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The Economic Effects of Renewable Energy Investments: Evidence from Firm-Level Data

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ABSTRACT

Companies' Investments in Renewable Energy (CIRE) offer well-known environmental and social benefits, but their economic impact remains unclear, particularly at the microeconomic level. Using the Generalized Method of Moments approach, our empirical study of 93 companies in Saudi Arabia from 2000 to 2023 assessed CIRE' effects on GDP growth, FDI inflows, employment, and exports. Our findings indicate that increased investments in renewable energy have significantly boosted GDP growth, attracted higher FDI inflows, and generated new employment opportunities, suggesting a favorable investment environment. However, the potential for export growth within this sector appears limited. Robustness checks and instrumental variables confirm these findings. The study provides policy recommendations for maximizing economic benefits from CIRE in Saudi Arabia.

Keywords: Energy, Saudi Companies, Investment, Economic Growth, Foreign Direct Investment
JEL Classifications: O47, O32, L60

1. INTRODUCTION

Countries are increasingly prioritizing investments in sectors that are believed to significantly boost economic performance, with renewable energy (RE) becoming a key focus in recent years. Sustainability goals, environmental conservation, and pollution reduction efforts drive this shift. Despite the well-documented social and ecological benefits of RE investments, including reduced carbon emissions, improved air quality, and enhanced energy security, their direct economic impact remains uncertain.

A substantial body of literature highlights the social and ecological advantages of investing in RE, but studies on its direct economic implications are still scarce. Most existing research relies on macroeconomic data, often overlooking firm-level data within the RE sector. For example, Li et al. (2021) explore the life-cycle environmental impact and investment decisions in distributed RE, considering profitability and ecological factors. They use separate cost minimization models based on the availability of electricity from utility companies to understand how this affects investment choices in distributed RE.

Other studies focus on specific countries. Lehr et al. (2012) analyze Germany's expanding RE sector and its economic impact. Fan and Hao (2020) examine the relationship between RE utilization, FDI, and GDP over 15 years across all 31 provinces in China. Pao and Fu (2013) investigate Brazil using annual data from 1980 to 2010, exploring the causal links between real GDP and various categories of RE consumption.

Additionally, some studies use a sample of countries. Ntanos et al. (2018) analyze the connection between RE consumption and economic growth across 25 European nations. Shahbaz et al. (2020) assess the impact of RE usage on economic development across 38 RE-dependent nations from 1990 to 2018.

Existing studies provide valuable insights into the relationship between renewable energy (RE) investments and economic performance; however, they often lack firm-level data within the RE sector. To address this gap, our study examines data from 93 companies operating in various segments of Saudi Arabia's RE industry. We focus on three key variables representing the Companies' Investments in Renewable Energy scale. Additionally, our study broadens the analysis of CIRE's macroeconomic impact. While most research emphasizes economic growth, we also consider the effects on foreign direct investment (FDI) inflows, employment rates, and total exports.

Saudi Arabia serves as an illustrative example for several reasons. The country is notable for its substantial investments in RE, supported by government policies such as the National Renewable Energy Program and the King Salman Renewable Energy Initiative (Alawaji, 2001). These initiatives, integral to Vision 2030, aim to optimize RE utilization, reflecting a strong commitment to sustainability and economic diversification. Saudi Arabia's dedication to RE sets a benchmark for sustainability and economic growth, demonstrating how CIRE can positively influence economic performance.

Our empirical approach utilizes an endogenous growth model, enhanced by three variables acting as proxies for CIRE: total research and development (R&D) spending allocated explicitly to renewable energy, capital expenditures for constructing or expanding RE production facilities, and the number of initiated or completed RE projects. We conducted a dynamic fixed-effect panel data analysis from 2000 to 2023, drawing on data from 93 companies operating within Saudi Arabia's RE sector. Employing the Generalized Method of Moments (GMM) approach, we evaluated CIRE's impact on four macroeconomic indicators: GDP growth rate, foreign direct investment (FDI) inflows, employment rate, and total exports. Additionally, we performed various robustness checks, including augmenting the model with two instrumental variables representing government policy changes and energy industry characteristics and employing alternative estimation methods, confirming our initial findings' reliability (Adams et al., 2018).

Our research suggests that CIRE significantly contributes to robust economic performance. While R&D spending and capital expenditures also stimulate FDI and job creation, their influence on exports is limited, influenced by factors such as international market demand, competition, and trade barriers. Furthermore, among the three CIRE variables, the number of RE projects initiated or completed seems to have minimal impact on economic performance, possibly due to incomplete representation of project scale or impact, suggesting that larger-scale RE projects could have a more substantial effect on economic performance than smaller ones. Finally, our study offers policy implications for policymakers leveraging CIRE for economic growth and development.

The subsequent sections of our paper are structured as follows: Section 2 provides a literature review, Section 3 analyzes the data, and Section 4 outlines the empirical methodology, detailing the statistical techniques and models used. Section 5 presents the results, discussion, the robustness of findings and policy implications. Finally, the concluding section summarizes our key findings.

2. LITERATURE REVIEW

Recently, countries have increasingly focused on investing in sectors thought to substantially improve economic performance, with renewable energy emerging as a critical area of interest. This trend is propelled by various factors such as sustainability objectives, environmental preservation efforts, and initiatives to curb pollution.

While the social and ecological benefits of investing in renewable energy (RE) are extensively documented, uncertainties persist regarding their direct economic impact. Contemporary literature reflects this ambiguity, with limited discourse examining the economic implications of such investments, particularly when utilizing microeconomic data from companies within the industry. Among the scant studies exploring this microeconomic data, Li et al. (2021) stand out for their comprehensive analysis. They consider the life-cycle environmental impact and explore investment decisions in distributed RE, balancing profitability and environmental considerations. Their research involves developing separate cost-minimization models based on the availability of electricity from utility companies. Additionally, they investigate how utility companies influence investment decisions in distributed RE, considering economic and environmental factors.

Much of the literature has leaned on macroeconomic data, often focusing on individual country cases or groups of countries. For instance, Lehr et al. (2012) conducted a thorough analysis highlighting the significant expansion of the RE sector and its broader impact on the German economy. Their study assessed the effects of substantial increases in renewable energy-powered electricity and heat generation technologies on factors like employment and international trade. The findings underscored positive net employment effects across various scenarios, indicating substantial economic benefits from RE investments within Germany.

Similarly, Fan and Hao (2020) examined the relationship between RE utilization, GDP, and FDI across all 31 Chinese provinces from 2000 to 2015. Their research employed statistical techniques to unveil sustained equilibrium relationships between per capita GDP, FDI, and RE consumption. The study suggested that while foreign direct investment might not significantly influence short-term changes in RE consumption, targeted investments alongside a moderate deceleration in GDP growth can substantially promote RE adoption in the long run.

Pao and Fu (2013) delved into the causal links between RE consumption and real GDP in Brazil, utilizing annual data from 1980 to 2010. Their study identified enduring equilibria between Brazil's real GDP and various forms of RE consumption, suggesting the potential for RE to propel economic expansion while mitigating environmental degradation. The research proposed that increasing RE utilization could bolster Brazil's economic growth and enhance its global competitiveness.

Ntanos et al. (2018) examined the relationship between economic growth and renewable energy (RE) consumption across 25 European nations. Their analysis, from 2007 to 2016, employed the autoregressive distributed lag (ARDL) model. The results suggested a long-term correlation between GDP and RE consumption, which is robust in countries with higher GDP levels. This study implied that RE consumption fosters economic growth, especially in more developed economies.

In a separate study, Alsagr (2023) focused on the financial efficiency of RE investments across 23 advanced and developing nations from 1996 to 2020. Using a nonlinear ARDL regression, they investigated whether financial efficiency exhibits symmetric or asymmetric impacts on RE investment. The findings indicated that enhanced financial efficiency symmetrically promotes long-term RE investment, while asymmetrically, an increase in financial efficiency encourages RE investment, whereas a decrease diminishes it, with varying effects observed across different economies.

Our study differs significantly from the ones mentioned above in several aspects. Firstly, while prior research mainly relies on macroeconomic data or national-level statistics, our analysis utilizes data directly from companies within the RE sector, providing a more detailed perspective on economic dynamics (AlKhars et al., 2020). Secondly, we diversify the proxy variables of RE investment by including a broader range of quantitative variables, enabling a more comprehensive analysis of investment patterns and their economic effects. Moreover, our study uniquely focuses on the economic impact of RE investments, distinct from the well-documented ecological impact explored in the existing literature. Additionally, we expand the scope of economic impact by not only examining its effect on overall economic growth but also considering its influence on foreign direct investment inflows, employment generation, and export trends.

3. DATA ANALYSIS

Our research evaluated the impact of three key variables, representing the investment behavior of Saudi companies in the renewable energy (RE) sector, on four major macroeconomic indicators. Data for our study were sourced from various outlets, including the Saudi Ministry of Energy, and proprietary information from 93 participating companies. Meanwhile, macroeconomic indicator data were obtained from the World Bank's World Development Indicators (WDI) database.

We illustrate the evolution of four key Saudi macroeconomic indicators: annual percentage change in GDP, employment rate, FDI as a percentage of GDP (net inflows), and exports of goods and services as a percentage of GDP. Additionally, we integrate two proxies for overall investment by Saudi companies in the RE sector: total research and development expenditure allocated explicitly to renewable energy (R&D) and capital expenditures designated for constructing or expanding RE production facilities (EXPEND). Figure 1 depicts these correlations from 2000 to 2023. The right axis represents the GDP growth rate, FDI, employment rate, and exports ratio, while the left axis represents the values of the R&D and EXPEND variables.

We observe a consistent increase in firm investment throughout the analysis period, indicating Saudi companies' commitment to expanding their investments in RE. Moreover, we note a positive correlation between CIRE and GDP growth, particularly since 2016, where fluctuations in CIRE align positively with GDP growth (Amran et al., 2020).

Figure 1 also reveals a positive correlation between CIRE and the employment rate, indicating that increased GDP growth from these investments drives employment. Conversely, a decline in CIRE between 2018 and 2020 corresponds to a decrease in employment, but subsequent years show increased investment, aligning with GDP growth.

Increased investment in RE corresponds to a rise in total foreign direct investment (FDI) inflows. Conversely, periods of decreased CIRE coincide with reduced FDI inflows. This link between CIRE and the surge in total FDI inflows is supported by previous studies highlighting how RE projects attract significant capital, thereby luring foreign investors seeking profitable ventures (Mahbub et al., 2022).

Regarding the impact on exports of goods and services, Figure 1 reveals a nuanced association between Saudi Arabia's exports and CIRE. Consistent with previous findings, the trajectory of both variables does not readily support a clear conclusion regarding whether exports increase or decrease following changes in RE investment.

It is essential to highlight the significant decline in GDP growth, FDI, exports, and CIRE in 2020, aligning with the peak of the coronavirus pandemic, which offers a plausible explanation for the deterioration of these economic indicators during that period.

4. EMPIRICAL METHODOLOGY AND VARIABLES

We utilize an endogenous growth framework akin to the ones utilized in studies by Barro (1991), Mankiw et al. (1992), Barro and Lee (1993), and Easterly and Levine (2002). Our model delves into the determinants of economic growth, incorporating factors such as investment, human capital accumulation, population growth, and institutional variables. The model is outlined as follows:

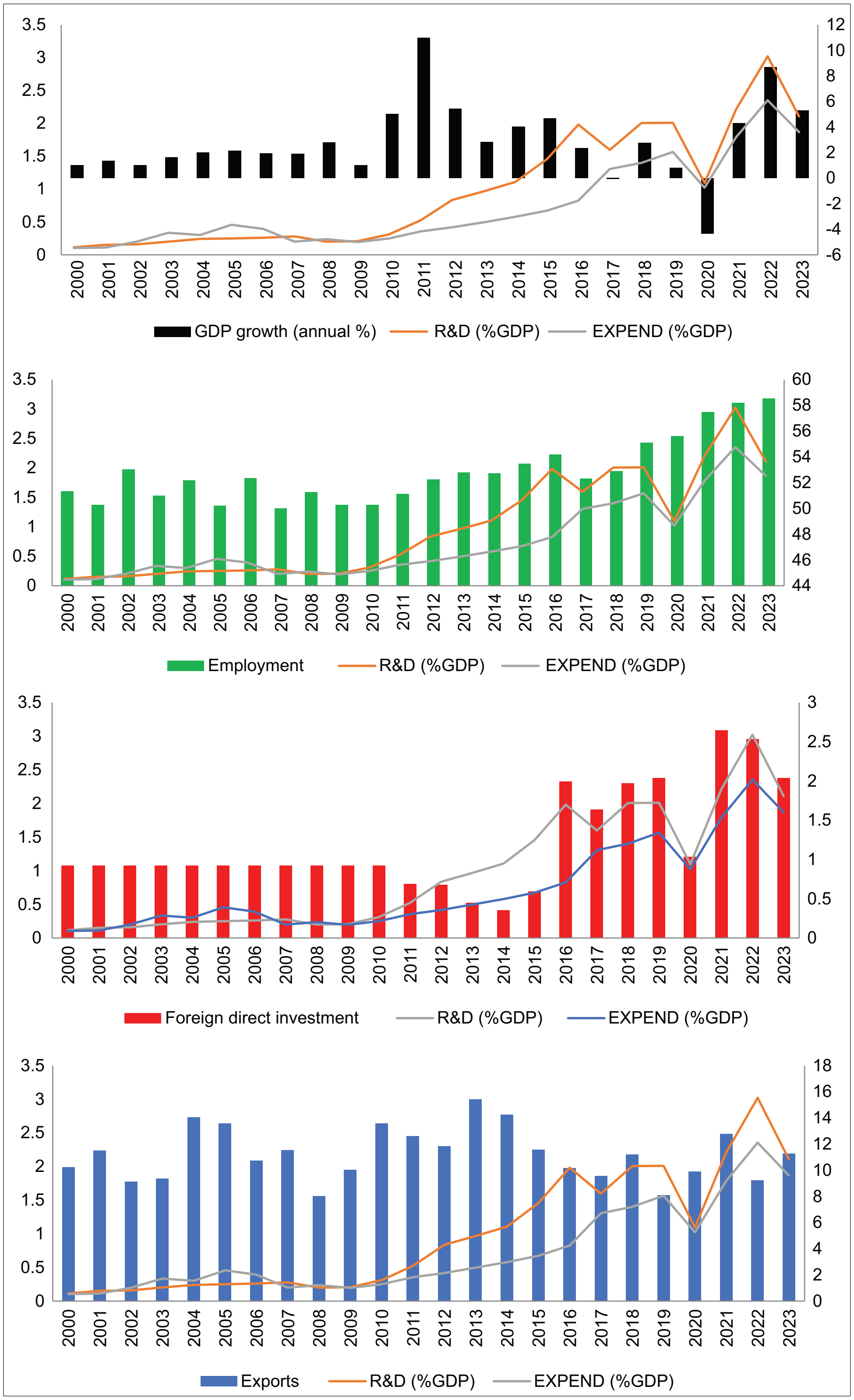
$$\Delta\ln(Y_t)=\beta_0+\beta_1\Delta\ln(Y_{t-1})+\beta_2\Delta\ln(I_t)+\beta_3\Delta\ln(H_t)+\beta_4\Delta\ln(K_t)+\beta_5\Delta\ln(L_t)+\beta_6\Delta\ln(G_t)+\epsilon_t \quad (1)$$

Where:

- $\Delta\ln(Yt)$, $\Delta\ln(It)$, $\Delta\ln(Ht)$, $\Delta\ln(Kt)$, $\Delta\ln(Lt)$, $\Delta\ln(Gt)$ are the growth rate at year "t" of real GDP, investment, human capital, physical capital, labor force, and government expenditure, respectively.
- $\beta 0$ is the intercept term,
- β_2, β_3, β_4, β_5, β_6 are coefficients representing the elasticity of GDP growth concerning changes in investment, human capital, physical capital, labor force, and government expenditure, respectively,
- ϵt is the error term capturing other unobserved factors influencing GDP growth.

We combine investment and physical capital, representing them collectively through gross fixed capital formation (GFCF). Human capital is assessed using the school enrollment rate (ENR), while

Figure 1: Companies' Investment in renewable energy and Saudi economic indicators



the labor force is approximated by the labor force participation rate, indicating the proportion of the working-age population employed or actively seeking employment (LFPR). Government expenditure is determined by the ratio of total government spending to gross domestic product (GOV). Furthermore, we enrich this model by incorporating variables that reflect Saudi Companies' Investments in Renewable Energy (RE vector). With these augmentations, we conduct a dynamic fixed-effect panel data regression, and our model can be expressed as follows:

$$\Delta \ln(Y_t)=\beta_0+\beta_1\Delta \ln(Y_{t-1})+\beta_2\Delta \ln(GFCF_t)+\beta_3\Delta \ln(ENR_t)+\beta_4\Delta \ln(LFPR_t)+\beta_5\Delta \ln(GOV_t)+\beta_6\Delta \ln(RE_t)+\epsilon_t \quad (2)$$

The RE vector comprises the following three variables:

- Total research and development expenditure, allocated explicitly to renewable energy (R&D).
- Capital expenditures earmarked for the construction or expansion of renewable energy production facilities (EXPEND).
- Number of renewable energy projects initiated or completed (PROJ).

In the next phase, we explore the connections between CIRE and other pertinent macroeconomic indicators in our investigation: foreign direct investment (FDI), employment (EMP), and exports (EXP). We utilize the fundamental model described in Equation (2) as our base and enrich it with additional variables commonly employed in literature to elucidate these newly dependent variables. Economic growth emerges as the principal determinant of these dependent variables, denoted in our baseline model by the variable Y_{t-1}. We incorporate the government effectiveness indicator from Kaufmann et al. (2011) to proxy institutional quality (IQ) in the FDI equation. In line with Buchanan et al. (2012), higher institutional quality attracts FDI, while lower quality institutions deter it. Additionally, we introduce the nominal exchange rate variable (XC) into the exports equation, as exchange rates can impact export demand by altering relative prices in global markets (Rahman and Serletis, 2009). We have omitted the Labor Force Participation Rate (LFPR) from the employment equation to avoid potential multicollinearity with the dependent variable' EMP'. Detailed descriptions and summary statistics of all variables employed in this study are provided in Tables 1 and 2, respectively.

The subsequent three models in our empirical approach are delineated as follows:

$$\Delta\ln(FDI_t)=\beta_0+\beta_1\Delta\ln(Y_{t-1})+\beta_2\Delta\ln(GFCF_t)+\beta_3\Delta\ln(ENR_t)+\beta_4\Delta\ln(LFPR_t)+\beta_5\Delta\ln(GOV_t)+\beta_6\Delta\ln(RE_t)+\beta_7\Delta\ln(IQ_t)+\epsilon_t \quad (3)$$

$$\Delta\ln(EMP_t)=\beta_0+\beta_1\Delta\ln(Y_{t-1})+\beta_2\Delta\ln(GFCF_t)+\beta_3\Delta\ln(ENR_t)+\beta_4\Delta\ln(GOV_t)+\beta_5\Delta\ln(RE_t)+\epsilon_t \quad (4)$$

$$\Delta\ln(EXP_t)=\beta_0+\beta_1\Delta\ln(Y_{t-1})+\beta_2\Delta\ln(GFCF_t)+\beta_3\Delta\ln(ENR_t)+\beta_4\Delta\ln(LFPR_t)+\beta_5\Delta\ln(GOV_t)+\beta_6\Delta\ln(RE_t)+\beta_7\Delta\ln(XC_t)+\epsilon_t \quad (5)$$

We utilize the Generalized Method of Moments (GMM) estimator to evaluate the impact of Saudi CIRE on economic indicators. GMM is selected for its capability to handle inherent endogeneity issues in such analyses and its resilience in addressing concerns related to heteroscedasticity and autocorrelation. Moreover, GMM is well-suited for dynamic panel data models, making it an appropriate choice for capturing evolving relationships over time.

Our empirical model demonstrates robustness and effectively tackles potential issues identified through diagnostic tests. The Arellano-Bond Test for AR(1) indicates the absence of first-order autocorrelation in the first-differenced errors, affirming the validity of our dynamic panel model. Similarly, the Breusch-Pagan Test fails to reject the null hypothesis of homoscedasticity, suggesting that the variance of the residuals is not systematically linked to the independent variables. Furthermore, the Sargan Test indicates the validity of the overidentifying restrictions in the GMM estimation. Overall, these outcomes offer compelling evidence that our empirical model is robust and adeptly handles potential biases, enhancing the credibility of our findings. We assessed the stationarity of the model variables using the Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) tests. Table 3 presents the outcomes of these tests, indicating that variables are non-stationary in their original levels. However, they exhibit stationarity after the first difference, with varying significance levels.

5. RESULTS AND DISCUSSION

The results of estimating Equations (2), (3), (4), and (5) are reported in Table 4. The estimates show a positive and significant

Table 1: Variables description

Variable	Symbol	Description	Sources
Dependent variable			
Economic growth	*Y*	Growth rate of real GDP	World Development Indicators (WDI)
Foreign direct investment	FDI	Foreign direct investment (net inflows % of GDP)	WDI
Employment rate	EMP	Employment-to-population ratio (15+total %)	WDI
Exports	EXP	Exports of goods and services (% of GDP).	WDI
Independents variables			
Determinants of economic growth/FDI/Employment/Exports			
Investment/physical capital	GFCF	Gross fixed capital formation	WDI
Human capital	ENR	School enrollment rate	WDI
Labor force	LFPR	Labor Force Participation Rate	WDI
Government expenditure	GOV	total government expenditure (% of GDP)	WDI
Institutionnal quality	IQ	Indicator of institutional quality	Worldwide governance indicators of Kaufmann et al. (2011)
Nominal exchange rate	XC	Nominal exchange rate	WDI
CIRE			
Research and development expenditure	R&D	Total research and development expenditure allocated explicitly to renewable energy.	Saudi Ministry of Energy and Companies data
Capital expenditures	EXPEND	Capital expenditures earmarked for the construction or expansion of renewable energy production facilities.	
Renewable energy projects	PROJ	Number of renewable energy projects initiated or completed.	

Table 2: Summary statistics

Variable	Mean	SD	Min	Max
Y	1.73	2.11	−4.34	10.99
FDI	0.63	0.12	0.35	2.65
EMP	51.62	7.34	50.37	58.68
EXP	25.67	18.65	8.62	15.42
GFCF	3.52	0.33	10.25	18.12
ENR	65.37	19.67	26.84	189.67
LFPR	42.82	13.06	40.25	49.43
GOV	25.52	11.57	15.21	21.94
R&D	1.31	0.24	0.31	3.02
EXPEND	0.95	0.31	0.25	2.35
PROJ	237	12	45	521
IQ	1.08	0.56	1.85	2.34

Source: Authors' calculations

Table 3: Tests for stationarity

Variable	ADF		PP	
	Levels	First differences	Levels	First differences
Y	2.1542*	3.4812**	2.0579	3.3924**
FDI	0.9276	1.8524*	0.8785	2.0578**
EMP	1.2578	3.6581*	1.6947	3.6527*
EXP	2.3581	4.6582*	1.9675	4.0385**
GFCF	2.0385	3.6821*	2.367	3.6291*
ENR	4.3262*	7.6284**	4.6902	8.0394*
LFPR	3.2687	3.2547*	2.6857	2.0821*
GOV	5.3287	4.6287*	4.6271	3.6827*
R&D	−2.3501	−1.8279**	−2.3674	−2.0584**
EXPEND	3.1578	2.96527**	1.9864	1.6543*
PROJ	1.2597	1.0587**	1.3547	1.1187*
IQ	3.6845	3.1570**	2.5816	2.0879**
XC	−2.3974	−2.6759*	−2.5198	−2.0476*

Significance is represented by *, **, and *** corresponding to 10%, 5%, and 1%, respectively

coefficient for the Y_{t-1} variable, indicating that past economic growth has a favorable influence on the current GDP growth rate and suggesting a degree of persistence in economic performance over time. Furthermore, previous economic growth has implications for foreign direct investment (FDI) and employment, although its impact on exports appears relatively weaker (Keynes, 1936). Besides, the results show that determinants of GDP growth rate (GFCF, ENR, LFPR, and GOV) exhibit positive and significant relationships, aligning with the predictions of endogenous growth theory. However, these coefficients show a decrease in strength and significance when included in the FDI, EMP, and EXP equations.

We find that CIRE significantly contributes to the economic growth of Saudi Arabia, as indicated by the positive coefficient associated with total research and development expenditure (R&D) in RE (Al Yousif, 2020). Additionally, the coefficients for capital expenditures allocated to constructing or expanding RE production facilities (EXPEND) and the number of RE projects initiated or completed (PROJ) are positive, albeit less significant than the R&D variable. These findings are consistent with the results reported by Shahbaz et al. (2020) and Li et al. (2021), reinforcing a central focus of our study: the positive relationship between investment in RE and the economic growth of Saudi Arabia. Furthermore, they align with the relationship depicted in Figure 1, which illustrates the association between these variables.

In analyzing the impact of CIRE on foreign direct investment (FDI), employment, and exports, our findings reveal that both research and development (R&D) spending and capital expenditures (EXPEND) significantly bolster FDI inflows and job creation. However, their effect on exports appears muted, as insignificant coefficients indicate. This limited influence on Saudi Arabia's exports can be attributed to various factors. Firstly, while domestic demand for RE products and services may be robust, international markets may lack equivalent demand (Wahyudi et al., 2023). Furthermore, the competitive nature of the global RE market presents challenges, with Saudi companies contending against entrenched players from other nations (Iqbal et al., 2023). Additionally, trade barriers, regulatory complexities, and logistical obstacles may impede the effective export of RE goods and services.

The number of RE projects initiated or completed (PROJ) seems to be the least influential variable supporting the positive association between CIRE and economic performance variables. The lack of significant impact can be attributed to the fact that the number of completed projects may not fully capture the scale or impact of each project (Al-Saleh, 2009). Larger-scale projects or those with substantial economic implications may disproportionately affect economic performance more than smaller projects (Zahoor et al., 2022).

Lastly, it is worth noting that integrating institutional quality into the FDI equation and including the nominal exchange rate in the exports equation bolsters the robustness of the regressions, evident from the significance of the coefficients linked to these variables.

5.1. Robustness Checks

To ensure the reliability of our empirical findings, we conducted robustness checks by exploring alternative variables and estimators. This approach allows us to assess the stability and consistency of our results under varying conditions.

Firstly, we expand our analysis by incorporating additional variables, which enables us to gauge the sensitivity of our conclusions to different operationalizations of key constructs, thereby enhancing the robustness of our analysis. Specifically, we integrate instrumental variables into our regressions to address endogeneity concerns. Two exogenous variables are identified and utilized to account for simultaneous causality between the companies' investment variables in RE and macroeconomic performance. The first instrument, government spending on RE investment (IV_GOV_ENERGY), assesses changes in government policies, commonly used indicators of policy changes in the literature (Chang et al., 2018). The second variable, the 'generation mix,' reflects the proportion of RE sources (e.g., solar, wind, hydro, biomass) in the total electricity generation portfolio (IV_GEN_MIX). Analyzing changes in the generation mix over time sheds light on trends in RE adoption and market share, influencing the potential impact of CIRE on economic performance (Zhai et al., 2023). After incorporating these two instrumental variables, we utilize fixed effects instrumental variable estimation. This method merges fixed effects estimation with instrumental variables to tackle endogeneity issues in panel data settings. Doing so ensures the consistent estimation of parameters while simultaneously accounting for unobserved individual-specific effects and potential endogeneity biases. The fixed effects

Table 4: Fixed effects instrumental variable estimation

	(GDP)	(FDI)	(EMP)	(EXP)
Y_{-1}	0.048*** (0.014)	0.014** (0.007)	0.033*** (0.010)	0.031* (0.015)
GFCF	0.031** (0.015)	0.009* (0.004)	0.008 (0.095)	0.069 (0.077)
ENR	0.045*** (0.010)	0.026 (0.067)	0.019* (0.009)	0.019 (0.075)
LFPR	0.028* (0.014)	0.018* (0.009)		0.010* (0.005)
GOV	0.066** (0.033)	0.025* (0.012)	0.061 (0.086)	0.024* (0.012)
R&D	0.032*** (0.012)	0.021** (0.10)	0.017** (0.008)	0.052 (0.160)
EXPEND	0.028** (0.013)	0.018** (0.009)	0.019* (0.009)	−0.251 (0.724)
PROJ	0.010* (0.005)	0.014* (0.007)	0.016* (0.08)	0.127 (0.313)
IQ		0.031* (0.015)		
XC				0.041** (0.020)
IV_GOV_ENERGY	0.028** (0.014)	0.031** (0.015)	0.019* (0.08)	0.011* (0.05)
IV_GEN_MIX	0.017** (0.08)	0.022** (0.011)	0.011* (0.05)	0.015* (0.07)
R-squared (within)	0.48	0.39	0.35	0.31
# of companies	93	93	93	93
# of observations	1013	1002	983	991

Table 4 presents the fixed effects instrumental variable estimation results for Equations (2), (3), (4), and (5), with corresponding columns labeled as GDP, FDI, EMP, and EXP, respectively. We have added two instrumental variables: IV_GOV_ENERGY and IV_GEN_MIX. Significance is represented by *, **, and *** corresponding to 10%, 5%, and 1%, respectively

instrumental variable estimation results are reported in Table 4. The results indicate an improvement in overall outcomes following the inclusion of instrumental variables. Notably, we observe stronger and more significant coefficients across four equations: economic growth, foreign direct investment inflows, employment, and exports (Wei et al., 2022). Both instrumental variables demonstrate positive and significant coefficients, underscoring their substantial role in the revised model specification. Additionally, we note that the coefficients associated with the "PROJ" variable have attained significance, albeit at a 10% level. Our previous conclusions regarding the positive influence of CIRE on Saudi Arabia's economic performance remain consistent post-amendments. Furthermore, the absence of a significant impact on exports persists.

Secondly, we employ alternative estimators further to validate our results' robustness against different statistical techniques, thereby minimizing the risk of methodological biases. We assess changes in our baseline model estimates using different estimators: Difference GMM, System GMM, and Maximum Likelihood Estimation. The utilization of alternative estimation approaches yields results closely aligned with the findings presented in Table 5, thus affirming the reliability of our conclusions[1].

5.2. Policy Implications

Launched in 2016, Saudi Arabia's Vision 2030 aims to enhance the country's economic diversification and sustainability efforts. Central to this vision is expanding non-oil exports and increasing the non-oil GDP share from 16% to 50% by 2030. Historically reliant on oil, Saudi Arabia has recognized the necessity of transitioning towards RE. The findings of this study can provide valuable insights for policymakers striving to achieve the objectives outlined in Vision 2030. Specifically, they underscore the significant role that investment in RE plays in shaping Saudi Arabia's economic landscape.

Saudi Arabian policymakers can implement various strategies to leverage CIRE for economic growth and development. Firstly, R&D in RE technologies can be incentivized through multiple measures, including tax incentives, grants, and subsidies. By providing financial support for R&D activities, the government can encourage innovation and the development of cutting-edge RE solutions tailored to the country's needs and environmental conditions.

Secondly, facilitating capital expenditures (EXPEND) for RE infrastructure is crucial for expanding the country's capacity. Streamlining bureaucratic processes related to project approvals and permitting can help expedite the construction of RE projects. Additionally, offering financial incentives such as low-interest loans or grants for RE investments can attract more private-sector participation and accelerate the deployment of RE technologies across the country.

Moreover, fostering public-private partnerships in RE projects can unlock additional resources and expertise for large-scale initiatives. By partnering with private companies, government entities can share risks and leverage private sector innovation and efficiency to drive the development of RE infrastructure and technologies. Investing in RE education and training programs is also essential for building a skilled workforce capable of supporting the growth of the RE sector. By establishing vocational training programs, educational initiatives, and research institutions focused on RE technologies, Saudi Arabia can cultivate talented professionals with the knowledge and skills to design, implement, and maintain RE projects.

Furthermore, removing barriers to exporting RE products and services can help Saudi Arabia capitalize on its expertise and resources in the global market. Achieving this goal may involve negotiating trade agreements, reducing tariffs, and harmonizing regulatory frameworks to facilitate the cross-border trade of RE goods and services. By enhancing its global RE market competitiveness, Saudi Arabia can attract foreign investment, create jobs, and generate revenue through exports, contributing to economic growth and diversification. By implementing these comprehensive strategies, Saudi Arabia can harness the potential

1 We have opted not to present the results of these estimations in order to avoid overloading the content.

Table 5: Renewable energy-investing companies and Saudi Arabia's economic performance

	(GDP)	(FDI)	(EMP)	(EXP)
Y_{-1}	0.032** (0.016)	0.012** (0.006)	0.028*** (0.005)	0.022* (0.011)
GFCF	0.027** (0.013)	0.008* (0.004)	0.014* (0.005)	0.006* (0.003)
ENR	0.035*** (0.011)	0.083 (0.197)	0.014* (0.007)	0.011* (0.005)
LFPR	0.025* (0.013)	0.015* (0.007)		0.009* (0.004)
GOV	0.063** (0.031)	0.021* (0.010)	0.013* (0.006)	0.012* (0.006)
R&D	0.021*** (0.007)	0.011** (0.05)	0.012** (0.006)	0.091 (0.260)
EXPEND	0.025** (0.012)	0.010* (0.005)	0.017* (0.008)	−0.341 (0.773)
PROJ	0.009 (0.084)	0.032 (0.411)	0.051 (0.310)	0.027 (0.213)
IQ		0.026** (0.013)		
XC				0.032** (0.016)
R-squared (within)	0.41	0.38	0.32	0.29
F-test	3.17***	4.24***	2.55***	3.38***
Arellano-Bond Test for AR (1)	5.68***	6.94*	7.12**	4.36**
Breusch-Pagan Test	6.38**	8.95*	5.94**	5.27**
Sargan Test	251.67**	214.95*	218.37*	158.96**
# of companies	93	93	93	93
# of observations	1027	1015	1034	964

Table 5 presents the GMM estimator results for Equations (2), (3), (4), and (5), with corresponding columns labeled as GDP, FDI, EMP, and EXP, respectively. The key variables, namely R&D, EXPEND, and PROJ, represent investments made by Saudi companies in renewable energy. LFPR has been excluded from the EMP equation to mitigate concerns regarding multicollinearity. Additionally, institutional quality (IQ) has been incorporated into the FDI equation, while the nominal exchange rate (XC) is included in the exports equation. Significance is represented by *, **, and *** corresponding to 10%, 5%, and 1%, respectively

of CIRE to drive sustainable economic development, create employment opportunities, and position itself as a global leader in the RE sector.

6. CONCLUSION

Utilizing data from companies investing in RE in Saudi Arabia, our analysis examined the potential impact of these investments on key economic performance indicators, including GDP growth rate, foreign direct investment (FDI) inflows, employment rate, and total exports. We found that firm investments positively influence economic growth, FDI, and employment, with notable impacts observed for research and development expenditure and capital expenditures. However, the number of RE projects completed showed less pronounced effects, and evidence supporting the impact on exports was inconclusive. To ensure the reliability of our findings, robustness checks, including the incorporation of exogenous instrumental variables and government policy changes, were conducted.

Building upon these findings, our study proposes policy implications that are aligned with the goals of Saudi Vision 2030 regarding RE investment. Policymakers can leverage this investment to drive economic growth by incentivizing research and development, facilitating capital expenditures, and fostering public-private partnerships. Investing in RE education, removing export barriers, and enhancing global competitiveness can further contribute to sustainable economic development.

Future research could delve deeper into the impact of RE policies, technological innovation, and supply chain dynamics on economic growth in Saudi Arabia. Investigating broader socioeconomic impacts and the long-term sustainability of RE investments can provide valuable insights for policymakers and researchers to understand the complex relationship between RE and economic development.

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