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Analysing the Impacts of Shadow Economy, Financial Inclusion and Economic Policy Uncertainty on CO_2 Emissions

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Abstract

The effects of the shadow economy on the environment have been amply documented in the literature; however, the relevance of financial inclusion and the unpredictability of economic policy are still up for debate. Therefore, this study examines the diverse effects of financial inclusion, shadow economies and economic policy on carbon emissions in 21 Sub-Saharan African countries from 2002 to 2019. To determine whether this hypothesis is true, this study uses the panel spatial correlation consistent (PSCC), method of moments quantile regression (MM-QR) and Dumitrescu–Hurlin (D–H) (2012) methodologies. The findings of the PSCC show that financial inclusion increases carbon emissions in SSA countries but the shadow economy and economic policy uncertainty have an adverse impact on emissions. Using the MM-QR estimation with fixed effects,

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the same results are obtained across all quantiles after accounting for the effects of the shadow economy and economic policy uncertainty over the conditional distribution of CO_2. The effect of financial inclusion on CO_2 emissions is positive, but only statistically significant at the 30th to 70th quantiles until traces of significance are erased. In addition, there is evidence of a two-way causal relationship between the shadow economy and CO_2 emissions, financial inclusion and the shadow economy, urban population and CO_2 emissions, renewable energy use and economic policy uncertainty, trade liberalisation and economic policy uncertainty, and financial inclusion and economic policy uncertainty. The empirical results of this study offer insightful policy suggestions to counteract the direct impact of financial inclusion and to amplify the damaging effects of the shadow economy and economic policy uncertainty on carbon emissions.

Keywords: Carbon emissions, shadow economy, economic policy uncertainty, financial inclusion, energy, sustainable development, MM-QR, Sub-Saharan Africa

Jel Classification: C10, G20, P28, Q50

1. Introduction

Two primary concerns of the development and environmental literature drive us to investigate the relationship between the shadow economy (SE) and environmental quality in Sub-Saharan Africa (SSA). There are gaps in the literature, which is an issue given that SSA economies rely significantly on informal markets. The following is an orderly discussion of these points: Firstly, because of the shadow economy's pervasiveness and relevance in SSA economies, it was critical to address its environmental impacts. The shadow economy has a substantial impact on Sub--Saharan Africa's GDP. In accordance with the IMF (2019), the shadow economy sector accounts for an average of 38% of the GDP in Sub-Saharan Africa. The shadow economy plays a crucial role in providing employment opportunities in Sub-Saharan Africa. It absorbs a significant portion of the labour force (ILO, 2018).

Secondly, CO_2 emissions have become a significant problem in the last two decades, attracting the attention of environmental organizations and global agencies (Ogede and Tiamiyu, 2023; Ogede *et al*., 2023a; Osabohien *et al*., 2023a). Africa emits approximately 43 billion tonnes of CO_2, accounting for 2.73% of the total global emissions. Despite its minor influence on global emission data, Sub-Saharan Africa (SSA) persists as one of the regions susceptible to CO_2 emissions due to its greater dependence on energy resources for agricultural output and a lack of technological innovation (Adzawla *et al*., 2019; Osabohien *et al*., 2023b).

Due to the high degree of impure activities in the region's industries in the lack of restrictions, the SSA countries have a higher issue of falling environmental quality than other countries, as noted by Alimi *et al*. (2022), who underscored this fact. The region has a great deal of resources for mining activities, which makes it appealing for the exploration of mineral wealth; however, these resources have severely harmed the natural landscape. The current policy ambiguity is another factor in the high air pollution in SSA. It is difficult to say whether a greater shadow economy improves or deteriorates given the conditions of Sub-Saharan African countries in relation to global shadow economies.

The relationship between economic expansion, income inequality, energy consumption, trade and geopolitical risk and CO_2 emissions, as well as the industry-specific value-added expansion and carbon emissions, has thus been extensively studied in empirical scholarship with the goal of precisely understanding the primary drivers of CO_2 emissions (Bekun *et al*., 2019; Benkraiem *et al*., 2019; Canh *et al*., 2019; Sohail *et al*., 2021; Camara, 2022; Yu *et al*., 2022; Chu *et al*., 2023). Similarly, earlier empirical literature showed a link between financial inclusion and CO_2 emissions (Le *et al*., 2020; Zhao *et al*., 2021; Khan and Muhammad, 2021; Qin *et al*., 2021; Zaidi *et al*., 2021; Lee *et al*., 2022; Shahbaz *et al*., 2022; Z. Yang *et al*., 2022; Ogede and Tiamiyu, 2023).

Owing to these studies, there may be both positive and negative consequences of the connection between financial inclusion and environmental quality. Another factor that hurts the environment is the ambiguity or unpredictability of government policies that influence economic activity. This is illustrated by the uncertainty of economic policy. Studies on the effects of economic policy changes on carbon emissions in the literature currently available virtually exclusively use cross-sectional analysis and primarily concentrate on the country-wide, sectoral and enterprise levels (See, e.g., Yu *et al*., 2021; Fu *et al*., 2022; Wu *et al*., 2022; Syed and Bouri, 2022; Tee *et al*., 2023; Iqbal *et al*., 2023; Zhang *et al*., 2023).

We speculate that the results of these studies may not accurately disclose the consequences of uncertain economic policies on CO_2, and this also constitutes a glaring gap in the body of literature, due to the economic policy uncertainty index at the national and sectoral levels lacking volatility and regional heterogeneity.

Hence, despite this, the connection regarding the shadow economy, financial inclusion, economic policy uncertainty and CO_2 emissions is still unexplored, emphasizing Sub-Saharan African countries as emerging countries and substantial contributors to global warming. As a consequence, we examine the heterogeneous impact of the shadow economy, economic policy uncertainty and financial inclusion on carbon emissions across different quantiles of Sub-Saharan Africa, and also whether mediation between the shadow economy and financial inclusion matters, which would provide valuable insights into their influence on high- and low-polluting sectors.

This study therefore contributes significantly to the body of knowledge through its research and econometric approach. In our opinion, this research is one of the first to examine the effects of the shadow economy on the environment in Sub-Saharan Africa. In spite of this, research of this type could help policymakers understand the role of the shadow economy in developing a greener economy, given the size of the shadow economy in the region. Furthermore, this study contributes to the body of literature by focusing on SSA's financial inclusion and the uncertainty associated with economic policy as it affects environmental degradation, which has not been addressed previously.

Furthermore, Machado and Silva's (2019) MM-POR method is combined with panel spatial correlation consistent ordinary least squares (PSCC-OLS) and Dumitrescu–Hurlin (D–H) (2012) to provide new insights into the relationship between shadow economy, uncertainty in economic policy and financial inclusion on carbon emissions in Sub-Saharan Africa. The remainder of the study is organized as follows: a review of relevant literature is given, followed by Section 3, which presents the data source, the empirical model and the econometric approach. Section 4 summarises the findings of the econometric investigation. The study's findings, along with some recommendations and future research directions, are described in Section 5.

2. Literature Review

In this section, we assess latest research with an emphasis on the linkages between the shadow economy and CO_2 emissions, financial inclusion and CO_2 emissions, and the correlation between economic policy uncertainty and CO_2 emissions. We also point out potential empirical gaps that demand further study. The corpus of knowledge analysing the relationship between the shadow economy and environmental quality is growing, with numerous studies using various metrics and arriving at varying conclusions. This expanding body of work includes contributions by Abid (2015), Imamoglu (2018), Shao *et al*. (2021), Camara (2022), Dada *et al*. (2022), Ahad and Imran (2023) and Dada *et al*. (2023). For instance, Imamoglu (2018) studied the relationship between Turkey's environmental quality between 1970 and 2014 and the volume of informal economic activity.

The results show a strong and positive correlation between environmental quality and informal economic activity. Using the panel threshold regression model, Shao *et al*. (2021) found that the underground economy has both a short-term and long-term detrimental influence on global environmental contamination. The cointegration results claimed by the authors revealed a long-term relationship between the variables under investigation, indicating that as the underground economy expands, so do the emissions of harmful gases. Camara (2022) claimed that the shadow economy decreased economic growth and CO_2 emissions in 14 ECOWAS countries between 1991 and 2016 using the system generalised method of moments (SGMM) and common correlated effects mean group (CCEMG) estimators.

In an additional investigation that examined a group of 30 African countries, Dada *et al*. (2022) found that while trade openness lessens the ecological footprint, the shadow economy, financial development, economic growth and urbanization increase it. The study also showed that a sound financial system considerably lessens the harm that the shadow economy causes to the environment. Additionally, two-way causation between the ecological footprint, the shadow economy and financial development was validated by Dumitrescu and Hurlin's non-causality tests. More recently, Dada *et al*. (2023) discovered that wealth disparity increases ecological degradation between the 5th and 30th quantiles but decreases it after that point. They also emphasized how the shadow economy weakens environmental quality by having a detrimental impact on environmental deterioration at all quantiles.

Numerous studies have also examined the connection between economic growth, CO_2 emissions and environmental quality. These empirical works have investigated the dynamics and causal relationships; however, their findings are contradictory. The following are a few examples of pertinent studies: Charfeddine and Kahia (2019), Biu (2020), Cucchiella *et al*. (2020), Gharleghi and Jahanshahi (2020), Amin *et al*. (2020), Demetriades and Andrianova (2004), Gök (2020), Jiang and Ma (2019), Khan *et al*. (2018), Kong and Wei (2017), Sunday *et al*. (2017). The relationship between financial inclusion and CO_2 emissions has not been adequately studied because of a lack of data and methodological discrepancies, even if the negative consequences of financial development on carbon emissions are still a matter of controversy. This shows that discussions about financial inclusion have been relatively underrepresented in the empirical research that has already been published. A small number of studies, however, have particularly looked at the connection between financial inclusion and carbon dioxide emissions or environmental quality. Le *et al*. (2020), Khan *et al*. (2021), Qin *et al*. (2021), Zaidi *et al*. (2021), Lee *et al*. (2022), Shahbaz *et al*. (2022) and Ogede and Tiamiyu (2023), among others, have all undertaken notable studies in this field.

Le *et al*. (2020), for instance, suggested a positive association between financial inclusion and carbon emissions by using cross-country panel data to argue that higher financial inclusion increases carbon emissions in a few Asian countries. By contrast, using fixed-effects panel regression analysis, Z. Yang *et al*. (2022) demonstrated a detrimental effect of financial inclusion on local carbon emissions in China. Their findings suggested that financial inclusion reduces carbon emissions through improved industrial structure and higher financial assistance, as well as increased vegetation coverage. Using panel quantile regression analysis and Kao and Johansen panel cointegration tests, Qin *et al*. (2021) found a long-term association between carbon dioxide emissions, financial inclusion, the production of renewable electricity, globalisation and economic growth. Financial inclusion, they discovered, is linked to decreases in carbon dioxide emissions at the 25th and 50th quantiles, but it is unable to account for fluctuations in emission levels at the 75th and 95th quantiles.

As demonstrated by Shahbaz *et al*. (2022), the effect of financial inclusion on carbon emissions varies spatially and is asymmetrical. They emphasized how influences on energy use and the structure of the energy system can indirectly contribute to cooperative pollution reduction. Ogede and Tiamiyu (2023) have used the PARDL and Granger causality methodologies to analyse the effect of financial inclusion on carbon dioxide emissions in SSA countries from 2004 to 2017. Based on their investigation, industrialization, trade openness, GDP per capita and financial inclusion have a significant positive impact on carbon emissions in SSA countries. The Granger causality test verified the direction of causality, showing that in SSA countries, financial inclusion, GDP per capita, industrialization and trade openness all cause carbon emissions but none of the other factors are caused by carbon emissions. However, understanding how economic policy uncertainty influences carbon emissions is critical for developing successful emission reduction targets and programmes (Li *et al*., 2022).

Numerous empirical studies, including those by Yu *et al*. (2021), Li *et al*. (2024), Degbedji *et al*. (2024), Okafor *et al*. (2023), Akpa *et al*. (2023), Fu *et al*. (2022), Khan *et al*. (2022), Wu *et al*. (2022), Syed and Bouri (2022), Tee *et al*. (2023), Iqbal *et al*. (2023) and Zhang *et al*. (2023), have addressed this issue. For example, from 1997 to 2020, Khan *et al*. (2022) investigated the relationship between carbon emissions and economic policy uncertainty in four East Asian countries (Japan, China, Singapore and South Korea). The researchers discovered a link involving economic policy uncertainty, trade, GDP and carbon emissions. They did, however, observe that foreign direct investment and renewable energy usage improve the environmental quality of these countries. They discovered a two-way relationship between carbon emissions and economic policy uncertainty, energy consumption, economic growth and trade using the Dumitrescu–Hurlin panel causality estimation.

Similar to the above, Syed and Bouri (2022) used a cutting-edge bootstrap ARDL methodology to examine how economic policy uncertainty affects CO_2 emissions in the USA. They discovered that significant economic policy uncertainty increases CO_2 emissions in the short run, indicating short-term environmental damage. Their findings, however, also suggested that economic policy uncertainty lowers CO_2 emissions over time, which suggests an improvement in environmental quality.

Recent studies by Tee *et al*. (2023), Iqbal *et al*. (2023) and Zhang *et al*. (2023) have also explored the link between economic policy uncertainty and carbon footprint. For instance, Tee *et al*. (2023) found a link between economic policy uncertainty and 2,782 enterprises' carbon footprints spread over 60 countries. They made the case that countries with stronger institutional governance lessen the large correlation between the unpredictability of economic policy and the carbon footprint. Similar to this, Iqbal *et al*. (2023) used ARDL to show that, regardless of whether a country is developing or developed, economic policy uncertainty greatly increases CO_2 emissions in both the short and long terms.

Zhang *et al*. (2023) used augmented ARDL and gradual shift causation to demonstrate how economic policy uncertainty lowers carbon emissions in the short and long term during the switch to renewable energy. They also discovered that ecological innovation helps lower CO_2 emissions over the long term. Above all, the aforementioned emphasizes how critical economic policy is to determining how much energy is consumed, how much carbon dioxide is emitted at the national level and how fast those three things grow.

Changes in economic policy have an indirect impact on energy efficiency and the shift to a low-carbon and green economy, in addition to changing people's expectations for future economic growth and industrial restructuring. Although most of the current literature relies on time-series studies and generally focuses on the effects of country-specific changes in economic policy on carbon emissions, there are several drawbacks. The findings of these studies may not accurately reflect the true impact of economic policy uncertainty on carbon emissions, representing a significant gap in the existing literature; it is hypothesized that it is because the economic policy uncertainty index at these levels lacks volatility and regional heterogeneity.

3. Data and Methods

3.1 Data

This study uses data from 21 Sub-Saharan African countries from 1996 to 2021 to conduct an analysis. These countries are Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Togo, Zambia, Zimbabwe, Ethiopia, Gabon, Gambia, Ghana, Kenya, Mauritius, Mozambique, Namibia, Niger, Nigeria, Senegal, and South Africa. They were chosen based on the availability of data relevant to the primary variables of interest. Table 1 contains specific information about the variables utilised in the analysis, such as descriptions and sources. To analyse financial inclusion, we created a financial inclusion index using the principal component analysis (PCA) technique, which allowed us to condense a large dataset into a smaller set while keeping the original information quality.

The composite index, following the approach of Le *et al*. (2019), Ogede *et al*. (2023a), Ogede *et al*. (2023b) and Ogede and Tiamiyu (2023), incorporates variables such as automated teller machines (ATMs), account ownership at financial institutions and commercial bank branches. The study measures the eigenvalues of each component and components with eigenvalues greater than one are retained as they explain a significant amount of the dispersion in the principal component. The results of the principal components of the financial inclusion index, derived from the three variables included in the model, are presented in Table 2.

Table 1: Description of variables

Variable	Measurement/descriptions	Source
Carbon dioxide emissions (*CO_2*)	CO_2 emissions (tonnes per capita)	World Development Indicators (2023)
Financial inclusion (*FI*)	PCA of ATM, ACNT and BRCH	Authors' computation using World Development Indicators (2023)
Automated teller machines (*ATM*)	Automated teller machines per 100,000 adults	World Development Indicators (2023)
Account ownership (*AMM*)	% of population aged 15+ with account at a financial institution	World Development Indicators (2023)
Commercial bank branches (*CBB*)	Ratio of commercial bank branches per 100,000 adults	World Development Indicators (2023)
Economic policy uncertainty (*EPU*)	World Uncertainty Index (WUI)	Ahir *et al.* (2018)
Shadow economy (*SHAD*)	Percentage of GDP[1]	Medina and Schneider (2019)
Renewable energy consumption (*REC*)	% of renewable energy consumption to final energy consumption	World Development Indicators (2023)
Trade liberalization (*TL*)	% of trade to GDP	World Development Indicators (2023)
Urban population (*URBPOP*)	% of urban population to total population	World Development Indicators (2023)

Source: Authors' own elaboration[1]

Table 2: Principal component analysis for financial inclusion

Financial inclusion index						
Principal components	**Component matrix**			**Proportion**	**Cumulative proportion**	**Eigen value**
	ATM	**Account**	**Bank branch**			
First PC	0.5798	−0.5208	0.6266	0.7966	0.796	2.3899
Second PC	0.5642	0.8115	0.1523	0.1181	0.914	0.3542
Third PC	0.5878	−0.2652	0.7643	0.0853	1.000	0.2558

Source: Authors' own calculations

1 Moving averages are adopted to determine 2018 and 2019 data.

3.2 Econometric methodology and strategy

In line with the goals and previous literature, we specify a baseline model based on the frameworks of Yu *et al*. (2022), Aderemi *et al*. (2022) and Dada *et al*. (2021) by incorporating financial inclusion and economic policy uncertainty into the model to address the goal of examining the heterogeneous impacts of shadow economy, financial inclusion and economic policy uncertainty on CO_2 emissions in SSA. It expresses CO_2 emissions as a function of the shadow economy, financial inclusion, economic policy uncertainty and a set of control variables:

$$CO_2 = f\left(SHAD, FI\_PHY, EPU\right) \tag{1}$$

$$CO_{2it} = w_0 + w_1 SHAD_{it} + w_2 FI\_PHY_{it} + w_3 EPU_{it} + \omega_4 K'_{it} + \mu_{it} \tag{2}$$

where CO_{2it} denotes the carbon emissions proxy with CO_2 emissions (tonnes per capita), $FIPHY_{it}$ represents financial inclusion, EPU denotes economic policy uncertainty, K'_i is the vector of control variables, w_0 is the intercept while w_i denotes parameters to be estimated, and μ_{it}represents the general error term. The effects of a shadow economy, financial inclusion and economic policy uncertainty on carbon emissions are not likely to be comparable. As a result, it is important to explain why these factors were chosen.

Financial inclusion has been suggested in studies investigating the elements that influence environmental quality and carbon emissions to either boost or weaken climate resilience. Economic policy uncertainty (EPU) is thought to have a beneficial impact on carbon emissions since it is associated with investment delays, uncertainty about future economic conditions and heightened risk aversion, all of which can contribute to higher carbon emissions. The shadow economy (SHAD) is defined as a proportion of GDP, according to Medina and Schneider (2019). This variable selection is consistent with the work of Syed and Bouri (2022), Tee *et al*. (2023) and Zhang *et al*. (2023), and it is expected to reduce carbon emissions. Furthermore, the selection of control variables such as renewable energy consumption (REC), trade liberalization (TL) and urban population (URBPOP) is compatible with contemporary CO_2 emissions literature, as evidenced in research by Tsaurai (2019).

The Driscoll and Kraay (1998) panel spatial correlation consistent ordinary least square (PSCC-OLS) methodology and the method of moments quantile regression (MM-QR) approach serve as the foundations for the econometric methods used in this study. The PSCC-OLS estimator is used to take into consideration any potential cross-sectional dependence that can develop as a result of regional proximity and shared characteristics among countries. Results may be skewed if the data autocorrelation, heteroscedasticity and cross-sectional dependency are not corrected (Pesaran, 2004).

The study incorporates the quantiles via moments approach, also known as MM-QR with fixed effects, proposed by Machado and Silva (2019) in order to capture the distributional heterogeneity in the relationship between the shadow economy, financial inclusion, economic policy uncertainty and carbon emissions. The PSCC-OLS and MM-QR regressions are therefore both used in this study. The MM-QR estimator has a number of benefits over Koenker's (2004) conventional panel quantile regression method. First of all, it makes the assumption that the covariate only affects the location and scale functions, as opposed to how location shifters are described in the literature (Adeleye *et al*., 2022). Furthermore, this estimator incorporates fixed effects, which permits individual effects to have an impact on the entire distribution (Adeleye *et al*., 2022).

In light of the aforementioned methods, the conditional quantile estimate for a model of location-scale variation is presented:

$$QCO_{2it}\left(\tau|X_{it}\right) = \beta_0 + \theta_1 SHAD_{it} + \theta_2 FI\_PHY_{it} + \theta_3 EPU_{it} + \mu_{it} \tag{3}$$

As stated in Equation (3), we consider the carbon emissions (CO_{2it}) to be the dependent variable observed over the sample period. The conditional quantile function at the τ^{th}quantile, denoted as $QCO_{2it}(\tau|X_{it})$, represents the relationship between CO_2 emissions and the explanatory variables X_{it}. These explanatory variables include shadow economy, financial inclusion and economic policy uncertainty. The error term, denoted as μ_{it}, is assumed to be independently and identically distributed across the individual countries *i* at the time *t*. The residuals, which are the differences between the observed CO_2 emissions and the predicted values based on the explanatory variables, are orthogonal to X_{it}. Furthermore, the residuals are normalized to satisfy the moment conditions described in Machado and Silva (2019). Equation (3) implies that:

$$QCO_{2it}\left(\tau|X_{it}\right) = \left(\alpha_i + \delta_i q\left(\tau\right)\right) + X_{it}'\beta + \boldsymbol{Z}_{it}'\gamma q\left(\tau\right) \tag{4}$$

The expression $\alpha_i(\tau) = \alpha_i + \delta_i q(\tau)$ represents a scalar parameter that indicates the quantile-τ fixed effect for the individual *i*. Here, $\boldsymbol{Z}$ is a vector of length *k* that contains identified components of *X*, which are differentiable transformations. Each element Z_l is defined as $Z_l = Z_l(X)$, $l = 1, \ldots, k$. In contrast to the least-squares fixed effects, the individual effects in this method do not correspond to intercept shifts (Adeleye *et al*., 2022). The varied consequences of these time-invariant characteristics vary depending on the quantiles of the conditional distribution of the carbon emissions variable. The following optimization problem is resolved by estimating the conditional quantile carbon emissions function from Equation (3) using the MM-QR method:

$$min_q \sum_i \sum_t \rho_\tau \left(\hat{R}_{it} - (\hat{\delta}_i + Z_{it}'\hat{Y})q\right) \tag{5}$$

Hence, the standard quantile loss function, denoted as $\rho_\tau(A) = \tau - 1AI\{A \leq 0\} + \tau AI\{A > 0\}$, is used to measure the deviation from a desired quantile. However, when there is a marginal change in the variable i, it affects the parameter of the dependent variable (CO_2). In this case, i represents the marginal change in the τ^{th}conditional quantile of $QCO_{2it}(\tau|X_{it})$.

4. Results and Discussion

An overview of the empirical research on the connections between the shadow economy, financial inclusion, ambiguity in economic policy and carbon emissions in Sub-Saharan African (SSA) countries is given in this section. There are two parts to how these findings are presented. Table 3 displays the descriptive properties and pairwise correlation analyses of the variables utilized in the models in the first section. The results of tests for slope homogeneity, stationarity and co-integration are also shown in Tables 4, 5 and 6. The second section digs deep into the particular empirical findings. For instance, Table 7 displays the panel spatial correlation consistent (PSCC) and location and scale results from the MM panel quantile regression. Table 8 also shows the outcomes of the panel D–H causality analysis. Each of these findings is supported by thorough justifications and discussions.

4.1 Preliminary analysis

The dependent variables and the important explanatory variables are the main topics of discussion. The shadow economy has an average mean value of 37.326 when taking into account the sample used in this study, as shown by the data in Table 3. This result indicates that over the study period, carbon emissions increased on average by 37% among the studied countries. The sub-region average carbon emissions were low, comparable to the contribution of the shadow economy. The mean value is 1.121. Table 3 also reveals that financial inclusion is low in SSA countries. On average, the SSA countries recorded 0.195, which indicates that financial inclusion is still lower in SSA countries relative to all countries in Africa and globally.

The economic policy uncertainty has an average mean value of 0.381, suggesting that the sampled countries record an average of 0.38% fluctuation within the period under review. Furthermore, Table 3 shows that all the variables are positively skewed, with the exception of renewable energy consumption, which is negatively skewed. Kurtosis statistics reveal that carbon emissions, financial inclusion, economic policy uncertainty and urban population are leptokurtic, whereas shadow economy, renewable energy consumption and trade liberalization are platykurtic. Jarque–Bera statistics also show that the series does not have a normal distribution, implying that the mean differs from the median. The bottom panel of Table 3 contains the results of the correlation matrix, which illustrates the relationship between regressors and outcome variables.

Table 3: Summary statistics

Statistics/ variables	*CO_2*	*SHAD*	*EPU*	*FI_PHY*	*REC*	*TL*	*URBPOP*
Mean	1.1210	37.326	0.3811	0.1957	64.197	65.641	41.702
Maximum	8.4393	61.400	3.8118	4.4958	96.040	150.33	89.741
Minimum	0.0203	21.900	−0.5460	−1.2860	8.9400	20.722	8.4610
Std. dev.	1.7608	9.0676	0.4826	1.3316	25.515	25.316	17.785
Skewness	2.6819	0.4844	3.3784	1.5427	−0.7556	0.6446	0.3497
Kurtosis	10.047	2.4641	18.700	4.7327	2.3153	2.6112	3.0140
Jarque–Bera	1304.1***	20.377***	4856.9***	208.18***	45.764***	30.151***	8.1386*
Observations	399	399	399	399	399	399	399
CO_2	1	–	–	–	–	–	–
SHAD	−0.2624	1	–	–	–	–	–
EPU	−0.1374	−0.0421	1	–	–	–	–
FI_PHY	0.6335	−0.4086	0.0399	1	–	–	–
REC	−0.6379	0.3999	0.1629	−0.7413	1	–	–
TL	0.2213	−0.2048	0.1657	0.4894	−0.4325	1	–
URBPOP	0.5524	0.0798	−0.0394	0.3432	−0.4487	0.3808	1

Note: *FI_PHY* = financial inclusion; Std. dev. = standard deviation; * and *** denote significance at 10% and 1% levels, respectively.

Source: Authors' own calculations

The tests for slope homogeneity and cross-sectional dependence (CD) are discussed in Table 4. Panel A of Table 4 exhibits cross-sectional independence since all of the variables reflect cross-sectional dependence. Furthermore, Panel B of Table 4 shows that the Pesaran and Yamagata (2008) and Blomquist and Westerlund (2013) tests both produce findings that are significant at the 1% level, indicating that the null hypothesis of homogeneous slope coefficients is rejected. The findings, however, compel the need to ascertain the long-term co-movements among the variables because there are varied slope coefficients.

The results of the CIPS and CADF unit root tests that were used to determine whether the variables were stationary while accounting for both intercept and temporal trends are shown in Table 5 of this study as a follow-up. The results show that either the level or the first difference is where all the variables are incorporated. Table 6 displays the cointegration process. It covers the findings of the bootstrap panel-based cointegration studies carried out by Pedroni (2004) and Kao (1999), which demonstrate the long-term co-movement of the variables.

Table 4: Results of cross-sectional dependence and slope homogeneity test

Panel A: Cross-sectional dependence test

Variables	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
CO_2	1625.1***	69.049***	68.466***	18.018***
SHAD	1998.7***	87.281***	86.698***	42.960***
EPU	400.45***	9.2932***	8.7098***	8.0558***
FI_PHY	2346.7***	104.26***	103.67***	45.081***
REC	1610.0***	68.317***	67.733***	27.312***
TL	877.36***	32.564***	31.980***	4.7437***
URBPOP	3674.1***	169.03***	168.44***	38.108***

Panel B: Slope homogeneity test

Tests	Statistics	*p*-value
Pesaran and Yamagata (2008)		
$\hat{\Delta}$ (delta) test	13.123	0 ***
$\hat{\Delta}$ (delta) adj. test	15.621	0 ***
Blomquist and Westerlund (2013)		
Δ_{HAC}	8.904	0 ***
(Δ_{HAC}) adj.	10.599	0 ***

Note: *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.
Source: Authors' own calculations

Table 5: Results of panel unit root test

	CIPS			CADF		
Variables	**Level**	**1st difference**	**Integration order**	**Level**	**1st difference**	**Integration order**
CO_2	–1.323	–3.387 ***	I(1)	–1.743	–2.498 ***	I(1)
SHAD	–1.987	–4.674 ***	I(1)	–1.795	–3.630 ***	I(1)
EPU	–1.298	–3.497 ***	I(1)	–1.380	–2.589 ***	I(1)
FI_PHY	–2.728	–5.265 ***	I(1)	–2.277	–4.359 ***	I(1)
REC	–1.662	–4.308 ***	I(1)	–2.335	–3.337 ***	I(1)
TL	–2.487	–3.674 ***	I(1)	–1.965	–4.361 ***	I(1)
URBPOP	–1.874	–2.765 ***	I(1)	–1.869	–3.585 ***	I(1)

Notes: *, ** and *** denote significance at 10%, 5% and 1% levels, respectively. Critical values are –2.07, –2.15, –2.30 for 10%, 5% and 1% significance level respectively.

Source: Authors' own calculations

Table 6: Results of panel co-integration test

Pedroni (1999, 2004)			Kao (1999)	
Tests	**Within dimension**	**Between dimension**	**Tests**	**Statistics**
***v*-statistic**	–3.405 ***	–	**Modified DF *t***	–0.3791
rho-statistic	5.783 ***	4.249***	**DF *t***	–1.4186 *
PP-statistic	–7.453 ***	–3.719**	**Augmented DF *t***	–1.8913 *
ADF-statistic	–5.617 ***	–2.815**	**Unadjusted modified DF *t***	–1.1326
–	–	–	**Unadjusted DF *t***	–1.8963 **

Notes: *v*: variance; PP: Phillips–Perron; ADF: Augmented Dickey–Fuller; DF: Dickey–Fuller; *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Source: Authors' own calculations

4.3 Empirical outcomes and discussions

4.3.1 PSCC-OLS and MM-QR estimation results

The PSCC-OLS and MM-QR estimation results are shown in Table 7, which demonstrates that the MM-QR technique reveals certain latent associations in the underlying distribution that the PSCC-OLS regression has not previously detected. According to the PSCC-OLS regression, which is similar to the location parameters of the MM-QR, the coefficient of the shadow economy is −0.0189, which means that for every unit increase in the shadow economy, there is an anticipated drop in carbon emissions of 0.0189 units. This low coefficient shows that reduced carbon emissions are correlated with a greater shadow economy.

This finding supports the claims made by Yu *et al*. (2022), Camara (2022), Sohail *et al*. (2021) and Dada *et al*. (2023), according to which there is a negative correlation with CO_2 emissions. Theoretically, the fact that unofficial, unregulated economic activities – which are typically associated with the shadow economy—might have less carbon-intensive production processes than conventional industries may justify. The results, however, contradict the findings of Ahad and Imran (2023) and Dada *et al*. (2022). Although the negative link between the shadow economy and CO_2 emissions may suggest some benefits for the environment, it is important to recognise the socio-economic difficulties that the shadow economy presents. These difficulties include the absence of labour safeguards, decreased tax income for governments and constrained economic expansion. The shadow economy's informality, which typically leads to lower salaries and altered spending patterns, is one noteworthy feature. People who work in the shadow economy frequently have limited access to goods and services, including those that require a lot of energy. Their overall energy consumption and associated CO_2 emissions are therefore typically lower than those in the formal economy.

As noted by Liu and Zhang (2022) and Khan *et al*. (2022), when other variables are held constant, a one-unit rise in economic policy uncertainty is connected with a 0.2720-unit decrease in carbon emissions. This association between economic policy uncertainty and carbon emissions is negative and statistically significant. This implies that greater economic policy uncertainty may result in fewer investments in carbon-intensive businesses, lowering carbon emissions. Additionally, a one-unit increase in financial inclusion is associated with a 0.5786-unit rise in carbon emissions, demonstrating a positive and statistically significant association between financial inclusion and emissions.

This positive link demonstrates that greater financial inclusion and higher carbon emissions are associated. In accordance with existing research (Yu *et al*., 2022; Dada *et al*., 2023; Liu *et al*., 2022), financial inclusion is a substantial and advantageous driver of environmental sustainability. In line with the findings, CO_2 emissions rise as financial inclusion does. Theoretically, having access to credit, savings, insurance and other financial tools will enable people to engage in entrepreneurial endeavours, make investments in firms and engage in the formal economy, all of which will promote economic growth. However, in countries with energy infrastructure that largely relies on fossil fuels, economic expansion is frequently accompanied by rising energy use and carbon emissions. People who have access to financial services may be able to raise their standard of living and enhance their purchasing power, which may lead to increased purchase of energy-intensive goods. As people's discretionary earnings increase, they might participate in more carbon-intensive activities.

The findings also show that there is a negative and robust link between trade liberalisation and carbon emissions; this is contrary to the work of Khan *et al*. (2023) and Zeeshan *et al*. (2022). With each unit of trade liberalisation, carbon emissions are predicted to fall by 0.0164 units. This negative correlation suggests that greater trade liberalisation and lower carbon emissions are related. This suggests that trade liberalisation promotes global trade and specialisation, enabling countries to concentrate on sectors in which they have a competitive edge.

As a result, specialisation may result in more efficient production methods and maybe lower carbon emissions. On the other side, the consumption of renewable energy has a detrimental effect on carbon emissions; this is consonant with the work of Khan *et al*. (2022). This finding suggests that a unit increase in renewable energy consumption is accompanied with a decrease in carbon emissions of 0.0122 units. The findings, however, indicate that greater use of renewable energy is associated with reduced carbon emissions since renewable energy sources provide electricity with lower or no carbon emissions. According to the urban population coefficient (0.0413), a one-unit increase in urban population is correlated with a 0.0413-unit increase in carbon emissions.

A higher urban population and higher carbon emissions are suggested by this positive coefficient. It is believed that metropolitan regions typically have denser populations and more concentrated economic activity, which results in higher energy use and carbon emissions. This finding supports the claims made by Camara (2022), Osabohien *et al*. (2021), Dada *et al*. (2022) and Khan *et al*. (2023), according to which there is a positive correlation with CO_2 emissions. The results, however, contradict the work of Dada *et al*. (2023) and Iqbal *et al*. (2023).

However, the dynamics take on a little more intrigue when distributional heterogeneity is taken into account. The scale parameters also support the application of the MM-QR technique based on the highly significant and identically negative direction scale coefficients for the shadow economy, trade liberalisation and renewable energy usage from the lowest to the greatest quantile. The negative effect of the factors becomes smaller in scale from the lowest to the highest quantile of the conditional distribution of carbon emissions. The magnitude of the positive effect of these variables, as indicated by the location parameter, increases across the conditional distribution of carbon emission from the lowest to the highest quantile, on the other hand, as indicated by the positive direction scale coefficients for financial inclusion and urban population. The MM-QR results for the 10th to 90th quantiles of carbon emissions are also shown in Table 7. The study, however, restricts consideration of the quantiles to only the dependent variables and important explanatory variables. Table 7 shows that while the negative connection in the various quantiles of the conditional distribution of carbon emissions is retained, the relevance of the shadow economy is not. As the magnitude of the coefficient also decreases across the conditional distribution of carbon emissions, this suggests some form of convergence event. It also shows that informal and unregulated economic operations, which are commonly linked with the shadow economy, may have a lower carbon impact than official economic activity. Additionally, it has been found that, at the 30th to 70th quantiles, respectively, financial inclusion significantly and positively increases carbon emissions by 0.4972%, 0.521%, 0.546%, 0.596% and 0.664%, respectively.

Notably, the positive effect of financial inclusion grows as the distribution is extended. The results suggest that when financial inclusion rises, carbon emissions rise along with it, showing that easier access to financial services and participation in the formal financial sector may have unforeseen effects on environmental sustainability. Based on the findings, if financial institutions do not give preference to green financing choices, a focus on sustainable and environmentally friendly investments may not necessarily go hand in hand with financial inclusion. As a result, more projects that contribute to carbon emissions would be financed without taking sufficient environmental considerations into account due to the increased access to financial services.

Contrarily, economic policy uncertainty shows a detrimental, negligible and declining impact on carbon emissions. This varying effect is more pronounced in the 10th quantile, showing that economic policy uncertainty (EPU) might have an adverse influence on carbon emissions. The results suggest that carbon emissions generally tend to decline across all levels of emissions during times of more economic policy uncertainty. The results also indicate that businesses may postpone or scale back investments in carbon-intensive projects such as raising production capacity or introducing new technologies that increase emissions when uncertainties seem high. The general decline in carbon emissions throughout the quantiles is a result of this behaviour.

Table 7: Results of PSCC-OLS and method of moments quantile regression (MM-QR)

Variables	PSCC-OLS	MM-QR with fixed effects										
		Location parameters	Scale parameters	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
SHAD	−0.0189***	−0.0189**	−0.0116*	−0.0055	−0.0082	−0.0113	−0.0135	−0.0159	−0.0206	−0.027	−0.0345	−0.0482*
	(0.0055)	(0.0247)	(0.0238)	(0.0294)	(0.0263)	(0.0238)	(0.0229)	(0.0229)	(0.0257)	(0.0337)	(0.0460)	(0.0716)
EPU	−0.2720***	−0.2720*	0.0525**	−0.3327	−0.3206	−0.3066	−0.2963	−0.2858	−0.2643	−0.2353	−0.2014	−0.1395
	(0.0945)	(0.3486)	(0.3362)	(0.4223)	(0.3781)	(0.3419)	(0.3287)	(0.3285)	(0.3686)	(0.4827)	(0.6587)	(1.0219)
FI_PHY	0.5786***	0.5786**	0.1237**	0.4356	0.4641	0.4972*	0.5213**	0.5460**	0.5968**	0.6649*	0.7447	0.8905
	(0.0832)	(0.2729)	(0.2632)	(0.3247)	(0.2905)	(0.2628)	(0.2526)	(0.2528)	(0.2843)	(0.3721)	(0.5076)	(0.7902)
TL	−0.0164***	−0.0164*	−0.0161*	0.0022	−0.0014	−0.0057	−0.0089	−0.0121	−0.0188*	−0.0276**	−0.0381**	−0.0571**
	(0.0034)	(0.0107)	(0.0103)	(0.0111)	(0.0099)	(0.0090)	(0.0086)	(0.0087)	(0.0100)	(0.0131)	(0.0177)	(0.0285)
REC	−0.0122***	−0.0122	−0.0046**	−0.0068	−0.0078	−0.0091	−0.010	−0.0109	−0.0129	−0.0154	−0.0185	−0.024
	(0.0034)	(0.0143)	(0.0138)	(0.0173)	(0.0155)	(0.0140)	(0.0134)	(0.0134)	(0.0151)	(0.0198)	(0.0270)	(0.0420)
URBPOP	0.0413***	0.0413**	0.0236*	0.014	0.0194	0.0257*	0.0303***	0.0351***	0.0448***	0.0577***	0.0730***	0.1008***
	(0.0040)	(0.0161)	(0.0156)	(0.0169)	(0.0151)	(0.0137)	(0.0131)	(0.0133)	(0.0152)	(0.0198)	(0.0269)	(0.0432)
Constant	1.9574***	1.9574	1.5462**	0.1708*	0.527	0.9394	1.2406	1.5501	2.1848	3.0348	4.0321	5.8546
	(0.2209)	(1.5771)	(1.5209)	(1.8294)	(1.6365)	(1.4810)	(1.4236)	(1.4278)	(1.6127)	(2.1063)	(2.8689)	(4.4930)

Note: The values in the parentheses are robust standard error of parameters; *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Source: Authors' own calculations

4.3.2 Results of Dumitrescu–Hurlin panel causality

The results of the Dumitrescu–Hurlin tests, which are summarised in Table 8, indicate that there is evidence of a bidirectional causal link between several components. Urban population and CO_2 emissions, use of renewable energy and uncertain economic policy, trade liberalisation and uncertain economic policy, as well as financial inclusion and uncertain economic policy, are some of these factors. The empirical data are consistent with a two-way causal relationship between these factors.

Table 8: Results of pairwise Dumitrescu–Hurlin panel causality tests

Direction of causality	*W*-stat.	Prob.	Remark
CO_2 ≠> SHAD	3.21805	0.0734	Bidirectional causality
SHAD ≠> CO_2	7.51706	0.000	
FI_PHY ≠> SHAD	1.25596	0.0744	Bidirectional causality
SHAD ≠> FI_PHY	4.59315	2.00E-05	
EPU ≠> SHAD	2.67217	0.4261	Unidirectional causality
SHAD ≠> EPU	3.54291	0.0172	
TL ≠> SHAD	1.66638	0.3001	Unidirectional causality
SHAD ≠> TL	3.8799	0.0027	
URBPOP ≠> SHAD	6.15039	1.00E-12	Bidirectional causality
SHAD ≠> URBPOP	4.13439	0.0005	
REC ≠> SHAD	2.85623	0.258	Unidirectional causality
SHAD ≠> REC	7.69497	0.000	
FI_PHY ≠> CO_2	3.08781	0.1204	Unidirectional causality
CO_2 ≠> FI_PHY	4.23275	0.0003	
EPU ≠> CO_2	1.56143	0.2196	Unidirectional causality
CO_2 ≠> EPU	3.51805	0.0195	
TL ≠> CO_2	3.08796	0.1204	Unidirectional causality
CO_2 ≠> TL	4.1515	0.0005	
URBPOP ≠> CO_2	6.24546	3.00E-13	Bidirectional causality
CO_2 ≠> URBPOP	3.80386	0.0043	
REC ≠> CO_2	3.7077	0.0073	Bidirectional causality
CO_2 ≠> REC	3.77841	0.0049	
EPU ≠> FI_PHY	24.5119	0.000	Bidirectional causality
FI_PHY ≠> EPU	7.6573	0.000	
TL ≠> FI_PHY	2.57932	0.5309	Unidirectional causality
FI_PHY ≠> TL	4.32265	0.0001	
URBPOP ≠> FI_PHY	3.95547	0.0017	Bidirectional causality
FI_PHY ≠> URBPOP	3.50984	0.0203	
REC ≠> FI_PHY	3.31312	0.0496	Unidirectional causality
FI_PHY ≠> REC	2.9228	0.2104	
TL ≠> EPU	4.6328	1.00E-05	Bidirectional causality
EPU ≠> TL	3.45698	0.0261	
URBPOP ≠> EPU	4.84166	2.00E-06	Unidirectional causality
EPU ≠> URBPOP	2.99634	0.1657	
REC ≠> EPU	3.50797	0.0204	Bidirectional causality
EPU ≠> REC	1.1481	0.0477	
URBPOP ≠> TL	5.42461	6.00E-09	Unidirectional causality
TL ≠> URBPOP	2.52669	0.5956	
REC ≠> TL	4.68904	8.00E-06	Unidirectional causality
TL ≠> REC	2.65683	0.4426	
REC ≠> URBPOP	6.69805	4.00E-16	Bidirectional causality
URBPOP ≠> REC	3.69734	0.0077	

Note: *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

The test statistics were estimated under the null hypothesis that the independent variable does not homogeneously cause the dependent variable against the alternative hypothesis. The optimal lag selection is based on the AIC and the symbol ≠> implies "does not cause homogeneously".

Source: Authors' own calculations

Additionally, Dada *et al*. (2022) profited from the feedback link between CO_2 emissions and the shadow economy. Due to this feedback relationship, it is possible for the shadow economy to be affected by changes in CO_2 emissions and vice versa. This emphasises the two-way causality between the shadow economy and CO_2 emissions, showing that changes to the shadow economy can have an impact on CO_2 emissions and vice versa. First off, the term "shadow economy" refers to unofficial operations that take place outside the purview of government inspection and regulation and entail high-emission practices. These activities may become more prevalent as a result of the shadow economy's growth, which would raise CO_2 emissions.

CO_2 emissions will afterwards contribute to climate change, which may therefore have an effect on the economy, particularly in sectors susceptible to hazards associated with the climate. Extreme weather events can have a significant impact on supply chains and agricultural activities, driving people and communities into the shadow economy in order to survive. The findings also show unidirectional causality between the shadow economy and economic policy uncertainty, the shadow economy and trade liberalisation, the shadow economy and renewable energy consumption, CO_2 emissions and economic policy uncertainty, CO_2 emissions and trade liberalisation, and financial inclusion and trade liberalisation. Yu *et al*. (2022) was aided by the feedback relationship between CO_2 emissions and trade liberalisation and between financial inclusion and trade liberalisation.

5. Conclusion and Policy Remarks

In this study, we examined the distributional influences of economic policy, financial inclusion and shadow economies on carbon emissions in 21 Sub-Saharan African countries spanning from 2001 to 2019. This study applied the Dumitrescu–Hurlin (D–H) (2012), method of moments quantile regression (MM-QR) and panel spatial correlation consistent (PSCC) techniques to test the validity of this hypothesis. In the panel spatial correlation consistent (PSCC) using OLS, empirical evidence showed that financial inclusion increases carbon emissions in SSA countries while the shadow economy and economic policy uncertainty have an adverse effect on CO_2 emissions. Using the MM-QR estimation with fixed effects to account for the effects of the shadow economy and economic policy uncertainty across the conditional distribution of carbon emissions, the results demonstrate that the shadow economy has a negative and negligible impact on carbon emissions across all quantiles.

This conclusion is attributed to the failure to put environmental regulations into practice as well as the need to improve enforcement strategies to include actions such as stricter emission monitoring, penalties for non-compliance and promoting transparency and accountability in the economic activities of the selected SSA countries. It is also blamed on the governments of these countries' incapacity to formalise informal enterprises by offering incentives, streamlining registration procedures, as well as offering support services. With a falling influence on carbon emissions, the adverse effect of economic policy uncertainty was statistically insignificant across the quantiles.

Economic policy uncertainty (EPU) may have a negative impact on carbon emissions, as evidenced by the fact that this variable effect is more pronounced in the 10^{th} quantile. Positive, but only statistically significant from the 30^{th} to 70^{th} quantiles before the traces of significance were eliminated, was the effect of financial inclusion on carbon emissions. Notably, as the distribution was broadened, the benefits of financial inclusion increased. The findings imply that as financial inclusion grows, carbon emissions grow as well, indicating that wider access to financial services and involvement in the formal financial sector may have unanticipated implications on environmental sustainability. There is also evidence of a bidirectional causal relationship between economic policy uncertainty and the use of renewable energy, trade liberalisation and economic policy uncertainty, financial inclusion and economic policy uncertainty, urban population and CO_2 emissions, and the shadow economy and financial inclusion.

However, the resulting findings are logically plausible and have significant policy ramifications, opening up a new path for the development of precise and clear policy proposals. At first glance, the quantile analysis of the conditional distribution of the negative relationship between the shadow economy and carbon emissions has various policy ramifications and suggestions. First and foremost, this discovery raises the possibility that reducing the size and influence of the shadow economy could help reduce carbon emissions.

However, policymakers in the selected SSA countries should concentrate on putting environmental regulations into place and bolstering them, as well as improving their enforcement mechanisms to include measures such as more stringent monitoring of emissions, consequences for non-compliance, as well as encouraging accountability and openness in economic activities. Additionally, the existence of a negative relationship suggests that integrating informal economic activities into the formal economy may reduce carbon emissions. However, it is crucial that these countries' governments formalise informal enterprises by granting incentives, streamlining the registration procedure and providing support services. These would make it simpler to control and keep track of their environmental impact. Secondly, the conditional distribution of carbon emissions shows a negative correlation between economic policy uncertainty and carbon emissions reported across quantiles, suggesting that lower carbon emissions are associated with higher levels of economic policy uncertainty across different segments of the distribution. However, this study shows that severe economic policy uncertainty may prompt governments and international organisations to take proactive policy measures.

Therefore, policymakers in these countries should concentrate on long-term planning and commitment to environmental policies aimed at setting clear and achievable targets for carbon emission reduction and adoption of renewable energy, with a long-term vision that extends beyond short-term political cycles, in order to mitigate economic policy uncertainty and promote sustainable practices. We also need to pay attention to the finding that financial inclusion has a favourable impact across quantiles of the conditional distribution of carbon emissions. Firstly, it suggests that a focus on sustainable and ecologically beneficial investments may not always go hand in hand with financial inclusion. Thus, in order to align financial inclusion efforts with environmental sustainability, government agencies and policymakers in SSA countries must encourage and provide incentives to financial institutions to prioritise green financing options and direct investments towards low-carbon activities.

This study has several limitations. There are restrictions on the quantity and quality of data that could be used for conducting empirical studies on the shadow economy and carbon emissions in SSA. The scope of our study is constrained by the difficulties in gathering accurate and consistent data for parameters such as economic policy uncertainty and the size of the shadow economy. The peculiarity of SSA, as well as the distinctive traits and dynamics of the region economies, may restrict the external validity of our findings and conclusions. Future studies might, however, make a replication of this study on a panel of other developing countries and compare the results across countries to have a deeper understanding of the debate.

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