Post-Pandemic Renewable Energy Development in Sub-Saharan Africa

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Abstract

In sub-Saharan Africa (SSA), renewable energy is expected to make up about half of the power generation by 2040 and contribute significantly to economic growth. Institutional quality and stability are essential for any economy to function effectively and are critical for a vibrant energy sector. The Global South, particularly SSA, offers abundant natural assets that can be leveraged to achieve sustainable and profitable renewable energy investments; hence, increasing access to green and cost-competitive energy, despite the related institutional quality issues. However, with COVID-19, the energy sector dynamics have received a new discourse that has further strained the limited infrastructural and financial resources needed to drive the process. This study examines the nexus between energy access, institutional quality, and environmental quality in SSA. To get insight into the relationship among the variables of interest, the study unbundles a set of institutional and environmental quality variables using the Bayesian vector auto-regression technique. The findings reveal that among institutions, technology adoption contributes most significantly to renewable energy development in SSA. The study recommends institutional development and strategic technological development to influence sustainable renewable energy utilization in the ongoing renewable energy revolution.

Keywords: COVID-19; energy access; environmental quality; institutional stability; renewable energy; SDGs

Introduction

Following the 2015 Paris Agreement, all countries were encouraged to contribute to addressing the global climate challenge. The agreement noted that greenhouse gas (GHG) emissions are a critical environmental challenge for developed and developing countries and therefore important for energy and environmental management. Notably, despite the Africa's relatively low contribution of GHG to the atmosphere, African countries are still faced with balancing economic growth and managing the increasing environmental challenges such as climate change. Thus, the existing economic models need to be appropriately designed and managed to offer ways to mitigate environmental challenges and ensure zero carbon emission commitments. One valuable policy tool in achieving this target may be institutional quality development, which will play a critical role in balancing economic growth and environmental sustainability achievement in Africa.

Statistics show that 940 million people worldwide lack access to electricity, and about 600 million of them are in SSA (International Energy Agency, 2019), representing over 50 percent of the population. This implies that electricity access in SSA is a critical issue to be addressed urgently, especially since renewable energy sources are expected to provide about half of additional electricity generation by 2040. The energy sector is essential to realizing sustained and inclusive growth. Furthermore, environmental concerns

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and climate change require Africa to adopt innovative approaches to achieve growth objectives without contributing to environmental degradation (Akinyemi et al., 2019a; Egbetokun et al., 2018). A clean environment is considered critical for a better quality of life (Hunjra et al., 2020).

Energy sources and cost are considered strategic determinants of a country's growth and development potential, mainly as factors influencing the cost of production and flow of investments. In Africa, sustainable development will be achieved through increased adoption of greener, cheaper, and more efficient energy sources since most productive economic and social activities need energy as an input (Owusu & Sarkodie, 2016). Increases in renewable energy consumption contribute to economic growth (Herrmann et al., 2018; Wang and Wang, 2020), whereas economic growth leads to an increase in CO_2 emissions. The COVID-19 pandemic has caused significant economic and social disruptions, including the environment (Zambrano-Monserrate et al., 2020).

The energy sector has been significantly affected by both pull and push factors. The economic lockdown, business shutdowns, and movement restrictions reduced energy demand while the supply glut exerted downward pressure on prices. The recovery process provides a rare opportunity to develop the necessary institutional and environmental mechanisms that stimulate sustainable economic growth for a better quality of life as well as a greener environment.

As the COVID-19 pandemic wanes, the energy sector is rapidly evolving, driven by growing customer demand, cost competition, digital technology development and innovation, and collaboration, opening tremendous opportunities. The share of renewable energy in the global energy supply is expected to be 63 percent in 2050, up from 14 percent in 2015 (Gielen et al., 2019). Consumers (households and industrial) have become increasingly aware of the consequences of their actions on climate change and are pushing for changes in the energy sector through their changing behavior. Technological innovations and digitization offer new and better energy sources that meet the urban and rural energy needs without necessarily requiring high sunk costs. To leverage these opportunities, reliable and capable institutional and environmental frameworks are essential.

To effectively achieve more sustainable energy systems after the pandemic, there is a need for public and private sector participation and collaboration in the energy sector. As a prerequisite for the collaboration, a hospitable institutional framework is necessary to attract the private sector to develop innovative energy solutions that complement government efforts to promote sustainable growth (Bhattacharya et al., 2017). This type of institutional environment would assure optimum quality of governance in terms of rule of law enforcement, effectiveness in regulatory responsibilities, and control of corruption. For instance, the growth of alternative power sources, such as independent power producers (IPPs), will require a reliable institutional mechanism that allows them to connect to the national grid to sell excess power. This will enable them to attract innovative financing that stimulates sector growth and contributes to sustainable development. Institutional quality, usually measured in a country by rule of law, risk of expropriation, corruption, regulatory quality, and government effectiveness, is often considered a critical factor in attracting investment, promoting environmental sustainability, and increasing economic growth (Cole, 2007). Despite the increased international interest and literature on the institutional framework, there is still a dire need for nuanced analysis focused on Africa. Thus, this study applies innovative data to shed more insight into a framework for the nexus of energy access, institutional quality, and environmental quality in SSA.

Materials and Methods

Empirical Model and Estimation Technique

Based on the objective to assess the influence of institutional development on renewable energy access in SSA, the study adapts the models of Hicham et al. (2019) and Shah et al. (2020). The model employed in the study, thus, expresses renewable energy as a function of institutional development (the key independent variable) and other necessary control variables, as informed by the literature. Notably, the model was made brief to ensure that it is compendious and informed from theory. The implicit model is expressed as in equation (1):

$$\begin{aligned} &\textit{Renewable energy access} \\ &= f(\textit{Institutions}, \textit{carbon emissions}, \\ &\textit{Technology adoption}) \end{aligned} \tag{1}$$

Carbon emissions and technology adoption are added as proxies for the necessary control variables, as informed by theory. These variables are intuitive because access to renewable

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energy is also a function of the technology utilized by economic agents and the quality of the environment. For example, if the households and firms in Africa fully utilize advanced mobile technology, renewable energy access can be increased with the use of mobile phone applications (Ejemeyovwi, Osabuohien, & Osabohien, 2018a). As another illustration, if environmental quality is damaged and proper awareness is created, the household and firms will always choose renewable energy options, which increase the access and utilization of renewable energy in SSA. The explicit form of equation (1) is further stated in short form in equation (2):

$$Rec_{it}{}^{n} = \alpha + \beta_1.inst_{it} + \beta_{2.}cbrn_{it} + \beta_{3.}techad_{it} + \varepsilon_{it} \qquad (2)$$

where rec_{it} stands for renewable energy consumption; $inst_{it}$ represents institutions, proxied by control of corruption, government effectiveness, and regulatory quality; $crbn_{it}$ stands for carbon emissions as measured in metric tons following Ejemeyovwi et al. (2018b); and $techad_{it}$ represents technology adoption, measured by Internet usage in line with Ejemeyovwi et al. (2019a). Also, the parameters to be estimated include β_0,β_1, β_2,and β_3. Furthermore, β_0 is the intercept, β_1 represents the coefficient of institutions, β_2 is the coefficient of carbon emissions, β_3 is the coefficient of technology adoption, and ε is the error term.

The study further employs the Bayesian vector auto regression (BVAR), developed by Litterman (1980), a method applied on the standard vector autoregression (VAR) to overcome weaknesses possessed in the standard VAR technique. Canova & Ciccarelli (2013) outlines detailed information on the disadvantages and advantages of VAR. Concurring with Todd (1984), BVAR models have been established to let modelers express their beliefs more precisely by specifying hyperparameters and to combine those beliefs with the information in historical data, in line with the standard VAR procedure. The BVAR method builds on the original VAR models, constituting imprecise limitations on the VAR coefficients using hyperparameters. Also, the BVAR caters to possible endogeneity and other econometric violations. More information about the BVAR modeling and application to this study can be found in Supplementary Material Appendix 1.

Data and Variable Description

This study utilizes data from 2000 to 2019 for 48 African countries that comprise SSA. The specific countries are provided in Table 1. This study makes use of panel data that combines observations from the different SSA cross-sections across time.

The specific variables utilized in the study are shown in Table 2, which describes the variables in terms of the proxies used to capture the dependent and independent variables and the a priori expectation for the coefficient of each variable based on theory.

Results and Discussion

Stylized Facts—SSA Renewable Energy Sector

In the last two decades, the economies of SSA have documented record growth rates, and the average energy per capita consumption has been growing, but is still one of the lowest globally. To increase energy production, usage, and reliability in SSA, realizing low carbon emission objectives will require a significant shift from reliance on fossil fuels to renewable energy sources. The government and quality of institutions will significantly influence the transition from nonrenewable to renewable energy sources while promoting environmental sustainability and economic growth (Akinyemi et al., 2019b).

SSA power consumption remains negligible relative to other regions. In the last 25 years, countries in the

Table 1. Description of Selected SSA Countries

Central Africa	East Africa	Southern Africa	West Africa
1. Angola	1. Burundi	1. Botswana	1. Benin
2. Cameroon	2. Comoros	2. Eswatini	2. Burkina Faso
3. Central African Republic	3. Djibouti	3. Lesotho	3. Cape Verde
4. Chad	4. Eritrea	4. Namibia	4. Ivory Coast
5. Democratic Rep of Congo	5. Ethiopia	5. South Africa	5. Gambia
6. Rep of Congo	6. Kenya		6. Ghana
7. Equatorial Guinea	7. Madagascar		7. Guinea
8. Gabon	8. Malawi		8. Guinea Bissau
9. Sao Tome and Principe	9. Mauritius		9. Liberia
	10. Mozambique		10. Mali
	11. Rwanda		11. Mauritania
	12. Seychelles		12. Niger
	13. Somalia		13. Nigeria
	14. South Sudan		14. Senegal
	15. Tanzania		15. Sierra Leone
	16. Uganda		16. Togo
	17. Zambia		
	18. Zimbabwe		

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Table 2. Summary Representation of the Model's Variables

S/N	Code	Variable	Description	Measure	Source	A Priori Expectation
1	REC	Renewable energy consumption	Percent share of renewable energy in total energy consumption	Percentage	World Bank (2020a)	positive
2	CRBN	Carbon emissions	Waste emissions from use of nonrenewable energy sources	Metric tons per capita	World Bank (2020a)	negative
3	INST	Institutions	Political institutions		World Bank (2020b)	positive
3a	COC	Control of corruption	Refers to the extent to which public power is exercised for private gain	Unit estimate	World Bank (2020b)	positive
3c	GE	Government effectiveness	Refers to the quality of public services	Unit estimate	World Bank (2020b)	positive
3f	RQ	Regulatory quality	Refers to the ability of the government to formulate and implement sound policies and regulations	Unit estimate	World Bank (2020b)	positive
4	TECHAD	Technology adoption	Internet usage	Percentage	World Bank (2020a)	positive

South Asia Region (SAR), East Asia and Pacific (EAP), Europe and Central Asia (ECA), and the Middle East and North Africa (MENA) have increased their power consumption. Equally, carbon emissions in all regions have increased, apart from ECA, where it has decreased, and SSA, where it has remained stagnant, as shown in Figure 1.

Although a low carbon emission rate is good news in SSA, the data can be explained by low power consumption, which implies low industrial production and low economic growth. To realize high economic growth rates in SSA, increases in energy consumption are critical, but this does not have to be a trade-off with environmental degradation. The adoption of greener energy sources will support economic growth while supporting ecological systems. Notably, even with low carbon emissions, there has been significant environmental degradation related to deforestation and climate change effects, mainly driven by overreliance on existing energy sources, including charcoal burning (Karakara & Osabuohien, 2020).

In Africa, energy contributes to growth in two ways: as an input to production operations, and as foreign exchange earnings from oil exports. Energy sources are undergoing a transition toward renewable energy sources, mainly wind and solar power, as noted in Figure 2. Demand for oil and related products is expected to decline overtime, which could lead to reduced exports. Moreover, renewable energy sources require significant investments to generate. Reimagining energy generation and use in Africa and developing necessary institutions to support them is critical for sustainable growth.

Econometric Results

The finding of the analysis described are presented in Figure 3, Figure 4, and Table 3. Drawing an inference from the impulse response function of the BVAR econometric simulation, renewable energy responded to institutions in various ways, given the institutional measure. For control of corruption, Figure 3 shows a sharp positive increase in renewable energy due to the introduction of a one standard deviation shock to control corruption. This increase is evident in Table 3, which shows that at period 1, control of corruption, recorded 0.0759 units. while at period 10, 0.3286 was recorded. This finding follows the apriori expectation and further implies that control of corruption shocks in SSA would play a significant role in driving renewable energy solutions in area.

The forecasted pattern of two other institutional variables (regulatory quality and government effectiveness) followed the forecast of control of corruption, as discussed, and the variable for institutional quality followed the apriori expectation. Figure 3 shows that, on average, a positive increase is spurred as a result of the introduction of a one standard deviation shock to regulatory quality and government effectiveness. This increase is also evident in Table 3, which shows that for regulatory quality, at period 1, −0.0349 units were recorded while at period 10, 0.0703 was recorded.

For government effectiveness, an institutional variable, the values were 0.0928 units in period 1 and 0.1403

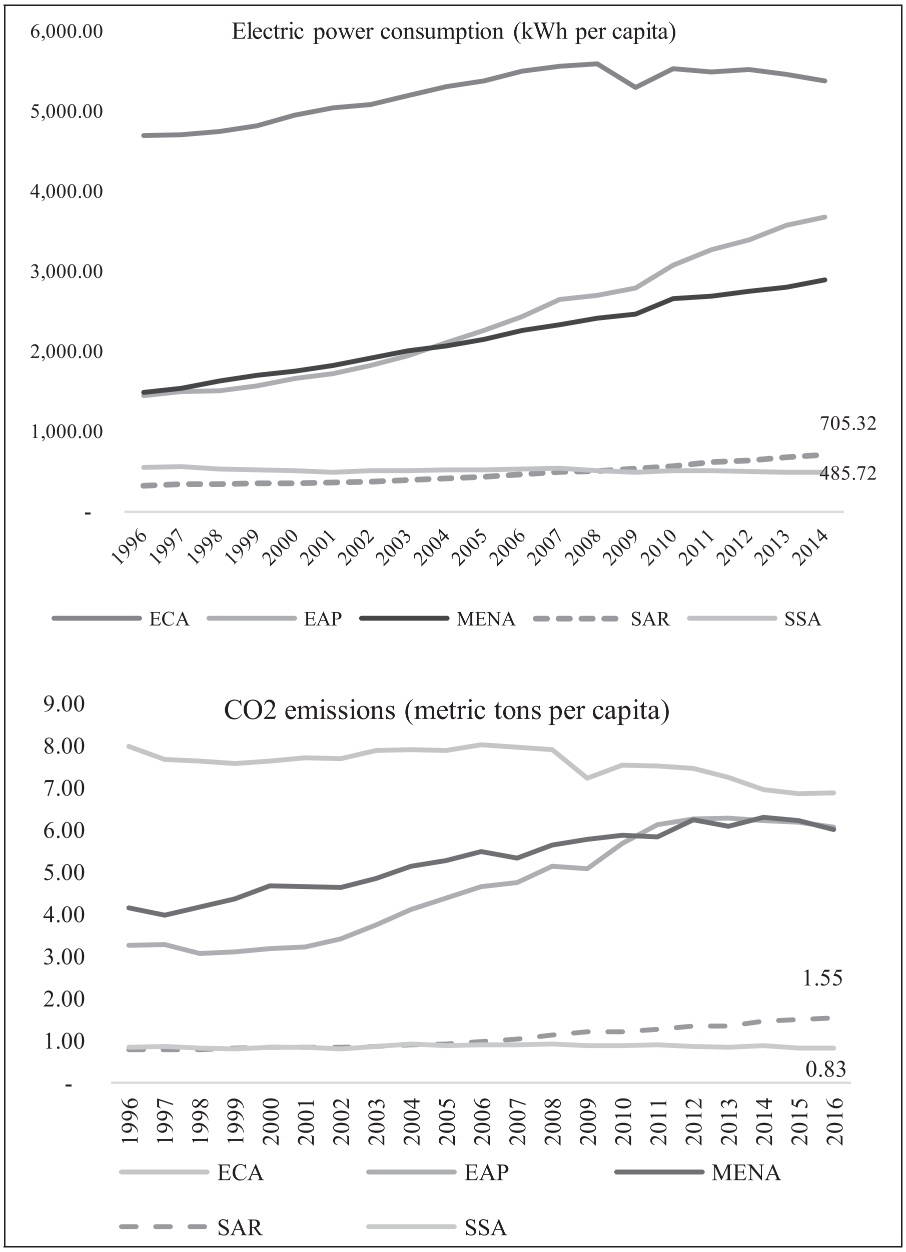

Figure 1. Electric power consumption and carbon emissions across regions of the world

units in period 10. These findings imply that regulatory quality and government effectiveness shocks in SSA would significantly drive renewable energy solutions.

The environmental geography is measured empirically by carbon emissions and technology adoption in the regions. For the environmental determinant, carbon emissions indicate an overall decrease in renewable energy consumption due to the introduction of a one standard deviation shock to carbon emissions (Figure 3). This increase is evident in Table 3, which shows that in period 1, carbon emissions were reported to be −0.1657 units, while in period 10, −0.2314 was recorded. This finding does not follow the economic-theoretical expectation. This result could be explained by the relatively low interest in the utilization of renewable energy sources in SSA given their relatively high cost. The effect could also be explained by the fact that most SSA countries make considerable financial gains and revenue from the production of fossil fuel deposits, and due to the abundance of fossil fuel deposits in SSA countries, the utilization of fossil fuels is relatively affordable compared to the renewable energy sources.

Technology adoption's shock impacts renewable energy consumption in SSA. As shown in Figure 3 and Table 3, in period 1, technology adoption reported −0.0752 units, while in period 10, 0.3708 was recorded. This consistently, positive result for technology adoption shock on renewable energy consumption in SSA is not surprising. Technology, despite its initial cost, tends to improve efficiency overtime, which can increase the productivity in energy access and reduce possible asymmetric issues associated with the energy value chain users (Ejemeyovwi & Osabuohien, 2020).

In sum, among the environmental and institutional determinants of renewable energy consumption in sub-Saharan Africa, it can be generalized that institutions improve renewable energy utilization and access. This generalization is valid because the government's readiness to carry out its responsibilities aptly, including enacting laws and policies that will drive renewable energy access in a country, acts as a significant determinant of renewable energy access in the post-pandemic era. With regard to the environmental factors captured by this study, it can be deduced that an ecologically

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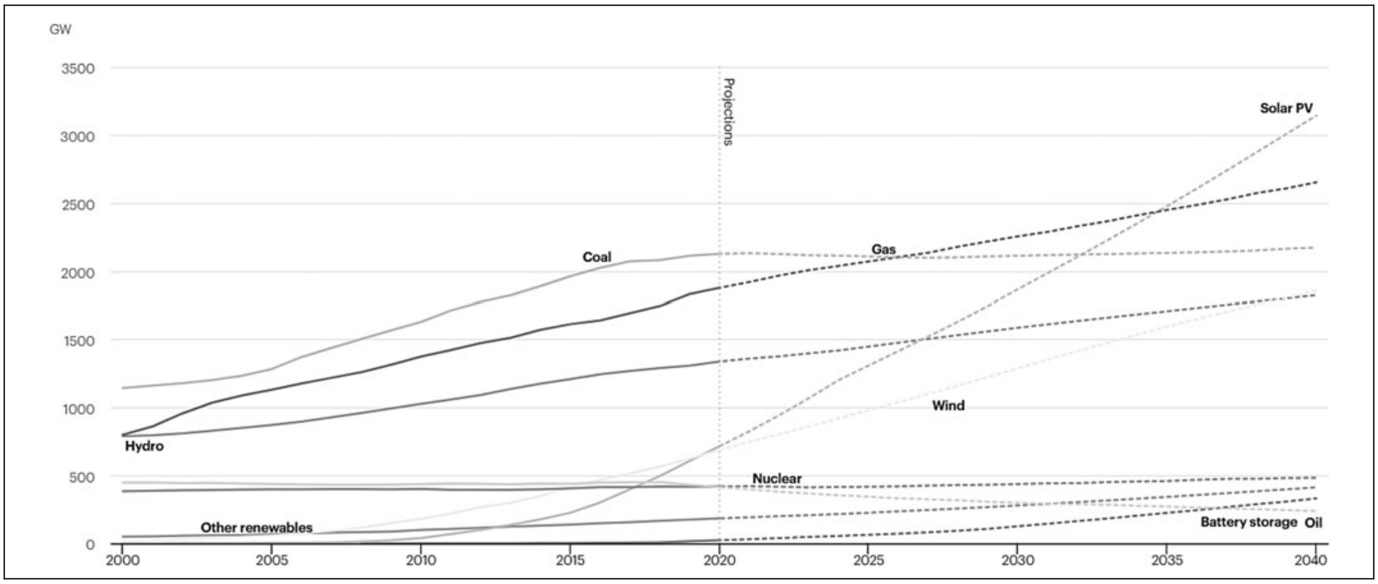

Figure 2. Power generation capacity in Africa

friendly environment is desired, and a technologically developed economy drives renewable energy consumption in SSA (Ejemeyovwi et al., 2019b; Ihayere et al., 2021). The accumulated responses of each of the determinants of renewable energy consumption utilized by this study further confirm this hypothesis. (See Figure 4.)

Moving from the use of nonrenewable energy sources toward the utilization of renewable energy sources during the post-pandemic era might not be easy; however, it remains a necessity because most economies are faced with the priority of funding post-pandemic survival, among other issues. Still, an easy and relatively less costly way to drive the green revolution is through institutional policies, which include the application of control of corruption, regulatory quality, and government effectiveness in the energy sector to ensure affordability and availability in the pricing channels. Through effectiveness in their responsibilities, the government could also provide incentives for renewable energy production firms to reduce cost and encourage the influx of entrepreneurs in that energy subsector. An example of this policy is in effect in Nigeria, although applied to infrastructure development, where private companies are encouraged to provide public infrastructure such as roads, with the incentive of a tax reduction.

Furthermore, the control of corruption will help ensure that policies are fully monitored and periodically evaluated, making the policy target more likely to be successful. Effective action would reduce the strain of limited infrastructural and financial resources and help drive renewable energy access and utilization in SSA, despite the recent COVID-19 pandemic.

Conclusion

This study investigated the nexus among institutional frameworks, environmental challenges, and renewable energy in sub-Saharan Africa. Using panel data for the 48 countries in SSA in the period between 2000 and 2019, the study found that shocks from control of corruption, regulatory quality, government effectiveness, and technology positively drive renewable energy consumption, while carbon emission shocks negatively drive renewable energy consumption.

Based on these findings, first, the study indicates that institutional development in most SSA countries should be prioritized. Recommended actions to drive renewable energy access and utilization include the control of corruption, government effectiveness in discharging responsibilities, and the development of a quality regulatory framework in SSA. Second, since technology adoption was observed to have the most significant positive impact on renewable energy access, technology development should also be prioritized. Third, due to the negative relationship observed between carbon emissions and renewable energy

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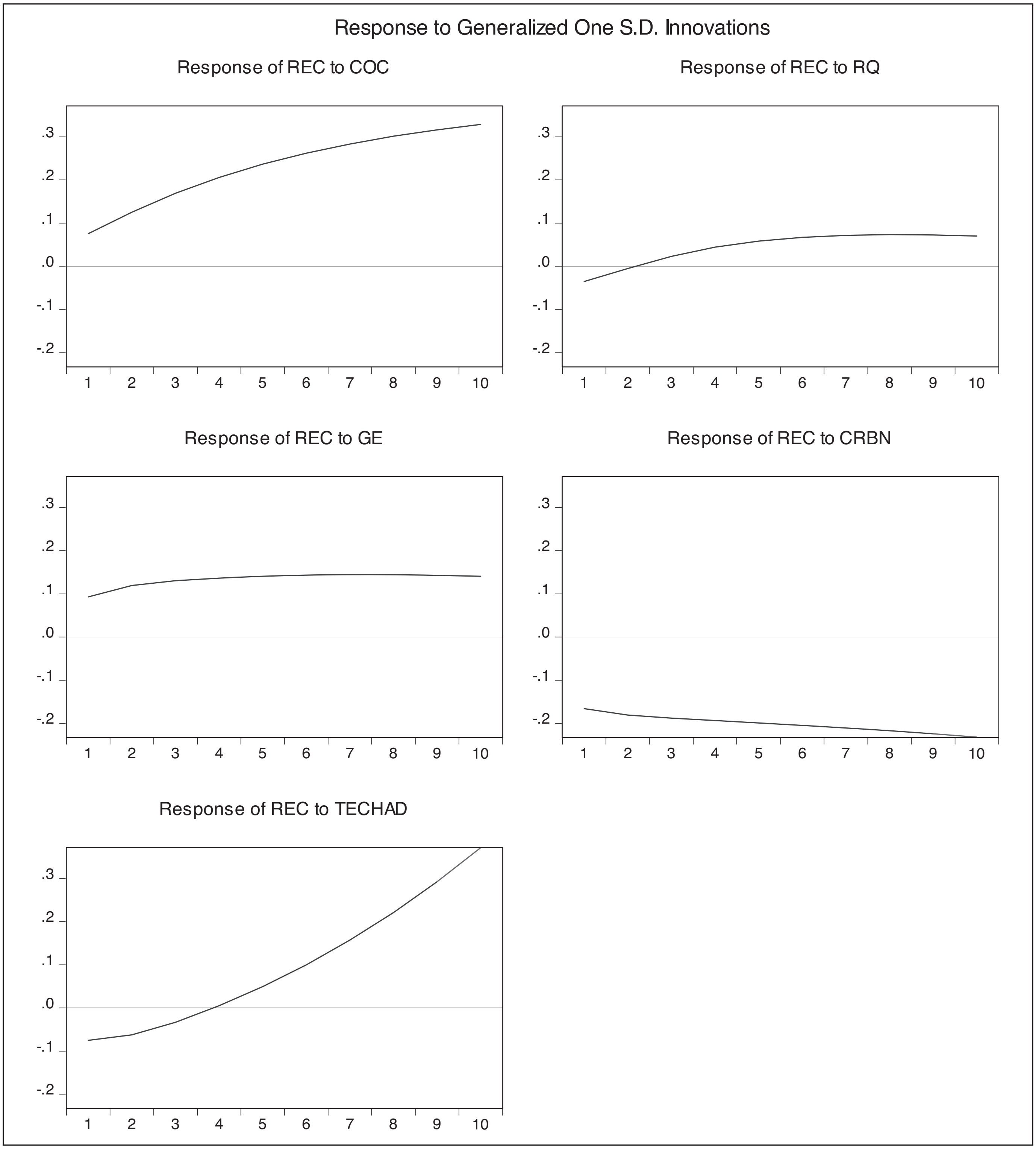

Figure 3. Individual response of renewable energy consumption to institutional and environmental variables' shock

utilization, renewable energy utilization should be perceived as an opportunity to reduce carbon emissions by SSA countries.

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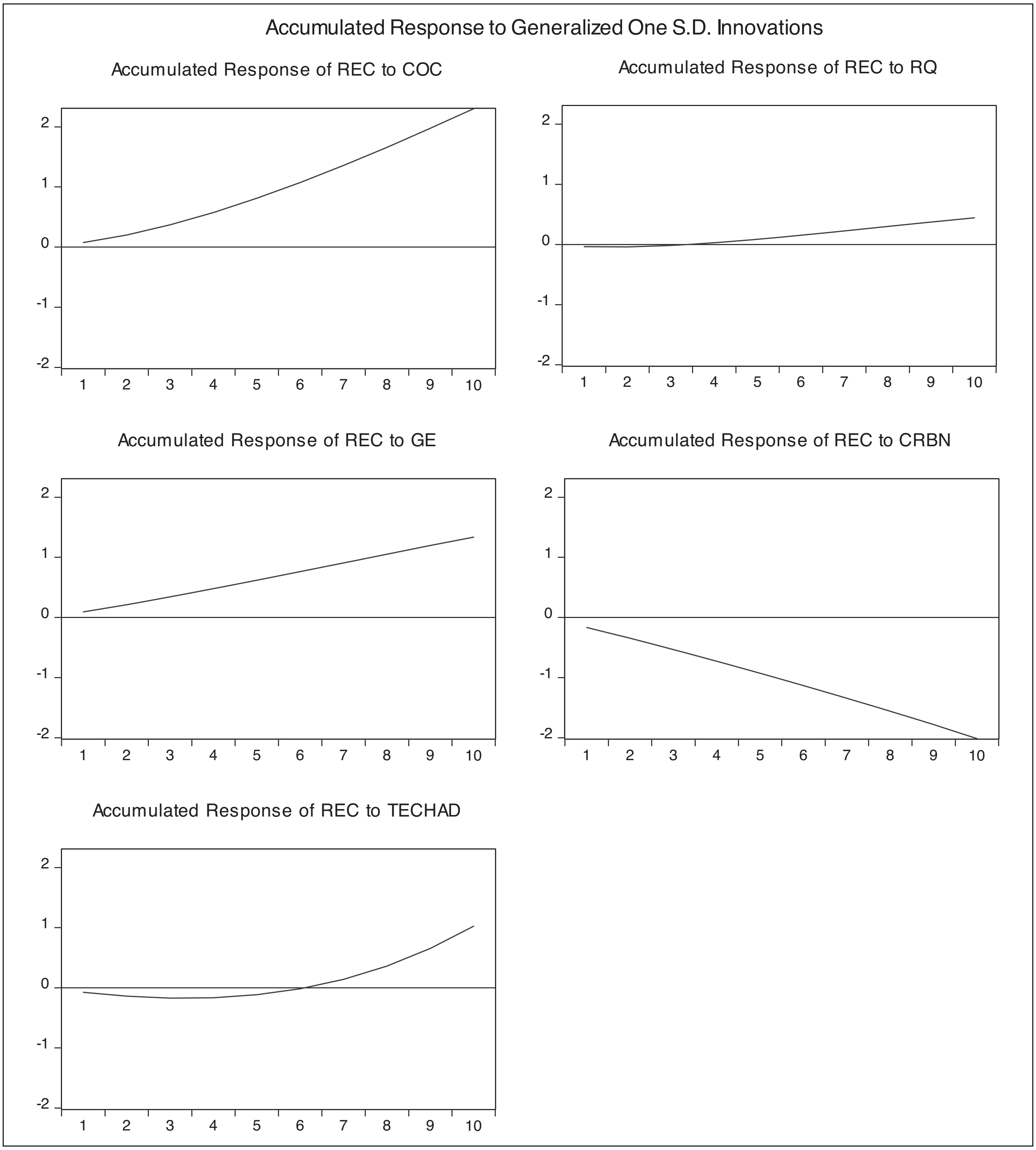

Figure 4. Accumulated response of renewable energy consumption to institutional and environmental variables' shock

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Table 3. Individual Response of Renewable Energy Consumption to Institutional Framework and Environmental Variables' Shock

Period	Control of Corruption	Regulatory Quality	Government Effectiveness	Carbon Emissions	Technology Adoption
1	0.0759	− 0.0349	0.0928	− 0.1657	− 0.0752
2	0.1253	− 0.0047	0.1194	− 0.1804	− 0.0621
3	0.1690	0.0234	0.1304	− 0.1878	− 0.0328
4	0.2059	0.0444	0.1365	− 0.1934	0.0050
5	0.2365	0.0584	0.1405	− 0.1989	0.0494
6	0.2621	0.0671	0.1431	− 0.2045	0.1001
7	0.2833	0.0717	0.1444	− 0.2106	0.1571
8	0.3011	0.0733	0.1444	− 0.2170	0.2208
9	0.3160	0.0727	0.1430	− 0.2240	0.2918
10	0.3286	0.0703	0.1403	− 0.2314	0.3708

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Author Disclosure Statement

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Supplementary Material

Supplementary Appendix SA1

Supplementary References

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