Climate Change and Productivity in Sub Saharan Africa

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Abstract. The issue of change in climate is a global experience with adverse effects on human lives, animals and the environment of countries. Climate change, therefore, can also be associated with low productivity depending on the type of productivity. Such productivity could be agricultural productivity, manufacturing productivity, service productivity, among others. Hence, this study particularly tries to determine the impact of climate change on agricultural and manufacturing productivity in Sub Saharan Africa (SSA). This study is important because most African countries are known to rely on agriculture that somewhat transcends to the manufacturing sector, which may be affected by climate change. Productivity effects caused by climate change could affect the health of workers, work hours and workplace both the agricultural sector and the manufacturing sectors. Therefore, the study of this nature is important to determine the long-run effect of climate change on agricultural and manufacturing productivity in Sub Saharan Africa. This study employed the use of Fully Modified Ordinary Least Square Method using annual data from 1986 to 2016. The result conforms to the apriori expectation and shows that climate change has a negative effect on aggregate productivity as well as agriculture and manufacturing productivity in Sub-Sahara. Thus, this study determines the impact of climate change on how it affects agricultural productivity and manufacturing productivity differently in Sub Saharan African.

Keywords: Climate Change, Agricultural Productivity, Manufacturing Productivity and Fully Modified Ordinary Least Square Method

1. Introduction

The issue of change in climate is a global concern to policymakers and government of nations across the globe. The justification is that change in climate has been found to have an adverse effect on human lives, plants, animals and the environment (McMichael, 2003; Solomon *et al.*, 2007; Balanagarajan and Gajapathy, 2018). In addition, it may result in the inability to predict weather conditions with negative consequences on food security, human health, ecosystem, livelihood, water resources, employment, industrial output, among others (McMichael *et al*., 2004: Lundgren *et al.*, 2013; Oduyoye, Ogunro and Aderinto, 2014).

Cognizance of these, various efforts to mitigate the adverse effects of climate change have been adopted in both develop and developing countries alike. The notable initiatives includes the Framework of Southern and Northern Africa Climate Change Programme, 1980, the Intergovernmental Panel on Climate Change (IPCC),1988; African Ministerial Conference on Environment (AMCEN), 1985; United Nations Framework Convention on Climate Change (UNFCCC),1992; the Kyoto Protocol, 1997; the Nairobi Work Programme, 2005; the Bali Action Plan, 2007; the East African Community Climate Change Policy, 2009; African Climate Change Strategy, 2014, among others (ACCS[1], 2014). Despite these efforts, average weather condition globally has continued to increase rising from -0.04°C in 1985 to 1.572°C 2016 (WDI[2], 2017).

The increase in climate change may have severe consequences on productivity. According to Weil (2012), productivity refers to the relative amount between the volume of output and the inputs. However, an upsurge change in climate may result in extreme weather conditions such as changing precipitation and rainfall patterns, excess sunlight, rise in sea level among others effects (Mendelsohn, 2000; Kurukulasuriya *et al.,* 2006; IPCC[3], 2007; FAO[4], 2008; Sowunmi and Akintola, 2010; Duru, and Obiechefu, 2013). In addition, it can also affect productivity by affecting the health of the workers, work hours spent and workplace in the agricultural sector as well as the manufacturing sector.

Furthermore, adverse effect of climate change causes reduction in productivity resulting to loss of land available for farming activities, increased drought, increased flood that washes away the required nutrients from the soil surface and pests/diseases invasion on crops as well as human (Hsiang, 2010; Oduyoye, Ogunro and Aderinto, 2014). Even though climate change may have adverse effects on manufacturing and agricultural productivity, the effect may be severe in the latter because they are mostly done outdoor (Iqbal and Siddique, 2008; Schlenker and Lobell, 2010). However, extreme climate condition may have a direct impact on the productivity of workers in the manufacturing sector whose activities are either indoor or semi-indoor (Kjellstrom *et al.*, 2009; Kjellstrom and Crowe, 2011; Lundgren *et al*., 2013). In essence, low productivity causes a reduction in output.

Studies exist on the impact of climate change on productivity. However, most of the reviews are either for a particular agricultural crop productivity or aggregate agricultural productivity (Ajetomobi and Abiodun, 2010; Ayinde, Muchie and Olatunji, 2011; Ajay and Pritee, 2013; Bandara and Cai, 2014; Mbanasor *et al.*, 2015; Cai *et al.* 2016; Park 2016; Chalise *et al.*, 2017; Balanagarajan and Gajapathy, 2018; Zhang *et al.,* 2018) and are country-specific studies. To the best of our knowledge, studies that exist on agricultural productivity are scanty for Africa (see Knox *et al.,* 2012; Ludena and Mejia, 2012) while extant studies on the impact of climate change on manufacturing productivity (kjellstrom and Crowe 2011; Sudarshan *et al.,* 2015;

[1] African Climate Change Strategy
[2] World Development Indicators
[3] Intergovernmental Panel on Climate Change
[4] Food and Agriculture Organizations of the United Nations

Balanagarajan and Gajapathy, 2018) have been examined for developed and developing countries in other regions asides Africa.

Therefore, accounting for the impact of climate change on both agricultural and manufacturing productivity in Africa is particularly imperative. This is because most African countries rely on agriculture, which somewhat transcends to the manufacturing sector. Thus, climate change can significantly influence the output of both sectors and affects the national output in Sub Sahara Africa (IPCC, 2001; Slingo *et al.*, 2005). Furthermore, climate change may have different effects on agricultural productivity and manufacturing productivity. It is against the preceding introduction that this study empirically provides answers to the following research questions i). To what extent does climate change affect aggregate productivity in Sub Saharan Africa? ii). To determine the long-run impact of climate change on agricultural and manufacturing productivity in Sub Saharan Africa?

This research article is divided into five sections. Following the introduction in section one, the empirical literature on climate change and productivity in Sub Saharan Africa are reviewed in section two. The third section contains the methodology used for the study, while section four provides the presentation and analysis of results. The fifth section contains the policy implications, and the conclusions of the study are provided.

2. Empirical Literature

Several studies have contributed to the literature on the impact of climate change and productivity. However, empirical results by existing studies seem inconclusive. Some of the results found are either positive or negative impact of climate change on productivity; other results found are no effect. Nevertheless, some authors at different times examined climate change impact on specific types of productivity. For country-specific studies on climate change and productivity (see Ajay and Pritee, 2013; Park 2016; Balanagarajan and Gajapathy, 2018; Zhang *et al.,* 2018), the studies showed that fluctuations in temperatures and rainfall pattern adversely affected productivity negatively.

Among the studies done on climate change and agricultural productivity was by the work by Iqbal and Siddique (2008). The study examined the impact of long term change in climate variables on agricultural rice productivity using regional fixed effects within 23 regions in Bangladesh. The study employed regional time-series data from 1975 to 2008 to determine the differences between regions. The results revealed a negative impact of climate change on agricultural productivity of region and year fixed effects. Extending the literature, Nastis *et al.* (2012) and Chalise *et al.* (2017) evaluated the economic impact of climate change on agricultural productivity in Greece and the Nepalese region, respectively. The results of both studies suggested that the economic estimates of climate change on the regions directly or indirectly shows significant economic damage to agricultural productivity.

Knox *et al.*, (2012), projected the impacts of climate change on eight major crops in Africa and South Asia using the review of the meta-analysis of data in studies. The study mainly addressed the impact of climate change on difference specific crops, regions and sub-regions in Africa and South Asia. The result shows a similar negative projected impact of climate change on agriculture for both regions. Similarly, Ludena and Mejia, 2012 focused on the decline of crop yield as a result of climate change using aggregated database of 10 regions and 12 sectors employing a general equilibrium model. The result reveals that the impact of climate change varies across different regions. In the Former Soviet Union (FSU), East Asia and South Asia showed a positive impact on productivity compared to Middle East Africa and North Africa, Sub-Saharan Africa and some regions in Asia which showed a negative impact of climate change on agricultural productivity.

In addressing the impact of climate change and manufacturing productivity, studies by Kjellstrom, 2009; Kjellstrom and Crowe, 2011; Balanagarajan and Gajapathy, 2018; Day *et al.*, 2018 and Zhang *et al.*, 2018 had different results to reveal. Thus the study by Kjellstrom, 2009; Day *et al.*, 2018 showed that climate change significantly affects the productivity of workers. In a somewhat different study, Zhang *et al.*, 2018 examined the effect of temperature on manufacturing firm productivity over the period of 1998 to 2007. The result showed that the increase in temperature exhibits a negative impact on the manufacturing firms in China. The authors concluded that the necessary climate adaptation technique should be put in place to avoid the further reduction in productivity in the future.

3. METHODOLOGY

3.1 Model Specification

To investigate the impact of climate change on productivity in Sub-Saharan Africa, the model by Zhang *et al.* (2018) is adopted with some modification as follows:

$$PDT_{it} = f(HCF_{it}, OPN_{it}, GDP_{it}, CC_{it}, INV_{it}) + \varepsilon_{it} \quad (1)$$

Where PDT represents productivity; HCF is human capital formation; OPN is the degree of openness; GDP is the gross domestic product; CC is climate change; INV is investment; ε_{it} is the stochastic disturbance term while i and t are the cross-section and time dimension. To estimate the model, equation 1 is expressed in an estimable form, as shown in equation 2.

$$PDT_{it} = \beta_0 + \theta_1 HCF_{it} + \theta_2 OPN_{it} + \theta_3 GDP_{it} + \theta_4 CC_{it} + \theta_5 INV_{it} + \varepsilon_{it} \quad (2)$$

β_0 is the intercept term, while $\theta_1 - \theta_5$ are coefficients of the explanatory variables respectively. On apriori, human capital formation is expected to have a positive effect on productivity. Similarly, the coefficient of openness, gross domestic product and investment are expected to be positively related to productivity. On the contrary, climate change is expected to be inversely related to productivity.

3.2. Technique of Estimation

Due to the nature of data, the analysis began by subjecting the variables to stationarity tests, since the assumptions for the classical regression model require that variables in the model be stationary and that the errors have a zero mean and constant variance (Gujarati, 2004). The study adopts the Augmented Dickey Fuller-Fisher heterogeneous panel unit process tests, and it is estimated with individual intercept and trend (t) in each of the series. If the variables are integrated of order one I (1), we test for the possibility of a cointegrated relationship using the Johansen Fisher Panel cointegration test. Once the cointegration among the variables is established, the coefficients of the long-run of the variables are estimated using the Fully-Modified Ordinary Least Square (FM-OLS).

This estimator corrects the standard pooled Ordinary Least Square for serial correlation and endogeneity of regressors that are usually present in a long-run relationship Pedroni (1996; 2000). In applying cointegration tests to long-run hypotheses in aggregate panel data, a primary concern is to construct the estimators in a way that does not constrain the transitional dynamics to be similar among different countries of the panel. Instead, only the information concerning the long-run hypothesis of interest was pooled, and the short-run dynamics allowed being potentially heterogeneous. This is a central theme for the panel fully modified (Bangake and Eggoh, 2011).

3.3 Data Source

The sample data covers the period of 1986 to 2016 and contain 31 annual observations. Specifically, five Sub-Sahara African countries, namely Angola, Congo, Nigeria, Ghana, South Africa and Lesotho are selected based data availability. Data for the study are extracted from the Food and Agriculture Organizations of the United Nations (FOASTAT) and World Development Indicators WDI (2018). The variables include Productivity, which is computed using the Value Added of Agriculture and Manufacturing divided by population. The degree of openness is computed as the sum of import and export divided by Gross Domestic Product. Gross Domestic Product is measured in millions of current US $. Human Capital Formation is estimated using the enrolment of both sexes in secondary. Climate change is measured using temperature change as obtained from FOASTAT, 2019.

4. PRESENTATION AND ANALYSIS OF RESULT

Table 4.1 shows the result of the Augmented Dickey Fuller-Fisher heterogeneous panel unit process tests in the level and first difference for all the variables in the model. As displayed in the table, the null hypothesis that the panel series contains a unit root at a level cannot be rejected. However, after taking the first difference, each panel series appear to be stationary.

Table 4.1: ADF-Fisher Unit Root Test Results

Variables	***Level***	***First Difference***
GDP	*-0.1217(0.4516)*	*2.5950(0.0047)*
HCF	*0.4107(0.6594)*	*-3.1882(0.0007)*
OPN	*-0.7138(0.2377)*	*3.3169(0.0005)*
PDT	*0.8232(0.6959)*	*3.4354(0.0022)*
CC	*3.1606(0.9961)*	*2.6730(0.0211)*
INV	*0.6176(0.7516)*	*-1.9067(0.0283)*
Critical values at 5%	*0.8432(0.8005*	*-4.8579(0.0000)*
	-2.0972(0.0186)	*-4.8392(0.0000)*

Note: *Value in parenthesis represents probabilities.*

Source: Author's Computation, 2019.

Since the variables are found to be stationary at first difference, the study proceeds to establish the existence of co integration among the variables using the Johansen Fisher Panel cointegration test. The co integration test result is shown in Table 4.2. The table shows that the Fisher statistics from the trace and Max-Eigen test indicates that the null hypothesis of no cointegration can be rejected.

Table 4.2 Johansen Fisher Panel Cointegration Test

Hypothesized No. Of CE(s)	***Fisher Stat* (from trace test)***	***Fisher Stat (from max-eigen)***
None	*289.9***	*121.0***
At most 1	*159.5***	*62.75***
At most 2	*103.2***	*55.13***
At most 3	*56.29***	*51.05***
At most 4	*47.50***	*31.05***
At most 5	*50.80***	*32.29***
At most 6	*31.08***	*16.46****
At most 7	*35.44***	*35.44***

Note: ***; ** & * indicate 1%; 5% & 10% level of significance.

Source: Author's Computation, 2019.

The implication of this is that productivity and its selected determinants used in the model are cointegrated for the panel of the selected Sub-Saharan African countries. With the established long-run relationship, it is convenient that the long-run coefficients of the model be estimated using a Panel Fully Modified Ordinary Least Square.

Tables 4.3 show the long-run coefficients of aggregate productivity as well as agriculture and manufacturing productivity in Sub-Sahara Africa. The result in columns 2 shows the result of aggregate productivity, while column 3 and 4 show the result of agriculture and manufacturing productivity. As shown on the table, the coefficient of climate change conforms to its apriori expectation across all models. This finding is similar to those of that of Nastis *et al*., 2012 that examined the impact of climate change on productivity. However, climate change variable appears to be a significant determinant of only manufacturing productivity in the long-run. A possible explanation for this is that in the long-run, the use of mechanized tools may result in a shift from agriculture, which is the major contributor to Gross Domestic Product in Sub-Saharan Africa to manufacturing. In the same vein, Human Capital Formation is statistically significant in explaining productivity in the long-run. This implies that the acquisition of skills through education is important to drive productivity in the long-run. The coefficient Investment also conforms to its expected sign having a positive and significant impact on productivity in the long-run. Gross Domestic Product and the degree of openness, although have a positive effect on productivity but do not significantly drive productivity.

Table 4.3: Fully Modified Ordinary Least Square Estimation Result

Regressors	**PDT**	**APDT**	**MPDT**
CC	-0.050**	-0.1212	-0.0801
GDP	0.0019	0.0029	0.0015
HCF	0.2603*	0.2950*	0.1546*
INV	0.3373**	0.3034*	0.4293**
OPN	0.5310	0.5163	0.6702
C	0.8132	0.7732	0.5541
D.W	1.67	1.55	1.73
R-Square	0.84	0.77	0.82

Note: *** & * indicate 1% & 5% level of significance; where APDT and MPDT represents Agricultural Productivity and Manufacturing Productivity respectively.*

Source: Author's Computation, 2019.

5. CONCLUSION AND POLICY RECOMMENDATION

The study examines the effect of climate change on productivity in Sub-Saharan Africa (SSA) countries from 1986 to 2016. The six SSA countries are namely Angola, Congo, Nigeria, Ghana, South Africa and Lesotho was selected based on data availability. To achieve the objectives of the study, productivity was disaggregated into agricultural and manufacturing productivity to examine the heterogeneous effect of climate change. Specifically, the time-series properties of panel data were examined using both the Augmented Dickey Fuller-Fisher heterogeneous panel unit root tests. Also, the study adopts the Johansen Fisher Panel cointegration test to establish long-run relationship among the series. Also, Fully Modified Ordinary Least Square cointegration approach is used to examine the long-run effect. The result of the study reveals that climate change has a negative effect on aggregate productivity as well as agriculture and manufacturing productivity in SSA. However, the variable is statistically significant in explaining only manufacturing productivity in the long-run. Thus, the finding suggests the shift from the agricultural sector, which is the major contributor to the Gross Domestic Product in SSA to manufacturing in the long-run. Based on the result, it is recommended that SSA countries should design appropriate policies to mitigate the adverse effect of climate change in the long-run. These policies should centre on setting tariff regulations and the use of advanced and efficient (greener) technology, among others.

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