and lower red doted lines are upper and lower bounds. Model will be fit if blue line lies in between upper and lower bounds.

Pairwise Granger causality with co-integrated testing series was used to determine the variables' short- and long-run causal relationships in this study. Table 7 presents estimations of causality correlations of each variable. The table further reveals that, in the long run, there is a causal relationship between *EUSE*, *EF*, and OP. Additionally, *EG* and *OP* have a causal effect on *BSD*, *EF*, and *IND*. Therefore, we can recommend green energy promotion for South Africa's long-term energy growth based on the presence of a causal relationship among the variables.

Table 7. Results of the Pairwise Granger causality testing approach.

Null Hypothesis	F-Statistic	*p*-Value
lnEG → *lnEUSE*	1.150	0.334
lnEUSE → *lnEG*	0.769	0.475
lnBSD → *lnEUSE*	1.399	0.267
lnEUSE → *lnBSD*	0.507	0.609
lnEF → *lnEUSE*	0.104	0.902
lnEUSE → *lnEF*	3.456 **	0.049
lnIND → *lnEUSE*	0.392	0.680
lnEUSE → *lnIND*	0.106	0.900
lnOP → *lnEUSE*	2.583 *	0.097
lnEUSE → *lnOP*	0.629	0.542
lnIND → *lnBSD*	1.502	0.244

Note: *, ** refer to the level of significance at 10%, 5%; *lnEUSE* = logarithm of energy use; *lnEG* = logarithm of economic growth; *lnEF* = logarithm of ecological footprint; *lnOP* = logarithm of oil prices; *lnBSD* = logarithm of banking sector development; *lnIND* = logarithm of industrial structure; *SE* = Standard Error.

5. Conclusions and Policy Recommendations

This study examined the impact of oil prices (*OP*), ecological footprints (*EFs*), banking sector development (*BSD*), industrialization (IND), and economic growth (*EG*) on energy consumption (*EC*) in South Africa (SA) between 1990 and 2019. South Africa was focused on because the country is sub-Saharan Africa's leading economy. The empirical literature found a correlation between oil prices, ecological footprints, banking sector development, industrialization, economic growth, and energy consumption in most countries. A linear production function between energy consumption and independent variables was estimated by an empirical model. This study found a short-run and long-run co-integration relationship between *OP*, *EF*, *BSD*, *IND*, *EG*, and *EC* using McNown et al.'s [26] newly developed "ARDL" lag model. All variables in this study had a positive relationship with *EC* in South Africa except *OP* and *BSD*, which negatively affected the energy sector but were still significant.

The findings explain that a 1% increase in *EF* and *IND* will cause an increase in energy use by 0.426 and 0.418, respectively. This means economic growth and high consumption of energy lead to environmental degradation. However, according to the Global Footprint Network (2019), if the country's biocapacity is less than its ecological footprint, such a country has an ecological deficit as a result of the largest CO_2 emissions. The outcome is supported by the findings of Nathaniel [60] and Kutlar et al. [78].

Meanwhile, the coefficients and short and long-run estimations confirmed a negative relationship between the *OP* and *BSD*. This means that in the short and long terms, if the oil price increases by 1%, then the energy use is reduced by 0.153 and 0.269, respectively. This is also confirmed by Ali et al. [58] and Abumunsher et al. [21]. Additionally, in the long run, energy use and banking sector development were positive but insignificantly related. That is, every 1% increase in banking sector development leads to a decrease in energy use by 0.161. These findings support the views of Mielnik et al. [27] and Ozili [28] that a well-developed banking sector will reduce energy consumption by helping firms update production technologies and equipment, thus improving energy efficiency.

Based on these findings, South Africa's energy sector needs a sustainable financial sector, sustainable energy use, and economic growth. This study, therefore, suggests some strengthening energy policies, and each variable's policy is recommended below:

Policy Recommendation

First, enhanced and sustainable economic growth in South Africa can be achieved with maximum utilization of energy. Therefore, it is recommended that South African stakeholders, governments, and environmentalists use renewable sources of energy rather than fossil fuel sources. To do so, the economists, government, and environmentalists should mutually reconsider the energy policy of the country to attend to the desired economic growth in line with environmental hazard-causing factors. Secondly, the ecological footprint must be controlled, as they are primarily caused by energy use, particularly dirty energy. The South African government must invest in green finance opportunities, such as introducing green technology initiatives and environmental taxes on economic organizations. Thirdly, oil, along with other sources such as coal and gas, are mostly used to meet the desired economic objectives of the country's business organizations and households. The increase in oil prices reduces the consumption of energy in the country and leads to a livable environment. The authorities must consider green energy sources to mitigate the enhanced price effect on oil. This will result from the country keeping on track with economic development while pursuing the sustainable development goals described under the SDGs. Lastly, policymakers must develop long-term policies and strategies in collaboration with industries to reduce energy use, particularly energy obtained from fossil fuels. To do so, we recommend an energy transition process from fossil fuels to clean energy. Additionally, we recommend the country's government and business units jointly develop the research and development department, with a prime focus on researching and introducing innovative technology opportunities. The implementation of such technologies will reduce the level of energy use in the industrial sector, and harmful effects on the environment will be reduced.

This research has limitations in terms of the availability of the data on the factors used in the conceptual research model of study. Therefore, in the future, the research model can be enhanced by taking into account other factors such as R&D, green finance, and other related antecedents. Moreover, for generalizability, this research model can be studied in other countries to validate the findings. Finally, the updated and latest economic techniques can be employed, such as NARDL, to test the asymmetric and symmetric effects.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/en16083365/s1.

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