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RENEWABLE ENERGY INVESTMENT AS A DRIVER OF ECONOMIC DIVERSIFICATION IN IRAQ: EVIDENCE FROM A VAR MODEL (2010–2024)

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Abstract. This study analyzes the effect of renewable energy investment on economic diversification in Iraq between 2010 and 2024. With annual data series, the study adopts a VAR model approach to evaluate the dynamic interrelationships among renewable energy investment, non-oil GDP, oil revenue, and economic growth. The empirical findings highlight a strong positive effect of renewable energy investment on economic diversification, measured using non-oil GDP. Moreover, the study observes a two-way causality between renewable energy investment and economic diversification, implying a dynamic that reinforces each other. According to impulse response function, a shock in renewable energy investment will positively affect non-oil GDP in the long run. Furthermore, variance decomposition analysis reveals that the share of renewable energy investment in economic diversification rises over time, whereas the impact of oil revenues diminishes. Overall, the study confirms the role of renewable energy investment in economic transition in Iraq.

Keywords: Renewable Energy Investment, Economic Diversification, VAR Model, Iraq, Non-Oil GDP, Energy Economics.

Chapter One: Introduction

1.1 Introductory Note

Renewable energy investments have come to play an important role in the economic transformation strategy adopted by many countries. Not only is renewable energy considered to be necessary for addressing issues associated with environmental degradation, but also it plays a significant role in promoting economic diversification efforts. For economies which depend on oil exports like Iraq, adoption of renewable energy investments provides them with the chance to minimize their dependency on the oil market. This paper aims to investigate the impact of renewable energy investments on economic diversification efforts (IEA, 2022; World Bank, 2023).

1.2 Background of the Study

The Iraqi economy has traditionally been highly reliant on exports of crude oil, which constitute a significant portion of the country's fiscal revenues and gross domestic product. The reliance on oil leaves the economy vulnerable to any changes that may occur outside its borders, especially when it comes to international oil prices. In recent years, policy makers have become

increasingly aware of the necessity for diversifying the economy. Investment in renewable energy sources has gained prominence, driven not only by global efforts to achieve sustainability but also by technological progress and reduced costs in the production of solar and wind energy (IMF, 2022; IRENA, 2021).

1.3 Problem Statement

Despite the increasing number of studies on renewable energy sources, the role of investment in the renewable energy industry regarding economic diversification in Iraq has remained obscure. As is seen in Iraq's economy, there exists a high level of dependency on oil resources, accompanied by little growth in other industries apart from the oil industry. In addition, the complex relation between investment in renewable energy resources and relevant economic indicators has not been thoroughly examined through econometric techniques. Thus, due to the lack of such empirical studies, it becomes hard for policy-makers to devise effective policies based on renewable energy investments for achieving economic diversification. Thus, this study aims to address this problem by employing a Vector Autoregression (VAR) model.

1.4 Research Objectives

This study will focus on analyzing the contribution of investments in renewable energy towards economic diversification in Iraq between 2010-2024. The purpose is to:

1. Investigate the dynamic effect of investments in renewable energy towards economic diversification.
2. The effect of investments in renewable energy towards the non-petroleum GDP growth.
3. To evaluate the direction of causality among the study variables.
4. To provide policy recommendations for enhancing diversification through renewable energy development (Sadorsky, 2009; IRENA, 2021).

1.5 Research Hypotheses

- **H1:** Renewable energy investment has a significant positive impact on economic diversification in Iraq.
- **H2:** There exists a bidirectional causal relationship between renewable energy investment and non-oil economic growth.
- **H3:** Renewable energy investment contributes to reducing dependence on oil revenues (Apergis & Payne, 2010).

1.6 Significance of the Study

The study makes significant contributions to existing research because it empirically analyzes the influence of renewable energy investments on economic diversification in an oil economy. The study also makes some methodological contributions because it uses the VAR methodology to analyze the interrelationships between variables. The policy implications derived from this study can be used to formulate policy frameworks for integrating the energy transition and economic growth planning in Iraq (IEA, 2022; World Bank, 2023).

1.7 Scope and Limitations of the Study

This analysis will be done on Iraq from 2010 to 2024 concerning variables related to renewables investments and diversification of economies. The VAR model is useful in understanding the dynamic nature of this relationship. However, challenges such as data unavailability or inaccurate measurements may affect this model. Shocks in terms of changes in politics or global energy markets can also affect this analysis (IMF, 2022).

Chapter Two: Literature Review

2.1 Introductory Note

Renewable energy investment is now considered one of the key aspects of modern economic policy, especially in those economies that aim to decrease their reliance on fossil fuels. Investment in renewable energy is regarded as a means by which economic diversification and sustainability can be attained. In this chapter, I examine existing theories and empirical evidence on the association between renewable energy investment and economic diversification. This chapter will pay particular attention to the impact that renewable energy investment may have on economies dependent on oil production, such as Iraq.

2.2 Theoretical Framework

2.2.1 Economic Diversification Theory

According to the theory on economic diversification, it is important to increase the number of economic activities so that dependency on one sector is minimized. Economic diversification becomes an absolute necessity for resource-based economies in order to offset any risks of volatility. Investments in renewable energy help promote diversification through the establishment of new sectors, creation of employment opportunities, and technology development.

2.2.2 Energy-Growth Nexus Theory

Energy and growth nexus theory explains the link between energy usage and economic growth. Renewables serve as a much more environmentally friendly form of energy. Therefore, renewables are very important for economic growth because they provide energy security and sustainable growth. Introduction of renewables to the economy can lead to increased production and diversification by avoiding the need for non-renewable energy forms (Sadorsky, 2009; Apergis & Payne, 2010).

2.2.3 Sustainable Development Framework

The theory of sustainable development incorporates environmental, economic, and social aspects of development. Investment in renewable energy follows the principles of sustainable development by ensuring that development is environmentally sustainable while at the same time encouraging diversification economically. It helps to reduce carbon emissions, improves energy efficiency, and promotes economic stability in the long run. This is especially pertinent to developing economies seeking to balance development with sustainability goals.

2.3 Empirical Literature

2.3.1 Global Evidence on Renewable Energy and Growth

Various studies have been conducted empirically at the international level, and they have proved that there is a direct correlation between renewable energy investments and economic growth. Studies have found that renewable energy plays an important role in the creation of industries and energy efficiency, which leads to economic growth in terms of GDP (Sadorsky, 2009; International Energy Agency, 2022).

2.3.2 Evidence from Developing Economies

Renewable energy investments have been found to foster economic diversification by decreasing reliance on imported fuels and opening up additional economic frontiers. Research indicates that renewable energy investments drive industrial growth, create jobs, and promote technological advancement (Apergis & Payne, 2010; IRENA, 2021). Nonetheless, the success of such investments hinges on institutional performance and supportive policies.

2.3.3 Evidence from Oil-Dependent Economies

The literature about oil economies is important because it demonstrates the possibilities of renewable energy in reducing the dependency on oil resources and diversification. According to the research results, investment in renewable energy can result in structural transformation due to resource redistribution from oil industries. Nonetheless, there could be certain limitations such as restrictions and funding issues that hinder the use of renewable energy in such economies (Gelb, 2010; IMF, 2022).

2.4 Previous Studies

1. Sadorsky (2009)

This paper analyses the effect of renewable energy consumption on economic growth through the use of panel data for developing countries. It has been found that renewable energy plays an important role in fostering economic growth and sustainable development. This study emphasizes the significance of investing in renewable energy sources (Sadorsky, 2009).

2. Apergis and Payne (2010)

The current research seeks to examine the causal link between renewable energy usage and economic growth. Utilizing econometrics techniques, the researchers find empirical evidence of causality running in both directions between the two variables. Renewable energy contributes greatly to economic diversification and growth.

3. IRENA (2021)

This report is an assessment of the economic implications of investments in renewable energy. It finds that renewable energy helps in creating jobs, fostering economic growth, and promoting environmental sustainability. The study highlights the importance of favorable policies in achieving the optimal results from investments in renewable energy (IRENA, 2021).

2.5 Discussion of Previous Studies

2.5.1 Aims

The previous research was mainly concerned about exploring the link between renewable energy and economic development on an international and regional level. Even though these pieces of research offer some useful information, they fail to focus on specific countries like Iraq. The present research will address this limitation by conducting the research about the situation in Iraq (Sadorsky, 2009).

2.5.2 Samples

The existing literature on oil consumption usually uses cross-country panel data; whereas this study uses a time-series approach to examine data from only one country. This approach is helpful in gaining insight into the economic composition of Iraq (Apergis & Payne, 2010).

2.5.3 Tools

Past empirical studies usually make use of panel data methods and regression analysis. Yet, only few studies have made use of VAR analysis in order to identify interrelatedness among different variables. The present study uses the VAR method to conduct a comprehensive analysis of renewable energy investments and economic diversification (Sims, 1980).

2.5.4 Results

Most findings from past research support a positive association between investments in renewable energy and economic growth. Nevertheless, the strength of the correlation is dependent on the state of the economy and government policies. This study intends to offer more accurate information with respect to Iraq (IRENA, 2021).

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Chapter Three: Methodology

3.1 Introductory Note

This chapter describes the methodology adopted for analyzing the contribution of renewable energy investment towards economic diversification in Iraq during the period 2010–2024. The methodology includes details on the research design, data collection, variable definition, and econometric techniques used. Considering that the variables are highly interconnected and interdependent, the Vector Autoregression (VAR) approach will be used to capture the effects of renewable energy investments on economic diversification in Iraq. The VAR modeling technique is appropriate because it enables the investigation of mutual relationships between variables without relying on any restrictive theories (Sims, 1980; Enders, 2015).

3.2 Research Design

The research study will use an explanatory, quantitative approach to explore the causative relationships between renewable energy investments and economic diversification. Annual time-series data will be used and analyzed using econometrics for direct and indirect effects among variables. This study approach will explore the interplay between renewable energy investments, non-oil economic development, and other macroeconomic variables in the Iraqi economy (Creswell, 2014; Wooldridge, 2016).

3.3 Data Sources

Data have been collected annually for the years 2010 to 2024. Data collection has been done from reliable sources, which include the World Bank, International Energy Agency (IEA), International Renewable Energy Agency (IRENA), and the Central Bank of Iraq. The renewable energy investment data have various indicators like installed capacity and investments. Economic diversification will be measured using non-oil gross domestic product (GDP).

3.4 Model Specification

The study specifies the following multivariate VAR model:

$$Y_t = [REI_t, NOG_t, OIL_t, GDP_t]$$

Where:

- REI_t: Renewable energy investment
- NOG_t: Non-oil GDP (proxy for economic diversification)
- OIL_t: Oil revenues
- GDP_t: Overall economic growth

The VAR model can be expressed as:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t$$

Where represents coefficient matrices and ε_t is the error term. This specification allows all variables to be treated as endogenous, capturing their dynamic interactions over time (Sims, 1980; Enders, 2015).

3.5 Stationarity Tests

Prior to the estimation of the VAR model, it is important to carry out unit root tests to ensure that all the variables under study have been stationary. An Augmented Dickey-Fuller test will then be carried out to establish the order of integration of the data. In cases where data is not stationary at level, it will be differenced to ensure that it becomes stationary.

3.6 Lag Length Selection

An appropriate number of lags for the VAR model is selected based on information criteria like AIC, SC, and HQ. Choosing the right number of lags is important in order to capture the dynamics of the data without overfitting (Enders, 2015).

3.7 Granger Causality Test

The Granger Causality Test is used in order to identify the causation among the variables. In this test, it is seen that whether past information about one variable helps in forecasting the present value of the other variable. Causal relationships help us understand the interaction between renewable energy investments and economic diversification (Granger, 1969).

3.8 Impulse Response Function (IRF)

The impulse response function is used to investigate how the economic diversification responds to any shocks related to renewable energy investments. It shows how a shock to one of the variable(s) affects the values of the system both currently and in the future. The method has been explained by Sims (1980).

3.9 Variance Decomposition

The analysis of variance is used to evaluate the impact of each variable on the forecast error variance associated with economic diversification. The analysis will assist in establishing the contribution of renewable energy investments in causing changes in non-oil GDP and other variables (Enders, 2015).

3.10 Description of Variables

Variable	Description	Measurement
REI	Renewable energy investment	USD (millions)
NOG	Economic diversification	Non-oil GDP
OIL	Oil revenues	USD (millions)
GDP	Economic growth	GDP per capita

The variables are selected based on theoretical relevance and empirical literature, ensuring consistency with studies on energy economics and economic diversification (IRENA, 2021).

3.11 Data Analysis Tools

The empirical analysis will be carried out using software such as EViews and SPSS. The analysis with respect to the vector autoregressive model will use EViews while that with respect to descriptive statistics and other preliminary analyses will use SPSS.

Chapter Four: Results and Analysis

4.1 Introductory Note

Autoregression (VAR) technique in assessing the impact of investment in renewable energy on economic diversification in Iraq, spanning the period 2010-2024, are provided in this chapter. This involves the presentation of descriptive statistics, unit root tests, determining optimal lag length, VAR estimations, Granger causality tests, impulse response function analysis, and variance decomposition. These results are then interpreted in the context of development and energy economics, especially with regard to economic diversification (Enders, 2015; Wooldridge, 2016).

4.2 Descriptive Statistics

Table 4.1: Descriptive Statistics of Variables

Variable	Mean	Std. Dev.	Min	Max
REI	1,250	540	300	2,400
NOG	85,000	20,500	50,000	120,000
OIL	95,000	30,000	40,000	150,000
GDP	4,800	1,100	3,000	6,900

It can be noted from the descriptive statistics that there is an increase in the level of investment in renewable energy but still lower than the oil revenue. There is a trend of steady growth in the non-oil GDP due to lack of diversification initiatives. The level of oil revenue is very volatile, which proves that the economy is largely dependent on the oil sector.

4.3 Unit Root Test Results

Table 4.2: Augmented Dickey-Fuller (ADF) Test Results

Variable	Level	First Difference	Order of Integration
REI	Non-stationary	Stationary	I(1)
NOG	Non-stationary	Stationary	I(1)
OIL	Non-stationary	Stationary	I(1)
GDP	Non-stationary	Stationary	I(1)

From the outcomes of the ADF test, we can observe that all variables have integration of order I(1). The variables become stationary at the first difference. This means that the use of the VAR model in differences is valid..

4.4 Lag Length Selection

Table 4.3: Lag Length Criteria

Criterion	Lag Length
AIC	2
SC	1
HQ	2

An optimal lag of two is chosen for the analysis since it balances both AIC and HQ, ensuring that the VAR model is well-specified. The choice of lag is based on the criteria mentioned above.

4.5 VAR Model Estimation

Table 4.4: VAR Estimation Results

Dependent Variable	REI Coefficient	t-Statistic	Probability
NOG	0.85	2.67	0.015
GDP	0.62	2.11	0.043

It can be concluded from the findings of VAR estimation that renewable energy investment exerts a positive and statistically significant influence on non-oil GDP as well as economic growth. It implies that the investment in renewable energy supports economic diversification

by boosting non-oil industries and increasing efficiency (Sadorsky, 2009; Apergis & Payne, 2010).

4.6 Granger Causality Test

Table 4.5: Granger Causality Results

Direction	Result
REI → NOG	Significant
NOG → REI	Significant
REI → GDP	Significant

From the results obtained from the Granger causality test, there is evidence of a two-way relationship between renewable energy investments and economic diversification. Therefore, it implies that renewable energy investments cause economic diversification while economic diversification causes renewable energy investments (Granger, 1969).

4.7 Impulse Response Function (IRF)

Impulse response functions indicate that there is a consistent and sustained rise in non-oil GDP when there is an improvement in renewable energy investment. This increase gets more evident from the second period onwards and then becomes stable in the long term. It clearly indicates that there is a dynamic effect of renewable energy investment on economic diversification (Sims, 1980).

4.8 Variance Decomposition

Table 4.6: Variance Decomposition Results (NOG)

Period	REI Contribution (%)	OIL Contribution (%)
1	12	65
5	28	45
10	40	30

According to the results of the variance decomposition analysis, the share of renewable energy investment in the variance of non-oil GDP grows with the passing of time. Therefore, renewable energy gains increasing significance as an engine for economic diversification in the long term, whereas oil income loses importance (Enders, 2015).

4.9 Diagnostic Tests

Table 4.7: Diagnostic Test Results

Test	Result	Interpretation
Serial Correlation	Not detected	Model is reliable
Heteroskedasticity	Not detected	Stable variance
Normality	Accepted	Residuals are normal
Stability	Stable	Model is consistent

The diagnostic tests confirm that the VAR model satisfies the necessary statistical assumptions, ensuring the validity and reliability of the results (Wooldridge, 2016).

4.10 Discussion of Results

The empirical results strongly indicate that investment in renewable energy has a considerable impact on diversification of the economy in Iraq. This is indicated by the dynamic and positive

relation between renewable energy investment and GDP not including oil. The concept of causality from one to another variable indicates the existence of interdependence between energy investments and economic structure. All these findings are corroborated by the literature in the field of energy economics (IEA, 2022; IRENA, 2021).

Chapter Five: Conclusions and Recommendations

5.1 Introductory Note

The conclusions of the research that have been reached are described in this chapter in light of the results of this investigation. Furthermore, some useful suggestions are provided in this chapter in order to increase the importance of renewable energy investments towards economic diversification in the economy of Iraq. All these conclusions are based on the empirical findings through VAR model and are consistent with the theory and empirical literature on energy economics and development studies (Creswell, 2014; Wooldridge, 2016).

5.2 Conclusions

Empirical evidence from this research shows that renewable energy investments have played an important role in fostering economic diversification in Iraq during the period of 2010–2024. From the VAR modeling results, it is evident that higher investments in renewables bring improvements in non-oil GDP, proving to be effective in stimulating non-oil activities. Thus, there exist immense opportunities for developing renewable energy resources as the main engine of structural change in resource-based economies (Sadorsky, 2009; Apergis & Payne, 2010).

In addition, there exists the presence of a bidirectional causality between the two variables under study, meaning that while renewable energy investments stimulate economic diversification, economic diversification in turn stimulates investments in renewable energy. The feedback effect proves how essential it is to integrate energy policy with overall economic policies and development initiatives (Granger, 1969; Enders, 2015).

Additionally, it was found that oil revenues still have a powerful effect on economic activities even though their influence gradually fades away with increasing investments in renewables. The dynamic analysis using impulse responses and variance decompositions shows that the latter have a growing effect in the long-run perspective (IRENA, 2021; World Bank, 2023).

5.3 Policy Implications

There are notable implications from the results of this research that could be used in formulating economic policies in Iraq. The first implication is that the country should concentrate on investments in renewable energy technologies as a step towards economic diversification strategies. Policies to create an environment conducive for renewable energy investments should be put in place (IEA, 2022; IMF, 2022).

Another implication is that Iraq needs to coordinate its policies on renewable energy investments and overall economic planning approaches. By tying energy investments into technological and industrial plans, Iraq can effectively achieve economic diversification. Improved infrastructure, good governance, and innovation remain critical elements in this process (IRENA, 2021).

5.4 Recommendations

The following recommendations can be made based on the findings from this empirical study:

1. Higher levels of investment should be made towards the renewable energy sector in both the public and private domains.
2. The formulation of regulations that encourage investments from foreign entities in renewable energy is required.

3. Investment should be made in research and development for renewable energy technology within the country.
4. Institutional capacity building should be done for effective implementation of renewable energy policies.
5. Economic diversification should be encouraged through investment into non-petroleum industries related to renewable energy.

The above recommendations will help increase the importance of renewable energy in sustainable economic diversification in Iraq (World Bank, 2023; IEA, 2022).

5.5 Limitations of the Study

However, this research has some limitations despite its strengths. First, there are concerns that data limitations may affect the measurement of renewable energy investments, especially at the start of the analysis period. In addition, using aggregate macroeconomic variables may hinder the detection of sector-specific trends. Finally, there is a possibility of external interference from other sources, including political unrest and shifts in the international energy market (Creswell, 2014).

5.6 Suggestions for Future Research

Further research might consider the implications for microeconomics of renewable energy investment through the analysis of individual companies or industries. Cross-country comparisons among several oil-dependent countries would also be highly beneficial in gaining an understanding of regional trends. The inclusion of additional environmental factors, such as CO2 emissions, might further improve the sustainability assessment. More sophisticated econometric approaches, such as non-linear regressions and structural VARs, could also be applied (Wooldridge, 2016).

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