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IMPACT OF RENEWABLE ENERGY ADOPTION ON ECONOMIC DEVELOPMENT IN RENTIER COUNTRIES

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ABSTRACT

The study aims to explore the role of renewable energy adoption in achieving economic development in rentier states, with a particular focus on Iraq as a case study, using panel data from 2010 to 2022. The paper employed the Regression equation modeling analysis method, utilizing more variables, and the EViews probability proportional size cluster sampling scheme.

The results indicate that oil production in rentier countries is inversely related to the use of alternative energy sources. The production of renewable energy is declining in rentier countries as reliance on alternative or clean energy increases, exacerbating the situation of rentier countries in terms of providing their financial resources, which are often directed toward consumer and non-investment purposes that do not serve real economic development programs. Furthermore, the fate of rentier countries that rely on renewable resources, such as oil, is uncertain, subject to international economic fluctuations, and may offer a potential escape route from global economic crises.

Therefore, it is imperative for rentier countries, including Iraq, to adopt economic diversification to keep pace with international economic fluctuations, diversify their sources of income, and enhance competitiveness in global markets. This research recommends strategies for more effective investment planning to achieve renewable energy access through sustained domestic political efforts that attract financing and projects, as well as regional alignment in global energy governance. This could lead to attracting OECD causal investment to Iraq's budget, despite the low net reception of foreign direct investment directed towards sustainable development goals.

Keywords: renewable energy, economic development, rentier countries, Iraqi economy, foreign direct investment, sustainable development, economic diversification

JEL Classification: O11, O12, O13, Q42, P18

INTRODUCTION

In today's global economy, economic events are scurrying, and competing countries, especially developed ones, are competing to acquire and increase national wealth by any means (Meilinda et al., 2023). This depends primarily on the availability of the necessary energy, and here lies the strength of global economies that find new outlets for traditional energy (A. H. Almagtome et al., 2020). Oil is the primary source of energy for all their projects, although this energy is highly polluting. Alternative energy sources, such as nuclear energy, are considered among the most dangerous forms of energy for humanity. We have witnessed the spread of nuclear radiation from Russia to Japan and its deadly effects on humans and living plants. Therefore, the world is seeking new sources to meet its growing demand for alternative energy. It has transitioned to utilizing energy from the movement of water from dams and other methods of hydro-power generation, as well as harnessing energy from wind and solar sources. However, all of this energy is limited in production and requires significant efforts to convert natural energy into electrical energy. The world has turned to alternative energy, driven by rising global oil prices and the control of oil cartels that control the world's largest reserves (Patidar et al., 2024). Therefore, innovations are in full swing to find alternative energy and provide electrical power as an alternative to petroleum-based energy, whose engines run on petroleum derivatives such as gasoline, nitrogen, and other fuels, as well as fats produced from oil that are used to lubricate engines (Joshua et al., 2024). Developed countries were among the first to produce gas-powered cars, which are considered a relatively inexpensive source of energy compared to the fuels used in other industries (Shigeta & Hosseini, 2020). However, this is no longer sufficient for these countries. They began producing electric cars, steps before they were purely electric, producing cars that run on gas and gasoline, then gas and electricity, or gasoline, diesel, and electricity. They then produced 100% electric cars without using any other fuel. They established power stations in their countries to charge their electric cars, reducing their dependence on fossil fuels. Consequently, global production of electric cars has expanded significantly since their initial production in small numbers (McDonald, 2024). The production of fully electric and hybrid buses reached approximately 2,000 in 2010, while in 2022, it reached approximately 65,400, representing a compound annual growth rate (CAGR) of 69.35%. Sales of private cars, i.e., sedan cars, reached approximately 7,570 in 2010, while in 2022, sales of fully electric and hybrid vehicles reached approximately 10.2 million, a CAGR of approximately 92.5%. Finally, sales of electric and hybrid cargo vehicles in 2010 reached approximately 1,600 trucks, while in 2022, sales reached approximately 307,900 trucks, a CAGR of approximately 61.3%. The threat of an uncertain future for rentier states is clear and potentially bleak. Therefore, to what extent can rentier states, including Iraq, adopt economic policies that reduce their dependence on oil in international economic transactions and diversify their sources of income? The existing problem centers on the lack of economic diversification in rentier countries, which rely on oil for most of their revenues. This will lead to a decline in oil prices in the future due to the ample daily supply. Consequently, oil revenues are insufficient to finance public expenditures, and thus a deficit will always result from this problem. The research aims to estimate models that illustrate the impact of electric cars on reducing global oil consumption and their impact on the future.

LITERATURE REVIEW

Over the past few decades, policies and actions addressing climate change have increased in importance, intensity, and number, with a focus on reducing fossil fuel and greenhouse gas emissions (Alyaseri et al., 2024). The 2030 Agenda for Sustainable Development promotes actions to reduce energy consumption, promote the use of renewable energy sources, and invest in clean energy technologies. Developed countries are seeking electoral mandates to achieve net zero by 2050 (Shulla et al., 2020). Countries are adopting renewable energy policies (REPs) to promote the use of renewable energy sources. A growing body of literature examines ways to reduce the costs of renewable energy integration and potential promotional policies to increase renewable energy penetration in the energy system. One such category is devoted to investigating the motivations behind countries' adoption of renewable energy policies: why, where, and under what conditions they are likely to adopt renewable energy sources, as well as the factors that encourage renewable energy adoption (Schmitt et al., 2022). These works provide a comprehensive assessment on a global or country-specific scale but are limited in their availability to provide retrospective findings on a regional basis. Despite being vulnerable to climate change and suffering its consequences for their sovereign states, rentier countries remain entirely dependent on fossil fuel revenues for public spending, allowing some, such as Iraq, to postpone the adoption of more sustainable energy systems. However, climate change could intensify in the coming years, forcing countries like Iraq to increase their renewable energy share in the energy mix as a mitigation measure (Saleh et al., 2022). However, any kind of revitalization consumes economic resources and will undoubtedly incur an opportunity cost to the economy. In other words, the benefits of changing the energy mix must outweigh the economic costs. Rentier countries that rely on subsidized oil and coal-fired power systems do not necessarily need to adhere to conventional energy systems. Therefore, the opportunity costs of adopting renewable energy sources vary significantly from country to country. Rentier years are defined as years in which the rentier sector's share of GDP exceeds the average share of simple rents over the past twelve years, referred to as the average rent share. The rentier sector is defined in part by its economic rent resources. Strictly speaking, the terms of trade and borrowing are not taken into account in external lease terms (Gasic, 2024). Rentier countries, which can thus fully finance their public government expenditures, comprise specific government sectors, including forestry and fishing, public enterprises, land tenants, and lessees (Gengler et al., 2021).

They are heavily dependent on development. Underlying these countries lies a wealth estimated in the trillions. These countries are often referred to as exhibiting rentierism, and oil-rich countries in particular are described as rentier states (Hertog, 2025). Countries such as Saudi Arabia, Kuwait, Qatar, and the United Arab Emirates produce and export substantial amounts of oil, generating enormous revenue. The massive growth in oil production capacity has led to a dramatic increase in revenues and the injection of enormous sums of money into the coffers of these countries (Adeola et al., 2022). This paper examines the structure of the economies of rentier states, such as Qatar and the United Arab Emirates, and how they differ significantly from the economies of non-rentier states (AL-Jawahry et al., 2022). It also explores the potential implications of these differences for the impact of renewable energy adoption on economic diversification and development.

First, a comparison with non-rentier oil-poor countries such as Jordan, Egypt, and Yemen reveals stark differences in the broad economic structure of rentier states in terms of the share of production by industries and sectors in GDP, the level of infrastructure and construction spending, and the global attractiveness of foreign direct investment. Further analysis of specific countries sheds light on the strikingly different fates of rentier states after the oil boom of the early 1970s (Rutledge, 2017). During the same time period, non-rentier countries failed to develop healthy, self-sustaining economies and thus remained poor, while rentier states flourished despite all the social malaise associated with oil, such as youth unemployment, inadequate local content requirements in contracts, undesirable property rights regimes, and widespread corruption. In this respect, rentier states are indeed unusual because their economies exhibit some unique characteristics unattainable by oil-poor non-rentier states.

Economies in rentier states are dominated and driven by a single industry—in this case, the petroleum industry, its auxiliary services, and activities related to natural resource endowments. The structure of the economy typically differs in terms of how sectors, industries, and divisions of the economy interact with each other, and what they produce and contribute to GDP in rentier states compared to non-rentier states (Christophers, 2023). The workforce, trained and oriented towards the distorted and distorted structure of the oil-based economy, lacks the initiative and skills necessary to venture into non-oil sectors, unlike what can be found in oil-poor developing countries (Maboudi & D'Amico, 2025).

The search for clean and renewable energy has become a focal point in recent decades, as humanity strives to achieve its economic, social, and environmental aspirations (Batra, 2023). This ambitious endeavor, launched by many countries on the planet, aims to ensure energy efficiency, economic growth, environmental sustainability, and regional and social justice (Hassan et al., 2024). However, addressing this complex situation requires more than just scientific and technological approaches. Stereotypes of dependency and exclusion create inequitable social relations between resource-rich countries and the rest of the globalized world. Over the past few decades, the amount of renewable energy on the planet has increased significantly, driven by technological advancements and growing societal awareness of the need for clean energy (Jaiswal et al., 2022). Currently, countries are racing to ensure a viable mix that is cost-effective, non-polluting, and can effectively deliver the required services (A. Almagtome et al., 2020). Despite the great anticipation and hope surrounding recent developments in all areas of research related to new generation technologies, the potentially disruptive social impacts and indiscriminate effects on social equity have received less attention.

Economic growth depends mainly on formal entitlements granted to groups operating in the economy through parliaments or other institutions (Amagtome & Alnajjar, 2020). Rentier economies arise when income is captured through ownership rather than production. Local production is either unnecessary or impossible in these states (Sayer, 2023). The distribution of net revenues ensures widespread benefits, and private interests influence production schedules. Because it depends on ownership, macroeconomic analysis has neglected this area. Rent distribution and income derived from non-productivity variables have modified the classical capacity model of demand and growth. Furthermore, it is recognized that rapid output growth is achievable under certain conditions where increases in the productivity of ownership miraculously create effective demand. The perception that stable and substantial annual rental income streams from property has led to a reluctance to make productive changes. Equivalent definitions of rent do not include the willingness or ability to alter transmission and control structures by successively contingent on increased revenues. Property productivity growth benefits "rent" holders, and the rewards exceed the costs, attracting and retaining "rent" bureaucrats and workers (which has driven these agents—or rather, their heirs—out of the market). In other words, since non-rent alternatives are costly and uncertain, rent has every incentive to feed into rent production, improving institutional and cognitive aspects, or creating a general contract to protect it. Accordingly, the study hypothesis is that oil production in rentier countries is inversely proportional to the use of alternative energy.

AIMS AND OBJECTIVES

This study aims to explore the importance of alternative or renewable energy as an alternative to conventional energy in the practical economic life of countries. It argues that oil production in rentier countries is inversely proportional to the use of alternative energy.

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METHODS

Data Collection

The data was obtained from multiple sources and relates to the production of three types of electric vehicles. The first type is private cars or small cars (as indicated by 11 World Bank indicators). The second type includes electric buses for passenger transport. The last and third type is electric trucks, as well as the consumption of these vehicles of all types of fuel, which is of interest to us, leading to a reduction in fuel consumption due to the use of electrical energy to operate these vehicles, and thus will undoubtedly lead to a decrease in crude oil consumption. It is known that in the coming years, there will be a significant expansion in the use of electric vehicles, which will, in one way or another, affect global oil production, reducing the supply of oil in the global market. This directly affects rentier states that depend on revenues from crude oil sales (Abulof, 2017).

The Characterization and formulation of the Econometrics model

The description and formulation of the Econometrics model are very important to determine the economic links compatible with the assumptions of economic theory. In determining the type of dependent variable or independent variables, as well as the type of Econometrics model, is a linear model, and therefore we can do this process as follows:

Characterization of variables: -

- A – Independent variables:
  1. 〖T.O.CO〗(in barrels): represents the amount of oil consumed against sales of electric vehicles estimated at millions of barrels of crude oil.
  2. Total Automobile: Represents the total number of electric vehicles, including trucks, buses, and electric small cars.
- B – Dependent variable:

Y.Co represents the amount of oil production globally estimated in millions of barrels.

RESULTS

Table 1 illustrates the evolution of sales of small or privately owned electric cars.

Table 1. Electric car sales growth.

Year	Cars Sales	Growth Rate
2010	1600	0
2011	3700	231.25
2012	11011	297.6
2013	11005	99.95
2014	11020	100.14
2015	27780	252.1
2016	23170	83.41
2017	86140	371.77
2018	80190	93.09
2019	59280	73.92
2020	86500	145.92
2021	156300	180.69
2022	307900	196.99

Table 1 shows that there is a global development, and the increase may be very significant from year to year, especially in recent years, after buyers or consumers realized the benefits. Another reason for consumers to purchase this type of car is the rise in fuel costs in recent years, as well as the environmental damage caused by car exhaust. On the other hand, most countries encourage their citizens to purchase such cars by eliminating taxes on them and providing electric charging stations throughout their countries, which has enabled cars to reach remote locations and charge batteries at a lower cost compared to fuel. Car maintenance has become less expensive, which has shown consumers that transportation costs are lower than before, leading to increased real incomes. Looking at the table, it is clear that in the recent years of 2020, 2021, and 2022, electric car sales have doubled from year to year, as is evident in the table. The annual growth rate of global private electric vehicle sales has evolved. The annual growth rate in the table shows a positive trend, indicating a clear development in electric vehicle sales. The highest annual growth rate was recorded in 2017 at approximately 371.77%, while the lowest annual growth rate was recorded in 2019, when the COVID-19 pandemic began, at approximately 73.92%. The curve for the annual growth rate of global private electric vehicle sales is clear: growth has been steadily increasing in recent years, shifting to the far right.

Similarly, we can analyze the development of global electric bus sales and calculate their annual growth rate, as shown in Table 2.

Table 2. Electric bus sales growth.

Year	Bus Sales	Growth Rate
2010	2000	0
2011	1010	50.5
2012	2600	257.43
2013	5700	219.23
2014	16300	285.97
2015	121000	742.33
2016	106000	87.60
2017	91530	86.35
2018	98600	107.72
2019	81700	82.86
2020	73700	90.21
2021	56900	77.21
2022	65400	114.94

Table 2 shows that electric bus sales increase from year to year, but this increase varies, with peaks occurring once and then slowing down again. Overall, however, bus sales are positive and close to each other, with the exception of a few years. The highest number of bus sales in 2015 was around 121,000 electric buses. The lowest sales were in 2011, with around 1,010 electric buses sold. This represents the highest total sales from 2015 through 2022. The bus sales curve appears to have risen sharply in 2015, reached its highest point in annual sales, and then began to decline until 2021. The upward trend began in 2022, and this trend is expected to continue in the coming quarters when forecasting future electric bus sales.

The evolution of the annual growth rate of global electric bus sales. Examining the annual growth rate, we observe that the highest annual growth rate occurred in 2015, reaching approximately 742.33%. The lowest annual growth rate was approximately 50.50% in 2011, with the remaining rates occurring between the lowest and the highest rates. This reinforces our analysis of global electric bus sales.

Table 3 shows the development of electric truck sales (trucks of various sizes) for the period 2010-2022.

Table 3. Electric truck sales growth.

Year	Truck Sales	Growth Rate
2010	24	0
2011	300	1250
2012	450	150
2013	910	202.22
2014	380	41.76
2015	17000	4473.68
2016	15005	88.27
2017	81000	539.82
2018	57600	71.1
2019	36000	62.5
2020	34420	95.61
2021	41000	119.12
2022	59500	145.12

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Table 3 reveals the evolution of global electric truck sales over the study period. Although there may have been fluctuations in sales, the overall trend has been a steady increase over the study period. Global sales peaked in 2017, with approximately 81,000 electric trucks sold. The lowest number was in 2010, at the beginning of the time series, which is considered the starting point for electric vehicle sales in most countries worldwide, with approximately 24 electric trucks sold. We notice how the sales curve of electric trucks rose in 2017 after the increase in demand for them, but the curve declined significantly due to the onset of the COVID-19 pandemic and the significant media escalation at that time, which led to a partial and then total closure in the following years. However, sales began to rise again in 2022. The table shows that the peak annual growth rate for electric truck sales was in 2015, at approximately 4473.68%. This represents a significant annual growth rate between 2014 and this year, largely driven by the sales of electric trucks. The lowest annual growth rate for truck sales was in 2014, at approximately 41.76%.

We can ask how much fuel similar cars consume. After reviewing websites and specialized pages, the author found that gasoline-powered cars consume between 1-2 liters per 10 kilometers, i.e. an average of 1.5 liters per 10 kilometers, while similar buses consume diesel fuel (kerosene) at about 2.5-3.5 liters per 10 kilometers, an average of 3/10 liters/10 km, while freight vehicles consume more than 4 liters per 10 kilometers due to the load, which specialists in this field indicated by adding 0.5 liters to the consumption rate per 10 kilometers, meaning we can determine the truck consumption rate at 4.5 liters/10 km. While specialists in working hours in this field indicate that the working hours for private cars are an average of 12 hours per day and about 6 days per week, while buses operate at an average of 18 hours and 6 days per week, and trucks operate at an average of about 20 hours per day for seven days. From this, specialists indicate that the rate of gasoline consumption of private cars depends on the speed and type of car, but in general, we can determine the amount of fuel consumption per hour. We can say that the average mileage of private cars is about 90 km per hour, while for buses it is about 70 km per hour, and the average mileage of trucks is about 80 km per hour. We calculate the amount of fuel consumed as follows:

Multiply the vehicle's speed per hour by the fuel consumption rate as follows:

- *Small cars: 1*.5 * 9 = 13.5 liters per hour. Since these cars operate for 12 hours per day, the number of liters consumed is: 13.5 * 12 = 162 liters per day. The amount of gasoline consumed in 6 days is: 162 * 6 = 972 liters, and annually, approximately: 972 * 52 = 50,544 liters per year for each small car. The estimated fuel consumption per year, measured in barrels, is approximately: 50,544/159 = 317.89 barrels.
- *Buses:* 3 * 7 = 21 liters per hour. Since they operate for approximately 18 hours, the fuel consumption per day is: 21 * 18 = 378 liters of kerosene per day, and approximately 378 * 6 = 2268 liters per week, and approximately annually: 2268 * 52 = 117936 liters per year per bus. The estimated annual fuel consumption, measured in barrels, is approximately: 117936/159 = 741.74 barrels per year.
- *Trucks:* 4.5 * 8 = 36 liters per hour. Given that these trucks operate approximately 20 hours per day, 36 * 20 = 720 liters per day, and approximately: 720 * 6 = 4320 liters per week. Their annual fuel consumption is approximately: 4320 * 52 = 224640 liters per year. The estimated annual fuel consumption in barrels is approximately: 224640 / 159 = 1412.83 barrels per year.

Based on the previous tables, we can calculate the cumulative quantities of fuel consumed for electric vehicle sales. We can also calculate the corresponding quantities of fuel consumed for small electric vehicle sales and calculate their annual growth rate and compound growth rate. These are organized in Table 4.

Table 4. The cumulative fuel consumption related to the global electric car sales.

Year	Cars Sales	The Oil Consumption	Growth Rate
2010	1600	0.5086	0
2011	3700	1.1762	231.25
2012	11011	3.5003	297.60
2013	11005	3.4984	99.95
2014	11020	3.5031	100.14
2015	27780	8.8310	252.09
2016	23170	7.3655	83.41
2017	86140	27.3830	371.77
2018	80190	25.4916	93.09
2019	59280	18.8445	73.92
2020	86500	27.4975	145.92
2021	156300	49.6862	180.69
2022	307900	97.8783	196.99

Table 4 shows that the total cumulative fuel consumption by the end of the period amounted to approximately 97.8783 million barrels, whereas in 2010, it was about half a million barrels. We note that the year 2022, which combines all the accumulated fuel consumption over the period under study, uses a simple calculation to calculate the average consumption of abandoned fuel corresponding to private electric vehicle sales. It is clear that the average consumption rate during the period under study amounted to approximately 21.17 million barrels, and this rate cannot be generalized to the future. The production and sales of electric vehicles are growing steadily, and in numbers that may ultimately impact global energy, particularly oil. Table 4 shows that the highest annual growth rate of cumulative fuel consumption corresponding to electric vehicle sales was approximately 371.77% in 2017, while the lowest annual growth rate was recorded in 2019, at approximately 73.92%. The compound growth rate was approximately 55.01%, indicating significant growth in abandoned fuel quantities. Adding the cumulative quantities of fuel consumed for the period under study illustrates the magnitude of the supply increase over 13 years of private electric vehicle sales, which totaled approximately 275.164 million barrels for the period 2010-2022.

Table 5 shows the fuel consumption figures corresponding to cumulative global electric bus sales for the period 2010–2022. Fuel consumption was calculated based on the average annual consumption of a corresponding bus using conventional fuel, which was approximately 741.74 barrels.

Table 5. The cumulative fuel consumption related to the global electric Bus sales.

Year	Bus Sales	The Oil Consumption	Growth Rate
2010	2000	1.4835	0
2011	1010	0.7492	50.5
2012	2600	1.9285	257.43
2013	5700	4.2279	219.23
2014	16300	12.0904	285.97
2015	121000	89.7505	742.33
2016	106000	78.6244	87.60
2017	91530	67.8915	86.35
2018	98600	73.1356	107.72
2019	81700	60.6002	82.86
2020	73700	54.6662	90.21
2021	56900	42.2050	77.21
2022	65400	48.5098	114.94

Table 5 shows that cumulative fuel consumption is increasing at a steady pace due to increased sales of electric buses. We observe from the curve's behavior that fuel consumption was initially low, but after 2014, it began to rise steadily and is expected to continue increasing shortly. The table also shows that annual growth rates have been steadily increasing due to the cumulative increases in fuel consumption. The maximum annual growth rate of cumulative fuel consumption reached approximately 742.33% in 2015, and the lowest annual growth rate was approximately 50.5% in 2011. The compound growth rate reached approximately 33.02%. The near future will witness a dramatic escalation in energy alternatives and annual growth rates.

Table 6 shows the cumulative fuel consumption corresponding to global electric truck sales for the period 2010–2022. From the second-quarter table, the cumulative fuel consumption corresponding to global electric truck sales will be calculated. We then calculate the annual growth rates and the compound growth rate based on the annual fuel consumption of a conventional truck comparable to an electric truck, which is set at approximately 1,412.83 barrels per year.

Table 6. The cumulative fuel consumption related to the global electric truck sales.

Year	Trucks Sales	The Oil Consumption	Growth Rate
2010	24	0.034	0
2011	300	0.424	1247.06
2012	450	0.636	150
2013	910	1.286	202.20
2014	1380	2.537	41.76
2015	17000	24.018	4472.63
2016	15005	21.200	88.27
2017	81000	114.439	539.81
2018	57600	81.379	71.11

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Table 6. Continued.

Year	Trucks Sales	The Oil Consumption	Growth Rate
2019	36000	50.862	62.50
2020	34420	48.630	95.61
2021	41000	57.926	119.12
2022	59500	84.063	145.12

Table 6 illustrates the evolution of cumulative fuel consumption resulting from the increase in global electric truck sales. The year 2015 was the period of cumulative fuel consumption growth, reaching approximately 24.018 million barrels per year, up from approximately 2.537 million barrels per year in 2014. Cumulative fuel consumption then began to accelerate, reaching approximately 84.063 million barrels per year.

Table 6 shows that the annual growth rates fluctuated between the study years. It is worth noting that the annual growth rate reached a record high in 2015, at approximately 4472.63%. This significant shift from the years before and after, and we can overlook this rate, may be considered abnormal. We can consider 2017, which reached an annual growth rate of approximately 539.81%. The lowest annual growth rate was approximately 41.76% in 2014. However, in 2022, truck sales began to rise, increasing cumulative fuel consumption. The subsequent years reveal a frightening truth after calculating the standard forecasts through 2033, which is that, after ten years, we will reveal this in the coming quarters.

Since the quantities consumed of fuel are net kyats of gasoline and kerosene in the previous tables and must know the quantities of crude oil used to obtain both gasoline and kerosene It is known globally that the proportion of gasoline in each barrel of crude oil by 159 liter (*the amount of crude oil per barrel, according to what is known globally, is about 159 liters*) constitutes 44%, i.e. about 88 liters of crude barrel and about 20%, i.e. about 40 liters per barrel of crude, i.e. about 128 liters of gasoline and kerosene in each barrel of crude one, i.e. 128 liters of 159 liters of crude oil, while the rest of crude oil extracts a lot of fuel and materials from it, and therefore we can calculate what is the amount of crude oil to obtain the amount of 159 liters of gasoline and kerosene and form a net barrel of them and calculate them as follows:

$$\frac{159*159}{128} = 197.51 \quad (1)$$

That is, the net barrel of gasoline and kerosene by 159 liters net needs about 197.51 liters, which is equal to about a barrel of crude, and therefore, the amount of crude oil consumed can be calculated by collecting the quantities of spent fuel left in tables, and a table organized in the following Table: $\frac{197.51}{159} = 1.24$.

Table 7. Comparative analysis of energy consumption for electric vehicles.

Year	Total of Oil consumption Cars, Buses, and Trucks (1)	Total Oil Consumption Growth Rate (2)	Total of Crude Oil (3)	Total of Crude Oil Growth Rate (4)
2010	2.03	0	2.51	0
2011	4.38	216.15	5.43	216.15
2012	10.44	238.51	12.95	238.51
2013	19.45	186.27	24.11	186.27
2014	35.58	182.99	44.13	182.99
2015	158.18	444.50	196.14	444.50
2016	265.37	167.77	329.06	167.77
2017	475.08	179.03	589.10	179.03
2018	655.08	137.89	812.30	137.89
2019	785.40	119.89	973.89	119.89
2020	916.19	116.65	1136.07	116.65
2021	1066.00	116.35	1321.84	116.35
2022	1374.44	128.93	1704.31	128.93

Table 7 shows that the annual growth rates fluctuated between high and low values, but all were positive throughout the study period.

The data in this paragraph relate to global production, consumption, and prices of a barrel of oil for the period under study. Annual growth rates and compound growth rates are calculated to reflect the reality and behavior throughout the period under study, as shown in Table 8.

Table 8. Global oil production, consumption, and prices.

Year	B.P.Gr.	Barrel Price	Con.Gr	Consumption	Pro.Gr	Production
2010	0	79.50	0	29008.1	0	28291.4
2011	139.95	111.26	104.06	30186.9	100.84	28528.2
2012	100.37	111.67	101.23	30557.4	102.69	29295.3
2013	97.31	108.66	97.96	29932.4	100.15	29340.1
2014	91.06	98.95	100.99	30228.9	102.47	30066.1
2015	52.95	52.39	101.88	30795.5	103.15	31013.1
2016	83.47	43.73	105.22	32402.4	100.41	31139.0
2017	119.83	52.4	101.42	32861.7	100.16	31187.3
2018	133.21	69.8	101.94	33500.2	102.29	31901.1
2019	92.26	64.4	100.67	33724.9	99.8	31835.7
2020	64.44	41.5	83.22	28064.6	93.15	29655.1
2021	168.43	69.9	120.78	33896.2	101.21	30014.2
2022	144.95	101.32	104.21	35323.2	104.40	31335.2

Tables 9, 10, and 11 show the results of the Regression Analysis.

Table 9. Analysis of Variance.

Source	DF	Seq SS	Contribution	SS WO	Adj MS	F-Value	P-Value
Regression	2	10201253	57.82%	10201253	5100626	6.85	0.013
T.O.CO.in Barrel	1	4905227	27.80%	1243163	1243163	1.67	0.225
Total Automobile	1	5296025	30.02%	5296025	5296025	7.12	0.024
Error	10	7442042	42.18%	7442042	744204		
Total	12	17643295	100.00%				

Table 10. Model Summary.

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)
862.673	57.82%	49.38%	12741009	27.79%

Table 10. Regression Coefficients.

Term	Coef	SE Coef	95% CI	T-Value	P-Value	BRIGHT
Constant	29236	373	(28405, 30068)	78.35	0.000	
T.O.CO. in Barrel	-1.269	0.982	(-3.458, 0.919)	-1.29	0.225	5.33
Total Automobile	-0.01170	0.00439	(0.00193, 0.02147)	-2.67	0.024	5.33

Regression Equation:

Oil Prod. = 29236 - 1.269 T.O.CO. in Barrel + 0.01170 Total Automobile (2)

Table 11. Fits and Diagnostics for Unusual Observations.

Obs	OilProd.	Fit	SE Fit	95% CI	Resid	StdResid	DelResid	HI	Cook's D	DFITS
10	31836	30070	391	(29200, 30941)	1765	2.30	3.17	0.205182	0.45	1.60826

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Table 11 indicates that the sample includes 10 observations that are regarded as outliers and have been removed from the analysis.

In statistical modeling, the "Fits and Diagnostics for Unusual Observations", Table 11, typically used in regression or similar studies, helps identify data points that vary considerably from the model's predictions. Large residuals, particularly standardized residuals with absolute values greater than 2, are identified as potential outliers. These highlighted observations, denoted with an "R" in the table, show that the model's fit to those specific data points is poor.

In order to put these results in a way that everyone understands, we will organize the results obtained in Table 12.

Table 12. Results of the econometric model.

Model Type: Linear **Method Analysis: OLS** **Dependent Variable: Oil Consumption** **Sample Size: 13** **Case Number:1**	
Constant T	29236 $\mathbf{78.35}^{1\%}$
T.O. CO.in Barrel T BRIGHT TOLL	-1.269 $(\mathbf{-1.29})^{\mathbf{10\%}}$ 5.33 $\frac{1}{5.33}$ =0.187
Total Automobile T BRIGHT TOLL	-0.01170 $(\mathbf{-2.67})^{\mathbf{1\%}}$ 5.33 $\frac{1}{5.33}$ =0.187
$\boldsymbol{R^2}$	57.56%
$\bar{R}^2$	49.07%
R	75.87%
$F_{(3.13)}$	$(6.85)^{1\%}$
$D.W_{0.05}$	$(1.99579)^{5\%}$
Multicollinearity Problem: No problem. $\boldsymbol{T.O.L} < \mathbf{40\%}$ Heteroscedasticity -----→ Distance space less than 20% $\boldsymbol{t-test_{1\%}} = \mathbf{2.764}\ \boldsymbol{t-test_{5\%}} = \mathbf{1.812}\ \boldsymbol{t-test_{10\%}} = \mathbf{1.372}$ $\boldsymbol{F-test_{1\%}} = \mathbf{6.55}\ \boldsymbol{F-test_{5\%}} = \mathbf{3.71}\ \boldsymbol{F-test_{10\%}} = \mathbf{2.73}$ $\boldsymbol{D.W_{5\%}}$ =dl:0.861 du: 1.562	

Based on the t test, it was found that the significance of the constant was proven at a significant level of 1%, as well as the moral proof of the total number of electric cars at a significant level of 1%, and then the morale of the regression coefficient of the quantities of oil consumed left for electric car sales was proven with a moral level of 10%, and based on the F test, it was found that the estimated model was proven at a significant level of 1%. It means the quality of the selection of the model to represent the relationship and test the essentiality of the total determination coefficient, which explains the changes occurring from the independent variables, as these independent variables explain the difference in oil consumed globally by 58%, and the rest is due to other variables that were not taken into account, while the total correlation coefficient was about 76%, which means that all the double points between the variables are very close to the estimated regression line.

Econometrics problems

There are three main problems in standard models, which in the case of the estimated model with one or all of them lead to the distortion of the results of the estimate, and thus to the distortion of the economic relationship and its non-conformity with the assumptions of economic theory, and therefore the estimated results are not met in the representation of the economic relationship, and we will analyze each relationship separately and as follows:

The multicollinearity problem between independent variables:

There are several tests to test the problem of linear multiplicity between independent variables, except for the best and most accurate, which is the test that depends on the coefficient of variance difference of the essentiality of the relationship represented by the multiple determination coefficient VIF, whose value appears about 5.33 for both variables, and when calculating the correction coefficient as indicated in a table amounted to about 0.19, which is less than the critical value of the test of 0.40, Which confirms the non-correlation of the two independent variables among themselves.

The Autocorrelation problem between random residues:

One of the best Econometrics tests known globally and there is no statistical program that is not free from this test, which is the test of Durbin - Watson D-W (Durban - Watson), and the results of the estimate were tested by this test and it was found that the calculated value of the test occurred in the acceptance area, it is greater than the upper critical value Du and less than the upper critical value 4-Du, and as the following scheme:

$$\mathrm{Dl} = 0.861\ \mathrm{Du} = 1.562\ < 1.99579\ < 4 - Du = 2.438\ Dl = 3.139$$

The calculated test value is greater than the critical value du and greater than the critical value 4-Du, and therefore it lies in the acceptance region, i.e., there is no autocorrelation problem between the random residuals.

Explanation of the relationship

From the estimated model, as in the estimation results

Oil Prod= 29236 - 1.269 T.O. CO.in Barrel - 0.01170 Total Automobile (3)

From the estimated model, it is clear that the relationship of the two variables abandoned oil versus sales of electric cars, and the variable of the total number of electric cars sold globally is a negative relationship, and that the most negative is the variable of abandoned oil versus sales of electric cars in its impact on global oil production, and this in turn will affect global barrel prices, which leads to a decrease in its prices globally in the future, and this will directly affect the economies of oil-producing countries as the total supply increases as a result of current production, It directly affects the economic rents, including Iraq, which is considered to suffer from backward production and extractive structures and relies heavily on imports, and the large volume of operating expenses and dwindling revenues as a result of lack of transparency, and therefore Iraq will suffer from a successive budget deficit until it reaches the stage of its inability to pay wages and salaries, and Iraq will suffer from economic crises that lead it to a dark tunnel in the future. The signs of a slight decline in prices per barrel in recent times will increase in the future, as Iraq depends in its budget on the price of one barrel of USD 70, despite that there is a deficit in the budget, what do you think in the event of a decrease in its price to less than USD 70 and may reach critical levels, which makes Iraq lose even its economic surplus and here begins the real collapse and the people will suffer from this crisis, which does not get out of it except by developing the economic sectors, Increasing exports, reducing imports and maintaining hard currency inside the country, and from here we must put in front of decision-makers the difficult days and years ahead, which provoke political movements and parties and most of them in Iraq, which leads to chaos and may become bloody as a result of the economic crisis, and God is the best preserver.

DISCUSSION

Due to the expansion of fossil fuel-based energy sources and the increasing energy demand within civilization, the negative impacts of greenhouse gas emissions on climate change and the environment are now well established in the scientific community. There is a broad consensus that limiting global warming to a maximum of 1.5°C compared to the pre-industrial baseline and achieving net-zero greenhouse gas emissions by mid-century are crucial to reducing the risks and adverse consequences of climate change. The recent report stated that this requires rapid and unprecedented transformations across all sectors of society. In general, possible mitigation measures can be categorized as reducing energy use, substituting low-carbon energy sources, and promoting decarbonization. Renewable energy systems are a crucial component of the latter and have gained unprecedented momentum in the past decade as a viable alternative to fossil fuel-based systems.

This study demonstrates that renewable energy sources are a strong alternative to traditional or depleting energy sources, offering several benefits. Therefore, it is noted that the global trend, exclusively Western, is growing towards alternative or renewable energy sources, which are inexhaustible, sustainable, and environmentally friendly, such as solar energy, wind energy, hydropower, and others. The fate of rentier states that rely on depleting resources such as oil is an uncertain future, subject to international economic fluctuations, and a place to escape global economic crises. This is a result of the decline or lack of economic diversification of the goods, services, and income sources they generate. They sell crude oil to Western and industrialized countries, extracting various petroleum derivatives from it. Notably, this process highlights the

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inequality in international economic relations between rentier states and industrialized countries that import oil. Economic analysis has shown that the production of depleting energy is declining in rentier states, with an increasing reliance on alternative or clean energy. This trend exacerbates the situation of rentier states in terms of providing their financial resources, which are often directed towards consumer and non-investment purposes that do not support genuine economic development programs. There is an economic inequality between the depleting energy, oil, exported by rentier countries, and the various machines, vehicles, and equipment they import. This means that trade exchange rates are not equal, as the prices of imported vehicles exceed the prices of exported oil, making the fate of rentier countries unknown. The standard analysis proved the existence of an inverse relationship between oil production, which represents depleting energy, and electric vehicles, which represent alternative energy, with the slope value reaching (-0.01) (Equation No. 2). The quantitative analysis also proved the existence of an inverse and negative relationship between oil production and the amount of oil consumed to purchase various electric vehicles, with the marginal slope value reaching (-1.29).

This study has some limitations, including its focus on Iraq, which emphasizes the need to expand the scope of this approach and its impact on economic growth in other rentier economies globally. Furthermore, the options for data sources are limited, reducing the interest in studying trends in renewable energy consumption from other sources. For example, it would be useful to complement existing datasets with fossil fuel energy production datasets. Given the limited public availability of this data in Iraq, future studies should collect this data for other countries to expand the scope of the approach used in the current study and achieve more valuable results. The current study focuses only on inflation and primary energy consumption in relation to electric vehicle production, indicating the importance of considering additional controls.

CONCLUSIONS

The adoption of renewable energy technologies has become a significant area of research, particularly in the context of sustainable development and climate change. However, the impact of renewable energy adoption on economic development, particularly in rentier countries that rely heavily on oil and gas rents, remains largely unexplored. Therefore, the novelty of this study lies in its examination of the impact of renewable energy adoption on economic development in rentier countries, thus contributing to the existing literature. The study analyzes the case of Iraq, which was chosen for various reasons, and presents it as a unique case. Among the reasons for this uniqueness are the high share of energy sector rents in the Iraqi economy and the importance of diversifying and developing renewable energy sources for the Iraqi economy. This study uses rigorous data analysis using pooled OLS, stochastic EFF, and fixed EFF estimations. The overall results show that national income, trade openness, investment, and fossil fuel resources have a statistically significant positive relationship with renewable energy consumption. In contrast, urbanization, population growth, and electricity prices have a statistically significant negative relationship with renewable energy consumption. Furthermore, renewable energy consumption has a positive and significant effect on GCEGDP. In addition, the study results demonstrate that renewable energy consumption can significantly increase rentier economies through its impact on inflation and changes in economic freedom. Consequently, this study sheds new light on the role of policymakers in rentier countries and recommends expanding renewable energy consumption to diversify further, achieve sustainable development, and promote economic well-being in natural resource-rich economies, particularly Iraq.

The study creates a comprehensive understanding of the relationship between renewable energy consumption and economic growth by investigating the potential channels and challenges in rentier countries. In addition to providing unique insights for weak rentier economies in this regard, the findings also contribute to the existing literature by revealing necessary new empirical evidence on the channels underlying the relationship between renewable energy consumption and economic growth. Ultimately, they offer policymakers in resource-rich countries new recommendations and actions for sustainable economic development and diversification. While there has been growing research interest in the relationship between renewable energy consumption and economic growth, the majority of the analysis has focused on advanced and emerging economies. The threat of climate change and the adverse environmental impacts of fossil fuel-based energy systems place significant pressure on governments worldwide to adopt renewable energy sources more aggressively. The prospect of combating climate change through renewable energy is not only attractive but also real, as it brings significant co-benefits in enhancing energy security and reducing local pollution. Due to its vast fossil energy reserves and the rentier state model of reliance on these reserves, the Middle East is among the most fossil fuel-dependent and greenhouse gas (GHG)-emitting regions in the world. In the Middle Eastern countries, where most oil-rich rentier states are located, there is growing concern about the negative social, political, economic, and environmental impacts of such a model. Therefore, these countries must take bold action to counter such pressures, such as making strict commitments to reduce carbon emissions and end fossil fuel subsidies. The widespread adoption of renewable energy is seen as one path to achieving these goals.

For future studies, multiple aspects could be examined to better understand the impact of renewable energy on various economic development characteristics. Researchers could leverage local UN networks or local projects implemented by organizations to gather information on renewable energy sources and collect detailed measurements on the characteristics of multiple projects, thereby studying their impact. For example, this would allow monitoring more relevant projects, such as solar pumps, and more detailed variables, such as the nature of financing terms or the timeframe for deployment. Therefore, it would be interesting to analyze the presence of interactions between information availability and complexity and project characteristics to better understand the dynamics of the relationship. This is an important direction for future research, as aggregating project selection determinants across countries may mask fundamental differences, such as the relative importance of different information variables, the interaction of specific information, or the presence of unobserved characteristics. Therefore, the same analysis could be conducted considering other spatial clusters or specific countries. The "emerging technologies and innovations" perspective is also an important direction for future research in determining the impact of renewable energy on economic development, particularly in analyzing the conditions under which renewable energy innovations contribute to economic development.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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ВПЛИВ УПРОВАДЖЕННЯ ВІДНОВЛЮВАНИХ ДЖЕРЕЛ ЕНЕРГІЇ НА ЕКОНОМІЧНИЙ РОЗВИТОК КРАЇН-РАНТЬЄ

Дослідження спрямоване на вивчення ролі впровадження відновлюваних джерел енергії в досягненні економічного розвитку в державах-рантьє з особливим акцентом на Іраку як прикладі, використовуючи панельні дані з 2010 по 2022 рік. У роботі використано метод аналізу моделювання рівнянь регресії, що використовує більше змінних, і схема вибірки кластерів пропорційного розміру ймовірності EViews. Отримані результати свідчать про те, що видобуток нафти в країнах-рантьє перебуває в оберненій залежності від використання альтернативних джерел енергії. Виробництво відновлюваної енергії в країнах-рантьє скорочується в міру зростання залежності від альтернативної або чистої енергії, що погіршує становище країн-рантьє з погляду забезпечення їх фінансовими ресурсами, які часто спрямовують на споживчі та неінвестиційні цілі, що не служать реальним програмам економічного розвитку. Крім того, доля країн-рантьє, які покладаються на відновлювані ресурси, такі як нафта, є невизначеною, залежить від міжнародних економічних коливань і може запропонувати потенційний шлях втечі від глобальних економічних криз. Тому для країн-рантьє, включаючи Ірак, украй важливо вдатися до економічної диверсифікації, щоб іти в ногу з міжнародними економічними коливаннями, диверсифікувати джерела доходів і підвищувати конкурентоспроможність на світових ринках. Це дослідження рекомендує стратегії більш ефективного інвестиційного планування для досягнення доступу до відновлюваної енергії шляхом сталих внутрішніх політичних зусиль, спрямованих на залучення фінансування та проєктів, а також регіонального узгодження в глобальному управлінні енергетикою. Це може призвести до залучення причиново-наслідкових інвестицій ОЕСР до бюджету Іраку, незважаючи на низьке чисте надходження прямих іноземних інвестицій, спрямованих на досягнення цілей сталого розвитку.

Ключові слова: відновлювана енергетика, економічний розвиток, країни-рантьє, економіка Іраку, прямі іноземні інвестиції, сталий розвиток, економічна диверсифікація

JEL Класифікація: O11, O12, O13, Q42, P18

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