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An Empirical Estimation of Clean Energy and Financial Development as Determinants of Sustainable Development in Iraq

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Abstract: In light of the current circumstances surrounding global warming and the rapid onset of climate change, the imperative for sustainable development has emerged as a pressing concern. In pursuit of this objective, numerous factors are suggested during climate change summits and conferences as potential measures to mitigate significant environmental risks and facilitate the attainment of sustainable development. The present study aims to evaluate the importance of clean energy and financial development in the context of achieving sustainable development in Iraq from 2000 to 2022. In addition, this current study investigates the significance of non-renewable energy sources and their impact on economic growth within the context of sustainable development. The initial analysis indicates that the Augmented Distributed Lag Model (ARDL) may be suitable for application in this study. Based on the results obtained from the ARDL estimation, it was determined that financial development has a statistically significant and negative influence on sustainable development. Conversely, clean energy was found to have a statistically significant and positive impact on sustainable development. Non-renewable energy sources and economic growth have been identified as factors that can impede sustainable development. However, it has been observed that there is a positive relationship between the quadratic term of growth and the increase in sustainable development. The post-estimation diagnostics, which encompass stability and coefficient diagnostics, have demonstrated the suitability of the empirical analysis. Based on the research findings, it is advisable for policymakers and the government of Iraq to actively encourage the utilization of clean energy resources through the implementation of effective energy policies. Additionally, it is recommended that the financial sector of Iraq transition its financing facilities to prioritize environmentally friendly and sustainable production practices and activities.

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1. Introduction

Our Common Future" is a renowned report authored by Brundtland (1987), wherein the author introduced the contemporary concept of "sustainable development. Bruntland proposes that sustainable development encompasses the notion of development that effectively meets the immediate requirements of the current generation, while concurrently safeguarding the capacity of future generations to fulfill their own needs. The primary focus of sustainable development, as defined here, is the preservation of resources for future generations while simultaneously meeting the needs of the current generation. Sustainable development is commonly understood within the scientific community as a state achieved through the harmonious integration of the social, economic, and environmental dimensions of development (Mensah, 2019). The environmental pillar, among the essential pillars of sustainable development, is experiencing rapid degradation due to the detrimental effects of economic practises and living standards. The contemporary state of economic expansion is not solely linked to the deterioration of the environment; rather, it is accompanied by the exacerbation of social and economic concerns resulting from detrimental climate change and global warming. Therefore, the alteration of development patterns pertaining to consumer behavior, governance, and stakeholder involvement is being prominently emphasized. This emphasis arises from the recognition that the existing growth patterns are unsustainable, and the pursuit of continued economic growth within these patterns would result in detrimental environmental consequences (Noor, Khan, Khan, & Rasheed, 2023).

There are present multiple prominent variables that are regarded as the primary contributors to environmental degradation, necessitating careful consideration by all nations throughout the sustainable development endeavor. Financial development is considered to be one of the key factors in the analysis. The role of financial development is significant in the upward trajectory of CO2 emissions due to various factors. Financial development is a significant factor that attracts foreign direct investment, leading to increased economic production as well as environmental pollution (Frankel & Romer, 2017). Furthermore, robust and prosperous financial development facilitates the accessibility of loans for consumers, thereby enabling them to acquire costly commodities such as refrigerators, automobiles, properties, air conditioners, washing machines, and various others. Therefore, this heightened consumerism contributes to increased environmental pollution (Sadorsky, 2010). Furthermore, the advancement of the stock market facilitates a reduction in financing costs for publicly traded companies. This, in turn, aids in the attainment of various financing modes and channels that foster growth. Additionally, it enables the optimisation of liabilities and asset structures, empowering these firms to invest in innovative projects with enhanced installations. However, it is important to note that these developments may inadvertently contribute to an increase in carbon emissions and energy consumption (Dasgupta, Laplante, & Mamingi, 2001).

On the contrary, there exist multiple arguments that support the notion of financial development playing a constructive role in the context of sustainable development. There is a contention that the development of the financial sector facilitates the adoption of technological innovations and new strategies for energy efficiency by firms, thereby promoting development through the reduction of pollution emissions. As a result, there would be a substantial reduction in the intensity of CO2 emissions. According to the findings of Claessens and Feijen (2007), companies or firms that possess an enhanced financial system are associated with promoting development while simultaneously reducing carbon emissions. The presence of financial development has been observed to enhance the operational efficiency of enterprises, leading to a decrease in energy consumption and carbon emissions (Zhang, 2011).

Energy consumption is a significant determinant of sustainable development, as it serves as a crucial catalyst for economic growth in both developing and advanced nations. The escalating energy demand is presenting numerous challenges to environmental sustainability daily (e.g., deforestation, air pollution, water contamination and global warming). However, traditional energy sources such as coal, oil, and gas are utilized for the generation of energy. Fossil fuels have been found to produce increasing quantities of greenhouse gases, thereby making a significant contribution to the phenomenon of climate change and the subsequent global warming observed over extended periods of time (Cai, Sam, & Chang, 2018).

Environmental policymakers contend that the promotion of clean energy resources, such as hydro, biomass, solar, geothermal, and wind power, facilitates the decoupling of economic growth from pollution (Piłatowska & Geise, 2021). The growing importance of clean energy can be attributed to various factors, including the escalating energy challenges and environmental debates arising from the surge in fossil fuel costs, concerns over energy security, macro-level instability, and emissions (Usman et al., 2020). Therefore, the utilization of clean energy possesses the capacity to reduce reliance on conventional energy sources and foster energy security, thereby contributing to the enhancement of environmental conditions and the promotion of sustainable development. Clean energy presents a range of potential remedies for environmental challenges, including but not limited to acid rain, global warming, biodiversity depletion, climate change, and the contamination of water and air through the mitigation of pollutants (Ullah et al., 2020). Additionally, the use of clean energy can help to achieve the goal of long-term sustainable growth because it promotes sustainable growth in the industrial, service, and agricultural sectors. The implementation of clean energy technologies has the potential to positively impact employment opportunities and living standards in emerging nations. This is achieved through the improvement of economic conditions, as well as the reduction of poverty and inequality (Wang, 2019).

Considering the facts, the objective of this study is to examine the impact of clean energy and financial development on the sustainability of Iraq's development from 2000 to 2022. Iraq serves as a significant case study due to the notable variations observed in sustainable development within the country, as depicted in Figure 1. The Gross Domestic Product (GDP) of Iraq has exhibited a positive trend over a period, accounting for approximately 0.32% of the global GDP. The (GDP) of Iraq experienced a significant increase over the course of several decades, rising from a low of 1.70 billion US dollars in 1960 to 197.72 billion US dollars in 2017. In the year 2014, an unprecedented sum of 234.65 billion US dollars was observed (Abdulla & Ali, 2019). However, the expansion of economic

activity is accompanied by a concomitant increase in environmental deterioration, which presents a significant challenge to the attainment of sustainable development. According to estimates made in 2019, Iraq's per capita GDP is approximately 4.83 metric tonnes. The energy consumption in Iraq has experienced a notable increase, rising from 0.86 to 2.12 exajoules during the period from 1990 to 2022. This growth signifies a growth rate of 7.1% in the year 2021 (BP, 2022). The increasing demand for energy due to the growth of the economy is currently met by the utilisation of oil and gas resources, despite the untapped potential of solar energy within Iraq's economy (Abed, Al-Douri, & Al-Shahery, 2014). The share of oil-based energy in Iraq's overall primary energy consumption during the period from 2017 to 2019 (Figure 1) is notably minimal. Additionally, there has been a significant rise in CO2 emissions resulting from energy production, increasing from 54.3 million tonnes in 1990 to 141 million tonnes in the period of 2021. This upward trend raises significant apprehensions regarding the sustainability of both the environment and economic growth (BP, 2022).

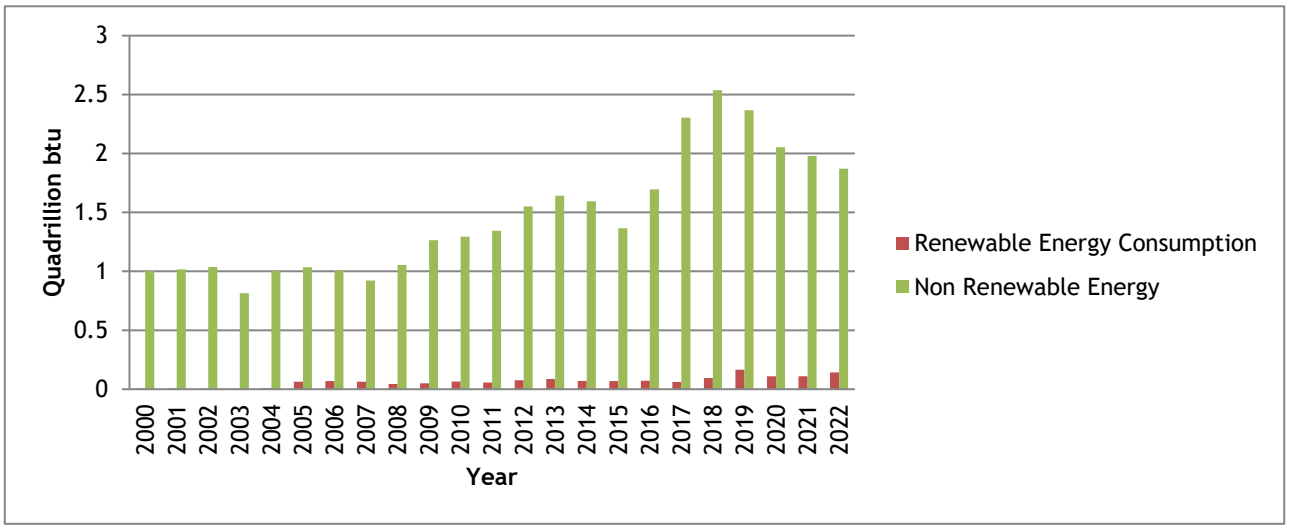

Figure 1: The Proportion of Renewable and Non-Renewable Energy Sources in Total Energy Consumption in Iraq (2000-2022)

The current state of sustainable development in Iraq prompts inquiries regarding the extent to which clean energy facilitates or impedes the progress of sustainable development. Additionally, this study also examines the significance of financial development in the pursuit of sustainable development. It acknowledges that Iraq has implemented numerous measures and reforms to enhance its financial system under the supervision of the Central Bank since 2003 (Abdullah & Abbas, 2022). The primary premise being examined proposes that the advancement of financial systems and the adoption of clean energy sources contribute positively to the attainment of sustainable development. The current study provides contributions to the existing body of literature in three distinct dimensions: The present study aims to examine the relationship between financial development and the promotion of clean energy and sustainable development within the specific context of Iraq. Previous research has examined the relationship between various factors within the context of different countries or groups of countries. However, limited attention has been devoted to investigating this relationship specifically within the context of Iraq. Secondly, the present study relies on Adjusted Net Savings (ANS) as a metric for assessing sustainable development, in contrast to prior studies which predominantly examined the impact of financial development on sustainable development, as measured by economic growth, CO2 emissions, or other sustainability indicators. However, it is important to acknowledge the economic growth, or any other singular measure fails to adequately evaluate sustainable development. Indeed, it has been argued that economic growth fails to account for the evaluation of social welfare and the negative impacts on the environment (Dos Santos Gaspar, Marques, & Fuinhas, 2017). The adjusted net savings index incorporates all forms of capital and considers the degradation of both human and natural capital, rendering it a suitable metric for assessing sustainable economic development. Thirdly, the study employs a composite index of financial development, which consists of three distinct measures of financial development. The specific details of this index can be found in section 3. In contrast, previous studies have predominantly relied on a single proxy of financial development to assess its impact on sustainability.

The subsequent section of the study is structured in the following manner: a concise overview of the current body of literature is presented in section 2. Section 3 of the paper presents a comprehensive overview of the variables, data sources, and applied methodology. In section 4, we analyze and present the empirical findings. The study's conclusion and policy recommendations, based on the findings, are presented in section 5.

2. Literature Review

The current body of literature can be categorised into two distinct strands for the purpose of this review. Firstly, we will examine the relationship between financial development and sustainable development. Secondly, we will explore the connection between clean energy and sustainable development.

2.1 Financial Development and Sustainable Development

A multitude of scholars have conducted extensive research on the interrelationship between financial development and sustainable development on a global scale, leading to the emergence of inconclusive and conflicting findings. Furthermore, various scholars have employed diverse

indicators to assess the concept of sustainable development, including but not limited to gross domestic product (GDP), carbon dioxide (CO2) emissions, and the notion of green growth. In a recent study conducted by Abbasi et al. (2022), an investigation was undertaken to assess the impact of financial development on sustainable development in Pakistan. The study specifically focused on measuring sustainable development through the variables of consumption and territorial carbon emissions. The authors utilised the DARDL estimation technique to examine the impact of financial development on sustainable development, specifically in relation to the increase in territory and consumption-based CO2 emissions. Their findings indicate a negative correlation, suggesting that financial development has a detrimental effect on sustainable development in terms of CO2 emissions. In their study, Bao (2020) employed data from a sample of 16 countries in Latin America and the Caribbean, spanning the years 1990 to 2014. The objective of their research was to assess the impact of financial development on sustainable economic growth, as measured by changes in GDP. The empirical estimation involved the utilisation of AMG and CCEMG methodologies. The study revealed a positive correlation between financial development and economic growth in a specific set of economies. Ahmed, Kousar, Pervaiz, and Shabbir (2022) carried out an estimation of the relationship between financial development and sustainable development in South Asian economies during the period of 2000 to 2018. The study employed both the FMOLS and DOLS estimation methods to examine the relationship between financial development and sustainable development in the countries under investigation. The findings of the study revealed a strong positive association between financial development and sustainable development in the studied countries. In their study, Paun, Musetescu, Topan, and Danuletiu (2019) conducted an analysis of the correlation between the development of the financial sector and sustainable development, as measured by the real GDP growth, across 54 countries that are part of diverse economic groups. The empirical evidence suggests that there is a positive relationship between financial development and economic growth in certain countries. In their study conducted in 2021, (Adebayo et al., 2021) utilised data from Latin American countries spanning the period from 1980 to 2017. The researchers sought to estimate the impact of financial development on environmental sustainability, as measured by CO2 emissions. The application of FMOLS and DOLS estimation techniques revealed a lack of statistical significance in the relationship between financial development and CO2 emissions. In their study, Shahbaz, Shahzad, Ahmad, and Alam (2016) examined the impact of asymmetric financial development on the environment in Pakistan. They employed the NARDL approach to analyze quarterly data from 1985 to 2014. The available evidence suggests that there is a positive correlation between financial development and environmental degradation. Acheampong (2019) conducted an analysis of the data from 46 economies in Sub-Saharan Africa and utilized the Generalised Method of Moments (GMM) approach to examine the impact of financial development on carbon dioxide (CO2) emissions. The findings of the study indicated that the relationship between FD and CO2 emission was non-linear. In addition, it was determined that the presence of financial development has a positive moderating effect on the relationship between economic growth and CO2 emissions, while it has a negative moderating effect on the relationship between energy consumption and CO2 emissions.

2.2 Clean Energy and Sustainable Development

The nexus between renewable energy and sustainable development has garnered increasing attention in recent scholarly discourse. A limited number of studies can be found in the existing body of literature that have attempted to investigate this relationship. Hanif, Bakar, and Nawaz (2022) conducted an analysis on the contribution of clean and fossil fuel energy resources to sustainable development within the G-7 economies from 1995 to 2020. The results obtained from conducting a CS-ARDL analysis revealed that clean energy had a positive effect on development during the period under study, while fossil fuel energy had a negative impact. In a study conducted by Güney (2019), the author examined the contribution of clean and fossil fuel-based energy sources to sustainable development. The analysis was based on data collected from both developed and developing economies, spanning the period from 1990 to 2014. The estimation techniques of Pooled Ordinary Least Squares (OLS) and System Generalised Method of Moments (GMM) were employed to analyze the impact of clean energy and fossil fuel energy on sustainable growth. The results indicated that clean energy had a positive effect on sustainable growth, while fossil fuel energy had a negative effect. In their study conducted in 2019, Kamoun, Abdelkafi, and Ghorbel (2019) examined the impact of clean energy on sustainable development within the economies of the Organisation for Economic Co-operation and Development (OECD) during the period spanning from 1990 to 2013. The study's findings, obtained using the FMOLS estimation approach, demonstrate the positive impact of clean energy innovations on sustainable development. In a study conducted by Güney (2021), data from OECD countries spanning the period of 1990-2015 was analysed to assess the impact of clean and fossil fuel energy on sustainable development. The application of 2SLS-IV estimation revealed that clean energy has a positive impact on sustainable development, while fossil fuel energy has a negative impact.

The study conducted by Wei and Huang (2022) examined the dataset encompassing ten Asian economies over the period of 1990-2020 to investigate the interrelationship between clean energy and sustainable development. Based on the utilization of AMG and CCEMG estimations, the authors arrived at the conclusion that a positive correlation exists between clean energy and sustainable development. In their study, Chen et al. (2022) conducted an estimation of the contribution of green energy sources to sustainable economic growth, as measured by GDP, within a time frame spanning from 1992 to 2018. The focus of their analysis was on eight Asian countries. Based on the AMG estimation approach, it was determined that the utilisation of green energy has a positive impact on economic growth. The study conducted by Noor, Khan, Khan, and Rasheed (2023) involved a comprehensive analysis of data pertaining to South Asian economies from 1995 to 2019. The primary objective of this research was to assess the significance of clean energy sources, as well as other forms of energy, in the context of sustainable development. By using the panel autoregressive distributed lag (ARDL) estimation approach, the study revealed that various forms of energy contributed to the advancement of sustainable development within the countries.

2.3 Literature Gap

The literature review has identified that empirical studies have thus far examined the relationship between financial development and sustainable development by measuring it in terms of CO2 emissions, economic growth, or green growth indicators. To the best of the author's knowledge, no prior research has been identified that has examined

the use of the autonomic nervous system (ANS) as a metric for assessing the relationship between sustainable development and this connection. To date, no prior research endeavors have tried to quantify the interrelationship between financial development and sustainable development within the specific context of Iraq. Secondly, there is a limited number of studies available in the existing literature that have assessed the correlation between clean energy and sustainable development, as measured by the indicator of Anthropocene Sustainability (ANS). However, it is important to note that there has been a lack of prior research investigating this relationship specifically within the Iraqi context. Consequently, after the identification of these gaps within the existing body of literature, the researchers endeavor to address and rectify these gaps, thereby making a substantial scholarly contribution to the fields of clean energy, financial development, and sustainable development.

3. Empirical Estimation Methods

The main objective of the present study is to assess the impact of clean energy and financial development on the attainment of sustainable development in Iraq. In accordance with the research objective, the dependent variable in this study is sustainable development, which is measured in terms of ANS. The primary exogenous factors encompass clean energy and financial development. We measure financial development by creating a composite index from three different financial development indicators: broad money, domestic private sector credit, and liquid liabilities as a percentage of GDP. The index is constructed using Principle Component Analysis. The metric used to quantify clean energy is the amount of renewable energy produced, typically measured in quadrillion BTUs. In addition, the research incorporates economic growth, its square, and fossil fuel energy use as control variables within the model. The temporal scope of the study encompasses the period from 2000 to 2022 (based on data availability).

The model of the study including all above mentioned variables is specified as:

$$SD_t = \beta_0 + \beta_1 FD_t + \beta_2 CE_t + \beta_3 NRE_t + \beta_4 GDP_t + \beta_5 GDP_t^2 + \varepsilon_t \quad (1)$$

In the context of this discussion, SD refers to the concept of sustainable development, while CE and NRE stand for clean energy and non-renewable energy, respectively. The variables GDP and GDP2 represent measures of economic growth and its square, respectively. The term ε_t denotes the error term.

Table 1 provides comprehensive descriptions of all variables and data sources, while Figures 2 to 5 depict time plots for each variable.

Table 1: Description of Variables and Their Data Sources

Variables	Measurement	Data Source
Sustainable development	Adjusted net savings (% of GNI)	WDI
Financial development	Index comprising of liquid liabilities (percent of GDP), domestic credit to private sector (percent of GDP) and broad money (percent of GDP)	WDI
Clean energy	Renewable energy (quadrillion btu)	EIA
Nonrenewable energy	Nonrenewable energy (quadrillion btu)	EIA
Economic growth	GDP per capita (US$ constant 2015)	WDI
Economic growth square	GDP per capita square	WDI

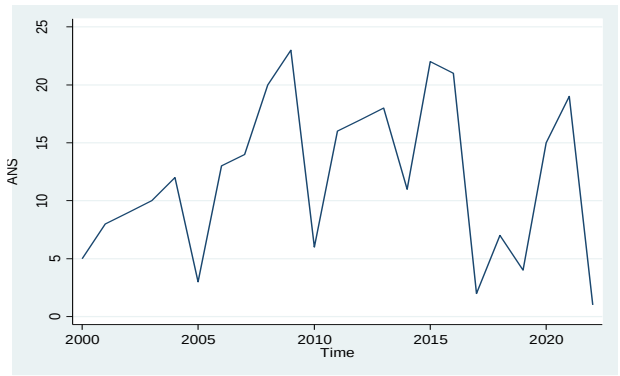

Figure 2: Time plot of Adjusted Net Savings in Iraq (2000-2022)

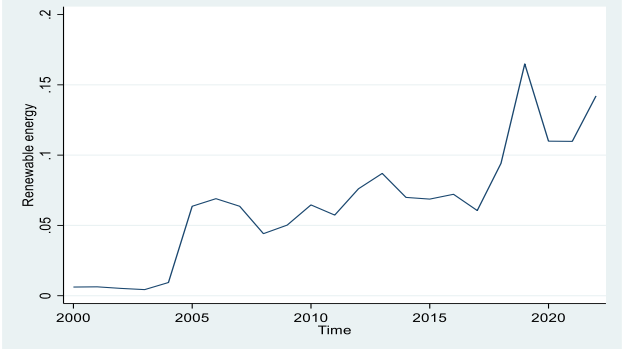

Figure 3: Time plot of Clean Energy in Iraq (2000-2022)

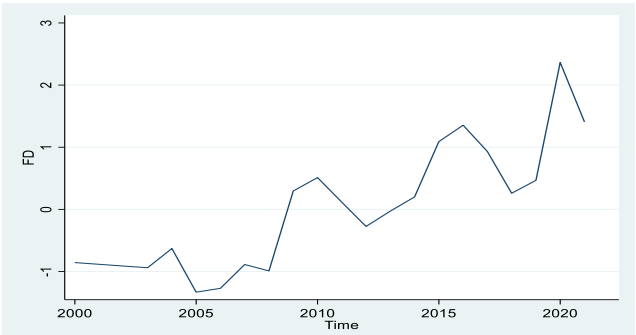

Figure 4: Time plot of financial development in Iraq (2000-2022)

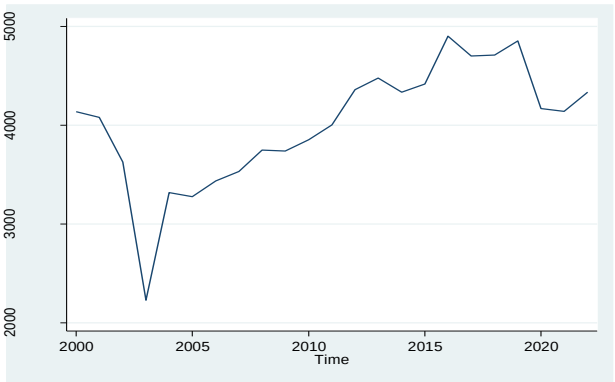

Figure 5: Time plot of Economic Growth in Iraq (2000-2022)

3.2 Estimation Approach

Augmented In the current study, the Dickey-Fuller (ADF) and Phillip Perron (PP) tests for stationarity are initially conducted at both the level and the first difference prior to coefficient estimation. The use of these tests is essential in order to assess the stationarity of the series and confirm that none of the variables possess a second-order integration. The ARDL estimation approach, which was developed by Pesaran, Shin, and Smith (2001), is commonly employed for empirical analysis. The Autoregressive Distributed Lag (ARDL) model is widely recognised as a robust estimation technique for analysing the short and long-run relationships between variables in a given econometric model. This approach offers several advantages over traditional cointegration methods, making it an effective tool for empirical analysis. Determining the integration order of a series is a crucial step prior to employing other cointegration techniques. However, it is worth noting that no preliminary testing is necessary for this method. The utilisation of lag length of variables in the ARDL model can serve to address the issue of endogeneity. Furthermore, this approach is applicable regardless of the method of integration employed for the series under investigation. The ARDL approach has the ability to generate precise findings even when working with limited sample sizes. The construction of the ARDL model is based on the specifications determined in the second stage, which are selected using the Akaike information criterion (AIC). Following that, a bounds testing approach is employed to ascertain the presence or absence of a long-run cointegrating relationship between the dependent and independent variables.

The model described in equation (1) can be equivalently expressed as equation (2) using the ARDL bound testing approach. Equation (2) clarifies the interdependence of the variables over an extended temporal duration.

$$\Delta SD_t = \alpha_0 + \alpha_1 SD_{t-1} + \sum_{i=1}^{l} \alpha_1 \Delta FD_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta CE_{t-i} + \sum_{i=1}^{o} \alpha_3 \Delta NRE_{t-i} + \sum_{i=1}^{q} \alpha_4 \Delta GDP_{t-i} + \sum_{i=1}^{p} \alpha_5 \Delta GDP2_{t-i} + \varepsilon_t \quad (2)$$

The estimation of short-run coefficients should be conducted subsequent to the determination of long-term relationships among variables. Equation (3) demonstrates that in order to obtain the short-run parameters, it is necessary to compute the error correction model (ECM).

$$\Delta SD_t = \varphi_0 + \sum_{i=1}^{l} \varphi_1 \Delta FD_{t-1} + \sum_{i=1}^{m} \varphi_2 \Delta CE_{t-i} + \sum_{i=1}^{o} \varphi_3 \Delta NRE_{t-i} + \sum_{i=1}^{q} \varphi_4 \Delta GDP_{t-i} + \sum_{i=1}^{p} \varphi_5 \Delta GDP2_{t-i} + \sum \varphi_5 ECT + \varepsilon_t (3)$$

In equations (2) and (3), the variables l, m, p, o, and r represent the lag length of the respective variables. The disturbance term is denoted as ε_t, while the first difference operator is represented by the symbol Δ. The equation mentioned above also demonstrates the dynamics of the error correction mechanism (ECM) and the long-term relationships between the series. Equation (2) is utilized to examine alternative and null hypotheses to figure out the presence or absence of a long-term relationship. The ultimate evaluation of the hypothesis is conducted by utilising the estimated F-statistic and comparing it with the critical value established by Pesaran, Shin, and Smith (2001). The null hypothesis is rejected when the observed statistical value exceeds the critical threshold of the upper bound. Support is indicated when the computed F-statistic falls below the lower limit. The null hypothesis (H0) is deemed to not be adequately rejected if the expected value falls within the range defined by the upper and lower values. Furthermore, we conducted an evaluation of the most suitable lag length by employing the Akaike Information Criterion (AIC).

4. Results and Discussion

4.1 Unit Root Test

The primary objective of this study is to investigate the correlation between financial development, clean energy, and sustainable development in the context of Iraq. Firstly, the utilisation of unit root testing is essential in determining the integration order of the parameters, which is a prerequisite for employing techniques aimed at establishing long-term relationships among variables. Therefore, to assess the level of integration of series, the Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) tests are utilized. The results of the unit root or stationarity test are presented in Table 2. All variables exhibit a unit root at the level but attain stationarity after undergoing the first difference.

Table 2: Unit Root Test Findings

Variables	ADF		PP	
	Level	first difference	level	first difference
ANS	-3.243	-5.924***	-3.243	-6.843***
FD	-1.308	-4.518***	-1.308	-4.518***
CE	-1.228	-5.268***	-0.671	-10.099***
NRE	-0.817	-3.988***	-4.218	-8.065***
GDP	-1.728	-5.408***	-1.728	-5.524***
GDP^2	-1.513	-4.997***	-1.497	-5.023***

4.2 Cointegration Test

The inclusion of the I(1) series in question necessitates the estimation of both short-term and long-term relationships between variables. The determination of the upper threshold for the significance level is achieved through the utilisation of the co-integration test, which relies on F-statistics. The null hypothesis for the F-test is that there is no cointegration. The statistics are presented in Table 3. The presence of a cointegration link between the dependent variable (ANS) and all independent variables has been determined through the bounds test, as shown in Table.

Table 3: ARDL Bound Results

Test Statistics	Value	Significance level	Level	First Difference	Decision
F-statistics	12.132	10%	2.08	3	Cointegrated
K	6	5%	2.39	3.38	
		1%	3/06	4.15	

Table 4: ARDL Long Run Estimation

DV (ANS)	Coeff	t-stat	P-value
FD	-17.109**	-2.48	0.0677
CE	1.450***	2.008	0.0000
NRE	-4.947***	-2.990	0.0177
GDP	-0.158**	-2.675	0.0555
GDP^2	0.0027**	2.69	0.0544
Cons	-312.21***	-2.509	0.0661

***=p<0.05 and **=p>0.05

Following the completion of all preliminary analysis, we proceed to conduct long run and short run autoregressive distributed lag (ARDL) analysis. The results of the long-term estimation are presented in Table 4. Firstly, empirical evidence suggests a negative correlation between financial development

and sustainable development. One potential explanation for the adverse effects of financial development on sustainable development could be attributed to the convenient accessibility of credit facilities for unsustainable economic and production endeavours. This is primarily due to the fact that unsustainable production activities tend to yield higher returns in many developing nations. Credit facilities are readily accessible for production activities that encompass resource extraction, forest depletion, and industries that generate pollution. Furthermore, this discovery substantiates the notion that loans play a crucial role in facilitating businesses to obtain financial resources and to enhance their investment capacity. Undoubtedly, this phenomenon contributes to the expansion of economic growth; however, it concurrently exacerbates carbon emissions, a situation further compounded by advancements in the financial sector (Zhang, 2011). In addition, both households and businesses derive benefits from the enhanced accessibility of financial capital that ensues from financial development. The enhancement of the financial system is correlated with the escalating demand for automobiles, machinery, and various other goods, thereby amplifying production and transportation methodologies. The above-mentioned phenomenon leads to an escalation in energy demand, consequently resulting in elevated levels of emissions of air and water pollutants (Shahzad, Kumar, Zakaria, & Hurr, 2017). The results of our study align with the previous findings presented by Odugbesan, Ike, Olowu, and Adeleye (2022) and Shahzad, Kumar, Zakaria, and Hurr (2017).

Second, it is evident that the utilization of clean energy has a substantial and favorable influence on the promotion of sustainable development over an extended period of time. The present discovery is consistent with the findings of Hassoun and Hicham (2020), Behboudi, Mohamadzadeh, and Moosavi (2017), as well as Vo and Vo (2021) from previous research endeavors. Moreover, it provides robust support for the seventh sustainable development goal, which prioritizes the utilization of affordable and clean energy sources. The utilisation of clean energy resources has the potential to enhance a nation's economic standing. Additionally, it is anticipated that this technology will generate energy that is more ecologically sustainable, potentially meeting the entirety of future energy demands. The study also suggests that Iraq should strive to acquire increasingly essential technologies in the future, which would facilitate the adoption of clean energy as a crucial means of mitigating resource depletion and ensuring their preservation for future generations.

Third, in contrast, to clean energy, which has a substantial and favorable influence on sustainable development, the coefficient of non-renewable energy is determined to be statistically significant but displays a negative trend over an extended period of time. This poses a significant challenge to the attainment of sustainable development objectives. The finding suggests that there is a necessity to alter the energy composition of Iraq by augmenting the share of renewable energy sources within the overall energy mixture. The findings of our study provide valuable insights for Iraq, a nation heavily dependent on energy sources derived from fossil fuels. The previous research conducted by Güney (2021) and Güney and Kantar (2020) provides substantial support for our discovery pertaining to the interrelationship between non-renewable energy and sustainable development nexus. However, the research conducted by Saboori and Soleymani (2011) presents a contrasting perspective to our study. Their findings suggest that non-renewable energy sources can also contribute to the promotion of sustainable development, which diverges from our own analysis.

Lastly, it is observed that the influence of GDP on sustainable development is negative, while the impact of GDP2 is positive in the long term, which aligns with the research findings of Kamoun, Abdelkafi, and Ghorbel (2020) and Ampofo, Cheng, Ayimadu, and Asante (2021). The lack of surprise regarding this outcome stems from the fact that developing countries such as Iraq tend to prioritise economic growth in the initial stages of their development, often at the expense of neglecting the deteriorating environmental conditions. This suggests that there is a positive correlation between the initial increase in economic growth and the subsequent increase in environmental pollution. This can be attributed to the fact that GDP, which encompasses various factors such as government expenditures, consumption, investment, and net exports, is primarily influenced by consumption. Notably, the rise in consumption is closely linked to the escalating energy consumption, which in turn leads to environmental degradation and a decline in sustainable development. However, once a particular income threshold is surpassed, the impact of GDP on sustainable development becomes positive. This suggests advancements in technology and a growing awareness among individuals about the adverse environmental effects associated with increasing GDP. These factors collectively contribute to the promotion of sustainable development.

4.4 ARDL Short Run Analysis

The error correction model (ECM), which captures the short-run dynamics, forms the basis for our short-run autoregressive distributed lag (ARDL) analysis. The coefficient of ECT exhibits statistical significance and a negative direction, with a value below 1, thereby meeting all three criteria. The model will ultimately attain a state of long-run equilibrium, as indicated by the negative sign, with a velocity of 68%. The results of the short-run dynamics are presented in Table 5. All of the short-run parameters exhibit statistical significance at a significance level of 1%. The findings from the short-term analysis indicate that the explanatory variables' variance, with an R2 value of approximately 0.94, explains 94 percent of the variability observed in sustainable development.

Table 5: ARDL Short Run Estimation

variables	Coeff	t-stat	P-value
D(ANS)	-0.577***	-9.508	0.0007
D(FD)	-3.530***	-5.067	0.0002
D(CE)	1.540***	2.960	0.0000
D(NRE)	-0.462***	-13.57	0.0002
D(GDP)	-0.063***	-6.820	0.0024
D(GDP^2)	0.012***	7.495	0.0017
ECM	-0.687***	-14.571	0.0001
R^2		0.97	
Adj. R^2		0.94	

***= P<0.05%

4.5 Stability and Diagnostic tests

The results of the diagnostic and stability tests are displayed in Table 5. The stability of the parameters is assessed using the stability tests of CUSUM and CUSUM square. The graphs presented in Figures 4 and 5 depict the results of the CUSUM test and CUSUM square test. These

graphs demonstrate that all observed values remain within the acceptable range, as determined by a significance level of 5 percent.

Table 6: Diagnostic Test Results

	Test-value	Prob
Serial Correlation	2.369	0.296
Heteroskedasticity Test	1.429	0.397
Normality Test	3.723	0.155
Ramsey RESET Test	0.149	0.724

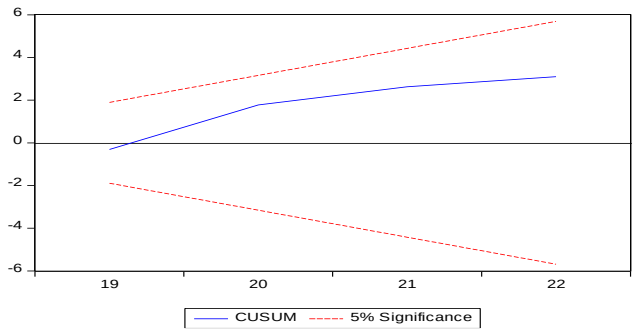

Figure 3: CUSUM Plot of Residual Stability

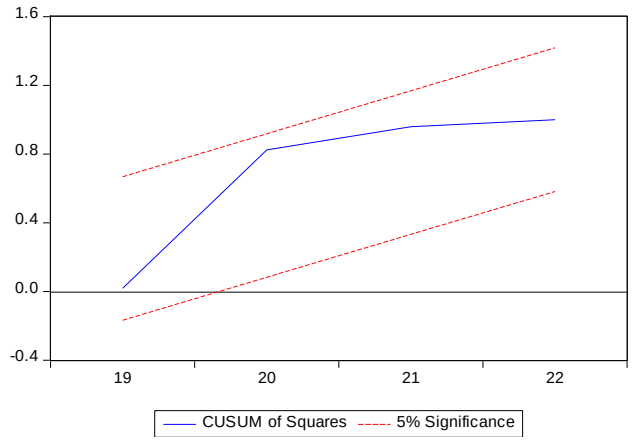

Figure 3: CUSUMSQ Plot of Residual Stability

5. Concluding Remarks and Policy Recommendations

The primary objective of the present study is to examine the impact of clean energy and financial development on sustainable development in Iraq from 2000 to 2022. In contrast to prior research that predominantly relied on GDP or CO2 emissions as indicators of sustainable development, this study employs a more comprehensive measure known as the Adjusted Net Savings (ANS). Consequently, this study represents a noteworthy contribution to the existing literature on sustainable energy and financial development. The initial unit root testing indicated that all of the series possess one order of integration. Hence, the present study employs the ARDL Bound testing approach to conduct empirical estimation. The results of both long-term and short-term estimation indicate that clean energy has a substantial and positive effect on sustainable development, while financial development has a negative impact during the period under study. Additionally, it is widely acknowledged that the utilization of non-renewable energy sources and the pursuit of economic growth pose significant obstacles in the pursuit of sustainable development. Therefore, it can be inferred that the utilization of clean energy plays a pivotal role in facilitating the advancement of sustainable development, while financial development poses a hindrance to this progress.

The aforementioned summary and findings of the study yield several noteworthy policy recommendations for governmental entities and policymakers in Iraq. Sustainable development necessitates the provision of adequate resources to meet the needs and sustain the living standards of future generations, akin to those enjoyed by present generations. It is imperative to prioritise the utilisation of renewable energy resources while minimising reliance on fossil fuel-based resources. The primary recommendation put forth by our study is to prioritise the utilisation of renewable resources in both production and consumption processes. This emphasis on renewable sources is crucial for advancing sustainable development objectives, as it effectively mitigates pollution emissions and contributes to the long-term welfare of humanity. By the year 2030, it is imperative to actively advocate for initiatives aimed at advancing the development and implementation of renewable energy production projects. The imperative for the Iraqi government to prioritise solar energy production and consumption arises from the significant untapped potential within the country's solar resources. The facilitation of investment in research pertaining to clean energy resources projects is imperative for the government of Iraq. This measure aims to generate climate-friendly electricity and bolster the economic benefits and efficiency of renewable energy resources. Furthermore, it is imperative to establish public-private partnerships and foster international collaborations aimed at promoting the utilisation of clean energy resources within a given nation. This strategic approach is crucial for enhancing sustainable development. Furthermore, it is recommended that the government provide subsidies for the utilisation of goods and services derived from clean energy sources, while concurrently implementing additional taxes on products derived from non-renewable resources. Nevertheless, it is imperative to incrementally raise the rate of imposed taxation in order to mitigate any detrimental impacts it may have on the overall expansion of the national economy. These aforementioned measures would prove beneficial in fostering sustainable development within the nation.

Secondly, the Iraqi economy should prioritize the enhancement of its financial development strategies by incorporating environmental sustainability objectives into its plans for economic growth. It is recommended that a substantial portion of credit allocation to the private sector be directed toward industries operating within the country that have a notable environmental impact. Also, it is imperative for the Iraqi government to promote the utilization of credits as a means of financing environmentally sustainable initiatives, with the aim of mitigating the adverse environmental consequences associated with economic expansion. The issuance of green bonds by the government can serve as a means to incentivize borrowers to invest in projects that are environmentally sustainable. The optimal approach to financial development in Iraq entails prioritising the enhancement of accessibility to green funding schemes, which play a crucial role in attaining sustainable development objectives.

Limitations of the Study and Future Studies Recommendations

Similar to multiple scholarly investigations, the current study offers a substantial theoretical and empirical contribution within the existing body of literature. Nevertheless, it is important to acknowledge that the study does have certain limitations. The study's scope is constrained as it exclusively examines data from Iraq within a restricted timeframe. In order

to expand the scope of future studies, it is suggested that additional countries from the Gulf region be included. The duration of the study should be extended in order to obtain a greater number of long-term empirical estimates. Moreover, future research endeavors may employ a disaggregated approach to examine various clean energy resources, such as solar, wind, hydro, and nuclear power. This comparative study aims to investigate the distinct impacts of these diverse resources on the promotion of sustainable development. In addition, various econometric methodologies can be employed to examine the non-linear and asymmetric impacts of the variables on sustainable development. Future research should consider additional variables that were not included in the current study but may have a significant impact on the promotion or hindrance of sustainable development. These variables include green finance, technological innovations, green innovations, globalization, and trade etc.

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