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Solar Energy and Economic Impact in Africa

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Abstract

This paper studies the causal relationship between the energy solar-economic consumption and growth in Africa countries: Egypt, Morocco, and South Africa. For this reason, the annual data from 1990 to 2019 is examined using panel random effects approach. We investigate the direction of causality between economic growth and solar energy by using panel Granger causality tests. The main empirical findings reveal the acceptation of the growth hypothesis, which advances that an increase in energy consumption may enhance the economic growth, and a reduction in energy consumption may adversely affect economic growth. This result indicates that the full panel economies are energy dependent. The results indicate a unidirectional link between economic growth and energy consumption. Thus, the economic growth in African countries acts positively to an increase of the solar energy consumption. Furthermore, we note the existence of a bidirectional connection between renewable energy consumption and economic growth for Egypt.

Keywords: Economic growth, Solar Energy, Random effect panel model, Panel Granger Causality, South African.

1. INTRODUCTION

The pandemic has produced many negative effects on business activities. The latest Istat data, relating to a very large sample survey, referring to approximately 1,019,786 companies with 3 or more.

The vulnerability of climate change underlining the necessity for pressing action to prevent the most catastrophic disaster. In fact, the energy sector is the main sector that can be investigated to develop it in the objective to attenuate the effect of the climate change. Following Irena (2019), the adoption of renewable energy and energy efficiency strategies are capable of achieving greater than 90% of the energy related CO_2 emission. The aim of sustainable development is to raise the proportion of the renewable energy in total consumption because the non-renewable energy can negatively affects the climate change. It has been important to specify that the renewable energy is composed by geothermal, win solar and biomass (coal, oil, and natural gas). The realization of sustainable development can be satisfied by using the renewable energy. In fact, this sustainability has different aspects: environmental sustainability (appropriate resource management); economic sustainability (development of infrastructure and service), social sustainability (supported that the poor benefits and that women's incomes legal right for all); and administrative sustainability (preserve and enhance administrative competence for program implementation) (Inglesi-Lotz, 2016). In addition, the use of the renewable energy has an economic impact on the environment durability and sustainability. In fact, studying the link between renewable energy consumption and economic growth became an interesting topic to prove the crucial role of the renewable energy. Following the literature review, we can present four hypotheses linked to this relationship as conservation hypothesis, growth hypothesis, feedback hypothesis and neutrality hypothesis. All these hypotheses describe the sense of the of the growth and / or renewable energy links.

Almost of the research on this topic are interested on the total of renewable energy consumption. For our case, we concentrate on the Solar energy that contribute of the important share of the renewable energy in three African countries: Egypt, Morocco, and South Africa This paper is motivated by the ambiguity of the findings of the previous studies, and by the importance of the renewable energy especially the solar energy in these countries.

This study provides the following valuable contributions. First, it is the first paper around renewable energy that interest on the solar energy for three African countries. Second, we showed that the full panel economies are energy dependent. The Granger causality results indicate unidirectional causality between energy consumption and economic growth running from solar energy consumption to economic growth in Africa countries.

We find the existence of a short-run causality from GDP to energy consumption, and from GDP to renewable energy consumption. The rest of the paper is structured as follows: Section 2 presents a literature review; Section 3 represents the econometric methodology; Section 4 presents the empirical results and discussion and finally the conclusions.

2. Overview Of Solar Energy

The researchers are beginning to investigate the causal link between renewable energy employment and economic growth; based on multivariate framework, using the last techniques of time series. Following the literature revue on the five last year's we can summarize four hypotheses: the absence of relationship between the two variables, the relation is bidirectional or unidirectional and mixed relationship. All these studies are focused on specifics geographies and countries: European countries, emerging countries, African Countries, ASEAN countries, OECD countries, China, USA, Tunisia. Furthermore, the most commonly employed methods contain vector error correction (VEC); panel VEC, vector autoregression (VAR), Panel VAR, Markov Switching VAR, cointegration, Panel cointegration, autoregressive distributed lags (ARDL), Nonlinear ARDL, panel causality, Symmetric and asymmetric causality, Quantile autoregression.

Table 1. Hypothesis for the relationship between Renewable energy and Economic growth

Source: Author's elaboration

Hypothesis	Author	Country/Region	Methodology
H_1: Absence of relationship	Fan and Hao (2020); Cevik et al. (2020); Ozcan and Ozturk (2019); Tuna and Tuna (2019)	China USA 17 emerging countries 5 ASEAN	VEC, Markov Switching VAR, Bootstrap panel causality, Markov switching VAR; Symmetric and asymmetric causality.
H_2: Unidirectional from renewable energy to economic growth	Bouyghrissi et al. (2021); Kouton (2020); Kasperowicz et al. (2020); Luqman et al. (2019); Maji et al. (2019); Shahbaz et al. (2018); Mbarek et al. (2018); Alper and Oguz (2016); Inglesi-Lotz (2016)	44 African countries, Morocco, 29 European countries. Pakistan; 15 West African Countries; 28- European countries; Tunisia; New EU Member Countries; 34 OECD countries	Panel VEC, Nonlinear ARDL; Panel cointegration; cointegration; VEC; Asymmetric causality; panel VEC.
H_3: Bidirectional relationship	Koengkan and Fuinhas (2020); Aydin (2019) ; Zafar et al. (2019); Shahbaz et al. (2018); Troster et al. (2018) ; Amri (2017) ; Kahia et al. (2017)	5 Mercosur countries; 26 OECD; APEC; USA; 72 countries; MENA	Panel VAR; Panel causality, Panel VEC; ARDL bounds test; Quantile autoregression; Dynamic simultaneous equation; Panel VEC.
H_4: Mixed	Banday and Aneja (2020); Can and Korkmaz (2019); Tugcu and Topcu (2018); Destek and Aslan (2017)	BRICS; Bulgaria; G7 countries; 17 Emerging Economies	Bootstrap panel causality; ARDL bounds test; ECM; asymmetric causality.

Following Table 2, we confirm the minority of the study centered on the relationship between economic growth and renewable energy in African countries.

Kouton (2020) focused on studying this relationship between RE and economic growth for 44 African countries[1].The results showed that RE consumption has a significant positive impact on inclusive growth in Africa.

Bouyghrissi et al. (2021) have interested on Morocco case, and the finding support that renewable energy start to give their positive effects on the economic dimension of sustainable development and it is established that there is a reciprocal relationship between renewable energy consumption and economic growth.

[1] Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Congo Dem. Rep., Congo Rep., Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia.

Table 2. Literature review

Source: Li and Leung, 2021

Author	Sample	Methodology	Results
Kouton (2020)	44 African countries 1991-2015	Dynamic Panel data model	Unidirectional from renewable energy to economic growth.
Bouyghrissi et al. (2021)	Morocco 1990-2014	ARDL model and Granger causality test.	
Li and Leung (2021)	7 European countries 1985–2018.	Panel cointegration	
Alam and Murad (2020)	25 OECD 1970-2013	Panel cointegration	Unidirectional from economic growth to renewable energy in long run.
Rahman and Velayutham (2020)	5 South Africa countries 1990-2014	Panel cointegration	Unidirectional from renewable energy to economic growth in long run and from economic growth to renewable energy in short run.
Fan and Hao (2020)	China 2000-2015	VEC	Absence of causality between renewable energy and economic growth
Kasperowicz et al. (2020)	29 European countries 1995-2016	Panel VEC	Unidirectional from renewable energy to economic growth.
Cevik et al. (2020)	USA 1973-2019	Markov Switching VAR	Absence of causality between renewable energy and economic growth.
Banday and Aneja (2020)	BRICS 1990-2017	Bootstrap panel causality	Mixed for different countries.
Koengkan and Fuinhas (2020)	5 Mercosur countries 1980-2014	Panel VAR	bidirectional from renewable energy to economic growth.
Can and Korkmaz (2019)	Bulgaria 1990-2016	ARDL bounds test	Mixed.
Aydin (2019)	26 OECD 1980-2015	Panel causality	bidirectional relationship between renewable energy and economic growth.
Luqman et al. (2019)	Pakistan 1990-2016	Nonlinear ARDL	Unidirectional from renewable energy to economic growth.
Maji et al. (2019)	15 West African Countries 1995-2014	Panel cointegration	
Ozcan and Ozturk (2019)	17 emerging countries 1990-2016	Bootstrap panel causality	Absence of causality between renewable energy and economic growth.
Tuna and Tuna (2019)	5 ASEAN 1980-2015	Symmetric and asymmetric causality	
Zafar et al. (2019)	APEC 1990-2015	Panel VEC	bidirectional relationship between renewable energy and economic growth.
Soava et al. (2018)	28- European countries 1995-2015	Cointegration	Unidirectional from renewable energy to economic growth.
Shahbaz et al. (2018)	USA 1960-2016	ARDL bounds test	bidirectional relationship between renewable energy and economic growth.
Mbarek et al. (2018)	Tunisia 1990-2015	VEC	RE → Y in SR
Saad and Taleb (2018)	12 EU countries 1990-2014	Panel VEC	Y → RE in SR; RE ↔ Y in LR
Troster et al. (2018)	USA 1989-2016	Quantile autoregression	bidirectional relationship between renewable energy and economic growth.
Tugcu and Topcu (2018)	G7 countries 1980-2014	ECM; asymmetric causality	Mixed for different energy proxies.
Amri (2017)	72 countries 1990-2012	Dynamic simultaneous equation	bidirectional relationship between renewable energy and economic growth.
Kahia et al. (2017)	MENA 1980-2012	Panel VEC	
Brini et al. (2017)	Tunisia 1980-2011	ARDL cointegration	Unidirectional from renewable energy and economic growth in long run; and controversy in short run.
Destek and Aslan (2017)	17 Emerging Economies 1980-2012	Bootstrap panel causality	Mixed for different countries.
Alper and Oguz (2016)	New EU Member Countries 1990-2009	Asymmetric causality	Unidirectional from renewable energy to economic growth.
Inglesi-Lotz (2016)	34 OECD countries 1990-2010	Panel VEC	

To investigate our study on the linkage between energy consumption especially solar energy and economic growth focusing on the creation of a new jobs. The literature review on the last five years demonstrates and confirm the hypothesis that the using of the energy can increase employment in many countries especially through the creation a new job (see Table 3).

Table 3. Solar Energy- Economic Impact

Source: Author's elaboration

Reference	Region Examined	Economic Impact/job employment
Nasirov et al. (2021)	Chile	Renewable energy (solar PV, wind, hydro): 20,958 jobs by 2026.
Ortega et al. (2020)	European Union	Renewable electricity technologies, photovoltaics (PV), wind on-shore and wind off-shore: 200,000 direct and indirect jobs are created in the period 2014 – 2050.
Ram et al. (2020)	9 major regions: Europe; Eurasia, MENA, Sub-Saharan Africa, SAARC, Northeast Asia, Southeast Asia, North America, South America	Solar PV, batteries and wind power are the principal job creating technologies during the energy transition from 2015 to 2050. The electricity generation: jobs at 897 jobs/TWh el in 2015.
Kattumuri and Kruse (2019)	Karnataka, India	Wind energy: 26,000 potential jobs. Biomass energy: 14,000 potential jobs. Solar energy: 833,000 potential jobs.
Bulavskaya and Reynès (2018)	The Netherlands	Renewable energy: 50,000 jobs by 2030.
Fragkos and Paroussos (2018)	European Union	Renewable Energy Sources: 200,000 direct jobs by 2050.
Irena (2018)	World	Renewable energy: 10.3 million jobs in 2017.
Zhang et al. (2017)	China	solar PV.
Jacobson et al. (2017)	139 countries of the world	wind, water, and solar power create 24.3 million jobs.
Guo et al. (2016)	China	Wind power: 16,500 direct employment and 211,400 indirect employments in 2010.

3. METHODOLOGY

3.1. Methodology and Data

The theoretical framework followed is proposed by Fang (2011), that is based on the general model of Cobb-Douglas production function (Cobb and Douglas, 1928).

$$Y = AL^{\alpha}K^{\beta} \tag{1}$$

where Y is the Gross Domestic Product, A is the total factor productivity; L is the labor input; K is the capital input; and α and β are the elasticities of labor and capital respectively.

Following Fang (2011), we use the solar energy as proxy of the total consumption of renewable energy and share of renewable consumption to the energy mix to study the influence of solar energy consumption to economic growth. In fact, to do our empirical investigation, we use the panel VAR models to examining the dynamics of the variables under consideration (Gross Domestic Product; the solar energy consumption; the share of solar energy consumption to total energy consumption; the gross capital formation; the number of employees; the R&D expenditure of each country). All the variables of the panel VAR are assumed to be endogenous and independent, but a cross sectional dimension is added to the representation (for more detail see Canova and Ciccarelli, 2013).

We use the PVAR model as expressed as follow:

$$y_{it} = \alpha_{it} + A_{it}(L)Y_{t-1} + \varepsilon_{it} \qquad \varepsilon_{it} \sim (0, \sigma_i^2) \tag{2}$$

For $i = 1, \ldots, N$; $t = 1, \ldots, T$

where $Y_t = (y'_{1t}, y'_{2t}, \cdots, y'_{Nt})'$ is a stacked version of y_{it}, which is a vector of G variables for each unit $i = 1, \ldots, N$; α_{it} is $G \times l$ vector of intercepts, $A_{it,1}$ are $G \times NG$ matrices for each lag l and ε_{it} is a $G \times l$ vector of random disturbances. It is assumed that there p lags for G endogenous variables. Model (2) can be described in a simultaneous equation format.

In our case the PVAR for three African countries are considered in the case $G = 6(GDP,\ SE,\ SSR,\ CAP,\ EMP,\ RD)$. Where GDP is the Gross Domestic Product; SE is the solar energy consumption; SSR is the share of solar energy consumption to total energy consumption; CAP is the gross capital formation; EMP is the number of employees; RD is the R&D expenditure. we make a natural logarithm form for all the variables except SSR and solar energy. We used the annual data covering the period going from 1990 up to 2019. The data is obtained from the World Bank, World Development Indicators (2021), and the Statistical Review of World Energy (see Fig. 1).

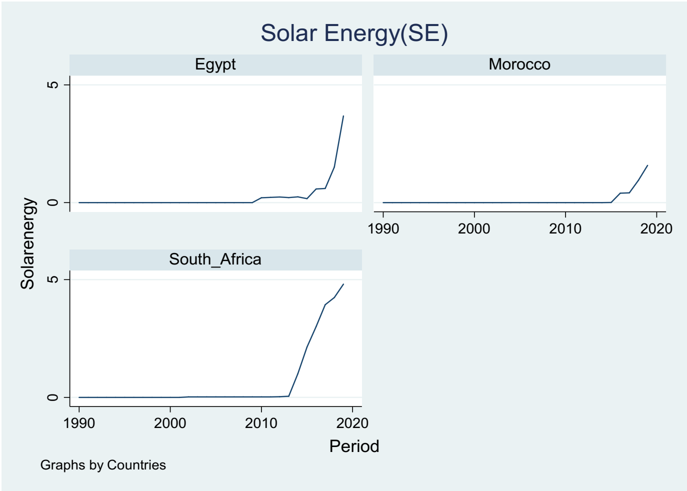

Figure 1: Solar energy evolution
Source: Author's elaboration

3.2. Results and Discussion

In our study, we are motivated to focus on some Africa countries: Egypt, Morocco and South Africa for different reasons. Firstly: Africa is a resource rich and diverse country with significant energy resources. reserves of oil and natural gas, but also of significant biomass potential, hydro, solar and wind power (Berahab, 2019). However, these countries suffering of electricity crises on 2012 for the limited access to the electricity. To overcome this problem, the authorities and the United Nations have put in place in 2012 an ambitious universal electricity access program on the horizon and anticipate the use of the renewable energy (Cantoni and Musso, 2017). In addition, the countries like Egypt, Ethiopia, Kenya, Morocco and South Africa have demonstrated a strong commitment to accelerate the use of renewable energy modern and are at the head of energy transition efforts. In fact, Africa has made significant progress in developing its solar energy markets in recent years. The continent has seen more than 1.8W growth in new solar installations, driven primarily by five countries: Egypt, South Africa, Kenya, Namibia and Ghana. Finally, according to our knowledge, this is few studies that studies the relationship between solar energy and economic growth in these countries (see Table 4 and 5).

Table 4. Description of variables

Source: Author's elaboration

Variable	Measure
GDP	Measured in US$ (constant prices 2010)
EMP	Number of people employed in the country
CAP	Gross fixed capital formation in US $ millions
SE	Solar energy kiloton of oil equivalent
SSR	The share of solar energy in total renewable energy consumption (percentage ratio)
RD	Expenditure in millions of US$ constant 2010 prices

Table 5. Descriptive statistics

Source: Author's elaboration

	GDP	EMP	CAP	SE	SSR	RD
Mean	11.188	7.201	10.483	2.960	0.338	11.039
S.D	0.296	0.167	0.268	0.340	0.957	0.429
Minimum	10.634	6.874	9.985	2.487	0	10.184
Maximum	10.635	7.477	10.938	3.470	4.809	11.549
Kurtosis	1.8738	2.0178	2.1970	68.9807	13.429	1.7091
Skewness	-0.2127	-0.1221	-0.0602	8.1338	3.3409	-0.4157
J.Berra test	16.930*** (0.000)	9.830*** (0.007)	5.120* (0.077)	60.970 *** (0.000)	1.4 e04 *** (0.000)	11.850*** (0.003)

Notes: GDP: gross domestic product, CAP is gross fixed capital formation (2010 constant US), EMP is the Number of people employed in the country; SE: Solar energy kiloton of oil equivalent; SSR: The share of solar energy in total renewable energy consumption (percentage ratio); RD: Expenditure in millions of US$ constant 2010 prices. All the variables are taken in the natural logarithm, except SSR and solar energy. ***, **, *Significance at 1%, 5% and 10% level, respectively.

The correlation matrix shows that there is presence of high correlation between the explanatory variables, suggesting that there is presence of multicollinearity between variables. The highest value of the correlation coefficients is 0.9544, and it is observed between solar energy (SE) and the share of solar energy in total renewable energy consumption (SSR) (see Table 6).

Table 6. Correlation matrix

Source: Author's elaboration

	GDP	EMP	CAP	SE	SSR	RD
GDP	1.0000					
EMP	0.769*** (0.000)	1.0000				
CAP	0.9214*** (0.000)	0.6553*** (0.000)	1.0000			
SE	0.2608** (0.024)	01913 (0.1002)	0.3015*** (0.0086)	1.0000		
SSR	0.4040*** (0.0001)	0.3216*** (0.002)	0.4797*** (0.000)	0.9544*** (0.000)	1.0000	
RD	0.9029*** (0.000)	0.3636** (0.0166)	0.9329*** (0.000)	0.2809* (0.0970)	0.3975** (0.008)	1.0000

Note: ***, **, *Significance at 1%, 5% and 10% level, respectively

In order to avoid the phenomenon that the variable can biased the results due to its instability, we need to test the stationarity of the variables. we employ PP-Choi unit root test. In fact the reject of the null hypothesis mention the stationary of panel data.

3.2.1. Unit root test

Since the methodology of this paper is based on panel and cointegration framework, it should be provided that the variables are stationary in level or in difference. As shown in Table 7, for the PP-Choi tests of the original series, the P-values of most of variables (GDP, CAP, SE, SSR, RD) indicate that the null hypothesis should be rejected. Therefore, there exists unit roots in these five series. Then we conducted a first order difference on the series. Moreover, for the PP-Choi tests for the first-order differences of the all series, the p-values are all less than 0.05 except for SSR variable. Therefore, at the 5% level of significance, the two variables of GDP and SE appear to be non-stationary. Instead, they are both first-ordered I(1) processes. However, there may be some kind of stable relationship among all three (GDP, SE, SSR) variables, which should be examined using cointegration tests (see Table 7).

Table 7. Panel unit root tests for the variables

Source: Author's elaboration

	Order	GDP	EMP	CAP	SE	SSR	RD
PP-Choi test	**In level**	2.9113 (0.9982)	-3.0244*** (0.0012)	2.1304 (0.9834)	3.0881 (0.9990)	1.7418 (0.9592)	0.8193 (0.7937)
	First Difference	-6.8590*** (0.000)	-2.8584*** (0.0021)	-4.9992*** (0.000)	-3.1837*** (0.0007)	0.8514 (0.8027)	-3.2948*** (0.0005)

Note: Z-statistics of PP-Choi tests and corresponding p-values in bracket are reported. ***, **, * are the significant level at 1%, 5% and 10% respectively.

The second step in the PVAR method is to choose the optimal lag order in panel VAR specification (see Table 8). The Akaike information criterion (AIC), the Bayesian information criterion (BIC), Hannan-Quinn information criteria (HQIC), selected lag 4.

Table 8. Lag length criteria

Source: Author's elaboration

Lag	CD	J	J-Pvalue	MBIC	MAIC	MQIC
1	1	0.06017	0.9704	-6.9925	-3.9398	-4.9809
2	1	0.04185	0.9793	-7.0109	-3.9581	-4.9992
3	1	**0.1847**	0.9999	-20.9734	-11.8153	-14.9385
4	1	0.1065	1	**-31.6307***	**-17.8935***	**-22.5783***

Note: * The optimal lag chosen by each criterion

3.2.2. Cointegration test

The results of panel unit root tests argue the presence of panel cointegration relationship. In order to test if there is a long-run equilibrium relationship between GDP, EM, Employer SSR, we test the null hypothesis of absence of cointegration between the variables against the alternative hypothesis of cointegration. In our study, we use the Granger panel non-causality test developed by Pedroni (2004). In order to allow for heterogeneity within the panel, we consider the group mean statistics of the Pedroni test. The number of lags is determined by the Akaike Information Criterion. The panel cointegration results are displayed in Table 9. For all the Group rho and Group-ADF, and Group PP statistics reject the null hypothesis of no cointegration.

Table 9: Panel cointegration results

Source: Author's elaboration

	Statistic	p-value
Group-rho	1.6789	0.0466
Group-PP	-6.2002	0.000
Group-ADF	-6.5090	0.000

We perform the Dumitrescu and Hurlin (2012) short-run Granger non-causality test in first differences. For our case, we use the z-bar statistic because we have a panel with more time periods than number of countries.

Table 10 summarizes the short-run causality results for the demand and production equations. There is short-run causality from GDP to energy consumption, and to renewable energy consumption, respectively. No short-run causality is found between energy and GDP. However, it exists a short-run causality between renewable energy and GDP. This result of causality from solar renewable energy consumption to GDP indicates that promotion of renewable energy use will stimulate economic growth. The Granger causality results reported in ve the share of RE consumption.

Table 10 indicate unidirectional causality between energy consumption and economic growth running from SSR (Solar renewable energy) to economic growth in Africa countries. This is assigned to as the growth hypothesis, which argues that an increase in energy consumption can enhance economic growth, while a decrease in energy consumption can harm economic growth. This result indicates that the full panel economies are solar energy dependent. Thus, Amoah et al. (2020) reveal that an increase in open market and regulatory performance measures increases the proportion of RE in total energy consumption. They mention that authorities in Africa should promote trade freedom to improve the share of RE consumption.

Table 10: Short-run panel causality results

Source: Author's elaboration

Causal direction	z-bar	p-value
GDP→ SE	0.6665	0.5051
GDP→ SSR	2.7851***	0.0054
SE→ GDP	-0.7575	0.4487
SSR→ GDP	-1.1536	0.2486

Notes: ***, Significance at 1%

In the single-country setting, the null hypothesis of Granger non-causality cannot be rejected for Egypt and bidirectional causality between economic growth and energy consumption was identified. This implies the existence of an interconnection between economic growth and energy consumption and can very successfully complement each other, which also supports the feedback hypothesis that the Egyptian economy is energy-dependent, so energy policy must be carefully considered.

Since there are only 14 time periods for each country, we believe that the non-rejection of H0 is due to a lack of power of the tests rather than genuine non-causality or differentiated results in the data. These results help justify the use of panel econometrics in analyzing this dataset (see Table 11).

Table 11: Short-run panel causality results.

Source: Author's elaboration

	Egypt (Lag=2)		Morocco (Lag=1)		South African	
Causal direction	**z-bar**	**p-value**	**z-bar**	**p-value**	**z-bar**	**p-value**
GDP→ SE	3.2696***	0.001	0.0816	0.9350	0.1155	0.9080
GDP→ SSR	2.9269***	0.0034	0.0816	0.9350	-0.7781	0.4365
SE→ GDP	-0.0716	0.9429	-0.6622	0.5079	0.4227	0.6725
SSR→ GDP	3.7391***	0.0002	-0.6622	0.5079	-0.5597	0.5757

Notes: ***, Significance at 1%

We may conclude that there is a long-run causality from economic growth, capital, energy consumption. We estimate a Random effects panel model following this expression:

$$GDP_{i,t} = \beta_0 + \beta_1 CAP_{i,t} + \beta_2 Emp_{i,t} + \beta_3 Energy_{i,t} + \beta_4 SE_{i,t} + \beta_4 SSR_{i,t} + \varepsilon_{i,t}$$

Table 12: Random panel estimation parameters.

Source: Author's elaboration

	Coefficient	Std.Err.
Constant	2.8672***	0.1627
CAP	0.2672***	0.0175
Emp	0.5555***	0.0198
$Energy$	0.5076	0.0120
SE	-0.00005*	0.00003
SSR	0.1539**	0.0686

Note: ***, **, *Significance at 1%, 5%, and 10% respectively

Following the results of

Table 12, we note that most of variable have a positive significant impact on the GDP growth except the energy. Indeed, the economic growth is influenced negatively by the solar energy, but positively by the renewable energy from the total energy consumption. As a consequence, an increase of the solar energy production is considered as a potential growth for the economy, similar to development, research, and investment in human.

4. Conclusions

Renewable energy, precisely solar energy has acquired great importance in the world, due to its less negative environmental effects. Besides, almost developing and developed countries incites to adopt this strategy into their policy of environmental protection and to increase production and consumption of renewable energy.

Our study examined the impact of solar energy consumption on economic growth in three African countries for the period 1990 to 2019. We have analyzed the potential long and short run causality link between solar energy and economic growth. We found the existence of short-run causality from GDP to solar energy consumption, and to renewable energy consumption, respectively. No short-run causality between energy consumption and GDP. However, there is short-term causality between solar energy and GDP. Furthermore, we find that for Egypt, we have a bidirectional causality between solar energy consumption and economic growth.

For further research, we extend the association between economic growth and solar energy consumption that can be analyzed for a more targeted economic sector, and its environmental impact. And we use the non-linear ARDL panel model to investigate the asymmetry link between solar energy, economic growth, and other determinants.

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