The influence of corruption on environmental sustainability in the developing economies of Southern Africa

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ABSTRACT

This paper analyses the impact of corruption on environmental sustainability in all 16 countries in the Southern region of Africa from 2010-2017. The paper uses two proxies of corruption: the Corruption Index and Corruption Ranking. Using two econometric methods, namely, the Dumitrescu and Hurlin (2012) Granger causality test and the Generalised Method of Moments (GMM) techniques this study found largely congruent results on both causation and relationships, respectively. Firstly, the two indicators of corruption harmoniously show that corruption Granger causes the existing state of environmental sustainability in Southern African economies, and vice versa. Moreover, in the short-run corruption was also found to worsen environmental sustainability for both regression models deployed using the two corruption indicators. In the long-term, the two measures of corruption conflicted with their findings. In this regard, though the relationship is contradicting in the long-run the corruption negative (becoming bad) effect of corruption ranking surpasses the corruption positive (becoming clean) effect of corruption index by nearly three times. This show how detrimental corruptible actions are to the natural environment. Overall, this paper consent to global reports explaining how Southern African environments are gradually deteriorating by putting corruption as one central practice causing extensive damage.

1. Introduction

Corruption is globally perceived as actions in which persons entrusted with power abuse it for personal benefit. Thus, Transparency International (2020) highlights that it can be categorized as grand, petty as well as political depending on the measure of money which have been lost along with the sector at hand. Machel and Coombes (2011) express that in a survey conducted in six countries from Southern Africa (Zimbabwe, South Africa, Malawi, Democratic Republic of Congo (DRC) and Mozambique) 62% of the respondents confirmed that corruption is getting worse and 56% of these respondents adds that they had to pay a bribe when they come in contact with government service agencies. Hence, Gavin (2010) adds that Southern Africa’s government leading political parties are contorted in tangles as they effortlessly try to keep their privileged offices in various sectors of the economy while also seek to address corruption which inevitably has lessened their integrity along with popularity. In that case, Choruma (2018) also contributes that despite all the Southern African states being signatories of African Union (AU) Convention on Preventing and Combating Corruption (AUCPCC) of 2013 and the Southern Africa Development Community (SADC) Protocol against Corruption (SADCP) of 2001 this challenge has increased to appalling levels and evolved to put large threat to stability, sustainable development along with socio-economic change in the region. In this vein, natural environmental issues also need immediate attention (Ganda, 2018, 2019).

In this regard, there is greater empirical literature that has established the reciprocal influence of corruption and the natural environment (Akhbari and Nejati, 2019; Sinha et al., 2019; Wang et al., 2020; Candau and Dieng, 2017). As such, evidence supports that corruption is one of the determining variables which impacts the procedure of natural environment preservation and lessening this cause has much influence on the rate of green economic development along with sustainability. It is plain that despite countries in Southern Africa having growth prospects, these economies have not been able to maximize their fullest their policies and practices owing to corruption problems (Gavin, 2010; Choruma, 2018). Thus, when corruption affects the sectors (social, economic and political)
of the country environmental sustainability initiatives will be inadequate in improving the state of the natural environment. In this vein, improving environmental sustainability has evolved into a prime focus of most empirical studies as some schools of thought argue that worsening of the natural environment is a result of inadequate resources-physical, intellectual, human and financial due to unnecessary wastage, ineffective use and poor allocation (Biswas et al., 2012; Sahli and Rejeb, 2015). Moreover, corruption has harmful impacts on environmental sustainability through minimizing the stringency of green strategies and policies as well as access to public commodities (goods and services).

The motivation behind this study is that the effect of corruption on the natural environment has led to increasing problems in the context of promoting sustainable development. The OECD (1997) express that corruption has demonstrated high impacts in less industrialised countries than high industrialised nations even though it is a common issue in both economies. World Bank (2010) also hints that African nations are predominantly constituted by weak institutional systems along with poor governance structures. In greater detail, the World Bank (2010:5) spotlights that “Corruption is embedded in the political economy of Africa. A number of studies describe the interaction between various forms of corruption and how it is intrinsically linked to the way power is exercised. In particular, when a social unit is highly diverse ethnically—as is the case in many post-independence African countries—there is likely to be suspicion and division among members, making the process of agreeing to rules for governance extremely difficult.” In this vein, the high prevalence of corruption in Africa coincides with weak performance in environmental sustainability platforms.

Thus when corruption becomes rampant in government and its agency structures and systems the natural environment is predisposed to continue being damaged owing to among others weak legislation and heightened complexity of the natural environmental matters. Thus there is no doubt that corruption is capable of disrupting government commitment, control and accountability for the natural environment (Lehman and Morton, 2017). In this vein, literature demonstrates that corruption decreases stringency of environmental regulations (in case of bias in the adoption, implementation and application stages), is the major motivator in misuse of land, ecological resources and encourages deforestation and desertification (Nyberg and Wright, 2013; Sahli and Rejeb, 2015). For instance, when a particular country experience increased levels of corruption some stakeholders can survive the impact of environmental regulations since they offer bribes to government environmental agencies. Moreover, it also makes it difficult for small and medium companies to get access to relevant environmental services and diverse green investment prospects (Lehman and Morton, 2017; World Bank, 2010). In that case, many challenges about resource depletion and natural environmental stress are born out of weak institutions and corruption fuels such situations thereby creating more problems to ecological systems and the dependent communities (Chang and Hao, 2017). The environmental costs of corruption are so hard to quantify primarily since corruption itself (owing to its characteristics and attributes) is often difficult to measure. Regrettably, for most growing economies that have large reserves of natural resources corruption is widely known as the major cause of natural environmental destruction (World Bank, 2010).

The goals of this research are hence to prove an in-depth and extensive investigation of the causation and linkages involving corruption and environmental sustainability in all the developing economies found in the Southern region of Africa. In so doing, this paper will find along with qualitative assessment index by using two distinct proxies of corruption, namely the corruption index as well as the corruption ranking. It is widely agreed that corruption in many instances link to particular cases and hence difficult to quantitatively estimate its extent in any societal system. However, the form of proxies of corruption deployed by this article are globally known, computed and used by global bodies such as Transparency International to look at the status of corruption. Moreover, other aims of this article is to; offer a detailed theoretical perspective of how corruption influence environmental sustainability, and give a synopsis of the study results and then elaborate on the implications such findings has for environmental policy of the studied countries in efforts towards improving environmental sustainability.

The contributions of this research are manifold. First, there are limited studies with evidence that have evaluated the effects of corruption on environmental sustainability in developing countries of Africa yet these economies are known as the most corrupt states in global rankings and statuses. Secondly, to the best of my knowledge, this paper is the first one to employ two different proxies of corruption to get their effects on environmental sustainability. In doing so, the paper will examine the congruence and contradictory nature of the findings to effectively acquire an accurate and strong view of the linkages, and causation. Third, despite this interest about corruption, it is still not clear if it causes and/ or relates to environmental sustainability and vice-versa since empirical studies still generate mixed findings. As such, this paper deploys two measures of corruption to the same group of countries to find out the scenarios. Fourth, this article is unique as it uses two advanced econometric procedures to first understand causation and secondly comprehend associations involving corruption and environmental sustainability. To show causation this paper adopts the Dumitrescu and Hurlin (2012) Granger causality tests which is one of the most recent techniques. Thus, this approach is suitable for heterogeneous panelized data frameworks which consider individual unit fixed effects. The paper will employ this method based on a bootstrap procedure since that process solves cross-sectional dependence challenges. To set-up relationships this article employs a two-step GMM approach and generally, the GMM technique considers country-specific effect along with simultaneity biases. In the two-step procedure, GMM acquires parameter estimates subject to the initial weight matrix, generates a new weight matrix dependent on those results and then re-calculate the parameters built on that weight matrix. The benefits of the two-step technique is that the number of equations, as well as parameters in the non-linear GMM step, do not increase with the number of perfectly estimated regressor factors hence it is very effective in improving consistency, efficiency and the power of related tests than one-step GMM and the difference GMM. The two-step GMM outputs are based on both short-run and long-run contexts.

This research is organised as follows. Section 2 provides a literature review of the linkages involving corruption and environmental sustainability. Section 3 describes the study method and data of this paper. Section 4 discloses and analyze the findings. Section 5 discusses the implications of the study. Section 6 concludes.

2. Literature review

A plethora of literature on corruption and environmental sustainability has received greater attention in recent years in different global contexts. Table 1 below presents some of the recent empirical literature on this subject.

The past literature in Table 2 employed diverse measures of institutional quality to check its effect on the natural environment. In this article, I adopt two of the major proxies of corruption to assess how they simultaneously influence environmental sustainability under similar conditions (such as, similar countries, period, econometric techniques, and the same control variables). Against the background of developing countries in the Southern African region’s political and economic frameworks the regions, natural environment landscape is consistently deteriorating and this paper is important to prove how corruption is impacting on environmental sustainability in this region.

3. Methodology

This section presents and discusses sections on the data, panel causality tests, cross-section dependence test and the Generalised Method of Moments (GMM) approach.
### Table 1. Showing empirical studies and their results.

| Author(s) | Country(s) | Period | Variables | Methodology | Result |
|-----------|------------|--------|-----------|-------------|--------|
| Akhbari and Nejati (2019) | 61 Countries | 2003–2016 | Carbon Emissions ($CO_2$); Gross Domestic Product (GDP); Primary Energy Consumption ($E$); Trade ($T$); Corruption Index (CORI); Human Development Index (HDI) and Urban Population Growth (UPG) | Panel threshold model. | In developing economies corruption increases emissions while in developed countries corruption no longer influences carbon emission levels. |
| Wang et al. (2018) | Brazil, Russia, India, China and South Africa (BRICS) | 1996–2015 | $CO_2$; GDP; $T$; CORI; Population Growth (PG); Urbanisation (U). | Partial Least Square Regression Model. | The moderating role that corruption play is critical on the association involving GDP and $CO_2$, U and $CO_2$, plus $T$ and $CO_2$. Corruption management lessens emissions. |
| Zhang, Jin, Chevalli, and Shen (2016) | 19 Asia-Pacific Economic Cooperation (APEC) economies | 1992–2012 | $CO_2$; GDP; $T$; CORI; Population (P); Urban Population (UP); PG; Inflation Rate ($I$); Democratic Accountability (DA); E. | Panel quantile regression Approach | The negative impact of corruption in APEC lower emission countries was noticeable but that influence was not significant in higher emission economies. Inverted U-shaped Environmental Kuznets Curve (EKC) between corruption and $CO_2$ is valid. Corruption possesses both a negative direct impact on $CO_2$ and positive indirect impact by its impact on GDP. |
| Sinha, Gupta, Shahba, and Sengupta (2019) | BRICS; and the Next 11 countries. | 1990–2017 | $CO_2$; GDP; $E$; $T$; U: CORI and P. | Generalized Method of Moments (GMM) | Corruption promotes environmental damage through lessening the positive effect of green energy use on environmental quality along with heightening the negative influence of non-renewables deployment. |
| Arminen and Menegaki (2019) | 67 high-income and upper-middle-income countries. | 1985–2011 | $CO_2$; GDP; $E$; $T$; Industrialisation (IDN); CORI, Physical Capital Stock (PCS); Human Capital (HC) and Temperature (TC). | Simultaneous equations framework | Climate and weather variables are more critical factors influencing $E$ and $CO_2$ when compared to corruption. Moreover, transformations in institutional quality (proxy is corruption) generate less effect on energy and environmental policy. |
| Wang et al. (2020) | China | 2006–2015 | Ecological efficiency level (EFL); Resource misallocation (RM); Corruption cases (CC); Government regulation (GR); Logistics level (LL) and Industrial structure (IS). | GMM | Corruption, as well as misallocation of resources, possess detrimental effects on ecological efficiency. Corruption also intensifies resource misallocation thereby further lessening ecological efficiency. |
| Dincer and Fredriksson (2018) | 48 United States of America (USA) states | 1977–1994 | Stringency of Law, Corruption Index; Trust; Income; Energy Prices; Land prices; Percentage of legal services and Education | GMM | Increased corruption minimizes the strictness of natural environmental policies in cases of low trust degree but that impact reduces and also develop to be positive in high levels of trust. |
| DiRienzo and Das (2019) | 180 countries | 2018 | Country Environmental Quality & Performance; Corruption; Women in influential political positions | Multi-step Regression Frameworks | Women in influential political positions have a positive influence |
| Author(s) | Country(s) | Period | Variables | Methodology | Result(s) |
|-----------|------------|--------|-----------|-------------|-----------|
| Chen et al. (2018) | 30 Chinese provinces | 1998–2012 | Environmental pollution; Environmental regulation; Shadow Economy; Government corruption; GDP; T; Education level; Value added by Industry (VI); Population density; Research and Development (R&D) strength. | GMM | Increases in the number of corrupt officials results in a less effective and/or weakened environmental legislation that eventually generates high illegal production along with total pollutant emissions. |
| Cole (2007) | 94 countries | 1987–2000 | Sulphur Dioxide; Carbon emissions; GDP(Income); Pollution; Corruption | Regression analysis involving the use of instrumental variables and sensitivity analysis. | Corruption has a direct positive impact on both Sulphur Dioxide and Carbon emissions although indirect impacts were determined to be negative and large. As such, the aggregate impact of corruption on environmental quality is negative for the majority of countries except the high-income countries where it tends to be positive. |
| Meehan and Tacconi (2017) | Indonesia | January 2011–November 2011 | Land-use planning; Awarding concession and permits to utilize forests; Monitoring and enforcement of regulations | Field Research | The effects of a diverse range of corruption on forest management can be direct, indirect, complicated and also negligible. Hence, anti-corruption initiatives should focus more on particular forms of corruption which are possibly adding to deforestation along with forest degradation. |
| Sahli and Rejeb (2015) | 21 MENA countries | 1996–2013 | GDP; Exports(X); Imports(M); T; VI; and population density; Carbon emissions; Corruption level. | Panel Dynamic Regression models | A direct positive effect of corruption on both emissions and GDP is present. The Environmental Kuznets Curve (EKC) is also a valid present. |
| Wu et al. (2017) | China | 2007–2014 | Total factor productivity (TFP); Government Expenditures; Corruption level; Industrial structure; Foreign Direct Investment; Financial Development | Dynamic spatial autoregressive model and the Panel threshold model | Heightened corruption incidences have a direct reducing impact on regional total factor productivity. The influence of government expenditures (administrative service, investment development and safeguard governance) on total factor productivity possess only one corruption threshold. |
| Candau and DieneSh (2017) | International European-controlled enterprises | 2007–2010 | Bilateral trade; Corruption Index; Inflation; Environmental Regulation; GDP; | Fixed Effects Regressions | Corruption reduces environmental standards |
| Biswas et al. (2012) | 100 countries | 1999–2005 | Sulfur Emissions; GDP; Corruption index; T; Energy Efficiency; U; P; Shadow Economy | Fixed Effects Regressions | A shadow economy and level of emissions are largely influenced by the level of corruption. |
| Krishnan et al. (2013) | 105 countries | 2004–2008 | E-government maturity; Corruption; GDP; Carbon emissions; UP; Exports; Political Stability; Regional Difference | Structural equation modelling (SEM) analysis | E-government maturity does not add to GDP and environmental damage although its significance is visible indirectly through its effects on corruption. |

(continued on next page)
3.1. Data

Data employed in this study is extracted from Transparency International and the World Bank over the period 2010 to 2017. The sample of countries which are the focus of the study are all the 16 Southern African countries. These are, namely, Angola, Botswana, Comoros, Democratic Republic of Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zambia and Zimbabwe. The full description of the variables utilised in this study is presented in Table 2.

3.2. Panel causality test

This paper makes use of the panel causality test introduced by Dumitrescu and Hurlin (2012). Panel causality tests will aid the paper to understand causality. This form of tests is an unambiguous framework of Granger (1969) non-causality test version for heterogeneous panelised data structures with fixed coefficients. Also, it considers two heterogeneity classifications (heterogeneity of the regression equation employed to investigate Granger causality along with the heterogeneity of the causality associations).

Thus, initially I take into account the following framework (Equation 1):

\[ y_{it} = a_i + \sum_{k=1}^{K} \beta_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_k^{(k)} x_{i,t-k} + \epsilon_{it} \quad i = 1, 2, \ldots, N; t = 1, 2, \ldots, T \]

In this case, \( x \) and \( y \) represents two stationary variables identified for \( N \) individuals in \( T \) periods. \( \beta = (\beta_1^{(1)}, \ldots, \beta_1^{(K)}) \) along with individual effects \( a_i \) are understood to be fixed in the time dimension specification. Further, the lag orders of \( K \) are assumed to be homogenous for the complete cross-section of the panelised data under the survey. Besides, autoregressive parameters \( \beta_k^{(k)} \), as well as \( \beta^{(k)} \) that are the regression coefficients, are permitted to be different across groups.

This test approach puts forward that the null hypothesis is assumed to have no causality association for any units available (\( x \) and \( y \)) in the panel data. Therefore if \( H_0 \) is rejected the study will state that causality from \( x \) and \( y \) exists. It also follows that \( x \) and \( y \) can be interchanged to investigate causality in the other direction (bidirectional causality) also referred to as feedback impacts.

This assumption that is often identified as the Homogenous Non-Causality (HNC) hypothesis and is explained as below:

\[ H_0 : \beta_i = 0, \forall i = 1, \ldots, N \]

The alternative hypothesis is recognized as the Heterogeneous Non-Causality (HENC) hypothesis. Therefore, under the HENC two subcategories of cross-section units are permitted.

On one hand, there is a causality association from \( x \) to \( y \) for the initial model, although it is not sufficiently founded upon the same regression framework. On the other hand, the second subcategory highlights that there is no causality association from \( x \) to \( y \). We are taking into account a heterogeneous panelised data framework constituting fixed coefficients (in time) as regards to this group. The alternative hypothesis is hence presented as:

\[ H_1 : \beta_i = 0, \forall i = 1, \ldots, N_1 \]
\[ \beta_i \neq 0, \forall i = N_1 + 1, \ldots, N \]

It is assumed that \( \beta_i \) can differ across groups plus there are \( N_1 \) (\( N \) individual procedures that have no causality from \( x \) to \( y \)). It is also that \( N_1 \) is not known but it permits the condition \( 0 \leq N_1 / N < 1 \).

As such, the average statistic \( W_{HNC}^{(K, T)} \) which is associated with the null HNC hypothesis is proposed as below:

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Table 2 (continued)
Table 2. Showing detailed description of variables.

| Variable | Definition | Unit | Source |
|----------|------------|------|--------|
| CORI     | Corruption Index | Points out of 100 yearly. Thus, 100 (very clean) to 0 (highly corrupt) (Transparency International, 2020) | Transparency International. |
| CORRA    | Corruption Rank | Position relative to other global countries that are included in the index (Transparency International, 2020) | Transparency International. |
| GDP      | Economic Growth | Gross Domestic Product (GDP) per capita | World Bank |
| EDB      | Ease of Doing Business | Index. Higher ranking (low numerical estimate) shows a better environment for doing business, and vice-versa (World Bank Group, 2020) | World Bank |
| EDU      | Adjusted savings: education expenditure. NB. This variable is a proxy of the state of education. | Percentage of GNI (Gross National Income) | World Bank |
| ENS      | Adjusted net savings, excluding particulate emission damage. NB. This variable is a proxy of environmental sustainability | Percentage of GNI (Gross National Income) | World Bank |

Note: [1] The Adjusted net savings, excluding particulate emission damage, indicates the dependent variable. The remaining variables are all explanatory variables. [2] The data was analysed in logarithm form to ensure compactness since most of the variables in this study are non-linear.

\[ W_{t}^{\text{HNC}} = \frac{1}{N} \sum_{i=1}^{N} W_{i,t} \]  \[ (2) \]

It follows that \( W_{i,t} \) illustrates the individual Wald statistics as regards to the \( i^{th} \) cross-section unit to match the individual test hypothesis \( H_{0} : \beta_{i} = 0 \).

Let \( Z_{i} = [e_{i} Y_{i} X_{i}] \) be the \( (T, 2K + 1) \) matrix, in which \( e \) shows a \( (T, 1) \) unit vector and \( Y_{i} = [x_{1}^{(1)}, x_{2}^{(2)}, \ldots, x_{K}^{(K)}] \), \( X_{i} = [x_{1}^{(1)}, x_{2}^{(2)}, \ldots, x_{K}^{(K)}] \). \( \theta_{i} = (\alpha_{i}', \beta_{i}') \) represents vector of parameters of the framework. Moreover, I let \( R = [0:1_{K}] \) be a \( (K, 2K + 1) \) matrix.

For every \( i = 1, \ldots, N \), the Wald statistic estimate \( W_{i,t} \) to match to the individual tests \( H_{0} : \beta_{i} = 0 \) is elaborated as follows:

\[ W_{i,t} = \theta_{i}^{T} R [\beta(Z_{i})^{-1} R]^{-1} \theta_{i} \]  \[ (3) \]

Concerning the null hypothesis of non-causality, every Wald statistic value links up to a chi-squared distribution that has \( K \) degrees of freedom for \( T \to \infty \).

\( W_{t} \to \chi^{2}(K), \forall i = 1, \ldots, N \)

The standardized test statistic \( Z_{t}^{\text{HNC}} \) for \( T, N \to \infty \) is presented as:

\[ Z_{t}^{\text{HNC}} = \frac{N}{2K} \left( W_{t}^{\text{HNC}} - K \right) \to N(0, 1) \]  \[ (4) \]

As well, the standardised test estimate \( Z_{t}^{\text{HNC}} \) for fixed T samples is outlined as:

\[ Z_{t}^{\text{HNC}} = \frac{N}{2K} \left( \frac{T - 2K - 3}{T - K - 1} \right)^{1/2} \left( W_{t}^{\text{HNC}} - K \right) \to N(0, 1) \]  \[ (5) \]

Thus, in equation (4) and equation (5), \( W_{t}^{\text{HNC}} = (1/N) \sum_{i=1}^{N} W_{i,t} \). To summarise, the statistic values explained above the Granger causality process output reports the values obtained for \( W(W-bar), Z(Z-bar), \) and \( Z(Z-bar tilde) \). Dumitrescu and Hurlin (2012) express that if \( N \) is large but \( T \) is small then \( Z \) should be favoured. Therefore, in this paper, I test for Granger causality in the panel set by employing Dumitrescu and Hurlin (2012) xtgrcausf command in the Stata package using specifically the bootstrap procedure as it is also able to solve problems associated with cross-sectional dependence (Lopez and Weber, 2017). Still, on the subject of cross-sectional dependence, this paper conducts a second-generation panel unit-root test most possibly the one suggested by Pesaran (2007).

3.3. Cross-section dependence test

As regards to panel data analysis process, before ascertaining stationarity of the series, there is a need to test the framework to determine if cross-sectional dependence is there or not. Therefore, the hypotheses set-up to analyze cross-sectional dependence are presented as below:

\( H_{0} : \) Cross-sectional dependence.
\( H_{1} : \) No cross-sectional dependence.

If \( H_{0} \) is rejected, a first-generation unit root test will be employed but if \( H_{0} \) is accepted a second-generation unit root test process will be deployed. In addition, cross-sectional dependence in the framework is also supported with an understanding of \( N > T \) along with \( T > N \). It is known that Pesaran (2004) Cross Sectionally Dependency Lagrange Multiplier (CDLM) test is normally applied in cases where \( N > T \) but the Breusch and Pagan (1980) CDLM 1 test as well as the Pesaran (2004) CDLM 2 test is usually employed when \( T > N \) condition. In this article, I test cross-sectional dependence under conditions \( N > T \) for the Southern African countries \((N = 15)\) over the period 2010–2017 \((T = 8 \text{ years})\).

As such, Pesaran (2004) had employed the CDLM test for studies with panels that have \( N \to \infty \) as well as \( T \to \infty \). Thus Pesaran test statistic is ascertained as follows:

Table 3. Statistical summary of variables.

| Variable | Min. | Std. Dev. | Max. | Mean | Skewness | Kurtosis |
|----------|------|-----------|------|------|----------|----------|
| ENS      | -40.98137 | 13.53447 | 32.13046 | 1.822031 | -0.2728881 | 2.996398 |
| CORI     | 15   | 12.73515  | 65   | 36.34028 | 0.4396753 | 2.12016  |
| CORRA    | 28   | 43.13015  | 168  | 97.61806 | 0.103078  | 1.680714 |
| GDP      | 322.4 | 3633.37   | 14014.9 | 3620.018 | 1.032786  | 3.046089 |
| EDB      | 17   | 45.38501  | 187  | 119.0694 | -0.4977871 | 2.334354 |
| EDU      | 2.75 \times 10^7 | 2.75 \times 10^9 | 2.41 \times 10^{10} | 1.92 \times 10^9 | 3.541297 | 14.32835 |
Table 4. Panel Unit test results.

| Variable | At Level | At 1st Difference |
|----------|----------|-------------------|
|          | Fisher ADF statistic | Harris-Tzavalis Statistic | Im-Pesaran-Shin Statistic |
|          | Fisher ADF statistic | Harris-Tzavalis Statistic | Im-Pesaran-Shin Statistic |
| ENS      | 5.9469 (0.0000)*** | -4.1391 (0.0000)*** | -1.5573 (0.0597)* |
| CORI     | 2.5080 (0.0061)*** | -1.7387 (0.0410)** | -1.1446 (0.1262) |
| CORRA    | -0.9693 (0.8338)   | -2.1784 (0.0147)** | -0.3420 (0.3662) |
| GDP      | 6.6090 (0.0000)*** | 2.4188 (0.9922)   | -0.2336 (0.4076) |
| EDB      | -0.9574 (0.8308)   | -0.0569 (0.4773)  | -0.2481 (0.4020) |
| EDU      | 0.9148 (0.1801)    | -4.3525 (0.0000)*** | -0.7449 (0.2282) |

Notes: ***: ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively.

Table 5. Showing CD tests results.

| Variable | CD test | p-value |
|----------|---------|---------|
| ENS      | -0.35   | 0.032** |
| CORI     | 21.79   | 0.000***|
| CORRA    | 5.65    | 0.000***|
| GDP      | 2.85    | 0.004***|
| EDB      | 1.47    | 0.018** |
| EDU      | 10.22   | 0.000***|

Notes: ***: ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively.

Table 6. Showing correlation matrix and multicollinearity.

| Correlation Matrix | Multicollinearity |
|--------------------|-------------------|
| Variable           | ENS  | CORI  | CORRA  | GDP  | EDB  | EDU  | $R^2$ | Tolerance | VIF |
| ENS                | 1    | 0.5653| -0.5944| 0.1958| -0.4455| -0.0349| 0.4828| 0.5172    | 1.93 |
| CORI               | 0.5653| 1    | -0.9636| 0.7724| -0.8314| 0.1054| 0.9471| 0.0529    | 18.89 |
| CORRA              | -0.5944| -0.9636| 1    | -0.7199| 0.8520| -0.1433| 0.9419| 0.0581    | 17.23 |
| GDP                | 0.1958| 0.7724| -0.7199| 1    | -0.6917| 0.2681| 0.7097| 0.2903    | 3.44 |
| EDB                | -0.4455| -0.8314| 0.8520| -0.6917| 1    | 0.2010| 0.7758| 0.2242    | 4.46 |
| EDU                | -0.0349| 0.1054| -0.1433| 0.2681| 0.2010| 1    | 0.2571| 0.7429    | 1.35 |

Figure 1. Showing the relationship between the Corruption Index (CORI) and environmental sustainability.
CDLM test = \sqrt{\frac{1}{N(N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T \rho_{ij}^2 - 1 \right)} \tag{6}

Where \( \rho_{ij}^2 \) is the sample value of the pair-wise correlation of the residuals. As mentioned earlier, Pesaran (2004) has utilized the CD test for the investigation of cross-sectional dependence when \( N \) is larger than \( T \). This type of test rest on the aggregate value of correlation coefficients involving cross-sectional residuals. Therefore, the test statistic is prepared as follows:

\[
CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij}^2 \tag{7}
\]

3.4. Generalised Method of Moments (GMM)

The paper will initially test the presence of the Random Effect or Fixed Effect in the framework before implementing the dynamic GMM procedure (ideal for this paper to show the direction of relationships on both short-run and long-run). In this regard, the Hausman tests will also be applied and inevitably rejects the null hypothesis which states that the Random Effect (RE) model is most suitable in favour of the alternative-Fixed Effect (FE), vice-versa. The GMM approach is an advanced econometric tool that is largely known for generating relatively efficient estimators. In this context, the rigour plus efficiency of any finite sample is scrutinized using Arellano–Bond and the Blundell–Bond GMM estimation techniques that take into account the presence of heteroskedasticity owing to the dynamic character of data involved as well as
endogeneity (Arellano and Bover, 1995; Blundell and Bond, 1998). For this paper, the GMM package is utilized to manage the dynamics, heteroskedasticity, and endogeneity found in the regression frameworks. Thus the regression models of this paper are presented as follows:

\[ ENS_t = \alpha_1 + \alpha_2 ENS_{t-1} + \alpha_3 CORRI_t + \alpha_4 GDP_t + \alpha_5 EDB_t + \alpha_6 EDU_t + \varepsilon_t \]  

where, \( i \) represents the country (\( i = 1, \ldots, N \)) while \( t \) shows the time period (\( t = 1, \ldots, T \)). ENS illustrates a measure/indicator of environmental sustainability. \( ENS_{t-1} \) is the lagged dependent factor of environmental sustainability. \( EDU \) demonstrates the proxy for the state of education level contexts. \( CORRI \) represents the corruption index. GDP shows the relationship between ease of doing business and environmental sustainability.

\[ ENS_t = \alpha_1 + \alpha_2 ENS_{t-1} + \alpha_3 CORRA_t + \alpha_4 GDP_t + \alpha_5 EDB_t + \alpha_6 EDU_t + \varepsilon_t \]  

where, \( i \) represents the country (\( i = 1, \ldots, N \)) while \( t \) shows the time period (\( t = 1, \ldots, T \)). ENS illustrates a measure/indicator of environmental sustainability. \( ENS_{t-1} \) is the lagged dependent factor of environmental sustainability. \( EDU \) demonstrates the proxy for the state of education level contexts. \( CORRI \) represents the corruption index. GDP shows the relationship between education and environmental sustainability.
economic growth of the country. CORRA is the corruption rank of the country. EDB is a variable which outlines the ease of doing business.

Therefore, when applying GMM; transformations in one explicatory factor influence dependent variables although it regulates over some time to that effect as it approaches its long-term equilibrium. Thus, the GMM handles the entire system of equations as regards to panel data plus extension to panel study and not just a single equation. As such, the dynamics of the data set are effectively monitored by this method through enveloping the cross-sectional variances along with including differenced lagged estimates as instruments making the estimators unwavering and steady.

This paper will make use of the system GMM estimator rather than the difference GMM (Arellano and Bover, 1995; Blundell and Bond, 1998). Arellano and Bover (1995) along with Blundell and Bond (1998) highlights that the difference GMM act mediocre and results to big sample wavering and steady.

4. Results and discussion

This section presents and outlines the findings of the paper. Table 3 illustrates the statistical attributes of the variables shown in the regression framework [Eq. 1 and/or 2]. It is clear that each variable shows diverse distribution patterns which are absolutely distinct. Hence, use of the Ordinary Least Squares (OLS) regression technique may generate biased outcomes. As such, the use of Granger Causality tests will help to show causality and the employment of the GMM approach will find the relationships of these variables.

It is widely accepted that there is a need to investigate the stationary level of each variable under study as they are normally viewed to be non-stationary. Out of the many panel unit root tests suggested in the available literature, this paper employed the Fisher ADF test, Harris-Tzavalis test, and the Im-Pesaran-Shin (IPS) test. These particular forms of tests have diverse roots plus they can reduce homogeneity challenges. The null-hypothesis of non-stationary is analyzed for each variable in the regression framework [Eq. 1and/or 2]. It is clear that each variable shows diverse distribution patterns which are absolutely distinct. Hence, use of the Ordinary Least Squares (OLS) regression technique may generate biased outcomes. As such, the use of Granger Causality tests will help to show causality and the employment of the GMM approach will find the relationships of these variables.

However, recent literature postulates that there is a possibility that panel data sets can be dependent on cross-sections. As such this study conducted a cross-section dependence (CD) test and the results are shown in Table 5 below. In this case, the outcomes demonstrated in Table 5 confirm that the null hypothesis (H0: Cross-sectional independence) is rejected and the alternative hypothesis (H1: No cross-sectional dependence) is accepted. Hence, the rejection of the null hypothesis implies that any changes and/or a specific shock for any variable of a country that is part of the study do not produce changes in that particular variable in the remaining countries that are part of the panel data set.

### 4.1. Findings about correlations of the variables

In this section of the paper, I discuss the correlation involving all the main variables of this study. High correlations are normally values that are significantly close to -1 and/or +1 and therefore show multicollinearity which inevitably requires estimation of the variance inflation factor (VIF). If VIF is more than 10, high multicollinearity is valid and may greatly affect results outputs of ordinary least square regression estimates (Hair et al., 1995; Wold et al., 1984). As illustrated in Table 6 all independent variables show a VIF less than 10 except for the dependent variables (Corruption Index (CORI) and Corruption Ranking (CORRA) since their VIF is greater than 10). It is vital to note that multicollinearity normally affects independent variables and not dependent variables (Hair et al., 1995; Wold et al., 1984) and this study is not affected by multicollinearity. Furthermore, to account for the multi-collinearity challenges this paper will also not substantiate findings generated by the OLS regression but employ the GMM approach along with the Granger causality approach.

The analysis indicated by Figures 1, 2, 3, 4, and 5 below reinforces the correlation results found in Table 6.

Figure 1 depicts the correlation between the Corruption Index (CORI) and environmental sustainability (ENS). It is moderately positive illustrating that as CORI increases Transperency International (2020) asserts that an increase in the Corruption Index (CORI) implies the country becomes clean from corruption) we anticipate that ENS will also heighten.

Figure 2 indicates the association involving Corruption Ranking (CORRA) and environmental sustainability (ENS). It is moderately negative demonstrating that as CORRA increase we expect ENS to decline.

Figure 3 above shows the two-way relationship between income (GDP) and environmental sustainability (ENS). The link is lowly positive outlining that as GDP increases we expect ENS to also increase.

Figure 4 depicts the correlation between the ease of doing business (EDB) and environmental sustainability (ENS). It is moderately negative illustrating that as EDB increases World Bank Group (2020) highlights that a high numerical EDB index implies the country’s companies have a bad environment for doing business, and vice-versa) we anticipate that ENS will decline.

### Table 7. Findings of pair-wise Granger Causality tests between variables and environmental sustainability.

| Null hypothesis | H(W-bar) statistic [95% critical value] | Z (Z-bar) statistic [95% critical value] | Z(Z-bar tilda) statistic [95% critical value] |
|------------------|----------------------------------------|----------------------------------------|------------------------------------------|
| CORI does not Granger-cause ENS | 2.5020 | 4.2484 (0.3300) | 0.7088 (0.3700) |
| ENS does not Granger-cause CORI | 2.9238 | 5.4414 (0.2200) | 1.0667 (0.2200) |
| CORRA does not Granger-cause ENS | 4.5400 | 10.0127 (0.2000) | 2.4381 (0.0900) |
| ENS does not Granger-cause CORRA | 5.1039 | 11.6675 (0.0600) | 2.9166 (0.0600) |
| GDP does not Granger-cause ENS | 3.1394 | 6.0510 (0.3100) | 1.2496 (0.0900) |
| ENS does not Granger-cause GDP | 2.3793 | 3.9011 (0.3100) | 0.6046 (0.4800) |
| EDB does not Granger-cause ENS | 1.6107 | 1.7274 (0.6400) | -0.0475 (0.9500) |
| ENS does not Granger-cause EDB | 1.2370 | 0.6703 (0.8800) | -0.3646 (0.6200) |
| EDU does not Granger-cause ENS | - | - | - |
| ENS does not Granger-cause EDU | 7.0969 | 17.2447 (0.0100)** | 4.6077 (0.0100)** |

Notes: ** indicates that the coefficients are significant at the 5% level of significance, respectively.
Southern African economies exists with feedback effects. This con-
to the best knowledge of this article causality involving the current state
are also both rejected. This implies that the causality results are
the Corruption Ranking variable is applied the null hypothesis that ENS
current state of environmental sustainability in the Southern African
cause the current level of environmental sustainability. Moreover, the
estimates as according to Dumitrescu and Hurlin (2012) this estimate will
generated through a bootstrap application technique. It is vital to note
causality tests are presented in the following section.

Granger causality tests to prove causation. The outcomes of Granger
investigate an in-depth analysis of this association more when we apply

Table 7 presents the findings of the Granger Causality test outcomes
generated through a bootstrap application technique. It is vital to note
that the outputs show $W$ (W-bar), $Z$ (Z-bar), and $Z$ (Z-bar tilde) estimates.
For the interests of this paper, I will only discuss that $Z$(Z-bar tilde) esti-
mates as according to Dumitrescu and Hurlin (2012) this estimate will
be favoured when $N$ is large and $T$ is small. To explain (using Corruption
Index), the null hypothesis that ENS does not Granger-cause CORI and
ENS does not Granger-cause CORI are both rejected by the
bi-directional causality. Moreover, in ascertaining the causality among energy use, emissions and
sustainability, and vice-versa. Recent studies add more insights. For
example, Abdouli and Hammami (2018) analysis of Middle Eastern and
North African countries spanning 1990 to 2012 found bi-directional
causality between economic growth and environmental degradation.
Moreover, in ascertaining the causality among energy use, emissions and
economic development for Pakistan, Mirza and Kanwal (2017) also
highlights that economic growth and environmental quality develop
bi-directional causality.

As well, the null hypothesis that EDB does not Granger-cause ENS and
ENS does not Granger-cause GDP is also rejected by the $Z$ (Z-bar tilde)
statistic. Thus, this implies that GDP does Granger-cause ENS and ENS
does Granger-cause GDP in the Southern African states thereby showing
feedback effects of these relationships. More precisely, economic growth
in southern African countries causes the current level of environmental
sustainability, and vice-versa. Recent studies add more insights. For
example, Abdouli and Hammami (2018) analysis of Middle Eastern and
North African countries spanning 1990 to 2012 found bi-directional
causality between economic growth and environmental degradation.
Moreover, in ascertaining the causality among energy use, emissions and
economic development for Pakistan, Mirza and Kanwal (2017) also
highlights that economic growth and environmental quality develop
bi-directional causality.

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Figure 5 depicts the correlation between Education (EDU) and envi-
ronmental sustainability (ENS). It is very lowly positive illustrating that
as the current level of EDU increases we anticipate that ENS will
decrease.

Figures 1, 2, 3, 4, and 5 only explain a one-to-one link. This paper will
investigate an in-depth analysis of this association more when we apply
the GMM approach that is dynamic and also add the effects of two or
more variables on the relationships. Moreover, this article conducts
Granger causality tests to prove causation. The outcomes of Granger
causality tests are presented in the following section.

Table 8. Findings of static panel data for regression 1: corruption index (CORI).

|                      | Pooled Ordinary Least Square (POLS) Model | Random Effect Model | Fixed Effect Model |
|----------------------|------------------------------------------|---------------------|-------------------|
|                      | Coefficient | Standard Error | Coefficient | Standard Error | Coefficient | Standard Error |
| CORI                 | 1.092267 (0.000)*** | 0.1489519 | 0.4152181 (0.007)*** | 0.154254 | 0.2649153 (0.104) | 0.1618429 |
| GDP                  | -0.0022555 (0.000)*** | 0.0039814 | -0.0017673 (0.019)** | 0.0007525 | -0.0041631 (0.001)*** | 0.0011752 |
| EDB                  | -0.0011944 (0.974) | 0.0370336 | -0.0322544 (0.364) | 0.0366359 | 0.0412009 (0.330) | 0.0412009 |
| EDU                  | 4.95 x 10^{-11} (0.806) | 2.01 x 10^{-10} | 4.02 x 10^{-10} (0.335) | 4.16 x 10^{-10} | 1.02 x 10^{-6} (0.082)* | 5.80 x 10^{-10} |
| R²                   | 0.4636 | 0.2722 | 0.0239 |
| Wald ($\chi^2$)      | 30.03 | 3.59 |
| Breusch-Pagan test ($\chi^2$) | 232.63 (0.000)*** |
| Hausman test ($\chi^2$) | 15.36 (0.001)*** |
| No. of observations  | 144 | 144 | 144 | 144 | 144 | 144 |

Notes: ***; ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively. Numbers in brackets are p-values.

Table 9. Findings of static panel data for regression 2: corruption ranking (CORRA).

|                      | Pooled Ordinary Least Square (POLS) Model | Random Effect Model | Fixed Effect Model |
|----------------------|------------------------------------------|---------------------|-------------------|
|                      | Coefficient | Standard Error | Coefficient | Standard Error | Coefficient | Standard Error |
| CORRA                | -0.3099589 (0.000)*** | 0.0416565 | -0.1613043 (0.000)*** | 0.0439541 | -0.1031326 (0.031)** | 0.0473334 |
| GDP                  | -0.0017139 (0.000)*** | 0.0008452 | -0.0016444 (0.015)** | 0.0006764 | -0.0036776 (0.001)*** | 0.0010699 |
| EDB                  | 0.0201881 (0.603) | 0.0387638 | -0.0069727 (0.851) | 0.037052 | 0.0464953 (0.259) | 0.0410138 |
| EDU                  | 6.5 x 10^{-11} (0.656) | 1.94 x 10^{-10} | 4.06 x 10^{-10} (0.324) | 4.11 x 10^{-10} | 9.98 x 10^{-10} (0.084)* | 5.72 x 10^{-10} |
| R²                   | 0.4680 | 0.3372 | 0.0091 |
| Wald ($\chi^2$)      | 16.31 | 4.16 |
| Breusch-Pagan test ($\chi^2$) | 262.99 (0.000)*** |
| Hausman test ($\chi^2$) | 10.51 (0.0147)** |
| No. of observations  | 144 | 144 | 144 | 144 | 144 | 144 |

Notes: ***; ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively. Numbers in brackets are p-values.
have to do with among others the natural environment and poverty eradication.

The outcome with the null hypothesis that EDU does not Granger-cause ENS was not confirmed through the bootstrap process. The outcomes also confirm that the null hypothesis which explains that ENS does not Granger-cause EDU is accepted by the Z (Z-bar tilde) statistic thereby showing that the existing status of environmental sustainability does not Granger-cause education in Southern Africa. This finding is supported by Mantaw (2012) who confirms that education for sustainable development in Africa is little to non-existent as most academic settings, governments, and business contexts do not understand how sustainable development is promoted by the role of education. The following section presents findings on regression frameworks using static models.

Table 8 above presents the estimation results of the regression model 1 (Equation [1]). The first concern relates to the heteroskedasticity of errors in the OLS framework. Thus, this paper implemented the Breusch-Pagan test (χ²) for heteroskedasticity. The results show that the estimate 232.63 with p-value of 0.0015 which is less than 5% thereby confirming the Fixed Effects Model. As such, for the regression model (Equation [1]), I go ahead to estimate the dynamic panel data framework with fixed effects using the GMM technique.

Table 9 above presents the estimation outputs of regression model 2 (Equation [2]). The findings illustrate that the Breusch-Pagan test (χ²) for heteroskedasticity support the Random Effect model than the POLS since the estimate 232.63 with p-value of 0.0015 which is less than 5% thereby confirming the Fixed Effects Model. As such, for the regression model (Equation [1]), I go ahead to estimate the dynamic panel data framework with fixed effects using the GMM technique.

Table 10 presents the two-step GMM short-run results to regression 1 (Equation [1]) that included corruption index and regression 2 (Equation [2]) which included corruption ranking as the main independent variables, respectively. The outcomes show that lagged environmental sustainability indicates a positive relationship with environmental sustainability. In this case, a 1% increase in lagged environmental sustainability generates a 0.23% and 0.29% increase in environmental sustainability for regression 1 and 2, respectively. In this regard, by employing regression model (a) 1 and 2 with different corruption proxies, a unit rise in past environmental sustainability scenarios propels a rise of 0.23 and 0.29 percent respectively in environmental sustainability for Southern African countries. However, this finding is conflicts with Darkoh (2009) who express that Southern African countries’ environments are being increasingly being affected by global warming, waste, pollution, desertification, deforestation, and loss of biodiversity.

Table 10. Two-step system-GMM findings with (a) corruption index (b) corruption ranking as the independent variables.

| Regression 1 (Corruption index) | Coefficient | Standard Error | Regression 2 (Corruption ranking) | Coefficient | Standard Error |
|-------------------------------|-------------|----------------|----------------------------------|-------------|----------------|
| SIT                          | -0.082506(0.000)**  | 0.049475      |                                           | -0.064918(0.000)**  | 0.038799      |
| CORI                         | -0.304192(0.000)**  | 0.047945      |                                           | -0.328150(0.000)**  | 0.063036      |
| CORRA                        | -0.390462(0.000)**  | 0.047945      |                                           | -0.390462(0.000)**  | 0.063036      |
| GDP                          | -0.082506(0.000)**  | 0.047945      |                                           | -0.064918(0.000)**  | 0.038799      |
| EDB                          | -0.082506(0.000)**  | 0.047945      |                                           | -0.064918(0.000)**  | 0.038799      |
| EDU                          | -0.082506(0.000)**  | 0.047945      |                                           | -0.064918(0.000)**  | 0.038799      |
| Hansen test of overidentifying Restrictions Chi-square χ² | 232.63(0.00000) | 11.97995 (0.00000) | 2.81339 | 2.81339 |

Notes: [1] ***; ** and * indicate that the coefficients are significant at the 1%, 5% and 10% level of significance, respectively. Numbers in brackets are p-values.
The findings also confirm that the corruption index (CORI) has a positive and significant relationship with environmental sustainability. In this case, as CORI increases (that is a decrease in corruption levels as countries become clean (Transparency International, 2020)) by 1%, then environmental sustainability also increases by 0.1069%. In addition, the results also highlight that corruption ranking (CORRA) has a negative and statistically significant link with environmental sustainability. In this regard, an increase in the rating of corruption of the country by 1% produces a decrease in environmental sustainability by 0.056%. Thus, for Southern African countries, it is quite evident that the harmonizing and congruent results contained in regression 1 and 2 by the GMM approach demonstrate that corruption practices degrade the natural environment in the short-term thereby in line with Wang et al. (2020) and Gandu and Dienesch (2017) surveys. For this study, it is also important to note that CORI (0.1069%) has the greatest impact on ENS than CORRA (0.056%).

For regression one (with CORI) income show a positive and significant association with environmental sustainability for the Southern African countries although that relationship is negative and not significant in the case of regression 2 (with CORRA). Thus, since regression 2 results are not significant we can confirm that economic growth in Southern African countries is also not causing heightening environmental damage in the short-run as shown by regression 1 (with significant results). These findings agree with Ozcan, Tzeremes and Tzeremes’s (2020) exploration of 35 OECD economies from 2000 to 2014. The study spotlights that economic growth adds to these countries natural environmental performance. However, Sarkodie and Strezov (2018) survey of environmental Kuznets curve (EKC) and environmental sustainability in a few selected global countries validated the EKC and found that economic growth sectors of transportation, agriculture and service are the major drivers of environmental degradation in both developing and developed countries.

Moreover, the ease of doing business (EDB) demonstrates a negative and significant association with environmental sustainability for both regressions 1 and 2. Hence, an increase of 1% of EDB (World Bank Group, 2020) - high numerical EDB index implies the country's companies have a bad environment for doing business, and vice-versa) worsen environmental sustainability by 0.056% and 0.027% for Corruption Index (regression 1) and Corruption ranking (regression 2), respectively in the Southern African developing economies. Therefore, the easiness of doing business practices in Southern Africa seem to be causing environmental damage. More elaborately Haile (2007) and Manteaw (2012) ascertains that the difficulties in conducting business in Africa include tough regulatory requirements, stringent bureaucratic structures, little access to finance channels, weak tax systems, reduced protection to stakeholders in the private sector, less exposure to conduct international trade. On that note, such considerations ultimately affect a company’s commitment to approaches that protect the natural environment in a negative way.

Furthermore, the level of education (EDU) illustrates a positive and significant connection with environmental sustainability in both cases (regression 1 and 2). Thus, education is vital to support and improve environmental sustainability in the Southern African states. These outcomes agree with Balaguer and Cantavella (2018) who employed higher education data of Australia from 1950 to 2014 and contributes that education has been proven to improve the environment through emission reductions. Furthermore, Shumba et al. (2008) exploratory study on Zimbabwe’s resettlement communities indicates that quality environmental education along with education for sustainable development implemented by participatory research was vital to engage communities involving academic institutions and the community such that natural environmental projects were then permitted to start, and even improve.

The following section presents the GMM long-run findings of the study.

Table 1 presents the long-run GMM regression outputs from regression 1 and regression 2. Firstly, the results show that the corruption index and corruption ranking produce a negative and statistically significant association with environmental sustainability in the long-run. However, their diagnosis show conflicting results. To elaborate, on one hand, a 1% increase in corruption index (a decline in corruption levels as countries become clean) results in decreased environmental sustainability by a significant 0.127%. This finding contradicts with earlier research such as Biswas et al. (2012) survey on 100 economies; Sahli and Rejeb (2015) study on 21 MENA countries along with Akbari and Nejati (2019) research on 61 countries who all found that corruption triggers environmental degradation. On the other hand, a 1% increase in corruption ranking (which is an increase in rating of country corruption) generates declines environmental sustainability by a significant 0.351%. Although the results are contradicting it is imperative to take into account that the corruption negative nature (becoming bad) as diagnosed by corruption ranking (-0.351%) on the natural environment is larger and seem to outweigh (nearly 3 times) the corruption positive nature (becoming clean) as diagnosed by corruption index (-12.7%).

Moreover, both regressions 1 and 2 also demonstrate that both economic growth (GDP) show a significant and negative link with environmental sustainability. Thus a percentage rise in economic growth produces a 0.23% (with CORI regression) and 0.2948% (with CORRA regression) decline in environmental sustainability for the studied African countries. As such Saud et al. (2019) study on 59 Belt and Road Initiative (BRI) economies also argue that heightening economic growth results in decreased environmental quality. In addition, Chakravarty and Mandal (2016) research on the BRICS economies reveals that environmental degradation increases monotonically with heightening economic growth.

The results found from both regressions 1 and 2 also confirm that ease of business (EDB) show a significant and negative connection with environmental sustainability. Hence, when EDB heightens by 1% then 0.291% and 0.321% is the reduced proportion on the state of the natural environment. Thus, the long-run outcomes are also supporting earlier outcomes generated by the GMM short-run results in the previous section. In this situation, it is generally confirmed that doing business in Southern Africa is not assisting to lower environmental damage for sustainable development (Asongu and Odhiambo, 2019; Ramachandran et al., 2009).

Furthermore, in the long-term, the level of education for both regressions 1 and 2 illustrates that their relationship to environmental sustainability is evidently negative and statistically significant. Thus 1% increases in the level of education (EDU) leads to decreases in environmental sustainability estimated at 0.23% (with CORI regression) and 0.29% (with CORRA regression), respectively. A number of studies contradict with outcomes of this paper. For instance, Zimmermann and Weible (2017) argues that when students in rural areas of Mid-Atlantic USA (in Pennsylvania) where taught environmental education concepts they recognise the relevance of supporting environmental health and environmentally sound projects as that experience coupled with education passed gives them direction in solving community environmental problems. In the same vein, Zachariou et al. (2017) conducted a research in Greece (Viotia prefecture) and contributes that the teachers’ behaviour concerning environmental education is strongly associated with their conduct towards the natural environment and its challenges. As well, their environmental knowledge and information are strongly linked to positive conduct towards environmental education.

5. Implications of the study

This study produced essential findings on both causation and relationships between corruption and environmental sustainability. Both proxies of corruption; corruption index and corruption ranking Granger cause the current state of environmental sustainability in Southern African countries, and that relationship is bi-directional implying that it has feedback impacts. The results also proved that in the short-run both indicators of corruption have a devastating and/or worsening effect on the existing state of environmental sustainability in the studied developing economies. In the long-run, the two proxies of corruption's effects on
environmental sustainability are contradicting although the corruption negative (becoming bad) effect outweighs impacts linked to the corruption positive (becoming clean) influence. This demonstrates the detrimental influence of corruption on the natural environments.

As such, there is a need for Southern African governments to set-up relevant agencies that are independent and show zero-conflict on interests in green economy projects and other important roles that deal with natural environmental matters. As well, there is a need for governments to make sure that channels that support movement of environmental and green funding are clear, follow acceptable ethical guidance and access to financing from interest groups at both local and international levels are adequately prioritized. Moreover, establishing national agencies equipped with the responsibility to manage public funds in the adoption and implementation of environmental sustainability projects is equally important. Ideally, governments can also integrate monitoring systems in the central frameworks of environmental and green policies and projects. Such systems are imperative to promote anti-corruption security in the fundamental components of green and environmental policies and draw out improved coordination of major elements thereby doing away with any possible irregularities, obscurities, and inadequacies which may pave way for corruptible actions.

Business organizations have also a major role to play in efforts to mitigate corruption to maintain and/or improve environmental sustainability. For example, corporates can engage in open participation of green economy initiatives along with disclosure of vital natural environmental information (emissions, waste, energy, water) both at local and global contexts so that impartial and long-lasting green economy standards are accepted by relevant stakeholders. Best practices of corporate governance which put focus on anti-corruption activities in business operation are also critical in prospective green and/or environmental investment projects through adhering to high transparency and accountability values.

The findings of the paper also demonstrate that there is a bi-directional relationship between economic growth and the current state of environmental sustainability. As well, the short-run results indicate that when the corruption index was employed as the main independent variable [regression 1] income was found to heighten the current state of environmental sustainability in the explored Southern African states. Nonetheless, the long-run findings in the context of both corruption index [regression 1] and ranking [regression 2] illustrate that when economic growth increases the environmental sustainability of the Southern African economies declines. As such, it is vital to note that the Southern African economies are unable to maintain a good natural environmental scenario at high-income levels which is quite worrisome. Thus there is a need to introduce effective long-lasting green regulatory policies and strategies that ensure that green production of goods and services is attained and ultimately maintained. These countries should also integrate tough green legislations and promote the employment of environmentally-compatible technologies and clean development mechanisms to encourage local production. It is also vital for the government to do away with permitting extreme and/or dirty emission and waste-producing industries which damage the environment. Pollution industries can also be supported with inducements for adhering to acceptable environmental law and/or policy standards as well as taking into account natural environmental demands in both operational and decision-making levels.

As well, the outcomes of this paper put forward that ease of doing business develops a bi-directional association with environmental sustainability indicating that there are also feedback impacts concerning this link. In terms of the direction of association in both short-run and long-run ease of doing business (low ranking show improved easiness of implementing business activity) show a negative and significant connection with environmental sustainability which implies that organizations in Southern part of Africa have difficulties operating in the current state of environmental sustainability scenarios. Hence, there are no compatible policies involving business practice and natural environmental interests. In this case, there is a need to promote the diffusion of green technologies, improved green management structures and green best practices from companies that are from developed countries to the developing economies in Southern Africa since such firms can sustain harmonizing green standards and processes across many countries. As well, these states should also revise their international business policy since the extent of country liberalization along with trade openness is also fundamental in attracting superior cleaner technologies and policies.

Lastly, the outcomes of this research highlights that environmental sustainability in Southern African countries do not Granger-cause education. Moreover, the short-term and long-term direction of association is conflicting. In this context, the level of education (EDU) illustrates a positive and significant connection with environmental sustainability in the short-run but that link becomes significantly negative in the long-run. Therefore, it is apparent that human capital in these countries understands that their level of education is important to improve sustainability but surprisingly that relationship work against environmental sustainability improvement in the long-term. The reason to explain this situation could be the effects of corruption itself, poverty and political instability amongst other factors influencing the link between environmental sustainability and education. As such, creating contexts that improve education by improving its capacity, employment, knowledge, and emancipation in diverse sectors (through training and qualification programs) of the Southern African countries is vital to spearhead environmental sustainability. In this case, better green and environmental education is vital to transform individual mentality on how they relate to the natural environment which inevitably changes towards policies (social, economic and political) that are compatible with nature interests.

6. Conclusion

This paper investigated the influence of different indicators of corruption on the environmental sustainability of all the 16 countries that make up Southern Africa over the period 2010 to 2017. The article also deploys the Dumitrescu and Hurlin (2012) Granger causality tests and the Generalised Method of Moments (GMM) econometric techniques to establish causation and relationships respectively. Firstly, both indicators of corruption found a bi-directional link between corruption and environmental sustainability and that association was confirmed to worsen environmental sustainability in the short-run although the relationship is contradicting in the long-run. Although the relationship is conflicting in the long-run the negative effect of corruption ranking surpasses the positive effect of corruption index by nearly 3 times thereby showing how detrimental corruptive actions are to the natural environment. Secondly, the research also establishes a bi-directional connection involving income and environmental sustainability. In the short-run corruption was ascertained to be increasing environmental sustainabil-
actions, greening economic growth strategies and policies, supporting green business policies and greening the education curriculum are fundamental processes vital to maintain proper environmental sustainability contexts in the Southern African region.

Declarations

Author contribution statement

F. Ganda: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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The authors declare no conflict of interest.

Additional information

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