Impact of Financial Investments in Renewable Energy Generation in Selected Developing Countries

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Abstract

The rising global energy needs and climate change threats command a careful analysis of renewable energy drivers. This paper investigated the effect of financial investments on renewable energy generation in selected developing countries. A multiple panel data regression analysis was used to investigate the effect of the amount invested and economic factors on renewable energy generation in selected developing countries. Developing countries analysed were purposefully chosen based on the availability of the data required to conduct the analysis. Findings revealed that economic factors examined impact renewable energy production diversely. Consistent with previous studies, a significant positive causal link was found between the dollar amount invested and the production of renewable energy. These results suggest that policymakers should consider the effect of these variables when formulating policies to accelerate the transition to a sustainable renewable energy supply system. Furthermore, the findings provide possible solutions for budgetary constraints which have limited the transformation of the energy industries in the selected developing countries. Potential to investigate this study further on a country by country basis as data becomes available exists.

Keywords: Renewable energy, Non-renewable energy, Green energy, Hydro power, Non-hydro power.

1. Introduction

Fossil fuels currently dominate the energy sector despite the rising global energy demand and climate change threats. Hence, an expedited transition to renewable energy is no longer just an option but a necessity. Various researchers argue that renewable energy generation is influenced by diverse factors, policies and stimulus (Li, Lin, Wu, Xie, Meng, Zheng, Wang & Zhao, 2020; Sharbaz, Raghutla, Chittedi, Jiao & Vo, 2020; REN21, 2021; Greencape, 2021). It is vital for economies to understand the factors that influence renewable energy generation and the effects of the policies it implements. The generation of renewable energy is affected by social, environmental, political, and economic factors. Some researchers argue that foreign direct investment is not correlated to renewable energy generation while GDP has a significant positive correlation with renewable energy generation (Sahlian, Popa & Cre¸tu, 2021; Kang, Khan, Ullah, Arif, Rehman & Ullah, 2021). On the contrary, Kilicarslan (2019) found that foreign direct investment is necessary for renewable energy development. An increase in renewable energy generation can have a positive or negative impact on the economy, society and the environment. According to Al-Darraji and Bakir (2020), a direct correlation exists between renewable energy and economic development though the relationship is inelastic. Therefore, a change from less efficient energy resources to an effective, sustainable option will stimulate economic growth. Furthermore, non-renewable energy is also positively correlated to economic growth (Sharbaz et al, 2020). Hence it can be said that energy has an impact on economic growth. However, the question exists whether these implemented mechanisms and factors identified have influenced the generation of renewable energy in developing countries. As the world transitions to renewable energy, this analysis is a subject of interest.

The share of renewable energy in the energy mix continued to increase despite the pandemic, reaching its highest ratio in the mix in years. Notwithstanding, the availability of possible benefits of renewable energy systems, most countries however did not achieve their renewable energy targets in 2020 (REN21, 2021). Despite the increase in the share of green energy in the world energy mix, an unconventional radical shift to sustainable energy is necessary to address the rising energy needs and meet the Sustainable Development Goals set by the United Nations (United Nations, 2021). Renewable energy is sustainable when contrasted to fossil-based energy which is finite and limited. The energy sector is currently dominated by energy generated from fossil fuels. Likewise, South Africa is heavily reliant on coal powered plants and has been crippled by rising energy needs (Akinbami, Oke & Bodunrin, 2021). The energy mix imbalance in the sector was exacerbated by COVID-19 support measures for unconventional energy which were six times greater than those for renewable energy (REN21, 2021). To augment renewable energy production, the United Nations Secretary-General has pleaded with countries to phase out coal power generation, cancel planned projects and divert funds to renewable energy projects. The energy transition report states that a gradual transition from the fossil-based system renewable energy is no longer viable to address the energy crisis and climate change (United Nations, 2021). Therefore, accelerating transition to renewable energy is of the immediate measures to contain the global energy crisis. Consequently, if unmonitored, the rising energy needs can hinder economic growth. Due to the anticipated growth, economies face a challenge to reduce the environmental damages of fossil fuel usage while growing at a rapid rate. Both public and private partnerships are required to expedite the transition to renewable energy. Thus, financial support has a significant role in achieving renewable energy targets (United Nations, 2021). Previous literature has mainly explored the effects of drivers in isolation and on individual countries. To enhance existing literature and bridge the knowledge gap this paper, this study examines the effect of the dollar investment in renewable energy and economic factors on renewable energy generation on selected developing countries.

2. Literature review

The preservation and value assessment of natural capital are gaining momentum (Vassallo, Paoli, Rovere, Montefalcone, Morri & Bianchi, 2013). It has become evident that the availability of natural capital constrains economic growth. Capital refers to the resources used to produce income by an economy or country. Natural capitalism, which forms the theoretical basis of this paper, has been diversely defined by researchers. Natural capital comprises non-exhaustible and exhaustible resources and the ecosystem. As such, Goodwin (2003), opines that natural capital encompasses the natural assets provided by the Earth and its ecosystem services. Natural resources and ecosystems contribute significantly to the generation of income and wealth creation. Various researchers claim that the increase in renewable energy deployment is due to the dire climate change effects of non-renewable fossil fuels (Al-Darraji & Bakir, 2020; IRENA & CPI, 2020; United Nations, 2021). Natural capitalism focuses on ways to increase resource productivity (Greenwood, 2001). This means that society, economic activity, and companies require natural stocks to survive. The generation of renewable energy is a reliable means of mitigating global warming and addressing energy security (Gielen, Boshell, Saygin, Bazilian, Wagner & Gorin, 2019). The effect of the increase in renewable energy investments is, therefore, expected to address the theory of natural capital. The use of renewable energy will assist in preserving the level of non-renewable resources that currently exist sustainably and curb the level of CO2 emissions. The study of the effect that renewable energy enablers have on the green energy produced will enable countries to preserve the natural capital and thereby corroborate the theory of natural capitalism.

Energy is vital to the functioning of all, if not most, of the industries in any economy (Cao, Chen & Huan, 2020). The deployment of renewable energy causes a corresponding rise in the development of a nation. Due to globalisation and the anticipated recovery from effects of the pandemic, increased energy demand is expected; this indicates that in the next century energy security will become a challenge (Saidi & Hammani, 2015; International Energy Agency, 2021). In response to the anticipated growth, transition towards clean energy is one of the Sustainability Development Goal (SDG 7) towards which most countries have committed to work towards. The Sustainability Development Goals report of 2020 emphasised that countries need to increase sustainable energy to alleviate energy shortages (United Nations, 2021). Additionally, the African Union has devised a 10-year plan, termed Agenda 2063 that is aimed at alleviating energy shortages, poverty and ensuring environmental sustainability (African Union, 2015). Nigeria's socioeconomic and technological development has been affected by its electricity demand which exceeds the supply (Emovon, Samuel, Mgbemena & Adeyeri, 2018; Okubanjo, Ofualagba, Okandeji, Patrick, Alao, Olaluwoye & Olasunkanmi, 2020). Likewise, the ongoing scarcity of energy crippled the economy of Pakistan and negatively impacted its people and commerce (Aziz & Ahmad, 2015; Valasai, Uqaili, Memon, Samoo, Mirjat & Harijan, 2017). Similarly, China experienced extensive electricity outages due to the accelerated economic growth which consequently resulted in a sudden increase in its energy demand (Xue, Feng & Liu, 2021). Hence extensive efforts are required to fulfil the current and future energy needs through all possible sources. There is no best overall approach for the design of renewable energy policies (Puig & Morgan, 2013; IRENA, 2016). As such it is important to identify which factors are relevant in developing countries.

2.1 Dollar amount invested in renewable energy

The deployment of renewable energy has swiftly risen globally over the last decade. Many studies have outlined how investments in renewable energy can or have been increased for countries to either meet their renewable energy targets or progress. For example, the world anticipates investing an average of USD 4 trillion per year in renewable energy to meet its climate change objective. Globally, governments have committed to invest an average of USD 100 billion for a decade with an aim to produce 826 gigawatts of renewable energy (UNEP, 2020). An investment in infrastructure exceeding USD 3 trillion was assumed to be required to meet growth targets set by developing countries and emerging markets. During 2019, investments in renewable energy and the output thereof by developing nations reached a high of USD 152 billion, this surpassed those of developed nations. South Africa invested an aggregate of ZAR 192 billion in renewable energy sources from 2011 till June 2015, which was intended to produce 6 323 MW (Greencape, 2016). An investment in renewable energy amounting to USD 800 billion is expected for the world to have sustainable energy and curb climate change by 2050 (IRENA & CPI, 2020). Bekhet and Harun (2017), found that a bi-directional long-run cause and effect relationship exists between the capital invested and renewable energy generated. The renewable energy sector continued to experience challenges such as insufficient policy support and enforcement, lack of infrastructure, the sluggish inclusion of renewable energy in the energy mix. Despite these challenges the increase in investment from USD 298 billion to USD 305 billion resulted in a 10% increment in the renewable energy generated in 2020. Yet again, China dominated the renewable energy market and contributed 27.5% of total renewable energy in 2020 (REN21, 2021). Investments in renewable energy reached their peak in 2019 and the additional capacity added was noteworthy. The renewable energy produced in that year amounted to 184 gigawatts. This increased capacity is also attributable to lower capital costs experienced in 2019 (UNEP, 2020). Previous studies therefore show that countries that have had an increase in the amount invested have experienced an increase in renewable energy produced. These researchers are, therefore, of the view that an increase in the dollar amount invested among other factors results in an increase in the renewable energy generated. The question one would ask is whether the increase in the amount of investment translates into a change in the renewable energy output generated in the selected developing countries.

2.2 Economic factors

The Development Indicators Report states that indicators of economic development and transformation include GDP, infrastructure development through public-private partnerships, and foreign direct investment (FDI), among others (Republic of South Africa, 2016). Pohl and Mulder (2013), submit that the level of education, economic growth, governance and economic policies stimulate renewable energy deployment.

Hence it can be noted as worthwhile that the impact of these factors on renewable energy should be analysed. Ayres and Voudouris (2014), state that economic growth requires the provision of sufficient and reasonably priced quantities of useful energy. As such, energy resources are critical drivers of economic advancement. This notion has been studied, and different results drawn. While literature reviewed above suggests that an increase in the dollar amount may be the driver, Grabara, Tleppayev, Dabylova, Mihardjo and Dacko-Pikiewicz, (2021), argue that a robust positive cause and effect relationship exists between GDP and the production of green energy. This suggests that as GDP increases an increase in renewable energy developed may be expected. For example, in China, renewable energy produced is greatly influenced by the level of economic growth. On the contrary, Can and Korkmaz (2019), hold forth that a negative relationship exists between economic growth and renewable energy output. Dissimilar to the latter and the former, Maradin, Cerovic and Mjeda (2017), argue that a bi-directional relationship between GDP and renewable energy output.

Doytch and Narayan (2016), however, argue that (FDI), a different economic factor has a favourable effect on renewable energy generation while an opposite relationship existed for non-renewable energy. Foreign expenditure has played a significant role in the progression of Pakistan and other developing countries. Investments in renewable energy infrastructure can therefore be enhanced by foreign expenditure. According to Grabara et al. (2021), FDI and renewable energy output have a positive relationship. FDI is relatively low in Africa when compared to expenditure throughout the globe. Pakistan received significant foreign investments in its power and energy sector due to its favourable renewable energy policies that encouraged investment (Latief & Lefen, 2019). Despite the state providing a significant level of investments made in the renewable sector in North Africa, continued reliance on state investments proved to not be sustainable (Komendantova, Patt, Barras & Battaglini, 2009). The Department of Energy (2015), states that there is the prospect for South Africa to use foreign investment to increase renewable energy production and curb CO2 emissions. The department submits that foreign investment, among other factors, will influence the level of renewable energy that will be produced within the next ten years. Significant investments in green energy are required to achieve renewable energy targets set by economies; therefore, there is a need for FDI.

Lee, Han, Gaspar and Alano (2018) assert that the level of investment made by public-private partnerships is an indicator of economic development. In spite, having made substantive progress, renewable energy technologies nonetheless struggle technically and financially (Scarlat, Dallemand, Monforti-Ferrario, Banja & Motola, 2015). Despite efforts by governments to invest in energy most citizens in Africa do not have access to electricity. To overcome this challenge, additional investments and reformed business models that encourage private expenditure will be necessary (World Bank Group, 2017). A joint effort from both private and public stakeholders is required to redirect funds dedicated to fossil fuel energy towards sustainable energy (IRENA & CPI, 2020). The involvement of the private sector in energy infrastructure development has played a vital role in improving service delivery and ensuring efficient use of energy facilities (World Bank, 2020). South Africa's inclusion of the private sector in the energy sector through the Independent Power Producer programme resulted in the addition of 4 gigawatts of renewable energy output (Baker & Wlokas, 2015). Many opportunities exist in the energy sector for the private sector to participate. Furthermore, private sector involvement in the energy industry will help resolve funding challenges and project backlogs faced by the industry (Aitken, 2014). Financing provided by private entities through PPPs benefits the energy sector significantly. Additionally, Nel (2018), argues that PPPs are essential in transforming the energy industry, reforming the current energy mix and improving the energy infrastructure. Due to the contractual nature of PPPs projects, they yield benefits such as efficient and timely completion of projects (Rakic & Radjenovic, 2011).

Despite plans to transition to renewable energy, which is more sustainable and desirable, most governments cannot finance this transition due to their constrained budgets (IRENA & CPI, 2020). Most developing countries have little or no funds to finance the high cost of renewable energy infrastructure because they have low tax bases and poor tax collection (David & Venkatachalam, 2018). The world requires trillions of dollars on an annual basis for water, healthcare, and energy infrastructure (OECD, 2017). The budget constraints faced by governments can be overcome through the inclusion of the private sector in renewable energy projects (David & Venkatachalam, 2018). Policy makers are slowly realising the need for private sector inclusion to accelerate transition to sustainable energy. South Africa recently amended the Electricity Regulation Act to allow companies to produce their own electricity up to 100 megawatts without a licence (Republic of South Africa, 2021). Provided that South African companies respond by increasing their investment in renewable energy, this could curb the energy crisis that is crippling the country. RE`100, a group of private companies that have committed to source hundred percent of their energy from green energy grew significantly in 2020 (UNEP, 2020). India, as well as other developing economies, are transitioning towards the inclusion of the private sector to enhance their green energy sector (David & Venkatachalam, 2018). As evidenced above, public-private partnerships have a role to play in enhancing the renewable energy sector.

Although the different factors and mechanisms, as well as their effect have been extensively studied as evidenced by the preceding literature, previously the research did not specifically focus on providing a comprehensive overview of the effect on developing countries. Furthermore, the bulk of the literature available has considered these factors in isolation and the mechanisms individually. In contrast to previous studies, this paper examines the effect of the dollar amount invested as well as economic factors on renewable energy generation in selected developing countries, thereby bridging the knowledge gap. This paper classifies renewable energy produced as either hydropower or non-hydropower which comprises of the gross generation from renewable sources including wind, geothermal, solar as well as biomass and waste. The study, therefore, narrowed the applicability of its results down to specific developing nations, including South Africa. Additionally, the study categorises the potential drivers as either investment or economic factors. Furthermore, the paper offers a unique opportunity for the researcher to explore which factors and enablers can be applied to improve renewable energy output. Findings of the paper can highlight the level of scrutiny to be applied when renewable energy enablers and influencers are chosen. Additionally, the results of this paper can be used to influence the structure of energy regulations and policies, encourage investment in renewable energy, and provide sustainable energy solutions.

3. Research methodology

3.1 Research Data

A panel data analysis was performed to investigate the type of relationship that exists between the amounts invested in renewable energy, the proxies for economic factors and the output thereof. Proxies used in this study include the GDP per capita, FDI and PPP investment in energy. Panel data analysed covers a period of 17 years from 2000 to 2016 and comprised of secondary data obtained from the World Bank and the British Petroleum (BP) Statistics databases. A quantitative study involves the gathering of numeral data for analysis (Hayes, Bonner and Douglas, 2013). Abuhamda, Ismail and Bsharat (2021), when a quantitative approach is followed the relationships between variables is tested. This research tested the relationship between proxies for economic factors as well as the dollar amount invested in renewable energy and renewable energy generated (output) in selected developing countries. Likewise, this research examined the relationship between the selected variables whose data is available in numeric form thus it adopted a quantitative approach. The selected variables were analysed using generalised panel data regression model on the STATA 15 software.

Description of variables and data sources

Variables	Unit of measure	Source	Notation	Type of variable
Renewable energy output (hydro & non-hydro)	Terawatts	BP statistics	*Hp* - hydro power *Nhe* – non-hydro power *Excludes cross border supply*	Dependent
Amount invested in renewable energy	(US$ - million)	BP statistics	*Ih* - investment in hydro power *Inhe* - investment in non-hydro renewable energy	Independent
GDP per capita	(US$ - million)	The World Bank	*lgdp* - log of GDP	Independent
FDI	% of GDP (US$ - million)	The World Bank	*FDI*	Independent
PPP investment in energy	(US$ - millions)	The World Bank	*PPPIE*	Independent

3.2 Data analysis method

Like this paper, Pohl and Mulder (2013), examined the correlation between the investment in non-hydropower, foreign direct investment, economic growth as well as economic policies among other factors and renewable energy deployment. Purposive sampling was applied due to the limitations faced in obtaining the relevant data for the selected developing countries. Due to the scarcity of consistent renewable energy data, the study used a combination of panel data and pooled regression to overcome this limitation. This paper considered a limited sample of developing countries for which the data required for analysis was available on reputable websites for the period chosen (2000 -2016). Other websites such as the International Renewable Energy Agency database, the International Energy Agency and the Renewable Energy Data and Information Services were considered however the data available was either insufficient to fulfil the objectives of the research or unavailable. In instances where data was found on the alternative websites mentioned above, the data missed some years and sometimes the data was not compatible with the level of breakdown the researcher intended. The specific definition of a developing country as provided by the World Economic Situation and Prospects report (2014), was used as a criterion for selection given that many definitions of the term exist (United Nations, 2014). Independent variables tested were chosen based on the availability of data and their applicability to the research. Given the panel nature of the data tested, the following generalised panel data regression model was used to analyse the data.

$$y_{it} = \propto + \beta X_{it} + \alpha_i + \mu_{it} \ldots\ldots + \varepsilon_{it}$$

Where, y = the dependent variable with i countries and t time period,
Xit = independent variable that varies over time;
α = the unknown intercept for each variable
μit = the error associated with variables that occur between countries
Ɛit = the error term associated with variables within each variable.
Therefore:

$$Hp_{it} = \propto_{it} + \alpha_i country\ id + \varepsilon_{it} \quad (1)$$

Where: Hpit = hydro renewable energy output; αI = total selected developing countries; Ɛit = error term.
The following fixed-effects equation model was applied:

$$y_{it} = \propto + \beta X_{it} + \alpha_i + \mu_{it}$$

Where, y = the dependent variable with i countries and t time period;
Xit = independent variable that varies over time;
α = the unknown intercept for each variable
μit = the error associated with the fixed-effects model.
Therefore:

$$Hp_{it} = \propto_{it} + \alpha_i country\ id \quad (2)$$

Where: Hpit = hydro renewable energy output; αI = total selected developing countries.

4. Discussion of results

The study relies on the data set from sixteen selected developing countries to investigate influencing factors and enablers in renewable energy generation. The data set was standardised, and the key variables include hydropower, non-hydro renewable energy, investment in hydropower, investment in non-hydro renewable energy, GDP, PPP investment in energy and FDI. The data set was panelised as strongly balanced, and the scope is 2000 to 2016.

First, the estimation focuses on selected developing countries; the analysis distinguishes between hydropower and non-hydro renewable energy. The developing countries have a significant negative impact on both hydropower and non-hydro renewable at the 99 percent confidence level of significance.

Table 4. 1: Overview of countries with hydro and non-hydro power

	(1)	(2)
	Hp	Nhe
VARIABLES	Hp	Nhe
country_id	-14.65***	-1.85***
	(2.19)	(0.46)
Constant	206.39***	25.85***
	(21.14)	(4.48)
Observations	272	272
R-squared	0.14	0.06

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.1 reveals that overall, for the selected developing countries, there is a highly significant negative impact on hydropower and non-hydro renewable energy output. The portion of hydropower is significantly high (2.19) while non-hydro renewable energy is (0.46) relatively small. The results in the table have a p-value of less than 1%. Thus, the level of hydropower and non-hydro power is significantly affected by the state of the countries.

Table 4. 2: Hydro and non-hydro power - Standard regression, fixed-effects and random effects

	(1)	(2)	(3)	(4)
	beta_Nhe	fe_Nhe	re_Hp	re_Nhe
Variables	Nhe	Nhe	Hp	Nhe
Ih	0.01**	0.00		0.00
	(0.00)	(0.01)		(0.00)
Inhre	0.98***	1.00***	1.46***	0.99***
	(0.01)	(0.01)	(0.06)	(0.01)
Lgdp	-0.37	0.26	8.57**	0.19
	(0.30)	(0.36)	(4.17)	(0.32)
PPPIE	-0.00	-0.00	0.00**	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)

FDI	0.25**	0.01	-2.07**	0.06
	(0.11)	(0.08)	(0.96)	(0.08)
Constant	2.19	-2.87	-36.84	-2.23
	(2.40)	(2.75)	(35.52)	(2.49)
Observations	272	272	272	272
R-squared	0.99	1.00		
Number of country_id		16	16	16

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Second, Table 4.2 presents estimation results using Standardised regression, fixed and random effects models. For a standardised regression result, the effect of covariates on hydroelectric power reveals different results. In this result, the researcher is interested in the determinant of hydropower and non-hydro renewable energy. In Column 1, the principal argument is that some factors such as the GDP and PPP investment in energy have a negative impact. In contrast, other mentioned factors have a positive impact on non-hydro renewable energy using standardised ordinary least squares. Investment in non-hydro renewable energy has a positive impact with a p-value less than 0.01 on the production of clean energy. Investment in hydroelectricity and FDI have a p-value of less than 0.05, which has a less significant effect on non-hydro renewable energy development. The other factors too have an insignificant correlation to non-hydro renewable energy output. Comparably, a unit change in GDP causes an 8.57% change in the production of hydropower. In using fixed-effects and random effects techniques, factors such as investment in non-hydro renewable energy, GDP and PPP investment in energy have a positive impact on hydropower and non-hydro renewable energy. The results in Column 2 reveal that investments in non-hydro renewable energy have a considerably high correlation to the non-hydro renewable energy that is generated. This is supported by the significant P-value that is less than 0.01.

Column 3 discusses the random effect results of the effect of the selected independent variables on hydropower. FDI has a considerable negative impact on hydropower using the random effects technique. In contrast, PPP investment in energy, GDP, and investments in non-hydro renewable energy positively affect the production of hydropower. The p-values for these variables reflect the existence of a significant relationship.

Column 4 shows the random effect of the selected independent variables on the generation of non-hydro renewable energy. Investments in non-hydro renewable energy have a significant positive influence on the production of non-hydro renewable energy at more than the 99% confidence level.

A standardised regression model, fixed-effects and random effects models were used to ensure the robustness of the results of the relationship between the independent variables and non-hydro power. In some instances, the models produced mixed correlation results and differing levels for the significance of the relationship between variables. The researcher considered the results with the same correlation results among the three models to be the most appropriate.

The correlation matrix is presented in table 4.3.

Table 4. 3: Correlation matrix

	Ih	Inhre	FDI	PPPIE
Ih	1			
Inhre	0.8303	1		
FDI	0.0847	0.0005	1	
PPPIE	0.3284	0.2429	-0.0028	1
lgdp	*0.1424*	*0.1484*	*0.3301*	*0.0951*

The analysis reveals that most variables have an insignificant relationship with one another. PPPIE is negatively correlated to FDI. This relationship is unusual given that foreign direct investments usually occur through private entities. On the other hand, the investment in non-hydro renewable energy is strongly correlated to investments in hydropower. This is expected, when investments in renewable energy increase the investments are usually distributed among all technologies.

Table 4. 4: Hydro and non-hydro power - Random effects

	(1)	(2)
	Hp_re	Nhe_re
VARIABLES	Hp	Nhe
Inhre	2.41***	0.99***
	(0.08)	(0.01)
Lgdp	12.90**	-0.93***
	(5.23)	(0.25)
Ih		0.01**
		(0.00)
Constant	-51.16	5.73***
	(44.51)	(2.13)
Observations	272	272
Number of country_id	16	16

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.4 above shows a random effect technique. It shows that some selected variables, such as investment in hydro renewable energy, have a significant positive effect on the generation of hydropower and non-hydro renewable energy. GDP has a positive influence on hydropower and a negative effect on non-hydro renewable energy. The positive effect is significant at a p-value of less than 0.05, while the negative impact is significantly high, with a p-value of less than 0.01. A unit change in investments in non-hydropower will result in a 2.41% and 0.99% change in the hydro and non-hydro power produced, respectively. Investments in non-hydroelectricity are positively linked to both non-hydro and hydroelectricity generation at a p-value of 0.01; this shows that these variables have a significant influence on the dependent variable. Similarly, investments in hydropower have a substantial positive effect on the production of non-renewable energy with a p-value that is significant and less than 0.05. On the other hand, GDP causes a 12.90% and -0.93% change in hydropower and non-hydro power, respectively, when there is a change in one unit. The change in non-hydro power is, however, very minimal whenever there is a change in investments in hydropower.

Table 4. 5: Hydro and non-hydro - Fixed effects

	(1)	(2)
	Hp_fe_1	Nhe_fe_1
VARIABLES	Hp	Nhe
Inhre		1.00***
		(0.00)
Lgdp	81.91***	-0.87***
	(9.38)	(0.26)
Constant	-585.43***	5.61***
	(76.51)	(2.11)
Observations	272	272
R-squared	0.23	1.00
Number of country_id	16	16

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.5 above shows a fixed-effect technique. Using some specific variables, it is evident that an investment in hydro renewable energy has a significant positive effect on non-hydro renewable energy. The GDP has a positive influence on hydropower and a negative effect on non-hydro renewable energy. All independent variables are substantially correlated to hydropower and non-hydro power with a confidence level that is more than 99%. The change per unit of GDP causes an 81.91% change in the hydropower that is produced, GDP thus, significantly influences hydropower production. Despite the positive relationship between investments in renewable energy and non-hydro power, a change in the investment has a minimal effect on the output of non-hydro power. A unit change in GDP, however, results in a 0.87% negative change in the non-hydro power that is generated.

Table 4. 6: GDP analysis of hydro and non-hydro power

	(1)	(2)	(3)	(4)
	Hp_1	Nhe_1	Hp_c	Nhe_c
VARIABLES	Hp	Nhe	Hp	Nhe
Lgdp			81.91***	
			(9.38)	
Algeria	-44.21	-1.13	59.24**	-1.13
	(27.04)	(10.08)	(25.53)	(10.08)
Brazil	311.90***	29.07***	361.40***	29.07***
	(27.04)	(10.08)	(23.98)	(10.08)
Chile	-21.97	2.86		2.86
	(27.04)	(10.08)		(10.08)
China	572.42***	86.26***	686.48***	86.26***
	(27.04)	(10.08)	(26.00)	(10.08)
Colombia	-3.19	-0.28	79.79***	-0.28
	(27.04)	(10.08)	(24.77)	(10.08)
Egypt	-30.92	-0.14	119.00***	-0.14
	(27.04)	(10.08)	(27.92)	(10.08)
India	62.26**	29.03***	272.90***	29.03***
	(27.04)	(10.08)	(32.12)	(10.08)
Iran	-33.03	-0.96	57.64**	-0.96
	(27.04)	(10.08)	(25.03)	(10.08)
Mexico	-14.04	0.99	15.27	0.99
	(27.04)	(10.08)	(23.78)	(10.08)
Morocco	-42.87	-0.98	93.89***	-0.98
	(27.04)	(10.08)	(27.16)	(10.08)
Pakistan	-16.57	-0.86	197.39***	-0.86
	(27.04)	(10.08)	(32.37)	(10.08)
Peru	-24.45	-1.00	71.81***	-1.00
	(27.04)	(10.08)	(25.24)	(10.08)
The Philippines	-35.69	1.26	125.84***	1.26
	(27.04)	(10.08)	(28.64)	(10.08)

South Africa	-42.89	0.23	28.90	0.23
	(27.04)	(10.08)	(24.44)	(10.08)
Thailand	-38.10	-0.26	57.80**	-0.26
	(27.04)	(10.08)	(25.23)	(10.08)
Turkey			35.59	
			(23.82)	
Constant	44.43**	1.16	-726.87***	1.16
	(19.12)	(7.13)	(87.41)	(7.13)
Observations	272	272	272	272
R-squared	0.82	0.38	0.86	0.38

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4.6 above shows the analysis of GDP on hydropower and non-hydro renewable energy. The study generates country dummy variables, as mentioned earlier the GDP has a positive influence on hydropower for some selected countries such as Brazil, China, and India. Dummy variables highlight the effect of categorical variables on research (Yip & Tsang, 2014). A change in one unit of GDP results in significant changes in the level of hydro energy that is produced in Brazil, China, and India. On a country-specific basis, the GDP has a significant positive effect on hydropower produced in countries such as Algeria, Egypt, China, Colombia, Egypt, India, Iran, Morocco, Pakistan, Peru, the Philippines, and Thailand. Similarly, GDP has a positive impact on the non-hydro power produced in selected countries such as Brazil, China, and India. The influence of GDP is considerably strong in most of the countries mentioned above; the p-values reflect a strong correlation at a confidence level that is greater than 99% (p<0.01). Furthermore, on a country by country basis, the results show that China's hydropower experiences a tremendous change amounting to 686.48% when there is a change in one unit of GDP. Likewise, the remaining countries with significant relationships between the GDP and hydropower have been identified. Thus, the change in the output per unit ranges from a lower end of 59.24% to as high as 361.40%.

In contrast, the movement in GDP for each country has a significantly lower effect on non-hydro energy output. For every unit change in GDP, the effect on the output ranges from a minimum of 29.03% to a maximum of 86.26%. Nevertheless, again, a movement in the GDP of China has the most significant impact on the non-hydro power produced, output increases by 86.26% when GDP changes by one unit. The non-hydro power output for Brazil and India is affected similarly by a move in GDP; a unit change causes a positive movement in the non-hydro electricity output that amounts to 29.07% and 29.03%, respectively.

Table 4. 7: Hydro and non-hydro power - Random effects

	(1)	(2)
	Hp_re_1	Nhe_re_1
Variables	Hp	Nhe
Inhre	1.45***	1.00***
	(0.06)	(0.01)
Lgdp	8.33**	0.26
	(4.24)	(0.36)
PPPIE	0.00*	-0.00
	(0.00)	(0.00)
FDI	-2.10**	0.01
	(0.95)	(0.08)
Ih		0.00
		(0.01)
Constant	-49.60	-5.19*
	(36.63)	(3.13)
Observations	272	272
Number of country_id	16	16

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4.7 above shows the analysis of investments in non-hydro power, GDP, PPPs investment and FDI on hydropower and non-hydro renewable energy using random effect techniques. The table further explores the aggregate effect of the variables noted above on the generation of hydropower and non-hydro power for all the selected developing countries. Investments in non-hydro power has a significantly high positive effect on the generation of hydropower. Likewise, the GDP has a material positive impact on the generation of hydropower. The analysis reveals that the relationship that exists between PPPs investment and investments made in hydropower is immaterial. FDI has a direct significant negative effect on the generation of hydropower at confidence levels greater than 99% and 95%, respectively.

5. Interpretation of results

The above section outlines the model specifications, empirical evidence in addition to the analysis of the results. This section discusses the applicability of the empirical evidence derived to the hypotheses being tested in this paper.

The results of the panel data analysis conducted show that the dollar amount invested positively influences the level of hydropower and non-hydro power produced. The results imply that an increase in the dollar amount invested is crucial for improving renewable energy output. The outcome of the study supports how China used a combination of mechanisms such as tax regulation, dollar amount invested and general regulation to boost renewable energy production. In support of the findings in this study, UNEP (2017), found that an increase in the amount invested has an incremental effect on the renewable energy output. Also, Bheket and Harun (2017) confirmed the existence of a bi-directional relationship exists between capitals invested and renewable generated. Likewise, South Africa also experienced substantial growth in its renewable energy sector due to the increased investment (Greencape, 2019). Hence, efforts by nations to increase the target amount of dollar invested are, therefore, commendable as they are likely to yield improved renewable energy output.

The study found that economic factors may have a negative or positive effect on renewable energy generation. The study results reveal that a relationship does exist between economic indicators and renewable output. The results showed that the GDP, an economic measure, had a positive association with hydropower while it had a negative correlation to non-hydro power production. This evidence shows that the GDP affects both non-hydro power and hydropower in a contrary manner. York and Mcgee (2017), found a positive relationship between GDP and renewable energy produced. Likewise, Grabara, Tleppayev, Dabylova, Mihardjo, Dacko-Pikiewicz (2021), found that economic growth positively impacts renewable energy production. Contrarily, Can and Korkmaz (2019), argue that there is a negative relationship between economic and renewable energy. A bi-directional relationship was found between GDP and renewable energy (Marinaş *et al*., 2018). This provides evidence that during different periods of economic growth the specific growth period determines whether hydropower or non-hydro power should be produced. Policymakers are therefore encouraged to consider the effects of these factors when deciding on which stimulants to apply.

Another economic factor considered was foreign domestic investment, the relationship with non-hydro power production is positive; however, the link with hydropower output is negative. These results indicate that an increase in FDI boosts non-hydro power generation, however, causes hydropower production to decrease. Besides, results indicate that depending on the movement in FDI, investment in either hydropower or non-hydro power should be considered. Illaria and Rolland (2015), contend that renewable energy infrastructure that enables the production of renewable energy can be enhanced by FDI. According to Grabara, Tleppayev, Dabylova, Mihardjo and Dacko-Pikiewicz (2021), a positive relationship exists between FDI and renewable energy output. Additionally, a negative causal relationship was identified between PPPs investment and non-hydro power output, while the impact on hydropower is significantly positive. These results reflect the exclusion of the private sector by governments in the energy sector. According to Nel (2018), PPPs have a positive effect on the transformation of the renewable energy sector. The World Bank (2020), states that the inclusion of the private sector played a key role in boosting the renewable energy sector. Considering the lack of financing faced by many governments, it is advisable to consider the inclusion of the private sector to accelerate the transition to sustainable energy systems. Similarly, David and Venkatachalam, (2018), PPPs can play a crucial role in transforming the energy mix to accommodate renewable energy.

Distinct from previous studies, this paper analysed renewable energy at a granular level as either hydropower or non-hydropower. Thus, the results from preceding studies either partly corroborate or refute the results of the study. The results of proxies for economic factors examined indicate that economic indicators influence the output of renewable energy in the selected developing countries. Policymakers are, therefore, encouraged to consider the effect of GDP, PPPIE and FDI when making policies relating to energy sustainability.

6. Conclusions

The objective of this study was to establish what type of relationship exists between the dollar amount invested and the renewable energy generated (output) in selected developing economies. Furthermore, the study examined if economic factors influence the renewable energy output in selected developing countries. The study found that the dollar amount invested in addition to economic factors impact on the production of hydropower and non-hydro power. Proxies used to measure the economic factors include GDP per capita, FDI and PPP investment in energy. Panel data comprising multiple observations (272) for sixteen selected developing countries for 17 years from 2000 to 2016 were used in this study.

The study provides significant insights regarding identifying enablers and influencers of renewable energy production in selected developing countries. Furthermore, it also addresses the effect of these factors in a South African context. The results of this study sought to address the ever-increasing energy crisis faced by many developing nations, including South Africa, and reduce greenhouse gas (GhG) emissions. The identification of key influencers and enablers that governments should focus on to increase renewable energy output is expected to address the energy shortages and minimise GhG emissions. The growth in renewable energy will have a sustainable impact on future generations. The study showed that the independent variables selected have an impact on hydropower and non-hydro power generation. The predictor variables explored in this study are the dollar amount invested and economic factors. This shows that hydro and non-hydro power react differently to the predictor variables; therefore, careful consideration should be given when selecting enablers and influencers. Furthermore, the study provides a guide that can be used by policymakers in formulating solutions for budgetary constraints on renewable energy projects.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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