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# Shadow economy, institutions and environmental pollution: insights from Africa

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## Abstract

**Purpose** – This study investigates the effect of shadow economy on environmental pollution and the role of institutional quality in moderating the impact in African countries between 1991 and 2015.

**Design/methodology/approach** – The study employs three pollutant variables namely: carbon dioxide emissions per capita, methane emission and nitrous oxide emission as robustness check. Also, battery of methodologies; ordinary least squares, fixed effects and system generalised method of moments are used to drive out the conclusions of this study.

**Findings** – The findings reveal that shadow economy and institutional quality contribute significantly to environmental pollution in Africa. Further, the interactive effect of shadow economy and institutional quality worsens environmental quality in the region. This reveals that weak institutional quality recorded in the region increases the level of shadow economy, thereby intensifying environmental pollution.

**Practical implications** – The study concludes that weak institutional framework in the region reinforces shadow economy and environmental pollution. Hence, findings from this study can help policymakers in the region to better understand the role of institutional quality in reducing shadow economy and environmental pollution.

**Originality/value** – This study enriches one's understanding on the role of institutional quality in the relationship between environmental quality and shadow economy in African context. It investigates the direct and indirect impact of institutions and shadow economy on environmental quality. The study also uses three different robust variables to measure environmental pollution (carbon dioxide ($CO_2$) emissions per capita, methane emission and nitrous oxide emission) for sensitivity analysis.

**Keywords** Environmental quality, Pollution, Shadow economy, Institutional quality, Africa

**Paper type** Research paper

## 1. Introduction

Shadow economy is one of the major problems faced by developing countries. Schneider *et al.* (2010) find that shadow economy is approximately three-quarters of the size of gross domestic product (GDP) in Georgia, Zimbabwe, Bolivia, Nigeria, Egypt and Thailand using physical input (electricity) and currency demand approaches between 1990 and 1993. Further, Medina and Schneider (2018) observe that shadow economy constitutes about 36% of the total GDP of developing countries between the period of 2002 and 2015. According to International Labour Organization (ILO) report in 2012, shadow economy creates more than 70% employment opportunities in nations such as Zambia, Uganda, Thailand, Nepal, Lithuania, Ghana, Nigeria and Gambia, with many of these firms engaging in pollution-intensive ventures such as transportation with inefficient and outdated vehicles, automotive repair, leather tanning, artisanal mining, bleaching and dyeing, brick and tile making and

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metal working which on the aggregate have significant impact on the environment (Cervero, 2000; Olowu *et al.*, 2018). The shadow economy has been recognised as one of the important sources of environmental degradation especially in the area of pollution in developing countries (Blackman and Bannister, 1998; Cervero, 2000; Maazhar and Elgin, 2013; Elgin and Oztunali, 2014a, b; Yu and Gao, 2015; Imamoglu, 2018; Olanipekun *et al.*, 2019; Swain *et al.*, 2020).

Moreover, environmental challenges such as air pollution, climate change, land degradation, including seaside and marine environment degradation have been on the rise in developing countries particularly in Africa, thus attracting attention from researchers, policymakers, governments and international organisations. For instance, in Africa, Nigeria and Angola top the list of countries with the highest gas flaring. Precisely, 425.9 billion standard cubic feet of gas was flared between January and November 2019 in Nigeria, while 22.6 million tons of carbon dioxide was emitted into the environment (NOSDRA, 2020). In Angola, 254 billion cubic feet of gas was flared in 2018. Apart from gas flaring, the extraction of non-renewable resources such as gold, coal and diamond also has negative influence on the environment (Baksi and Bose, 2010; NOSDRA, 2020). For instance, abandoned mining sites in many African countries, such as the case of coal burning from power stations for generating electricity and use of mercury in South Africa, gold mining sites in Ghana (Dondeyne *et al.*, 2009; Baksi and Bose, 2010; Dada, 2019) constitute high level of air and water pollution, causing great hazard to human health. Further, activities from the household such as bleaching, dyeing and tanning also contain hazardous substances which contaminate ground water and rivers if not properly disposed. However, recent trends in both theoretical and empirical cycles have shown that the link between shadow economy and environmental quality could be altered in the presence of institutions (Udemba *et al.*, 2020).

The role of institutions has continued to gain momentum in environmental literature due to the crucial role it plays in setting rules of the game and discipline the behaviour of economic agents (Johnson *et al.*, 1998; Friedman *et al.*, 2000; Biswas *et al.*, 2012; Huynh and Ho, 2020). Quality of institutions could affect environmental quality either directly or indirectly through its determinants. One of such determinants considered in this study is shadow economy. Strong institutions boost the confidence of investors (local and foreign), promote fairness and equitable distribution of resources (North, 1990; Jutting, 2003), reduce the presence of shadow economy; thus, abating pollution emission (Biswas *et al.*, 2012; Huynh and Ho, 2020; Fahimi *et al.*, 2020). Besides, productions and emissions could increase in the underground sector of the economy as a result of implementing strict environmental regulation policies such as increasing tax rate on pollution emission (Gupta, 2006; Chaudhuri and Mukhopadhyay, 2006; Mazhar and Elgin, 2013). Similarly, weak institutions such as laxity in the implementation of environmental laws and regulations can increase the number of firms operating in the shadow economy, thereby increasing the production of goods and emissions (Baksi and Bose, 2010). In addition, slackness in institutions might trigger firms to subcontract their production to other firms operating in the shadow economy in order to lessen cost associated with pollution control, which in the long run further worsens the environmental quality. As a result of these different roles, institutions could play in shadow economy–environmental quality relationship, little attention has been given to it either by policymakers or researchers (Baklouti and Boujelbene, 2019).

Although there exists numerous empirical studies that have investigated the determinants of environmental quality (Dasgupta and Maler, 1995; Harbaugh *et al.*, 2000; Narayan and Narayan, 2010; Imamoglu, 2018); environmental quality and institutions nexus (Pargal and Wheeler, 1996; Panayotou, 1999; Hettige *et al.*, 2000; Dasgupta *et al.*, 2002; Cole, 2007); environmental quality and shadow economy relationship (Blackman and Bannister, 1998; Biswas *et al.*, 2012; Croitoru and Sarraf, 2012; Mazhar and Elgin, 2013; Elgin and Oztunali, 2014a, b; Nkengfack *et al.*, 2020), hardly have these three variables been taken together in a study particularly in Africa. Therefore, this present study adds to the literature in diverse ways. First, it investigates the direct and indirect impact of institutions and shadow economy on environmental quality. Second, it employs an interactive term to assess the marginal effect of institutions in mediating the impact of shadow economy on environmental quality. Third, this study examines the effect of shadow economy on environmental quality in Africa as a whole, with special focus on the role played by institutions in such link. As researched, Africa is one of the continents with highest number of shadow economy (ILO, 2010; Medina and Schneider, 2018; Ajide *et al.*, 2021) and has also witnessed various deterioration in her environmental quality. Finally, the study uses three different robust variables to measure environmental pollution (carbon dioxide ($CO_2$) emissions per capita, methane emission and nitrous oxide emission) for sensitivity analysis.

The rest of the paper is sectionalised as follows: section 2 presents an overview of shadow economy while section 3 presents a review of related literature and hypothesis. Methodology, data and sources are presented in section 4. Results and discussion of findings are presented in section 5 while concluding remarks are presented in section 6.

## 2. Overview of shadow economy in Africa

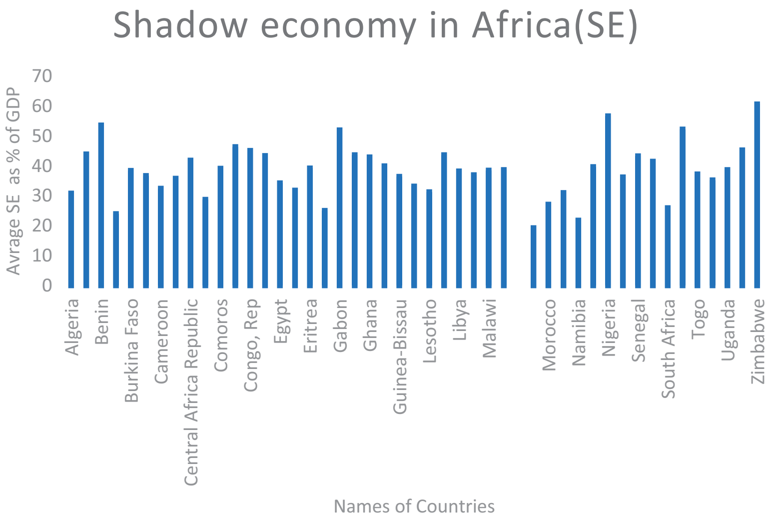
In the literature, shadow economy [1] connotes all economic events or activities taking place outside the bureaucratic public and private sector establishments (Ihrig and Moe, 2004; Hart, 2008; Ajide *et al.*, 2021). The activities may produce legal goods, but no operation is taking place within the regulatory environment (Ihrig and Moe, 2004). Shadow economy is an illegal economy because most of the activities are unrecorded and the income in this kind of sector is acquired from creation of legal goods and services. The income or the transactions taking should have been taxable but are not presented to tax authorities. Shadow economy is generally difficult to measure and attempt to measure it using different methodologies (Medina and Schneider, 2018; Hashimzade and Heady, 2016; Schneider, 2005; Bitzenis *et al.*, 2016) has resulted in varying results. Gomis-Porqueras *et al.* (2014) opine that shadow economy is any cash transactions done solely to evade levied taxes. People engage in shadow economic activities by evading taxes and employ workers irregularly (Álvarez-Herránz *et al.*, 2017).

Figure 1 shows that Zimbabwe has approximately 60.6% of GDP as the size of shadow economy while that of Nigeria is over 50% of GDP in sub-Saharan African countries on the average. In all country groups, shadow economy is more than one-third of the country's GDP. This clearly shows that shadow economy is still increasing in developing countries especially Africa (Medina and Schneider, 2018).

## 3. Literature review and hypothesis development

The theoretical basis of most issues on environmental quality revolves around Environmental Kuznets Curve (EKC) framework (Grossman and Krueger, 1991, 1995; Dinda, 2004; Akadiri *et al.*, 2019; Gokmenoglu *et al.*, 2019). The EKC provides a useful foundation for analysing the link between economic variables and environmental variables in an economic setting which is one of the contemporary issues in relation to global pollution and the presence of shadow economy. It has been well established in economics literature that environmental quality may be affected by the size of shadow economy (Biswas *et al.*, 2012). However, little or nothing is known on the nexus among institutional quality, quality of environment and extent of shadow economy in Africa. In the investigation of Elgin and Oztunali (2014) on informal economy–pollution nexus and energy use over a period of 1999–2009 for 152 countries, results reveal an inverse-U shape among the variables of interest. The authors conclude that informal sector is associated with lesser pollutant emission.

In another related study by Imamoglu (2018), the size of shadow economy has direct impact on the quality of environment in Turkey over a period of 1970–2014 after using




**Source(s):** Authors' computation but data from Medina and Schneider (2018)

**Figure 1.** Average shadow economy in Africa (1991–2015)

dynamic ordinary least square, fully modified ordinary least square and autoregressive distributed lag techniques. Chen *et al.* (2018) investigate the effect of environmental regulation, shadow economy and corruption on environmental quality within a panel setting of 30 provinces in China between 1998 and 2012 using generalised method of moment (GMM) estimation technique. Outcome of the study reveals that regulations and the size of shadow economy both have positive impacts on pollution in China. The results also show that tighter control of the environment would help in reducing pollution at a threshold level of the shadow economy. The study of Baklouti and Boujelbene (2019) shows that public corruption affects growth and its impact depends on the level of informal economy. Using OLS and SGMM, they establish that increase in corruption and large magnitude of shadow economy reduce growth in 34 OECD countries.

The recent study of Huynh (2020) empirically examines the impact of fiscal policy in the relationship between air pollution and shadow economy in 22 Asian nations from 2002 to 2015. Using fixed effect and system GMM, the results show that shadow economy has direct impact on air pollution while expansionary fiscal policy decreases the detrimental impact of air pollution through shadow economy. Furthermore, Pang *et al.* (2020) examine the size of shadow economy through multiple indicators multiple causes (MIMIC) model including its direct relationship with pollution level. The authors conclude that shadow economy has direct impact on environmental pollution in China. Similarly, Swain *et al.* (2020) examine the impact of informal sector and governance indices on pollution, globally and locally in 58 countries between 1996 and 2011. Evidence from GMM technique reveals that size of informal sector contributes significantly to environmental quality and conditioned on the level of development. In order to further enrich the literature, we formulate the following hypotheses:

*H1*. The size of shadow economy significantly increases the level of environmental quality in Africa

*H2*. Institutions play a significant role in mediating the relationship between environmental quality and the size of shadow economy

These two hypotheses were tested in the subsequent sections.

## 4. Methodology

### *4.1 Empirical model*

We adopt similar model used in the literature to examine the link among environmental quality, institutions and shadow economy (Biswas *et al.*, 2012; Chen *et al.*, 2018; Wang and Dong, 2019; Huynh, 2020; Pang *et al.*, 2020; Huynh and Ho, 2020; Nkengfack *et al.*, 2020). Thus, the baseline model is stated as:

$$\mathrm{ENV}_{i,t} = f(\mathrm{SE}_{i,t}, \mathrm{INS}_{i,t}, X_{i,t}) \tag{1}$$

Where $\mathrm{ENV}_{i,t}$ is environmental pollution for country $i$ at period $t$. $\mathrm{SE}_{i,t}$ is shadow economy for country $i$ at time $t$, $\mathrm{INS}_{i,t}$ is institutional quality for country $i$ at time $t$. $X_{i,t}$ is a vector of other control variables that affect environmental quality in the literature. From Eqn 1, the study adopts the standard specification of the cross-country equation. The specific model is stated thus:

$$\mathrm{ENV}_{i,t} = \beta_1 \mathrm{ENV}_{i,t-1} + \alpha_1 \mathrm{SE}_{i,t} + \gamma_1 \mathrm{INS}_{i,t} + \delta_1 X_{i,t} + \mu_i + \varepsilon_{i,t} \tag{2}$$

$\mu_i$ signifies country-specific effect, $\varepsilon_{i,t}$ is the error term. The lag value of environmental pollution is included in the model since it historical value influences the current state (Chen *et al.*, 2018). However, since the study intends to examine the role institutions play in environmental quality–shadow economy relationship, an interaction term is added in order to obtain the marginal and mediating role of institutions. Equation 1 is therefore re-specified as:

$$\mathrm{ENV}_{i,t} = \beta_1 \mathrm{ENV}_{i,t-1} + \alpha_1 \mathrm{SE}_{i,t} + \gamma_1 \mathrm{INS}_{i,t} + \eta_1 (\mathrm{SE} * \mathrm{INS})_{i,t} + \pi_1 X_{i,t} + \mu_i + \varepsilon_{i,t} \tag{3}$$

Where SE * INS is the interactive term of shadow economy and institutional quality.

Consequently, from Eqn 3, the *a priori* expectations of the variables are as follows; α is expected to have a significantly positive impact on environmental pollution (Cervero, 2000; Chaudhuri and Mukhopadhyay, 2006; Elgin and Oztunali, 2014; Chen *et al.*, 2018; Ajide and Osinubi, 2020). This suggests that shadow economy worsens environmental quality in Africa. $\gamma$ is projected to have a negative effect on environmental pollution if strong institutional quality is in place, while the opposite is expected for weak institutional quality. This shows that strong institutional quality reduces environmental pollution in Africa. Concerning the interactive term ($\eta$), a negative sign suggests that the effectiveness of a sound institutional framework reduces environmental pollution through reduction in the presence of shadow economy. Contrast, a positive sign signifies that shadow economy is larger where institutional quality is weak, thus, increasing environmental pollution. However, an insignificant effect of the interactive term ($\eta$) implies that shadow economy and institutions do not interact in affecting environmental quality in the region (Chen *et al.*, 2018). The sign of $\pi$ depends on the type of control variables used in the model (see description of variables for details).

In order to obtain the marginal impact of shadow economy on environmental pollution in the presence of institutions in Africa, Eqn 3 is differentiated with respect to shadow economy.

$$\frac{\delta \mathrm{ENV}_{i,t}}{\delta \mathrm{SE}_{i,t}} = \alpha + \eta \mathrm{INS} \tag{4}$$

The marginal value is obtained by inserting the maximum value of institutional quality.

Three different techniques of estimation, namely traditional ordinary least square (OLS), fixed effect (FE) and two-step system GMM are used as estimation techniques. The FE model takes into account the unobserved heterogeneity characteristics of the sampled countries. The FE is selected because the Hausman probability is significant. However, the presence of lagged value of the dependent variable as part of the explanatory variables in Eqn 3 renders the traditional panel inappropriate, since there is high degree of correlation amongst lagged values of the dependent variable and the unobservable country-specific effect $[E(\mathrm{ENV}_{i,t-j}\,\mu_i) \neq 0]$; therefore, the estimate from the dynamic two-step system GMM is relied on. Further, two-step system GMM resolves the problem of endogeneity usually observed in environmental literature and provides better asymptotic efficient estimate (Olomola and Dada, 2017; Dada, 2020). Sargan test of over-identifying restrictions is used to test the validity of the instruments. In addition, descriptive statistics, correlation matrix and panel unit root test are conducted in order to identify the statistical and econometrics characteristics of the variables.

The scope of this study spans from 1991 to 2015. This period is chosen based on availability of data especially shadow economy data as provided by Medina and Schneider (2018). In total, 35 countries, namely Algeria, Angola, Botswana, Burkina Faso, Cameroon, Congo democratic, Congo Republic, Cote d'Ivoire, Egypt, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Liberia, Libya, Madagascar, Malawi, Mali, Morocco, Mozambique, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia and Zimbabwe are selected. However, the choice of the sample size and time frame of this study is dictated by the data availability.

### *4.2 Variables and sources*

*Environmental (ENV) pollution* is measured using three indicators so as to improve the robustness of this study. The three indicators are carbon dioxide ($CO_2$) per capita (measured in parts-per-million, ppm), methane emissions (kt of $CO_2$ equivalent) and nitrous oxide emissions (thousand metric tons of $CO_2$ equivalent). $CO_2$ emission is chosen as proxy for environmental pollution since it is the most commonly used proxy in the literature (Chen *et al.*, 2018; Huynh, 2020; Aluko and Obalade, 2020; Akinlo and Dada, 2021). Presently, $CO_2$ is the most "popular" source of pollution and greenhouse gas in developing countries which is one of the major concerns of environmentalists and policymakers (Dhrifi *et al.*, 2019). Furthermore, nitrous oxide and methane emissions contribute to greenhouse gases which result in global warming (NASA, 2019). Blackman *et al.* (2006), Egbetokun *et al.* (2019) and Azam *et al.* (2020) used nitrous oxide and methane emissions to measure environmental pollution in addition to $CO_2$. Data on carbon dioxide per capita, methane emissions (kt of $CO_2$ equivalent) and nitrous oxide emissions (thousand metric tons of $CO_2$ equivalent) are obtained from World Bank Development Indicators (2018) edition.

*Shadow economy (SE)* data is obtained from Medina and Schneider (2018), and it is measured using MIMIC. This approach is commonly used due to its flexibility and robustness of the result (Schneider, 2005; Schneider *et al.*, 2011; Chen *et al.*, 2018; Swain *et al.*, 2020).

*Institutional Quality (INS):* Five indicators are used to measure institutional quality, namely: corruption control, law and order, government stability, bureaucracy quality and democratic accountability. These indicators are average to generate an index of institutional quality following the works of Kose *et al.* (2011), Agbloyor *et al.* (2016), Ajide and Dada (2021) and Dada and Abanikanda (2021). Whenever the value of institutional quality is lower than its average value, it is regarded as weak institutional indicator, otherwise, strong institutional quality (Olaniyi and Oladeji, 2020; Dada and Abanikanda, 2021). Data on these indicators are sourced from International Country Risk Guide (2018, edition).

*Other control variables (X)* included in the model are:

Per capita income is used to capture economic growth/development (Agbloyor *et al.*, 2016; Chen *et al.*, 2018; Huynh, 2020). Economic growth is anticipated to have positive and significant effect on environmental pollution since rising income spurs economic activities such as production and consumption, which are detrimental to the environment. This has been named Environmental Kuznets Curve (EKC) in the literature (Muller-Furstenberger and Wagner, 2007; He, 2007; Hossain *et al.*, 2011; Hao and Wei, 2015).

Trade openness is calculated as the sum of export and import (% of GDP) (Du *et al.*, 2012; Chen *et al.*, 2018). Trade openness is expected to have negative (positive) effect on environmental pollution if clean (bad) technologies are employed; this will reduce (increase) pollution and waste emission (Lau *et al.*, 2014; Ahmed, 2014; Dhrifi *et al.*, 2019).

Population density is defined as the number of individuals per unit geographic area. The effect of population density on pollutant emission is ambiguous (Hao *et al.*, 2016; Chen *et al.*, 2018; Swain *et al.*, 2020). The increase in population density especially in industrialised cites will increase environmental pollution, while an increase in population density might force government to embark on stringent environmental regulations, which in turn reduce environmental pollution.

Education is proxy by proportion of exact secondary school enrolment to the expected total enrolment. Education is expected to reduce environmental pollution, since the populace is aware of environmental and health hazard of pollution (Balaguer and Cantavella, 2018; Chen *et al.*, 2018). Nevertheless, some studies have found increasing effect of education on environmental pollution (Gangadharan and Valenzuela, 2001; Hill and Magnani, 2002; Jemiluyi and Dada, 2018). Data on per capita income, trade openness, population density and education are sourced from World Development Indicator (WDI), 2018 edition.

## 5. Findings and discussion

*5.1 Characteristics of the data*

Sequel to empirical investigation of the effect and moderating role of shadow economy and institutional quality in environmental pollution in Africa, the statistical and econometrical properties of the data are inspected so as to disclose the nature and characteristics of the variables under consideration. From Table 1, average value of $CO_2$ emission per capita is 1.12 ppm, while the maximum $CO_2$ emission generated by individual in the region is 9.98 ppm which is relatively high compared with other developing countries. Similarly, on average, 19857.26 of methane emissions (kt of $CO_2$ equivalent) and 9748.61 of nitrous oxide emissions (thousand metric tons of $CO_2$ equivalent) are being generated annually in Africa. Furthermore, the descriptive statistics shows that the values of shadow economy in Africa range from 37.68% to 66.61% of GDP. This indicates that shadow economy in the region is greater than one-third of GDP for those at bottom of the ladder while it is greater than

| | $CO_2$ | MET | NIT | SE | INS | GDP | TOP | POP | EDU |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 1.12 | 19857.26 | 9748.61 | 38.49 | 3.62 | 1966.74 | 67.70 | 49.49 | 43.64 |
| Median | 0.32 | 10601.40 | 5003.93 | 37.68 | 3.65 | 1102.23 | 62.04 | 38.04 | 38.10 |
| Maximum | 9.98 | 189678.0 | 149775.0 | 66.61 | 5.58 | 11826.75 | 165.64 | 198.88 | 134.83 |
| Minimum | 0.01 | 596.19 | 28.72 | 20.35 | 0.60 | 164.94 | 21.44 | 1.79 | 0.69 |
| Std. dev | 1.92 | 22348.31 | 14931.62 | 8.613 | 0.68 | 2124.55 | 25.42 | 41.58 | 28.11 |
| Skewness | 3.01 | 2.42 | 3.95 | 0.59 | −0.36 | 1.89 | 1.01 | 1.13 | 0.72 |
| Kurtosis | 12.18 | 11.09 | 24.59 | 3.30 | 3.85 | 6.92 | 3.97 | 3.89 | 2.79 |
| Observations | 629 | 629 | 629 | 629 | 629 | 629 | 629 | 629 | 629 |

**Note(s)**: $CO_2$ is carbon dioxide emission per capita, MET is methane emission, NIT is nitrous oxide emission, SE is shadow economy, INS is institutional quality, GDP is gross domestic product per capita, TOP is trade openness, POP is population density and EDU is education

**Table 1.** Descriptive statistics

two-third of GDP for countries at the peak of the ladder such as Nigeria and Zimbabwe. This further lends credence that shadow economy is higher in developing countries. The mean value of institutional quality is 3.62, which is relatively below average when compared on a scale of 0 (weak institution) to 8 (strong institution). The low value of institutional quality reveals that institution is still very weak in Africa (Dada and Fanowopo, 2020). Average of $1,966.74 income is available for individual in the region annually. Additionally, the average value of trade openness is 67.7. Thus, the level of trade openness in the region is relatively high (Dada and Awoleye, 2018). The mean values of population density and secondary school enrolment are 49.49 and 43.64, respectively. This reveals that only 43.6% of those of secondary school bracket are actually in school. Further, the findings from descriptive analysis reveal that only institutional quality is negatively skewed, while other variables are positively skewed. Also, Kurtosis, which measures the peakness of the distribution, shows only secondary school enrolment (EDU) is platykurtic since its value is less than 3, while other variables are leptokurtic (value greater than 3).

Table 2 presents correlation among the variables under study. The results indicate that all the variables have moderate correlation on one another since their coefficients are less than 0.8 which is usually taken as the benchmark (Green, 2008). This reveals the absence of high or exact multicollinearity among the variables. Explicitly, the coefficients of correlation in Table 2 range from −0.41 to 0.79. From the correlation matrix, shadow economy and economic growth have positive and significant impact on various pollutant emissions. Institutional quality has a reducing effect on methane and nitrous emission in Africa, while it increases $CO_2$ emission.

In addition, the synopsis of the panel unit root test is presented in Table 3. Battery of panel unit root tests are carried out for adequacy and robustness checks following existing studies (Olomola and Dada, 2017; Dada, 2020). The result reveals that some variables are stationary at level (I(0)) while others are stationary at first difference I(1).

*5.2 Effect of shadow economy and institutional quality on environmental pollution*

Since the statistical and economic criteria of the variables have been explained in previous section, this section investigates the impact of shadow economy and institutional quality on environmental pollution in Africa. Table 4 presents array of techniques that are used. OLS is used in models 1–3, FE is used as estimation technique in models 4–6 while models 7–9 make use of two-step system GMM. Furthermore, three different proxies are used to measure environmental pollution (carbon dioxide emission, methane emissions and nitrous oxide). For brevity, only estimate from the two-step system GMM is explained based on the following reasons. Two-step system GMM produces better asymptotic coefficient estimates than OLS and FE estimators in the presence of autocorrelation. Further, GMM solves the problem of endogeneity usually found in the environment–shadow economy nexus. In addition, most of the variables used in this study are not stationary at level, thus GMM technique is more appropriate than other traditional approaches (OLS and FE) (Jemiluyi and Dada, 2018; Baklouti and Boujelbene, 2019; Dada, 2020). Similarly, the non-stationarity of the variables at levels makes previous values of the variables unfit as instruments to be used, hence, leading to biasness in large finite sample (Blundell and Bond, 1998). Consequently, first difference of the dependent variable which is stationary is used as instrument. Sargan test of over-identifying restrictions is used to test the reliability and validity of the instruments. The results of Sargan test for models 7–9 show that the instruments are valid. This reveals that the instruments are not related to the error term. Other diagnostic tests reveal the absence of first- and second-order serial correlation (AR(1) & AR(2)). The presence of lagged value of the dependent variable in each of the models is also justified since its value is significant in all the models. Specifically, previous values of environmental pollution from carbon dioxide,

**Table 2.** Correlation matrix

| | $CO_2$ | MET | NIT | SE | INS | GDP | TOP | POP | EDU |
|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ | 1.00 | | | | | | | | |
| MET | 0.08 (0.0364)** | 1.00 | | | | | | | |
| NIT | −0.18 (0.0000)*** | 0.82 (0.0000)*** | 1.00 | | | | | | |
| SE | 0.39 (0.0000)*** | 0.20 (0.0000)*** | 0.24 (0.0000)*** | 1.00 | | | | | |
| INS | 0.25 (0.0000)*** | −0.12 (0.0018)*** | −0.10 (0.0087)*** | −0.38 (0.0000)*** | 1.00 | | | | |
| GDP | 0.79 (0.0000)*** | −0.03 (0.4835) | −0.24 (0.0000)*** | −0.37 (0.0000)*** | 0.28 (0.0000)*** | 1.00 | | | |
| TOP | 0.053 (0.1835) | −0.33 (0.0000)*** | −0.26 (0.0000)*** | −0.16 (0.0000)*** | 0.02 (0.5475) | 0.36 (0.0000)*** | 1.00 | | |
| POP | −0.16 (0.0000)*** | 0.22 (0.0000)*** | 0.10 (0.0093)*** | 0.18 (0.0000)*** | −0.05 (0.1679) | −0.30 (0.0000)*** | −0.25 (0.0000)*** | 1.00 | |
| EDU | 0.58 (0.0000)*** | 0.05 (0.1721) | −0.09 (0.0154)** | −0.41 (0.0000)*** | 0.076 (0.0551)* | 0.65 (0.0000)*** | 0.45 (0.0000)*** | −0.09 (0.0147)** | 1.00 |

**Note(s)**: Where *, ** and *** indicates 10, 5 and 1% level of significance, respectively; ( ) is probability value

**Table 3.**
Unit root test

| Variables | LLC | IPS | ADF-Fisher | PP-Fisher | LLC | IPS | ADF–Fisher | PP–Fisher |
|---|---|---|---|---|---|---|---|---|
| | | Level | | | | First difference | | |
| $CO_2$ | 2.59 | 3.69 | 50.04 | 69.79 | −11.37*** | −12.58*** | 290.67*** | 732.00*** |
| MET | −0.50 | 1.62 | 75.84 | 119.43*** | −15.83*** | −18.14*** | 427.66*** | – |
| NIT | −2.32** | −0.41 | 93.35** | 100.59*** | – | −18.12*** | – | – |
| SE | 2.16 | 3.99 | 40.07 | 44.85 | −10.26*** | −15.60*** | 363.70*** | 834.44** |
| INS | −7.17*** | −6.17*** | 166.75*** | 126.57*** | – | – | – | – |
| GDP | 4.52 | 7.80 | 24.20 | 39.53 | −10.44*** | −11.12*** | 265.19*** | 414.58*** |
| TOP | −2.58*** | −2.44*** | 88.45** | 98.57*** | – | – | – | – |
| POP | 17.45 | 20.31 | 15.68 | 14.39 | −10.27*** | −12.04*** | 365.69*** | 224.17*** |
| EDU | −6.38*** | 5.20 | 42.01 | 46.30 | – | −4.67*** | 117.52*** | 273.50*** |

**Note(s)**: Where LLC is Levin, Lin & Chu test, IPS is Im, Pesaran and Shin W-stat, ADF–Fisher is Augmented Dickey–Fuller–Fisher Chi-square, and PP–Fisher is Philip–Perron– Fisher Chi-square; *, ** and *** indicate 10, 5 and 1% level of significance, respectively

Table 4.
Effect of shadow economy and institutional quality on environmental pollution in Africa

| Models | OLS | | | Fixed effect | | | System GMM | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 ($CO_2$) | 2 (MET) | 3 (NIT) | 4 ($CO_2$) | 5 (MET) | 6 (NIT) | 7 ($CO_2$) | 8 (MET) | 9 (NIT) |
| ENV(-1) | | | | 0.585*** (0.0000) | 0.228*** (0.0000) | 0.255*** (0.0000) | 0.498*** (0.0000) | 0.015*** (0.0000) | 0.001*** (0.0000) |
| SE | 0.098*** (0.0002) | 9.688* (0.0648) | 3.191 (0.3868) | 0.004 (0.4919) | 5.140 (0.9849) | 0.379 (0.9068) | 0.003*** (0.0000) | 0.733*** (0.0000) | 0.107 (0.3901) |
| INS | −0.886*** (0.0035) | 20.223 (0.7343) | −2.330 (0.9557) | −0.037 (0.5356) | −45.085 (0.1546) | −20.972 (0.3708) | 0.059*** (0.0000) | 11.846*** (0.0000) | 5.341*** (0.0000) |
| SE*INS | 0.024*** (0.0019) | −0.939 (0.5285) | 0.361 (0.7300) | 0.001 (0.4709) | 0.657 (0.3716) | 0.405 (0.4571) | 0.0002*** (0.0000) | −0.348***(0.0000) | 0.019 (0.3934) |
| GDP | 0.001*** (0.0000) | 0.004 (0.4014) | −0.020*** (0.0000) | 0.001*** (0.0000) | 0.044 (0.6508) | 0.008 (0.2394) | 0.0002*** (0.0000) | 0.014*** (0.0000) | 0.002*** (0.0000) |
| TOP | −0.024*** (0.0000) | −3.834*** (0.0000) | −1.629*** (0.0000) | 0.001 (0.3249) | 0.382 (0.1391) | 0.175 (0.3597) | −0.001*** (0.0000) | −0.013 (0.4850) | −0.082*** (0.0000) |
| POP | 0.001 (0.9616) | 0.600*** (0.0038) | −0.251* (0.0857) | −0.001 (0.9142) | 0.034 (0.3906) | 0.931*** (0.0019) | −0.003*** (0.0000) | 1.143*** (0.0000) | 1.684*** (0.0000) |
| EDU | 0.016*** (0.0000) | 2.664*** (0.0000) | 1.688*** (0.0000) | 0.002** (0.0102) | 0.030 (0.4827) | 0.349 (0.2751) | 0.005*** (0.0000) | 0.218*** (0.0000) | −0.265*** (0.0000) |
| *C* | 4.519*** (0.0000) | −13.941 (0.9482) | 21.792 (0.8853) | 0.181 (0.4605) | 16.208 (0.2038) | −11.05 (0.9068) | – | – | – |
| *R* | 0.724 | 0.244 | 0.161 | 0.996 | 0.921 | 0.903 | – | – | – |
| No of observation | 629 | 629 | 629 | 604 | 604 | 604 | 569 | 569 | 604 |
| No of instruments | – | – | – | – | – | – | 35 | 35 | 34 |
| Marginal effect | – | – | – | – | – | – | 0.004 | −1.208 | 0.21 |
| AR(1) | – | – | – | – | – | – | (0.9587) | (0.2952) | (0.3026) |
| AR(2) | – | – | – | – | – | – | (0.9915) | (0.2759) | (0.2538) |
| Sargan | – | – | – | – | – | – | 25.426 (0.5505) | 29.136 (0.3543) | 26.088 (0.4582) |
| No of countries | 35 | 35 | 35 | 35 | 35 | 35 | 34 | 34 | 34 |

**Note(s):** 1. ENV is environmental pollution (it is proxied by carbon dioxide emission, methane emission and nitrous emission), $CO_2$ is carbon dioxide, MET is methane emission, NIT is nitrous, SE is shadow economy, INS is institutional quality, SE*INS is the interactive term of shadow economy and institutional quality, GDP is gross domestic product per capita, TOP is trade openness, POP is population density and EDU is education; 2. *, ** and *** indicate 10, 5 and 1% level of significance, respectively; 3. ( ) is probability value; 4.marginal effect of shadow economy on environmental pollution in the presence of institutional quality is obtained through equation 4.; 5. the Sargan test is for the over-identifying restrictions. AR(1) is the Arellano–Bond test of first-order while AR(2) represent sthe Arellano–Bond test of first-order and second-order autocorrelation.; 6. differences in the number of observations are due to the unbalanced data set methane and nitrous oxide emissions show positive and significant effect on current environmental pollution. This signifies that the current environmental pollution is directly linked to its historical values. This corroborate the studies of Du *et al.* (2012), Chen *et al.* (2018), Sung *et al.* (2018) and Huynh (2020).

In all the models on Table 4, especially models 7–9, shadow economy has positive and significant effect on all the proxy of environmental pollution. This indicates that an increase in activities in the shadow economy worsens environmental quality in Africa. This is consistent with the findings of Chaudhuri and Mukhopadhyay (2006), Elgin and Oztunali (2014), Yu and Gao (2015), Swain *et al.* (2020) and Huynh (2020). In terms of magnitude, shadow economy has more impact on nitrous oxide emission than other pollutant emissions used. In recent times, nitrous oxide emission is one of the top pollutants responsible for greenhouse gases which resulted in global warming. Shadow economy has significant impact on environmental pollution in Africa due to the large number of firms and employees working in the informal sector which makes it difficult to regulate. As observed by Blackman and Bannister (1998), developing countries especially sub-Saharan African countries are characterised with low technology, unlicensed micro enterprises which are responsible for major pollutant emissions in the region. Further, institutional quality has positive and significant effect on all the pollutant emissions used in this study. This shows that weak institutional quality as recorded from the descriptive statistics worsens environmental quality by increasing environmental pollution. In addition, due to weak institutions, economic agents break the regulatory framework which leads to higher shadow economy activities and environmental pollution respectively. Since institutions set the rules for economic agents and instil discipline in order to limit opportunist behaviours among economic agents, weak institutions will make economic agents to function in the shadow economy in order to maximise profit, thus increasing environmental pollution.

Surprisingly, the interactive effect of shadow economy with institutional quality has mixed outcome on pollutant emission in Africa. Specifically, the interactive effect of institutional quality and shadow economy has positive effect on $CO_2$ emission and nitrous emission. This reveals that shadow economy is large in region with weak institutional framework, thereby increasing $CO_2$ emission and nitrous emission. Intuitively, weak institutional quality may lead to the relaxation of environmental regulation, which may trigger activities in the shadow economy and later deteriorated environmental quality. Further, the sharp practices and corruptions weaken environmental regulation in the region. In contrast, the interaction of institutional quality and shadow economy reduces methane emission in Africa. This suggests that the level of institutional quality is enough to reduce methane emission. Studies such as Panayotou (1997), Xie and Saltzman (2000), Halkos and Tzeremes (2013), Chen *et al.* (2018), Huynh and Ho (2020), Swain *et al.* (2020) found that strong institution reduces environmental pollution. On the other hand, studies such as Midlarsky (1998) and Halkos and Paizanos (2013) have found a direct relationship between strong institution and pollutant emission, that is, strong institutional quality increases environmental pollution. Besides, the marginal impact of shadow economy on environmental pollution in the presence of institutional quality is obtained through equation 4. The results of the marginal effect further buttress the result obtained from the interactive term of shadow economy and institution. At the maximum value of institutional quality (5.58), shadow economy increases carbon dioxide emission and nitrous emission by 0.004% and 0.21% respectively, while methane emission is abated by 1.21%.

Other control variables such as per capita income have positive and significant effect on all the pollutant emission used in this study. This suggests that a rise in the level of income available to individuals spurs production and consumption of goods and service, consequently producing a resultant increase in environmental pollution. More emissions are produced by industrial and agricultural activities as a result of increase in the demand for goods and services. This is in support of existing studies (Musolesi *et al.*, 2010; Huynh, 2020) that increase in per capita income increases environmental pollution. Furthermore, trade openness has a reducing effect on all proxy of environmental quality in Africa. This suggests that through knowledge spillover, domestic firms can have access to energy efficiency equipment and transfer of environmentally friendly technologies (Biswas *et al.*, 2012; Zhang and Zhou, 2016; Magombeyi and Odhiambo, 2018). In addition, through trade openness, domestic firms can source their production outside the region, thus reducing environmental pollution. This is in tandem with the works of Du *et al.* (2012) and Chen *et al.* (2018) but contradicts to studies of Baek *et al.* (2009) and Le *et al.* (2016) that the higher the degree of trade openness, the more the level of environmental degradation. Population density on the other hand has mixed effect on environmental pollution in Africa. Moreover, population density increases $CO_2$ emission, while it leads to a decrease in both methane and nitrous emission. This shows that the number of people living in a particular area affect $CO_2$ emission negatively. This is in line with the studies of Chen *et al.* (2018). Similarly, education proxy by secondary school enrolment increases both $CO_2$ and Methane emissions, but reduces nitrous emission in Africa. Intuitively, increase in education will lead to more labour working in both the formal and informal sectors, thereby increasing environmental pollution. This is in support with the study of Hill and Magnani (2002) whose findings reveal that higher educational level could trigger environmental pollution especially emerging countries where higher educational level could boost the prospect of underprivileged people to be employed in better-paid pollution-intensive industries. On the other side, the more the populace is educated, the more they are informed about the havoc of environmental pollution, thus reducing environmental pollution. This follows the study of Balaguer and Cantavella (2018), who conclude that increase in educational rate abates the level of $CO_2$ emissions in Australia.

## 6. Concluding remarks

This study examines the moderating effect of institutional quality in the relationship between shadow economy and environmental pollution. The study covers 35 countries in Africa between 1991 and 2015. For robustness check, environmental pollution is proxied by three indicators, namely: carbon dioxide ($CO_2$) emission, methane emission and nitrous oxide emission. The study uses a battery of estimation techniques (OLS, FE and two-step system GMM) to achieve the stated objectives.

The outcome of this study provides new insights into the nexus among institutions, shadow economy and environmental pollution in developing countries especially Africa. First, outcome of this study reveals that shadow economy has positive impact on all the proxy of environmental pollution in the region. This implies that increase in shadow economy worsens environmental quality in Africa. Therefore, policymakers in the region need to reduce the level of shadow economy, since the continent has one of the highest values of shadow economy. Furthermore, policies (such as tax subsidy, reduction in heavy bureaucracy involved in business start-up) that will bring firms operating in the underground economy into the formal sector should be implemented. Nevertheless, stringent environmental regulation must be put in place in order to protect the environment. Second, institutional quality in Africa increases environmental pollution. This reveals that the level of institutions is very weak. Therefore, policymakers need to improve and strengthen the level of institutions in the region so as to set the standard, and also punish offenders, in order to serve as deterrent to others. With these, economic agents (firms, households and government) will observe all environmental rules that are set up. Third, the interactive effect of institutional quality and shadow economy on environmental pollution provides interesting results. The interactive term of institutional quality and shadow economy has an increasing effect on $CO_2$ and nitrous emission but a decreasing effect on methane emission. This implies that the impact of shadow economy through weak institutional quality is more felt on $CO_2$ and nitrous emissions which are major sources of greenhouse gasses. Policymakers need to establish or strengthen existing regulatory bodies in order to curb harmful effect of shadow economy on environmental pollution. Regulatory institutions need to be harmonised with those of the neighbouring countries in the region so as to reduce shadow economy and environmental pollution. Fourth, this study reveals the importance of including trade openness as part of control variables. Since trade openness reduces environmental pollution in the region, policymakers need to adopt a more open-door policy that will allow the importation of environmentally friendly technology.

It is worthy of note that this study has contributed to literature by examining the effect of shadow economy on environmental pollution in Africa in the presence of institutional quality. Further, no known study from Africa has examined the moderating role of institution in such relationship, thereby making the study unique. However, this study is limited based on the availability of data on shadow economy. Further study can extend this data set to more recent year and consider other developing countries in a country-specific study.

## Note

1. Shadow economy is known as illegal economy, black economy, undeclared economy, parallel economy, underground economy, unrecorded economy, unreported economy, informal economy, clandestine economy, second economy, irregular economy or household economy. The shadow economy comprises of both the illegal activities and unreported or undeclared income from the production of legal goods and services.

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