Effect of Climate Change on Economic Growth in at Risk African Nations

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Abstract:

This paper looks at the possible negative effects climate change could create on the growth of at risk African Nations. This study takes known climate change metrics and puts them into an economic growth model to shine light on environmental issues becoming more prevalent in our world today. Climate change indicators will be modelled alongside economic growth indicators to paint a picture of the positive or negative effect that could slow African Nations' Economies now and into the future. The results of this regression are predicted to be that the climate change indicators will have a negative effect on economic growth in these at risk nations and will shine light on a problem that will likely influence policy in the future.

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1.0 Introduction

Climate change has become a more pertinent issue through the years and is beginning to threaten life as we know it here on earth. Climate change will hurt some countries more than others and affect these at risk countries in many different ways. It's in these at risk countries where the largest impact will happen and where the world will see the biggest need for help now and into the future. One of the more important things that will need to be looked into is how climate change effects economic growth in countries.

This study will take a look at the relationship between climate change and economic growth in many at risk African Countries. This is an important topic to look at because of the huge implications it has on different initiatives that would need to take place on both the national level and throughout the world. If climate change does slow down economic growth in nations, then it would be important to direct policy towards bettering the environment and nixing climate change in order to fix the damages done by climate change.

Finding ways to limit carbon dioxide emissions while also promoting a strong economy will be vital as we push into the future. Some ways in which this study will look at is from a study from Asongu, (2017). In the 2017 study, it was found that both information and communication technology will help in limiting the effects of carbon dioxide emissions and the effects of climate change in Africa. Finding ways to conserve water and the need for combating that issue with a warming earth. In the Wit and Stankiewicz (2006) study, they forecast how precipitation changes due to climate change will affect the continent of Africa in the future.

This paper differentiates itself from past studies in two different ways. The first of which it takes a look at climate change effects on at risk African Nations, noting that previous studies do not look at such a precise area with regards to Climate Change and economic growth. It should

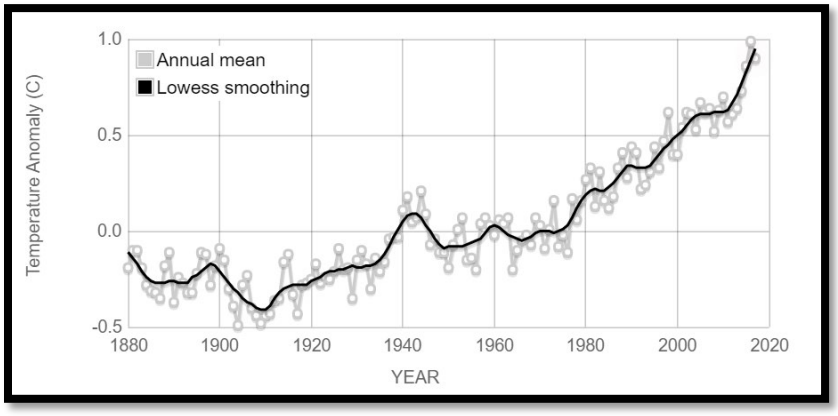
also be noted that this study takes a more recent picture of the effects, as more data is available and updated at this time.

The section layout for the rest of the paper will be shown as follows: In Section 2 the study provides a review on literature as it pertains to this topic. Section 3 will give the empirical model that will be used in this study. Whereas Section 4 will look at the data and general estimates for the results of the study. Then in Section 5 where we will also discuss these results. Finally, in Section 6 will show the conclusions of this study.

2.0 Trends

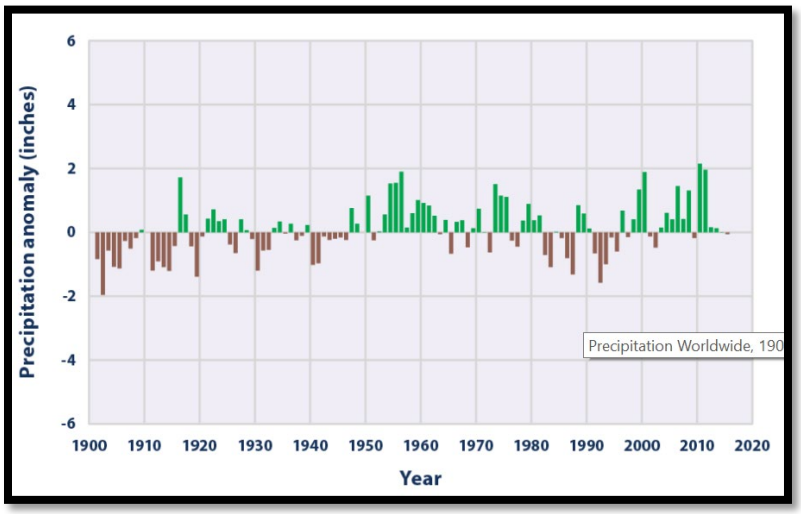
Here are some trends that have been seen in the past few years with regards to climate change in the African region and around the world are shown in figure 1 and figure 2.

Figure 1: Global Mean Temperature Change



Source: NASA: Vital Signs of the Planet

Figure 2: Worldwide Precipitation from 1901-2015



Source: The U.S. Environmental Protection Agency

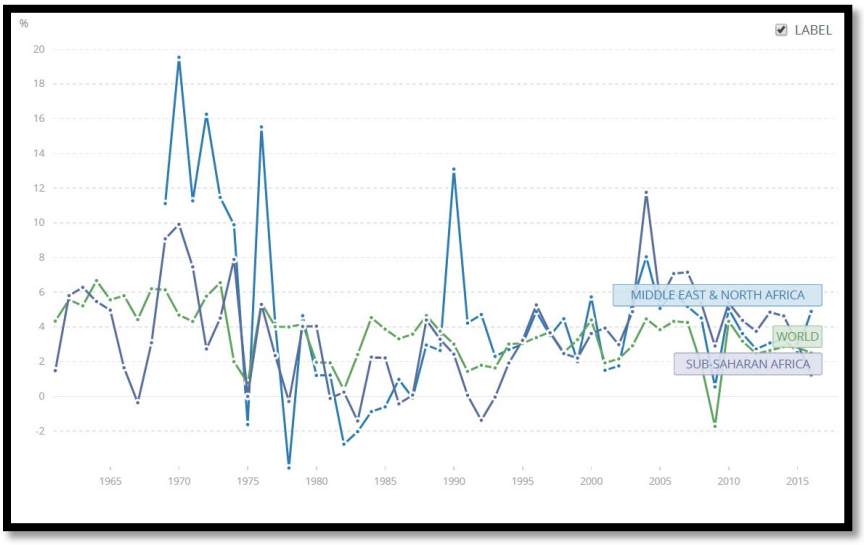
These first two figures show the trends in which certain climate change proxies are headed in. For temperature, we see that it is increasing at a much more rapid rate as we progress through the years. This shows the increasing pressures that climate change is putting on our society and the nations that make up the world.

Continuing on to Figure 2, the trend seen is what would be thought of as interesting. The graph shows an increase in the amount of precipitation. It would be thought that with an increase in temperature, there would be less precipitation, however it is actually believed that the warmer the air, the more precipitation it is able to hold and then eventually dispel. Not to mention that a majority of rain water comes from Ocean evaporation, coupled with an increase in ice glacier melt, and we have an increase in the amount of precipitation falling from the sky.

Applying this to what was seen in the Wit and Stankiewicz (2006) study, what has been seen in the trends for worldwide precipitation goes against the study and predictions of Wit and Stakiewicz (2006). The trends actually show that there is an increase in precipitation which would lead to more surface water. This goes against the findings however, the trends have been

for worldwide and not just for the continent of Africa, which could show a different trend that would go more in line with the previous study.

Figure 3: Annual GDP Growth Rate for World and African Region



Source: World Development Indicators

In Figure 3 it's seen where most of the African region stacks up against the world in terms of annual GDP growth. Currently the world is outperforming the Sub-Saharan Africa, but it has been back and forth between them. This figure is interesting because it shows the general trend of the Sub-Saharan Africa's GDP, and as being one of the more susceptible areas to climate change, this can prove rather large in terms of the effects of climate change. While being rather erratic, it seems as if their % change in GDP has slowly decreased over the years.

3.0 Literature Review

There are many different ways that climate change can effect a community. One of those ways is that climate change can have huge implications on a nation's economy. Climate change has become a hot topic as of late, and can be attributed to many different things. A few issues with climate change is increased in temperature and an increase in the length and severity of

droughts. One of the biggest spots this will impact is with the water supply. In a study by Wit and Stankiewicz (2006), they found that through the predicted precipitation changes, present surface water will be significantly affected at upwards of 25% across Africa by the time we hit the next century.

Climate change is definitely going to become a more prevalent issue than it already is if actions are not taken that will change our current path. However, it is currently unclear how much climate change will effect economic growth, however there are studies that have begun to peel back the cloud to just what extent it can effect growth. In a 2005 study by Fankauser and Tol (2005), they took a different look at the economic impact of climate change. Their study looked through both savings and capital accumulation. This study found that households have in fact increased consumption instead of trying to save for the inevitable issue that climate change will bestow on them. Following up on this, in the study that this paper is based off of, Akram (2012) tried to predict the effects of climate change on at-risk nations. While this study is going to be very similar to Akram's (2012), he looked at Asian countries and their economies where this study looks at vulnerable African economies. Through his research, Akram (2012) was able to conclude that the proxies used to describe climate change do in fact hinder economic growth. However, it has an even bigger effect on agriculture, while manufacturing is the least effected sector studied. Not only was this study able to look at the economy as a whole, but also for different sectors as well.

Following suit with the previous study, another study took and empirical look at the effects of different climate variables on economic growth at the national level. This study by Brown et al. (2016), took temperature with other extreme climate variables like drought and flood and used a model to determine the impact that these different looks had on economic

growth. The study concluded that the temperature variable actually had little impact. However, what did have an impact was drought which had a very large negative impact and flood which also had a negative impact.

The next two studies that inspired this paper come in the form of a study from Mendelsohn and Dinar (1999), and Sudarkodi and Sathyabama (2011). Both studies look at the effect of climate change and the effect it will have on the agriculture sector. Mendelsohn and Dinar (1999) note that in most developing countries, agriculture is relied on heavily, so climate change threatens everything from the population to the economy of these developing countries. In their simulations, they see that yes higher temperatures will decrease crop yields. However, they also note that while this is the case, hopefully farmers will adapt by making production decisions that fit their needs and will give them the most utility. Following that up with the study by Sudarkodi and Sathyabama (2011), it is also announced that agriculture is extremely vulnerable to climate change. Crop yields will shrink and while agriculture is open for adaptation, climate change will ultimately prove to be more detrimental to the sector even with adaptation.

These papers show the need for intervention already with regards to the issue of climate change. These studies show that the agriculture sector will greatly be effected by climate change and that overall economic growth will be effected. The model this paper is incorporating will give us a better look at the issues that at-risk African nations will face, and will look at policy that will help mitigate or even reverse this effect.

4.0 Data and Model Methodology

4.1 Data

This study uses Panel Data from the years 2000 – 2014. The data was obtained from the World Development Indicators, the United Nations Human Development Reports and The World Bank Group for temperature and precipitation data. Summary Statistics will be provided in the Table 1 that follows bellow. A correlation Matrix will be provided in the appendices.

Table 1: Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
log(GDP)	90	24.6098	1.3133	22.7499	27.2877
CO2E	90	1.5859	3.2873	.0533	9.8705
log(POP)	90	17.2518	.6126	16.2470	18.394
UR	90	19.5318	9.8976	1.7574	34.468
INFL	90	10.4177	7.6552	-8.2378	44.3912
PR	90	118.37	44.2014	35.1149	195.8228
FDI	90	1.32e+09	2.21e+09	5,302,623	9.89e+09

4.2 Empirical Model

This study incorporates a model from Akram (2012). The model has been adapted by changing a few variables and also, instead of using it on Asian countries, this study will look at some of the at-risk countries in Africa.

The model can be written as follows:

$$\log(GDP)_{it} = \beta_0 + \beta_1 CO2E_{it} + \beta_2 \log(POP)_{it} + \beta_3 UR_{it} + B_4 INFL_{it} + \beta_5 PR_{it} + B_6 FDI_{it} + \varepsilon_{it} \quad (1)$$

The dependent variable in this model is written as GDP and is the annual change in GDP growth for a given country. So that the results for this model will end up showing us how each variable effects GDP growth. Figuring out if these variables effect GDP growth will allow us to take a look at how these countries can go about improving their GDP growth.

For independent variables, the first one is written as CO2E, or carbon dioxide emissions, with PR, or precipitation, we have our proxies for climate change. The next variable is written as log(POP), which is just the natural log of a county's population. For the next variable we have written it as UR, as it represents the percent of population living in urban areas, another sign of a more developed nation. The fourth and sixth variables are INFL, inflation and FDI, or foreign direct investment. These two variables help explain economic growth and are put in so the model does not suffer from omitted variable bias.

5.0 Empirical Results

In Table 2 the empirical estimation results are shown. The results show that with more carbon dioxide emissions, the more economic growth a country has. Also seen is that precipitation is a positive coefficient showing that the introduction of more precipitation is beneficial to an economy. The model shows that as a whole, Climate change seems to have a positive impact on the economy, although that could mostly be because these nations are developing and expelling more CO2, even if carbon dioxide exacerbates climate change and

causes issues down the road. It would be interesting to run a study that looks into the costs and benefits of this.

Table 2: Regression Results

Log(gdp)	
Constant	-31.82*** (3.033)
CO2E	.0723* (.0424)
log(POP)	3.319*** (.1911)
UR	-.0559*** (.0152)
INFL	.0022 (.0015)
PR	.001 (.0007)
FDI	7.18e-12 (7.5e-12)
R^2	.7007
F-Statistic	180.19***

Note: *** , **, and * denotes significance at the 1%, 5%, and 10% respectively. Standard errors in parentheses

In this study the model shows three variables that are significant. The two variables that are significant at the 1% level are log(POP) and UR. The third significant variable we saw was CO2E which was significant at the 10% level. For the significant variables we see that urbanization is negatively associated with GDP. Both population and carbon dioxide emissions were positively associated with GDP, with precipitation also being positively associated. With both of the climate change proxies being positively associated with GDP, let's dive into the real meaning behind the fact. Looking at precipitation first, the coefficient reads like this, for each

additional millimeter of rain, GDP increases by .001%. While this number seems insignificant, and technically it is, it should also be noted that 1 millimeter of rain is a very small amount too. Unfortunately, this study was unable to find precipitation significant, going against Akram's (2012) study and what was found. The fact that it is a positive association also is not at all surprising as this would make sense, more precipitation would boost the agriculture sector. Continuing on, the positive association between carbon dioxide emissions and GDP show an unsurprising trend, the more emissions expelled, the more growth that should be obtained, especially over the long run.

The coefficient on CO2E reads that for each additional metric ton of carbon dioxide emissions per capita in a country, there is a .07% increase in GDP for that country. With regards to the coefficients on population and urbanization, for a 1% increase in the population of a country, there is a 3.3% increase in GDP, where a 1% increase in urbanization yields a .059% decrease in GDP, and the urbanization result was interesting as the coefficient went against what was found in Akram's (2012) study. Finally, when looking at the coefficients on inflation and foreign direct investment, we see that a 1% increase in inflation yields a .0022% increase in GDP where a one-unit increase in FDI increases GDP by 7.18e-12%, a very small number in fact.

It is known that carbon dioxide emissions are one of the leading contributors to climate change, so it will be imperative that policy follows ways in which CO2 emissions are not only limited, but also technologies are implemented to replace heavy CO2 emitting devices and processes. Again I would like to refer back to Asongu's (2017) study, who noted ways in which carbon dioxide emissions can be limited in these developing African nations. Using different ways to limit the effect of climate change will be vital in these countries, the African continent, and around the world.

Ultimately, this study does have a few limitations. The first of which is a small data size. This study was relatively small when looking at the number of year it encompassed, and I think that the intermittent access to data in this region hurt this study. Also adding more countries would be an interesting addition to the study. Also being able to find more ways to incorporate other climate change variables into the mix, for instance actually being able to find a way to use the temperature variable in this study and to incorporate droughts and floods into the study as well. This would be something to look into in the future as well and would have greatly improved this study as a whole.

5.1 Policy Implications

When looking at policy implications for this study, it should be noted that the study finds carbon dioxide emissions to promote economic growth. While this seems like a good thing, it should also be noted that these emissions are one of the main if not the main contributors to climate change. Unfortunately, in this study, the other climate change variable proved to be insignificant, but in future studies the hope is to implement drought and flood variables to better encapsulate the effects that climate change has on the weather. This will help paint a better picture as to how climate change effects the economy. With that being said, countries should look to implement renewable resources to help limit their CO2 emissions as to limit the promotion of climate change. In future studies, look for better models to show the relationship between climate change and economic growth.

6.0 Conclusion

Looking back through the study, it was seen that CO2 emissions are significant. The results in this study show that it will be necessary to implement policies which look to limit the production of CO2 emissions. Unfortunately, this study does have its limits. In the future, it would be beneficial to assess the effects of drought and floods on economic growth instead of precipitation. This would be important because climate change exacerbates the effects of these natural disasters.

In a future study I would like to implement these variables also. While it is known that these disasters negatively impact economic growth, it would be interesting to see how the effect has either heightened or decreased over the past few years. In general, however, this model shows that the climate change proxies do effect economic growth. While this was a very basic study, it allows us to progress in the future towards newer and different studies that will help the world understand how exactly climate change will effect, hinder or promote economic growth in the future.

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Appendix A - Variable Description and Data Source

Variable	Description	Source
log(GDP)	The natural log of the Gross Domestic Product of a given country.	World Development Indicators
co2e	Carbon dioxide emissions per capita	World Development Indicators
log(pop)	The natural log of the population for a given country.	World Development Indicators
ur	Percent of population located in urban areas.	World Development Indicators
infl	Inflation rate.	World Development Indicators
pr	Millimeters of precipitation.	The World Bank Group
FDI	Amount of Foreign Direct Investment annually.	World Development Indicators

Appendix B - Variables and Expected Signs

Variable	Description	Expected Sign
log(GDP)	**The natural log of the Gross Domestic Product of a given country.**	**n/a**
co2e	Carbon dioxide emissions per capita	+
log(pop)	The natural log of the population for a given country.	+/-
ur	Percent of population located in urban areas.	+
infl	Inflation rate.	+/-
pr	Millimeters of precipitation.	+
FDI	Amount of Foreign Direct Investment annually.	+

Appendix C – Correlation Matrix

	log(GDP)	CO2E	UR	log(POP)	INFL	FDI	PR
log(GDP)	1						
CO2E	.8147	1					
UR	-.6609	-.7812	1				
log(POP)	.7346	.3396	-.409	1			
INFL	-.2397	-.2696	.0586	-.109	1		
FDI	.5883	.6819	-.41	.2658	-.2624	1	
PR	-.6917	-.4311	.2799	-.4703	.2733	-.2099	1