ESSAYS IN DEVELOPMENT ECONOMICS

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I certify that all material in this thesis which is not my work has been identified and that no

material has previously been submitted and approved for the award of a degree by this or any other University.

Signature.....................................

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Abstract

The first paper examines the crop composition effects in 50 African countries from 1960 to 2013. The paper aims to assess the effects of climate extremes and other non-climate-related factors on major agricultural outputs across African countries. The estimation results, using fixed effect regression and ordinary least square both individually and jointly for all African countries, shows that climate extremes are not altogether bad news as it increases hectares planted of some crops. The policy recommendations for the paper are for crop mix and/or substitutability of crops owing to relative changes in the climate-and non-climate-related factors, effective fertilizer policies and increasing agricultural workers productivity in the African countries.

The second paper contributes to the policy debate on the role of political institutions as an intervening factor for the relationship between natural resource abundance (of different types) and growth performance in African countries. Using panel data econometrics for 28 Sub-Saharan African countries from 1960 to 2012, the research finds that good quality institutions can aid economic growth, and natural resource endowments are beneficial in the selected countries and not a curse. The research culminates with discussions on improving executive constraints, political participation and political openness, as these are intrinsic in the institutional measure adopted, in other to optimise the benefits of natural resource endowments.

The third paper compares the results of Datta and Reimer (2013) which is based on 100 countries over 17 years with a similar but expanded analysis of 43 African countries over 22 years. Using various econometric techniques and model specifications, the paper finds a statistically significant reciprocal relationship between income and malaria using both database. This research further finds that income is the largest driver of the negative reciprocal relationship between income and malaria using both database, and lastly that the magnitude of the effect of income on

malaria is higher using the Datta and Reimer (2013) database than in the database of 43 African countries. The research culminates with recommendation on increased economic growth for the African countries and effective distribution of insecticide-treated nets in countries where malaria is rife.

Chapter 1 Introduction

The essays below focus on development economics within the geographical context of Africa. Todaro and Smith (2012, p. 8) defines development economics as the study of "how economies are transformed from stagnation to growth and from low-income to high-income status, and overcome the problems of absolute poverty". This definition pre-supposes that development economics is based on the economic dynamics of developing or poor countries. In other words, development economics is economic growth accompanied by improvement in income distribution and desirable social structure that enriches human lives.

According to World Bank (2013) classification of developing countries- gross national income, all of the 54 African countries are developing countries, hence the need to carry out more empirical research on Africa. According to Nafziger (2006, p.18), Africa's economic prospect is not as bright as the remaining developing countries. Nafziger also write that Africa is the sick child of international economy, as the Gross Domestic Product (GDP) per capita of Africa in 1990 was lower than what it was in 1960. While Africa's economic gross national income per capita was US$1589 in 2010, it ranged from US$180 to US$13,720. This shows the vast inequality and poverty that the region will be marked with, as Dudley Seers (1969) sees development economics as largely addressing the problem of poverty, unemployment and inequality.

Of the development challenges facing African countries, three stands out: using agriculture as a catalyst for economic development; translating natural resource wealth into real sustainable development, and tackling deadly diseases in the continent. To this end, the three essays focus on agriculture for development; the relationship between natural resources and economic growth, and the causal relationship between health and economic growth. The importance of these topics cannot be over-emphasised in Africa as the continent is arguably the richest in natural resource wealth and is yet poor owing to weak institutional framework in the management of natural resource wealth; debilitating effects of infectious diseases and inability to use agriculture as a catalyst for development especially in rural Africa.

The first essay examines the impact of climate and non-climate factors on the composition of crops planted in Africa. The objectives of the research are to: assess the impact of climate factors on the agricultural output of Africa; examine the effect of climate factors on the composition of crops planted within a country, and to compare the composition of crops planted in Africa owing to climate and non-climate factors. The paper review extant literature on climatic impact on agriculture and grouped them into climate- related and non-climate related studies. The research adapts the cross-country agricultural production function of Mundlak, Butzer and Larzon (1997) in an empirical fashion before running various Fixed Effect (FE) regressions for 50 African countries from 1960 to 2013. The research finds that climate extreme can either leads to crop substitution in some countries, decreased hectares planted in some countries and increased hectares of crops planted in other countries. The paper also find that the measure of technical progress is negatively related to hectares of crops planted in Africa and that productivity of workers in 'high-fertilizer' utilising countries needs to be improved. The research culminates with policy discussion on agricultural development in Africa.

The second essay investigates the role of political institution as a mediating factor between natural resource abundance and economic growth in 33 African countries from the period of 1960 to 2012. After reviewing the existing literature on natural resource abundance and institutions and economic growth, the paper then examine the role of polity and regional democratic diffusion on agriculture, crude oil and total natural resources in a panel data framework. The major findings of the paper are that natural resources on their own are a blessing and not a curse and that democratic institutions and polity are growth-enhancing for natural resource abundant countries. This research finding is robust to different specifications and various resources used for specification. The major recommendation of the paper is to improve executive constraints, political participation and openness in the selected African countries, as these measures are intrinsic in the institutional measure chosen for estimation, and are growth-enhancing.

The third essay compares the global studies of Datta and Reimer (DR) 2013 on the probable reciprocal relationship between income and malaria incidence, which is based on 100 countries across the world for the period of 1985-2001, and a similar but expanded analysis of 43 African countries for the period of 1990-2011. I argue that Health Expenditure Per Capita (HEPC), and Insecticide-Treated Nets (ITN) are more germane for malaria-income analysis than the investment share of Gross Domestic Product (GDP) employed by Datta and Reimer. Using Ordinary Least Square (OLS), Two-Stage Least Square (2SLS), Three Stage Least Square (3SLS), and Seemingly Unrelated Regression (SUR), the research finds some similarities: that there is a negative and significant relationship between income and malaria incidence using both DR (2013) database and the 43 African countries; and that income is the largest driver of the negative reciprocal relationship using both database. On the other hand, the research find that the income effect of malaria incidence is higher in magnitude using the DR(2013) database than in using the database of the 43 African countries. The research recommendations for this paper are for increased drive by African governments on boosting economic growth and for effective insecticide-treated nets distributions to areas most prone to malaria incidence.

Chapter 2 Crop Composition Effects in Agriculture in Africa: The Effect of Climate and Non-Climate Related Factors.

2.1 Introduction

Climate change is one of the main global environmental concerns of this century. The United Nations Framework Convention on Climate Change (UNFCCC), in its article 1 defines climate change as: "a change of climate, which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". The Intergovernmental Panel on Climate Change (IPCC), reports that the period 1995-2006 ranks among the warmest 12 year period in terms of global average temperature since 1850. Specifically, year 1998 and 2005 are reported to be the warmest years since 1850 in terms of global surface temperature (IPCC, 2007). The relevance of climatic change to agriculture in Africa is based on the fact that rain-fed agriculture accounts for 88 percent of cultivated area in sub-Saharan Africa (Janvry and Sadoulet, 2011) and increased temperature and low rainfall (if caused by climatic changes) may lead to desertification and low crop yields as argued by IPCC.

According to IPCC (2012), the occurrence of extreme weather events and extreme climate events is what is referred to as 'climate extreme'. In the IPCC report (2012, p.126-7), less emphasis is placed on the difference between weather and climate events, and attention placed on the impact of these events on human lives, agriculture and social development. This research will follow the same tact and estimate the effects of climate extremes on crop yields in Africa.

However, there are non-climatic factors affecting crop yields across African countries e.g. producer prices, fertilizer consumption, irrigation, soil quality and technical progress. In this regard, there is the need to control for these factors so that the climatic factors affecting agricultural production can be properly looked at. In all, this research intends to guide practical policy decision making in agricultural development across African countries.

The importance of this study is predicated on the fact that African economy is largely agricultural and agriculture is the sector employing the largest number of the workforce. On average, agriculture contributed over 18 percent to the African economy over the period of 1960-2010 (African Development Indicators (ADI), 2013). Although, the contribution of agriculture to GDP is on the decrease (which might be due to structural transformation of the economy and/or other factors), the importance of the agricultural sector cannot be over-emphasised for reasons associated with the production of food.

In addition, agriculture plays an important role in African development as a channel for poverty reduction and economic growth (Janvry and Sadoulet, 2011). The agricultural sector also has high multiplier effects on other sectors of the economy, as it supplies raw materials to the industries and also uses manufactured product from the industrial sector of the economy.[1]

The rest of the study is divided into four sections. The next section reviews the literature on determinants of agricultural outputs of various African countries. Section three details the empirical approach. Sections four and five cover results and conclusions, respectively.

2.2 Review of Literature

The literature on agricultural outputs and it's cross-country determinants are vast and so are the approaches. Specifically, the positioning of this research is within econometric studies of crop yield/acreage planted and climate-and non-climate related factors. The review of literature below is under two broad groups: climate-related literature on agricultural output determinants and non-climate-related literature.

For climate-related literature, I shall review literature on agronomic model, Ricardian or Cross-Sectional Model of climate change and agriculture, and studies that infer climate change impact on crops from random weather fluctuations. The other models of the agricultural impact of climate change: integrated assessment models and agro-ecological zone models, which relies on the use of computable general equilibrium models and specialised softwares for assessing land-yield-climate-relationships (and making future forecasts given various climate change scenarios), shall not be considered in this review of literature as I intend to focus more on the

[1] Tractors, hoes, machineries and other agricultural equipments are examples.

studies of crop yield/acreage determinants.

On the other hand, the non-climate-related literature are crop composition studies. I shall critically assess the literature under these categories drawing on the strengths and weaknesses of each approach, and then summarise the literature before making a statement of my contribution to the existing works on the subject.

2.2.1 Climate-Related Literature on Determinants of Agricultural Output

2.2.1.1 Agronomic Model of Agricultural Impact of Climate Change

In terms of nomenclature in the literature of climate change and agriculture, this approach has also been referred to as agronomic-economic method, production function approach, or crop simulation models. This approach estimates impact of climate change or weather variables by varying one of the inputs of crop production. Furthermore, the crop yields forecasts are made under controlled experiments and relies on explicit modeling of agricultural output and climate relationships. For instance, CERES-Maize is a model used for maize yield. The forecasts of maize yield in different regions and at various times is based on experiments (Thornton et al. 2010; Thornton, 2009 and Lobell and Burke, 2010).

In terms of the chronology, this approach is the earliest methodology devised to assess the impact of climate change on agriculture, especially in the United States (U.S.). The advantage of this approach is the detailed modelling of scientific component(s) of crop yield or other agricultural outputs that goes beyond the boundary of economic science.

As the modelling process takes the farmers adaptation to climate change as given; adaptation has to be modelled implicitly in the experiment by alternating growing seasons, crop types, soil types, harvesting dates and technologies (FAO, 2000). In this light, Kaiser et al. (1993) examines three models of atmospheric, agronomic and economic processes and incorporate alternative methods of growing crop into the models as the weather gets drier. Using the various climate change scenarios, Kaiser et al. (1993) find that farmers in Minnesota are better able to cope with changing climate than farmers in other regions of United States by delaying the harvesting seasons, changing crop types, and cultivars.

Criticism of Agronomic Model Mendelsohn, Nordhaus and Shaw (1994) itemised a number of weaknesses in the agronomic model: non-modelling of irrigation or fertilizer in the crop-yield model. Consequently, Mendelsohn, Nordhaus and Shaw (1994) write that the results of the studies of climatic impact on US agriculture as reported in Agronomic studies are overestimated. Moreso, the approach did not give room for substitution of crops in farmlands as some crops are heat loving and other crops that would not grow well as temperature rises above certain threshold.

Deschenes and Greenstone (2007) also criticises agronomic approach as estimating only the long-term climate change impact on agriculture without giving accounts of short-term fluctuations in farmer's profitability owing to varying weather conditions.

2.2.1.2 Ricardian/Cross-Sectional Model of Agricultural Impact of Climate Change

In this section, I focus on Ricardian/Cross-Sectional Model of agricultural impact of climate change pioneered by Mendelsohn, Nordhaus and Shaw (1994 and 1996).

Cross Sectional Models This method is based on adaptive behaviour of farmers to varying climatic conditions and is referred to as the Ricardian approach or Hedonic model, predicated on David Ricardo's theory that changes in future profitability of land gets capitalized into the land value immediately. According to Mendelsohn, Nordhaus and Shaw (1994), the approach is called the Ricardian approach because, "instead of studying yields of specific crops, we examine how climate in different places affects the net rent or value of lands". In the thinking of Mendelsohn, Nordhaus and Shaw (1994), examining the impact of climate change on net farm values measures the direct effect of climate change on crop yields and the indirect effects of other adaptation needs, such as soil quality, fertilizer usage etc.

The model accounts for adaptation of farmers to the impact estimates of climate change to maximise farm net revenues. The model measures the farm revenue/performance across various agro-ecological zones and how it varies with climate variables and irrigation, fertiliser's application and sometimes taxes relevant for agricultural production. The model postulates that farmers are able to mix the "heat-loving" crops with crops that are not heat-loving, in order to maximize farm-level revenue while holding constant the future prices of crop yields. The same logic applies to livestock as farmers will breed various animals in mixed forms in various seasons in order to maximise farm level revenue. The method which was pioneered by Mendelsohn, Nordhaus and Shaw (1994), is usually based on farm surveys at various districts/regions, and has been widely applied in various empirical studies of climate change. In conclusion, the econometric results of this approach are combined with various climate change scenarios to make future forecasts.

Most studies on the agricultural impact of climate change in Africa have been predicated on the Ricardian approach which has been tabulated below.

Table 2.1: Empirical Estimates of Ricardian Approach

Author	**Technique**	**Impact**
Seo & Mendelsohn (2008a)	Newton-Raphson iterative nonlinear optimization 2002-2004 (11 African countries).	Negative: In the next 20 years, the damages will be between US$9billion and US$12billion.
Seo & Mendelsohn (2008b)	Microeconometric model :2 Stage (10 African countries).	50 percent fall in farm income with mixed farm but 75 percent fall in farm income without mixing.
Seo *et. al.*, (2008)	Regression with & without fixed effects 2002-2004 (11 African countries).	Positive in humid and negative in Savannah.
Benhin (2008)	Regression for 416 farms in South Africa for 2002-2003.	$1°C$ increase in temperature will increase revenue by US$80 for the country, US$191 for irrigated farm and US$588 for large scale farms.
Mano & Nhemachena (2007)	Regression for 700 households in Zimbabwe: 2002-2004	$2.5°C$ increase in temperature reduce farm revenues by US$0.4billion and increase revenue by US0.3billion with irrigation

The table detailed the net revenue or loss using measured in US$ for African countries. Despite these literatures on Ricardian approach to climate change, the model has been criticised. The arguments against the accuracy of this approach are presented below.

Criticisms of Ricardian Model The Ricardian approach to estimating agricultural impact of climate change has come under various criticisms. Cline (1996) points out that the approach over-estimates the benefits and under-estimate climate damages by holding future prices of agricultural products constant, as prices could be adjusted to accommodate the impact of climate change and maintain profitability of farmers.

Also, the assumptions of well-defined market and farmer's knowledge in adaptation in Ricardian approach may not hold in developing countries as agricultural education are not readily available in developing countries as is the case in developed countries. Also, in Africa, there is jointness in production and consumption of crops.

Mendelsohn, Nordhaus and Shaw (1996) write that the Ricardian method is limited as omitted variable bias and other statistical inaccuracies could impinge upon the accuracy of the result. Likewise, unwanted variables can also affect the accuracy of the estimate.

Quiqqin and Horowitzn (1999) also criticises the approach for not accounting for adjustments costs which should be the basis of climate change damage estimates. Quiqqin and Horowitzn argues that the specification of temperature by MNS is not accurate.

Additionally, Deschenes and Greenstone (2007) argues that previous estimates of Mendelsohn, Nordhaus and Shaw (MNS) (1994) are not accurate as the cross-sectional model is conceptually mis-specified– the regression estimates changes as the control variables are changed. Deschenes and Greenstone re-specified the cross-sectional regression of MNS; changed year fixed-effects to state-by-year fixed effects and also changed the dependent variable to be agricultural profits which MNS had taken to be land values. Deschenes and Greenstone found a positive impact of climate change on profitability of farmers in the United States to the tune of $1.3 billion in 2002 which MNS had predicted to be negative. In contrast to the findings of Deschenes and Greenstone

(2007), Fisher *et. al.,* (2012), pointed out that the climate data employed by Deschenes and Greenstones are missing and inaccurate and the climate scenarios used are not those considered by IPCC.

2.2.1.3 Economic Studies on Climate Change and Crop-Yield Using Weather Data

Similar to Ricardian approach, these studies are based on production or profit function but here, inference is made for climate change from weather variables. In turn, the production or profit function modelled is estimated using statistical or econometric regression models mostly panel data models. The basic difference between these studies and other studies that uses production function, as Ricardian model, is that these studies make inference for climate change from the econometric results based on weather data or year to year variabilities in temperature and precipitation without using climate change scenarios to make future forecasts**.**

In plain terms, historical crop yield are coupled with weather data and other factors (fertilizer, irrigation, soil quality, etc) to estimate the impact of climate change on agriculture. While the Ricardian model estimate the long term impact of climate change on crop yield, these approach estimates the short term weather variables on crop yield.

In this group, Deschenes and Greenstone (DG) (2007) estimate the effect of short term fluctuations in weather on agricultural land in United States. DG models the profit function of a representative farmer in United States and estimate the empirical model with panel data model based on county level data in the United States. The research find, contrary to the findings of the Ricardian approach, climatic change will increase agricultural profits by $1.3billion in the United States in year 2002, claiming that the econometric results of Mendensohn, Nordhaus and Shaw (1994 and 1996) are highly sensitive to sample, weighting and control variables.

Schlenker and Lobell (SL) (2010) estimate production function for five staple crops in sub-Saharan Africa by linking the logarithm of crop yields with various weather specifications within a panel data framework. SL itemised the benefits of these approach over previous methods of estimating climatic impact on agriculture as follows: (i) actual crop yield responses are preferable to field trials which are based on assumptions; (ii) country fixed effects accounts for other differences that cannot be explicitly modelled or captioned in Africa owing to non-availability of data and, (iii) the model accounts for both short term weather fluctuations and longtime climatic change. For estimation purposes, SL adopt different weather specifications and find that climate extremes reduces the five staple cropyields (maize, sorghum, millet, groundnut, and cassava) by 22, 17, 17, 18 and 8 percent respectively within 1901-2002.

Choi and Helmberger (1993) investigate the sensitivity of prices, and other non-climate factors to corn, wheat and soybean yields using a profit function approach of a typical price-taking farmer from 1964-1988. In the empirical study, climate variables are used as control variables and other non-climate related variables. The research findings are that the crop-yields are insensitive to price but responsive to fertilizer demands. However, the research finds, contrary to conventional wisdom that land idling program or rotation have no significant effect on crop yields.

Similarly, building on the work of Choi and Helmberger (1993) and Braulke (1982), Huang and Khanna (2010) estimate the relationship between cropyield and acreage in the United States using weather variables as part of the predictor variables in the study. In the study, historical data of corn, soybeans and wheat are used to infer the effect of climate and non-climate factors on crop yield and acreage. Huang and Khanna finds through the econometric analysis that wheat and corn yield have an inverted U shape during the period of 1980-1993 while the inverted U shape is not valid for soybean within the period. The main finding is that climatic change reduces the yield of grains in US; however the impact are more severe in some counties.

Criticisms of this Approach SL (2010) itemise the following weakness to this approach: weather shocks are different from, and cannot be used to make inference for climate change; panel data methods used by most of the studies are amenable to the weakness of panel data methods.

2.2.1.4 Crop Composition Effects

As one of the policy reforms advocated for the agricultural sector of many developing countries (Trimmer (1997)), crop composition, crop substitution or crop mix offers to be one of the most feasible. The technique which involves spatial shifts in crops or agricultural outputs to higher- valued crops, even when the productivity of land is constant seem to be one of the most practicable way to increase the profit of farmers. More often than not, this practise requires response mechanism whereby the profit-maximising farmer responds to the signals of the market or re-allocate hectares of land to other crops in other to cope with either climate change or non-climate factors. In a nutshell, the crop composition effects of the agricultural sectors of various African countries measures the changes in the agricultural outputs in order to maximise profits.

Crop composition studies is important because it helps to investigate how the behaviour of farmers change, as a result of climate and non-climate related factors in the allocation of land to crops or to other higher-valued agricultural activities of the farmer that can increase the profitability of the farmer. This approach is to be preferred above the Ricardian model (which is the most popular approach in the literature),which estimates in monetary terms the net benefits or loss of climate change because African markets are underdeveloped and there is non-separability between production and consumption in the agricultural sectors of most African countries.

2.2.2 Summary of Literature Review

Summarising in broad terms, the cross-country determinants of crop yield/acreage planted can be grouped into two categories: studies relating to climate change and non-climate-related studies of agriculture. The models differ in terms of methodology, data requirements and theoretical underpinnings.

While agronomic model relies on laboratory experiment (which is often beyond the bounds of economic science) to determine agricultural output; Ricardian approach estimates the impact of climatic change on net farm values in monetary terms. Furthermore, economic studies that infer climate change using weather data uses historical weather data and econometrics to determine the effects of weather on agricultural output while crop-composition studies use comparative-static technique to determine acreage allocation to crops or crop yields.

These approaches have some limitations in determining the effects of climate and socio-economic factors on relative changes in agricultural outputs across African countries. Firstly, Ricardian approach relies on well-functioning markets which is not obtainable in most African countries and also production and consumption are non-separable in most African countries. Secondly, agronomic model and economic studies that infer climate change from weather studies does not account for substitutability of crops as is the case with Ricardian approach.

The specific aim and objectives of this study are in the next subsection.

2.2.3 Research Objectives and Questions

This paper investigates crop-composition effects of agricultural sectors in 50 African countries in relation to changing climate or weather variables and other shifters of agricultural supply curve.

Specifically, this study intends to:

- assess the impact of climate factors on agricultural outputs in Africa,
- compare the composition of agricultural outputs across African countries owing to climatic and non-climatic factors,
- examine the effect of climate factors on the composition of crops planted within a country.

2.2.4 Statement of Originality and Contribution to Literature

This paper contritubes to extant literature on cross-country determinants of crop-yield/land allocations in various ways. Firstly, the study is the first cross-country study to my knowledge, that will investigate the composition of crops planted and farmers behaviour in 50 African countries. In African context, most of the studies on economic impact of climate change are based on the Ricardian approach and it is usually restricted to 11 African countries (Niger, Burkina Faso, Senegal, Ghana, Kenya, Ethiopia, Cameroun, South Africa, Zambia, Egypt and Zimbabwe).

Hence, this research is more representative of farmers' behaviour in Africa.

At a more detailed level, I shall extend one of the cross-country agricultural production models and obtain a reduced-form regression equation and make inference on the relevance of climate-and-non-climate related factors on agricultural outputs in African countries, as is the fashion in weather/agricultural outputs literature reviewed. Specifically, I shall run a panel data regression for hectares of each crop planted across African countries owing to climate-and non-climate related factors, and also investigate the within-country crops composition owing to climate factors.

Secondly, the crops used in this study are the first-five most cultivated crops, in terms of area harvested, in Africa. According to Rosegrant and Thomas (2012), the top 5 crops in Africa measured in areas harvested from year 2006 to 2008 are millet, sorghum, cowpeas, maize and rice and these the crops selected for estimation in this study.

Lastly, this study is novel in its use of flood, storm, and drought data as measures of climate extremes; no other study in the literature of crop yield and extreme weather events has used this measure. What's been used mostly for in the literature is increase in minimum or maximum temperature and precipitation; degree of cold days or frostiness. This measure chosen is better as it represents the aggregation of weather and climate events into one measure. For instance, floods and droughts are precipitation extremes. Therefore, the phenomena measured are more of long term effects of climatic situations on crop yields (IPCC, 2012 p. 115).

2.3 Empirical Approach

2.3.1 Theoretical Channel

The aim of this research is to investigate crop compositions effects in the agricultural sectors of various African countries due to climate and non-climate relate factors. This section details the theoretical framework of agricultural outputs of various types of crops and the inputs used in the production process. The underlying premise is that the agricultural production function is similar for all the African countries, and producers have the choice of inputs and outputs used for production together with the technique of production. The production function below follows the approach of Mundlak, Butzer and Larzon (1997). Let Z be the vector of inputs and $F_i(Z)$ be the production related to ith technique of production. It is assumed that the production function is twice differentiable and concave, and the available technology, T, the collection of technologies , $T = \{F_i(Z); i = 1, ..., I\}$. The agricultural producers choose the technique of production subject to environment and all their constraints. Here, the inputs used for production is broadly categorised as exogenous environmental inputs (k), such as climate, soil and water quality, and purchased (v) inputs, $z = (v, k)$. The optimisation function aims at the choice of the level of inputs that maximizes acreage allocation to the five crops. For ease of analysis, the comparative statics framework omit the time index, and therefore the Langrangian function is given as:

$$L = \sum_i F_i(v_i, k) \tag{2.1}$$

Subject to $F_i(.)\epsilon T; v_i \succeq 0.$

The solution of this Lagrangian equation is characterised by Kuhn-Tucker necessary conditions, the solution of the optimisation problem is given as: v_i^*, k. The optimal allocation of inputs v_i^* and k, given ith technique yields the optimal output level of $y_i^* = F_i(v_i^*, k)$ and the technology implemented is $IT(c) = \{F_i(v_i, k); F_i(v_i^*, k) \neq 0, F_i \epsilon T\}$ hence, the aggregate production function expresses aggregate outputs as a function of aggregate inputs. The output of interest in this specification is acreage of land devoted to the crops planted in the African countries.

2.3.2 Empirical Approach

Given that the aim of cross-country agricultural production is to allocate the changes in output over time to changes in input with the assumption that the production function in subsection 2.3.1 above is the same across the agricultural sectors of the selected African countries. Specifically, this research intends to infer the relative importance of climate and non-climate factors on the composition of crops planted in the country. Given that the optimal output level $y_i^* = F_i(v_i^*, k)$ contingent on the exogenous environmental inputs, purchased inputs and technical progress (t, t^2). The specification of the climatic factors (k) in the literature has been diverse; this motivated Schlenker and Lobell (2010) to use four specifications. This research follows the same procedure by adopting one of the four climate specifications: quadratic weather specifications. The purchased inputs (v^*)The econometric representation of this equation is given as:

$$y_{it} = \beta_0 + \ \beta_1 EW_{it} + \ \beta_2 EW_{it}^2 + \beta_3 F_{it} + \beta_4 AGV_{it} + \beta_5 t + \ \beta_6 t^2 + c_i + \xi_{it,} \tag{2.2}$$

where $i = 1, ...N$, denoted country dimension and $t = 1, ..T$; and y is the outcome variable, here the hectares planted of each of the five crops. β is a vector of inputs (both exogenous environmental and purchased), and the error term ξ,is assumed to be independent and identically distributed as: $\xi_{it} \sim N(0, \sigma^2)$. The quadratic time trend in this regression is to capture technical progress modelled in the theoretical subsection above (where t denotes time and t^2 is time squared). The term-EW- denotes floods, droughts, storms and other forms of extreme weather events as percentage of population, and EW^2 is squared measure of extreme weather events, and F denotes fertilizer application on agricultural land, and AGV agricultural value-added per worker. As countries differ in terms of fertilizer application, soil quality and other country-specific characteristics; there is a need to capture this in the regression within a fixed-effect framework and that why c_i is included in the model specification. The specification of the empirical approach above follows the approach adopted by (Schlenker and Lobell (2010), Kaufmann and Snell (1997) & Isik and Devados (2006)). The justification for the specification above is that implemented technology is dependent on state variable and exogenous variable.

2.3.2.1 Data & Variables Description

Areas Cultivated: Data for land under cultivation in hectares at country level for (cowpeas, maize, millet, rice and sorghum) is used as dependent variable in all the regressions. These crops are used as they both constitute the major crops grown in Africa and main source of calories. The data reported in ADI contains dry grains only. Also, according to the data compiled by International Food Policy Research Institute (IFPRI) as cited by Rosegrant and Thomas (2012), the crops used are the top five planted in Africa. For instance, in Western Africa between the period of 2006-2008, 16002237,14288715,10297759, 7747435 and 5725947 are planted in hectares planted for millet, sorghum, cowpeas, maize and rice respectively. Furthermore, these fives crops are important sources of nutrition in the 50 African countries and are also cash crops in many African countries. The data is available at ADI (2013). The variables used for regressions are defined below:

*aco= Areas cultivated for cowpeas per hectares,

*ama= Areas cultivated for maize per hectares,

*ami= Areas cultivated for millet per hectares,

*ar= Areas cultivated for rice per hectares and,

*as= Areas cultivated for sorghum per hectares.

Fertilizer (F): The data of fertilizer application on crop land used in this study is nitrogen plus phosphate P205 nutrients in total. The data was sourced from FAOSTAT. This variable is used as one of the predictor variables in the models in equation 2.2 above.

Agricultural Value-Added per Worker (AGV): Agricultural value-added per worker measured in constant US $ is used as one of the measures of agricultural productivity in African countries. The variable is retrieved from ADI (2013). This variable is used as one of the independent variables in equation 2 above.

Extreme weather measure (EW, EW2): The data chosen to represent extreme weather events is the data representing the effect of floods, drought, storms (and other climate related disasters) as it affects agricultural land. The data is available at EM-DAT (The international disaster database). In the recent IPCC (2012) publications, it has been established that extreme weather event such as floods, drought and storms affect agricultural farmlands and output more devastatingly than increase in minimum temperature and other measures of climate extremes that are used in the literature of climate change and crop yield. As the impact of extreme weather in the database was not measured in acreage lost but in the number of human lives affected; the impact of extreme weather events are captured by estimating the percentage of human lives affected by floods, drought, storms, and other extreme weather events. This is estimated as (total number of people affected by extreme weather events/total population * 100). This variable is used as one of the predictor variables of crop acreage planted. The squared form of extreme weather event (EW2) is added to the specification as previous literature shows that climatic factor is in quadratic term (Schlenker and Lobell 2010).

I settled for this measure in African countries as against the weather data by Climate Research Unit (CRU) as the emerging consensus in measuring the effect of climatic impact on agriculture is to use measures of extreme weather event (IPCC, 2012). Moreso, the time-series data of extreme weather data of temperature, precipitation, and frost in Africa and South-Asia are limited; which could either be due to non-availability of weather stations, restricted access to weather data by institutions, short-period data or data with gaps, and ill-maintained weather stations (Ramirez-villegaz and Challinor (2012, p.27)).

2.3.2.2 Summary Statistics and Exploratory Graphs

Table 2.3 below details the summary statistics of the variables to be used for estimation. Data on the crop yields show that there is variabilities in yield and acreage planted in different African countries. On average, 415091.1, 474372.6, 446422.5, 147395.6 and 479128.4 hectares of cowpea, maize, millet, rice and sorghum are planted from 1960 to 2013 in African countries.

Also, the hectares planted are vastly dispersed across African countries, hence, all variables are expressed in logarithmic term to reduce the spread of data.

Aside from the summary statistics, figure 2.1 below show the dynamics of extreme weather events (droughts, storms, floods and other extreme weather events), from 1960 to 2013 as percentage of percentage of population. As expected, the fluctuations in the graph show the erratic nature of extreme weather events with peaks of these events from lates 1960s to early 1980s in Eritrea, Tunisia, and Mauritania; and Zimbabwe, Kenya, Congo DR and Sao Tome and Principe.

Furthermore, Figures 2.1 to 2. 6 shows the relationship between Extreme Weather (ew) and areas cultivated for maize, millet, cowpeas, rice and sorghum per hectares respectively. The graphs show that on average, there is a negative relationship between hectares of crops planted and extreme weather event. Given that there might be a negative relationship between extreme weather events and acreage planted of various crops; there is the need for further research on how this will impact on the composition of crops planted within a country and for African as a continent in a panel data context.

Table 2.2: Summary Statistics

Var	**Obs**	**Mean**	**Std. Dev**	**Min**	**Max**
aco	823	415091.1	959770.8	781	5600000
ama	2479	474372.6	840259.5	14	6000000
ami	1872	446422.5	1023930	216	7300000
ar	2165	147395.6	317651.9	0	2700000
as	2084	479128.4	1127804	20	9900000
f	333	25.16754	73.30651	0	521.2
ew	2602	1.672368	8.246752	0	118.0255
ew2	2700	68.21056	635.6173	0	13930.02
t	2700	27.5	15.58867	1	54
t2	2700	999.1667	884.4608	1	2916
agv	1275	759.8944	887.996	33.1165	6013.12

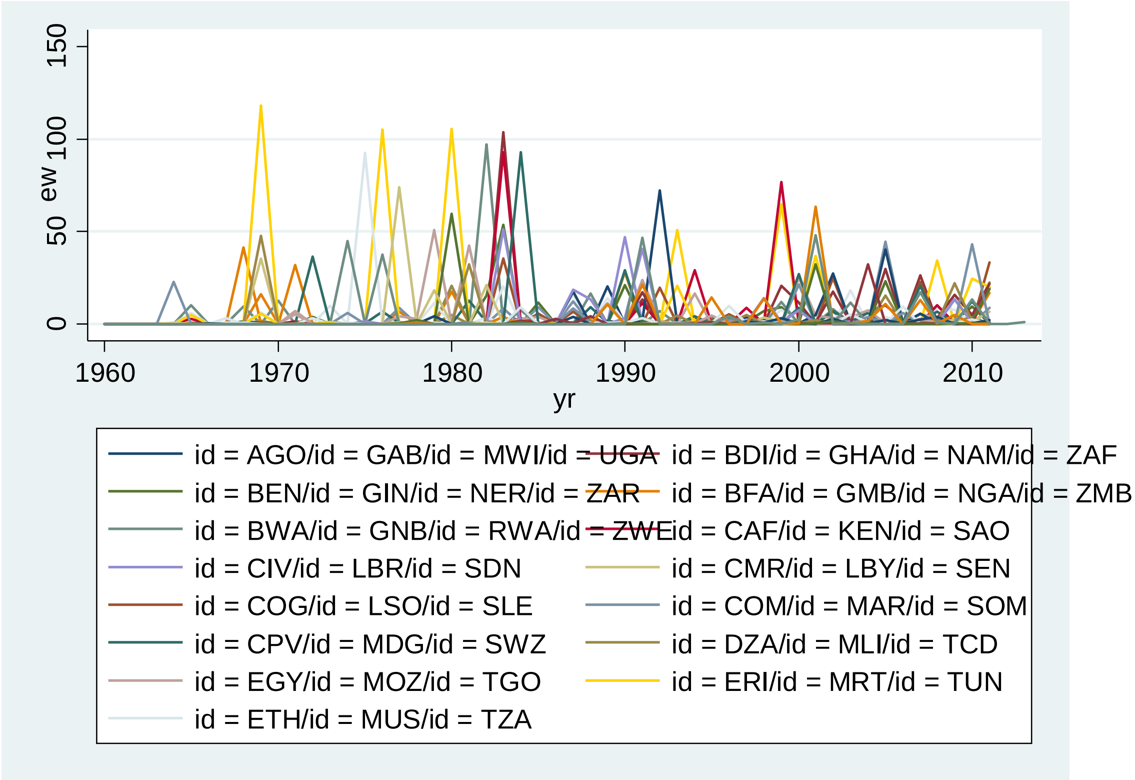

Figure 2.1: Graph of Extreme Weather Event as Percentage of Population Affected from 1960-2010

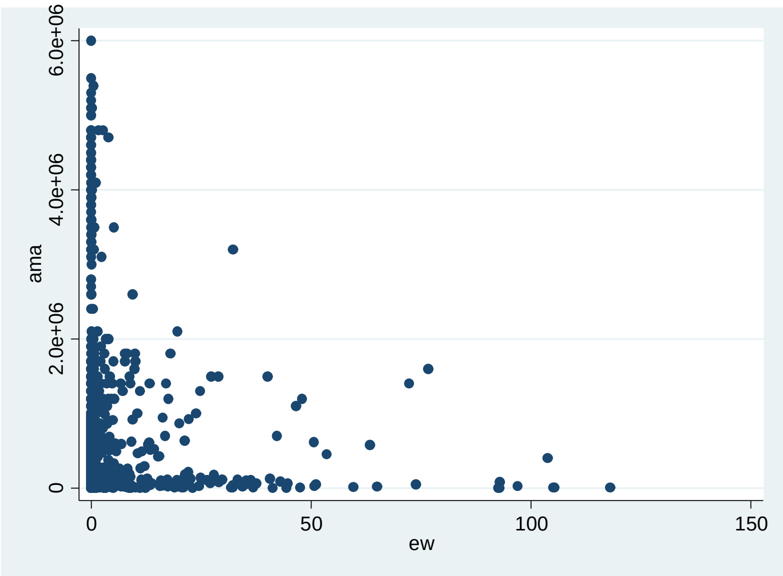

Figure 2.2: Graph of Hectares of Maize planted vs Measure of Extreme Weather Event

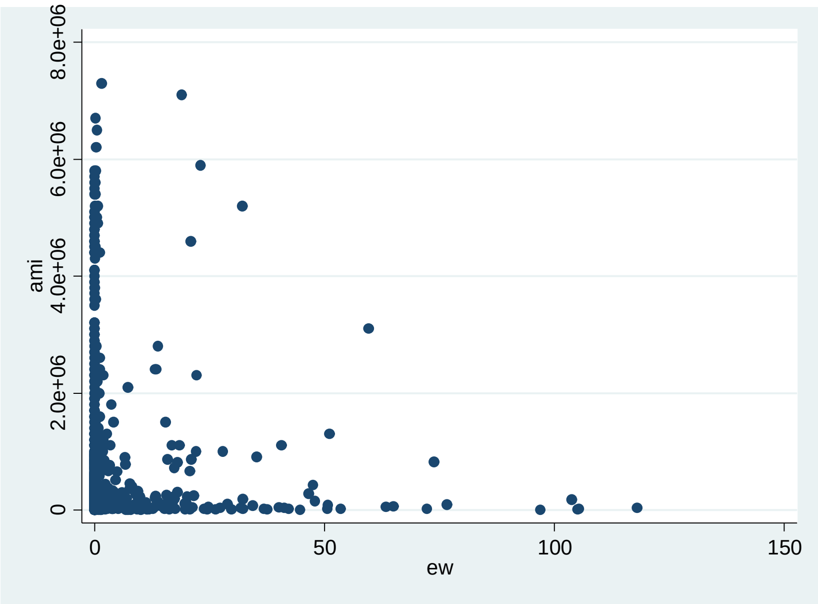

Figure 2.3: Hectares of Millet Planted vs Measure of Extreme Weather Event

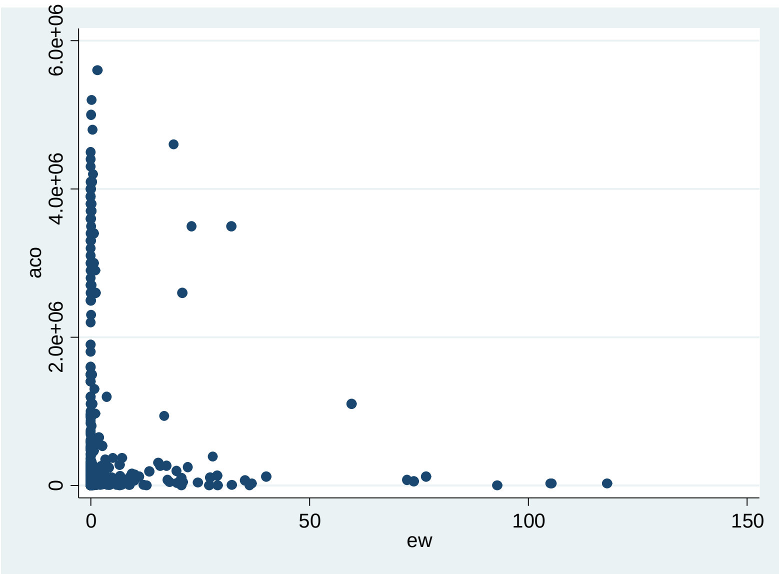

Figure 2.4: Hectares of Cowpeas Planted vs Measure Extreme Weather Events

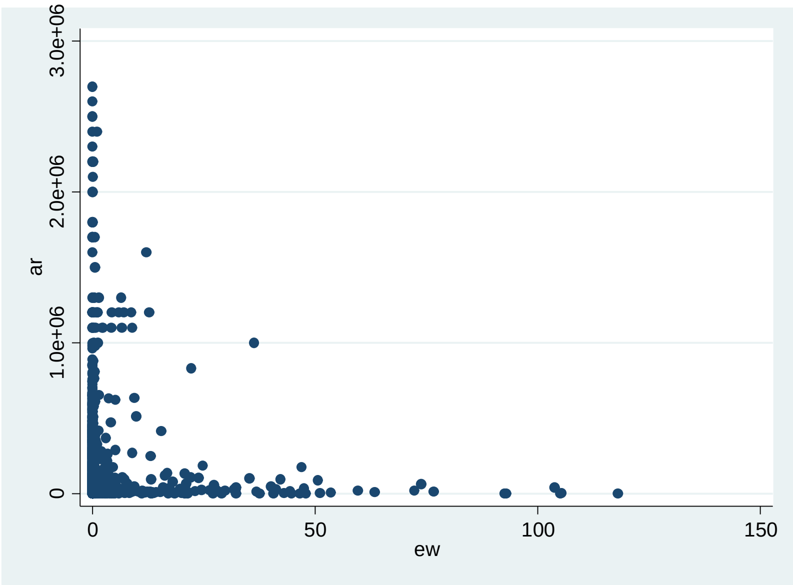

Figure 2.5: Hectares of Rice Planted vs Measures of Extreme Weather Event

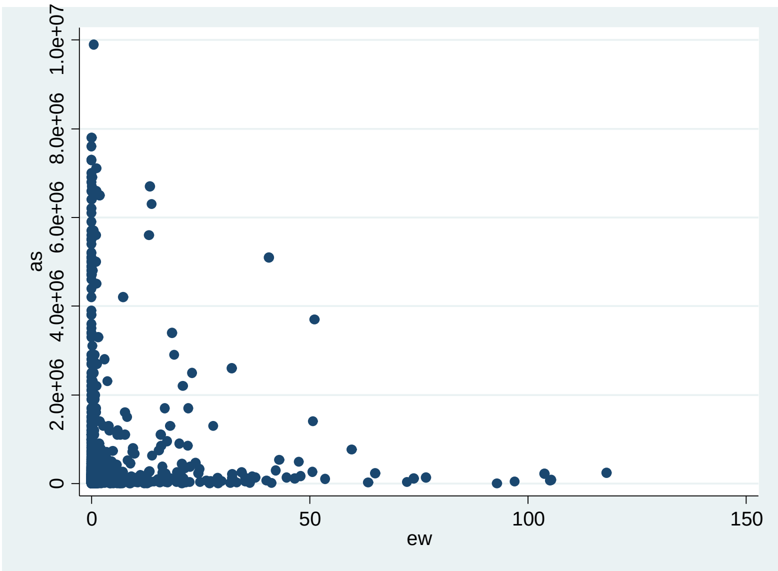

Figure 2.6: Hectares of Sorghum Planted vs Measure of Extreme Weather Event

2.4 Results

2.4.1 Regression Results for All African Countries

Firstly, in line with the research objective, I ran regressions of equation 2.2 above with a view to comparing the composition of Agricultural outputs across African countries owing to climate-and non-climate related factors. The regression result displayed in table 2.3 below shows that extreme weather events as percentage of population, in levels, has a negative and significant impact of acreage planted for maize while the squared term is positive. The estimates for other crops are statistically insignificant, thus not different than zero. The estimate for maize indicates that a 1% percent increase in the extreme weather events as percentage of population will reduce the hectares of maize planted by 0.0071%.

The coefficient for fertilizer application for the hectares of land planted for rice gives 0.0458 indicating that 1% increase in fertilizer application increase hectares of rice planted by 0.0458%. The estimates for the four other crops are not statistically significant.

Agricultural value-added is also positively related to the acreage of rice planted (0.7258%). In terms of size of significant estimates, agricultural value added per worker is the largest indicating that workers productivity plays a significant role in acreage planted of different crops.

However, the term representing technical progress (time trend) has negative impact on acreage planted millet and rice at levels, and a positive and significant squared term. This implies that as technical progress increases, say by 1% in the African countries, hectares of rice and millet planted decreases by 0.25% and 0.3280% respectively. This finding is contrary to the findings of Isik and Devadoss (2006) that technological progress has a positive and significant relationship with mean yield in Idaho, United States.

2.4.2 Regression Results with Climate Factors Only for All African Countries

Secondly, this research intends to assess the impact of climate factors on agricultural outputs.

Regression results displayed in table 2.4 in the appendix section shows that only the hectares planted for maize has significant relationship with extreme weather event at levels and in squared term. The table shows that extreme weather event, in levels, leads to increase in hectares planted for maize but the estimates for other crops are not statistically significant. On the other hand, the squared term of extreme weather events shows a negative and significant relationship with hectares planted of maize and rice implying that fewer hectares of maize and rice would be planted if the extreme weather event doubles in it's occurrence.

2.4.3 Regression Results Based on Fertilizer Usage

Schlenker and Lobell (2010) established that Zimbabwe and South Africa are historically characterised with high fertilizer usage and that may affect agricultural output in these countries. Therefore, I divided the 50 African countries according to fertilizer usage: low fertilizer utilising-and high fertilizer utilizing countries; and ran the regression of equation 2.2 again. The high fertilizer utilising countries are South Africa and Zimbabwe and the remainder 48 African countries are low fertilizer utilizing countries. The regression results are displayed in tables 2.5 and 2.6 in the appendix section below.

2.4.3.1 Regression Results for Low Fertilizer African Countries

The regression results displayed in table 2.5 shows that extreme weather events have a negative and significant relationship with hectares planted of millet by 0.01311 implying that a 1% increase in extreme weather event as percentage of population decreases the hectares of millet planted by 0.01311%. The estimates for the four other crops are not different than zero.

Fertilizer application to agricultural land has a positive relationship with hectares planted of millet, rice and sorghum respectively. Specifically, a 1% increase in fertilizer application increases hectares planted of millet, rice and sorghum by 0.0377%, 0.04741% and 0.03939% respectively.

Similarly, agricultural value-added per worker has a significant and positive relationship with hectares of rice planted but the estimates for other crops are not statistically significant. Time trend is significant and negative for hectares of millet and rice planted implying that as technical progress increases, there would be contraction of hectares of millet and rice planted.

2.4.3.2 Regression Results for High Fertilizer African Countries

The regression results for South Africa and Zimbabwe subsets as displayed in table 2.6 below shows that the squared term of extreme weather event is positive and significant for hectares of maize and sorghum planted but extreme weather events for the four crops are not different from zero.

Quite strikingly, fertilizer application to agricultural land have a negative and significant relationship with hectares rice planted in these two countries. Perhaps, the increased fertilizer application in these countries is to compensate for the shrinking allocation of land to rice planted. The estimates for other three crops are statistically insignificant.

Also, agricultural-valued-added per worker for South Africa and Zimbabwe are significant and negatively related to hectares planted of maize and sorghum. Contrary to the results in the previous regressions, the measure of workers productivity is negative in high fertilizer African countries.

2.4.4 Regression Results for Crops Composition Within a Country

Lastly, in line with the third objective of this research, the regression results displayed in tables 2.7-2.9 reports the composition of crops planted within each of the 50 African countries as a result of climate factors only. In the tables below, there are three categories of countries based on the effect of climate factors on the allocation of land: countries where there is re-allocation of hectares of crops planted from some crops to the others; countries where extreme weather events leads to increased hectares of crops planted, and countries where the climate factors brinks about reduced allocation of land to the different crops planted.

Firstly, the occurrence of extreme weather event would lead to less of some crops being planted and more of other crops being planted in terms of hectares allocation, in Angola, Burundi, Egypt, Gambia, Malawi, Sierra Leone, South Africa, Sudan, Uganda and Zambia. In Angola a 1% increase in extreme weather events will cause hectares of maize planted to increase by 0.0162% but reduce the hectares of rice planted by 0.0583%. The estimates for other crops in these countries are not statistically significant thus cannot be used for policy recommendations. Similarly, a 1% increase extreme weather events in Burundi would cause hectares of maize and millet to reduce by 0.0017% and 0.0071% respectively while increasing the hectares of rice and sorghum by 0.03432% and 0.0093%. In Egypt, a 1% increase in extreme weather events would cause the acreage of cowpeas planted to reduce by 1.0309% while increasing the acreage of maize planted by 0.38995%. Similar policy implications implies applies for the remainder of the countries under these category.

Secondly, climate factors would cause more hectares of crops to be planted in Cape Verde, Comoros, Gabon, Guinea, Guinea Bissau, Kenya, Mauritius, Morocco, Namibia, Tanzania, Togo and Tunisia. Specifically, in Cape Verde, Comoros, Gabon, Morroco, and Namibia, only one crop is statistically significant and positively related to extreme weather events. The estimates for other hectares are not significant so, it's difficult to infer if climate factors are beneficial in these countries.

Lastly, the climate factors would cause a contraction of hectares planted of different crops in Benin, Congo Republic, Ghana, Lesotho, Madagascar, Nigeria, Sao Tome & Principe, Senegal, Somalia, and Zimbabwe.

2.4.5 Post Estimation Test

There are two issues that bear noting in the estimation of equation (2.2). Firstly is the issue of constant variance. It's likely that the error terms are correlated among nearby geographical areas, and other factors which will invalidate the assumption of constant variance/homoskedasticity. To address this issue, all regressions are run with vce(robust) command in stata which uses Huber/White heteroskedasticity-consistent standard errors.

Secondly is the issue of collinearity. In the data used for estimation, soil quality in the hectares planted in all the 5 crops chosen for estimation are perfectly related so the variable is dropped owing to perfect collinearity.

2.5 Conclusion

This paper investigates composition of crops planted across and within African countries owing to climate and non-climate factors. Specifically, this paper adapts a model of cross-country agricultural production function, and implement this theoretical model by fixed effect regression to estimate the effect of climate- and non climate factors on hectares planted of cowpeas, maize, millet, rice and sorghum across and within 50 African countries from the period of 1960-2013 using country level data. The estimated model is then used to infer the impacts of extreme weather events, and non-climate factors on the hectares of various crops planted in African countries.

The results from the econometric model for all African countries and for low-fertilizer utilising countries shows that extreme weather events would cause lesser hectares of maize and millet to be planted. The estimates for the other crops are not statistically significant so will used for policy recommendation. However, the regression results of climate factors only show that more hectares of maize will be planted across the African countries. On the policy side, there would be need for adaptation and mitigation strategy (ies) to be adopted by the government of various African countries to cope with, or prevent the occurrence of floods, storms, droughts and other climatic factors as it affects the agricultural sector.

Fertilizer application to the hectares planted of various crops is found in this paper to increase with the hectares of millet, rice, and sorghum planted in joint regression for the African countries and also in the low fertilizer utilising countries subset. On the contrary, unsurprisingly, the amount of fertilizer applied to the agricultural land is negatively correlated to the hectares planted of rice planted in South Africa and Zimbabwe, which are high fertilizer utilising countries. Given these results, more fertilizer would need to be supplied to agricultural producers across African countries and also in the low fertilizer utilising African countries.

Furthermore, agricultural value-added per worker, a measure of agricultural workers productivity, is found to be positively correlated with hectares of rice planted in the joint regression and in the regression subset for low-fertilizer utilising countries. Given the importance of workers productivity to agricultural output; policies geared toward increased workers productivity should be adopted in by the agricultural producers in the African countries. On the flip side, the regression subset for high fertilizer utilising African countries shows that agricultural productivity is negatively related to the hectares of maize and sorghum planted. The policy recommendation for South Africa and Zimbabwe regarding workers productivity is that more should be done by the producers to improve on it, as high fertilizer application to the agricultural land should not be a deterrent to workers productivity in agricultural production.

Time trend is negative in all the regressions indicating that the higher the technical progress, the lower the hectares of land allocated to millet and rice in all the African countries. This can be due to structural transformation in the economy or any other factor.

The within-country regressions shows that the occurrence of extreme weather event would either cause more of hectares of some crops to be planted while lesser of other crops are planted; increase the hectares planted of crops in the country or decrease the hectares of crops planted within the country. The regression results shows that the effect of extreme weather events on the composition of crops planted within a country therefore cannot be generalised as the effect is contingent on the country been analysed. Therefore, as climate extreme is beneficial to some crops, there can be crop mix or substitution in different countries in order to cope with the negative effects of climate change.

There is room for much additional research on the estimation of impact of extreme weather event on the composition of crops planted within and across African countries. For example, there is the need to compare the econometric studies on climate impact on agriculture in Africa in relation to realities in these countries.

Table 2.3: Fixed Effect Regression for All African Countries

Variable	**Cowpeas**	**Maize**	**Millet**	**Rice**	**Sorghum**
Extreme Weather	0.0169	-0.0071	0.0095	0.0029	-0.0106
	(0.0226)	(0.0039)*	(0.0059)	(0.0099)	(0.0074)
Extreme Weather^2	-0.0003	0.00024	0.00026	-0.00004	0.0004
	(0.0006)	(0.0001)*	(0.0002)	(0.0003)	(0.0003)
Fertilizer	-0.02287	-0.00693	0.0363	0.0458	0.03853
	(0.0391)	(0.0127)	(0.0209)	(0.0179)**	(0.0241)
Agric.Value-added	-0.8237	0.1676	-0.1321	0.7258	0.2393
	(0.6124)	(0.1545)	(0.2624)	(0.2081)***	(0.3962)
Time Trend	0.1699	-0.09438	-0.2567	-0.3280	-0.1129
	(0.1693)	(0.1026)	(0.1094)**	(0.1667)*	(0.1331)
Time Trend^2	-0.0014	0.0012	0.0029	0.00398	0.0013
	(0.002)	(0.0011)	(0.0012)*	(0.0018)**	(0.0015)
Constant	11.2055	12.946	17.9471	12.4097	12.2756
	(5.4563)*	(2.4687)**	(2.192)***	(3.7074)***	(3.4682)***
Observation	114	265	214	241	240
Prob>F	0.163	0.2001	0.0246	0.0011	0.3908
$R^2(Within)$	0.0893	0.0535	0.0847	0.3130	0.0485
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
* , **, *** indicate that the parameter is significant at 10%,5% and 1% levels respectively.					

Table 2.4: Fixed Effect Regression with Climate Factors Only

Variable	**Cowpeas**	**Maize**	**Millet**	**Rice**	**Sorghum**
Extreme Weather	0.0074	0.0066	0.0019	0.0133	0.00274
	(0.0050)	(0.0025)**	(0.0036)	(0.0082)	(0.00386)
Extreme Weather^2	-0.00008	-0.00008	-0.00003	-0.00019	-0.00005
	(0.00005)	(0.00003)***	(0.00005)	(0.0001)*	(0.00004)
Constant	10.9697	11.3148	11.2719	9.8733	11.4836
	(0.0059)***	(0.0028)***	(0.0032)	(0.0074)***	(0.0043)***
Observation	785	2385	1800	2065	2005
Prob>F	0.3003	0.0266	0.8401	0.1310	0.0438
$R^2(Within)$	0.0047	0.0016	0.0003	0.0055	0.0012
Country Fixed Effect	No	No	No	No	No
* , **, *** indicate that the parameter is significant at 10%,5% and 1% levels respectively					

Table 2.5: Fixed Effect Regress for Low Fertilizer African Countries

Variable	**Cowpeas**	**Maize**	**Millet**	**Rice**	**Sorghum**
Extreme Weather	0.01836	-0.0057	-0.01311	0.00615	-0.01231
	(0.0232)	(0.0041)	(0.0057)**	(0.0107)	(0.0075)
Extreme Weather^2	-0.00021	0.00017	0.0003	-0.0002	0.00032
	(0.0006)	(0.0001)	(0.0002)*	(0.00029)	(0.0002)
Fertilizer Applicat.	-0.01975	-0.00625	0.0377	0.04741	0.03939
	(0.03888)	(0.0128)	(0.0207)*	(0.01799)**	(0.0236)***
Agric. Value-Ad	-0.8674	0.2468	0.0097	0.83703	0.59712
	(0.6323)	(0.1912)	(0.3373)	(0.2385)***	(0.3622)
Time Trend	0.1752	-0.1056	-0.2593	-0.3545	-0.09187
	(0.1752)	(0.1059)	(0.1155)**	(0.1713)**	(0.1421)
Time Trend^2	-0.0015	0.0013	0.00288	0.00481	0.00095
	(0.0021)	(0.0012)	(0.0013)**	(0.0019)**	(0.0016)
Constant	11.3533	12.5291	17.3267	12.6359	9.9245
	(5.4121)*	(2.6595)***	(2.2893)***	(3.9881)***	(3.5527)***
Observation	105	247	196	223	222
Prob>F	0.0000	0.0202	0.0000	0.0002	0.1763
$R^2(Within)$	0.0956	0.0688	0.0982	0.3673	0.0934
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
* , **, *** indicate that the parameter is significant at 10%,5% and 1% levels respectively					

Table 2.6: Fixed Effect Regression for Higher Fertlizer Countries

Variable	Cowpeas	Maize	Millet	Rice	Sorghum
Extreme Weather	-	-0.0098	0.02162	-0.00276	-0.0299
	-	(0.0018)	(0.0087)	(0.0027)	(0.0067)
Extreme Weather^2	-	0.0004	-0.0005	0.0002	0.00159
	-	(0.00002)**	(0.0003)	(0.00006)	(0.00018)*
Fertilizer	-	0.4384	-0.5504	-0.6646	-0.5638
	-	(0.4129)	(0.2464)	(0.0074)***	(0.7222)
Agric.Value-added	-	-0.3167	-0.4626	-0.0136	-0.52389
	-	(0.0190)**	(0.1531)	(0.0395)	(0.0511)*
Time Trend	-	-0.7839	-0.7230	-1.1619	-1.6853
	-	(1.2587)	(0.8632)	(0.1289)*	(1.5867)
Time Trend^2	-	0.0081	0.0076	0.01195	0.01834
	-	(0.0132)	(0.0088)	(0.0015)*	(0.01665)
Constant	-	37.1876	33.0189	36.8919	55.804
	-	(31.0845)	(22.7783)	(2.5191)**	(39.8666)
Observation	-	18	18	18	18
Prob$>$F	-	-	-	-	-
$R^2(Within)$	-	0.5188	0.4987	0.5467	0.5627
Country Fixed Effect	Yes	Yes	Yes	Yes	Yes
* , **, *** indicate that the parameter is significant at 10%,5% and 1% levels respectively					

Table 2.7: Country-Specific Regressions

Country	Cowpeas	Maize	Millet	Rice	Sorghum	Obs
Algeria	-	0.2784		0.0905	0.2037	50
	-	(0.2575)		(0.1611)	(0.2948)	
Angola	-	0.0162	-0.0016	-0.0583	0.2513	50
	-	(0.0064)**	(0.0093)	(0.0086)***	(0.2519)	
Benin	-	0.0015	-0.0086	0.004	-0.0026	50
	-	(0.0036)	(0.0037)**	(0.0098)	(0.0018)	
Botswana	-	-0.0031	-0.0008	-	-0.0038	50
	-	(0.0027)	(0.0042)	-	(0.0035)	
BurkinaFaso	-0.0011	-0.0034	-0.0032	0.0026	0.0014	50
	(0.0113)	(0.017)	(0.0045)	(0.0017)	(0.0048)	
Burundi		-0.0017	-0.0071	0.03432	0.0093	50
		(0.0008)**	(0.0022)***	(0.0116)***	(0.0035)**	
Cameroon	7.4148	-0.0019	0.06454	-0.06805	-0.0216	50
	(4.8783)	(0.0453)	(0.03700)*	(0.0325)**	(0.0092)**	
Cape Verde	-	0.1322				50
	-	(0.0466)***				
Central A. R	-	0.3452	0.06314	0.4079	0.0898	50
	-	(0.2331)	(0.07403)	(0.2595)	(0.1250)	
Chad	-	-0.0088	-0.00899	0.0022	-0.0074	50
	-	(0.0229)	(0.0087)	(0.0073)	(0.0078)	
Comoros	-	-0.0011			0.00449	50
	-	(0.0042)			(0.0022)*	
Congo DR	0.05932	0.0209	0.0444	0.0775	-0.04022	50
	(0.0761)	(0.1521)	(0.1048)	(0.1185)	(0.2539)	
Congo	-	-0.1944		-0.18679		50
	-	(0.0922)**		(0.0960)*		
Cote D'Ivoire	-	2.5688	0.6661	4.1021		50
	-	(5.3674)	(1.4749)	(2.9273)		
Egypt	-1.03094	0.38995	-	0.04843	-0.12462	50
	(0.3462)***	(0.0967)***	-	(0.4175)	(0.2219)	
Eritrea	-	0.0013	-0.0005		0.01233	19
	-	(0.0028)	(0.0022)		(0.0113)	
Ethiopia	-	0.0090	-0.0089	0.02641	0.0041	50
	-	(0.004)**	(0.01007)	(0.0324)	(0.0082)	
Gabon	-	0.5885		-0.0373		50
	-	(0.1261)***		(0.2087)		
Gambia	-	-0.03117	-0.00692	0.0131	-0.0102	50
	-	(0.0061)***	(0.0033)**	(0.0022)***	(0.0026)***	
Ghana	-	-0.0010	0.00005	-0.0064	-0.00035	50
	-	(0.0011)	(0.0005)	(0.0010)***	(0.0006)	
* , **, *** indicate that the parameter is significant at 10%,5% and 1% levels respectively						

Table 2.8: Country-Specific Regressions

Country	Cowpeas	Maize	Millet	Rice	Sorghum	Obs
Guinea	-	1.8661	1.846	1.1472	0.47904	50
	-	(1.0694)*	(1.3035)	(0.6241)*	(0.3138)	
Guinea Bissau	0.08272	0.1164	0.1123	0.03514	0.1085	50
	(0.01599)	(0.0398)***	(0.0292)***	(0.0242)	(0.0285)***	
Kenya	-0.00021	0.00329	0.00257	0.0097	-0.0025	50
	(0.0014)	(0.0017)*	(0.0018)	(0.0054)*	(0.002)	
Lesotho	-	-0.0031			-0.0132	50
	-	(0.0020)			(0.0071)*	
Liberia				0.00348		50
				(0.0033)		
Madagascar	-0.01313	0.00073		0.00211		50
	(0.0059)**	(0.0096)		(0.0045)		
Malawi	0.00592	0.00397	0.00029	0.0016	-0.00885	50
	(0.0038)	(0.0014)***	(0.0062)	(0.0067)	(0.0036)***	
Mali	0.0099	0.03231	0.02227	0.02549	0.0221	50
	(0.01574)	(0.0428)	(0.01668)	(0.0248)	(0.0174)	
Mauritania	0.00026	0.0004	0.00032	-0.0092	-0.0028	50
	(0.0004)	(0.0015)	(0.0034)	(0.0054)	(0.0033)	
Mauritius	0.01399			0.02204		50
	(0.0032)***			(0.0053)***		
Morocco	-	-0.3827	-0.3190	0.5739	-0.7574	50
	-	(0.2417)	(0.4271)	(0.3132)*	(0.5308)	
Mozambique	0.02115	-0.0003	-0.0033	0.0027	-0.00021	50
	(0.0395)	(0.0052)	(0.0069)	(0.0043)	(0.0032)	
Namibia	-	0.01616	0.01318		-0.0042	50
	-	(0.0086)**	(0.0076)		(0.0076)	
Niger	0.0098	0.0106	0.0085	0.0020	0.00998	50
	(0.0116)	(0.0089)	(0.0068)	(0.0035)	(0.0118)	
Nigeria	-0.1951	-0.0252	-0.2007	0.1114	-0.1837	50
	(0.0440)***	(0.1506)	(0.0412)***	(0.1758)	(0.0408)***	
Rwanda	-	-0.00093	0.0039	-0.01676	-0.0007	50
	-	(0.0033)	(0.0041)	(0.0103)	(0.0021)	
Sao Tome& Principe	-	-0.0054	-	-	-	50
	-	(0.0012)***	-	-	-	
Senegal	-0.0069	-0.0053	-0.0006	-0.0014	-0.00296	50
	(0.0021)***	(0.0018)***	(0.0005)	(0.0022)	(0.0007)***	
Sierra Leone	-	-0.0784	0.1566	-0.04272	0.1652	50
	-	(0.0202)***	(0.0209)***	(0.0103)***	(0.0262)***	
Somalia	-	-0.0098	-	-0.0075	0.0033	50
	-	(0.0046)**	-	(0.0081)	(0.0031)	
* , **, *** indicate that the parameter is significant at 10%,5% and 1% levels respectively						

Table 2.9: Country Specific Regressions Continued

Country	**Cowpeas**	**Maize**	**Millet**	**Rice**	**Sorghum**	**Obs**
South Africa	-0.0083	-0.0065	-0.0035	0.0039	-0.01187	50
	(0.0017)***	(0.0018)***	(0.0013)***	(0.0007)***	(0.0053)**	
Sudan	-	0.0113	0.0046	-0.02182	0.0107	50
	-	(0.007)	(0.0051)	(0.0106)***	(0.0054)**	
Swaziland	0.0003	0.0015	-	-0.0125	-0.0041	50
	(0.0009)	(0.0011)	-	(0.0111)	(0.0062)	
Tanzania	0.0624	0.05865	0.0104	0.0917	0.0323	50
	(0.0168)***	(0.0232)**	(0.0114)	(0.0282)***	(0.0152)**	
Togo	-	0.0284	0.0098	0.0152	0.0307	50
	-	(0.0285)	(0.0228)	(0.0268)	(0.0145)**	
Tunisia					0.1427	50
					(0.0494)***	
Uganda	0.0100	0.1209	-0.1073	0.3159	-0.0057	50
	(0.0323)	(0.0682)*	(0.0328)**	(0.1383)**	(0.0309)	
Zambia		-0.0061	-0.0071	0.0207	-0.01599	50
		(0.0025)**	(0.0041)*	(0.0106)*	(0.0039)***	
Zimbabwe	-	0.0023	-0.0091	-0.02345	-0.0022	52
	-	(0.0018)	(0.0042)**	(0.0053)***	(0.0041)	
* , **, *** indicate that the parameter is significant at 10%,5% and 1% levels respectively						

Table 2.10: The 50 African Countries Chosen for Estimation

Algeria	DZA	Libya	LBY
Angola	AGO	Madagascar	MDG
Benin	BEN	Malawi	MWI
Botswana	BWA	Mali	MLI
BurkinaFaso	BFA	Mauritania	MRT
Burundi	BDI	Mauritius	MUS
Cameroon	CMR	Morocco	MAR
Cape Verde	CPV	Mozambique	MOZ
Central African Republic	CAF	Namia	NAM
Chad	TCD	Niger	NER
Comoros	COM	Nigeria	NGA
Congo DR	ZAR	Rwanda	RWA
Congo Republic	COG	Sao Tome and Principe	STP
Cote D'Ivoire	CIV	Senegal	SEN
Egypt	EGY	Sierra Leone	SLE
Eritrea	ERI	Somalia	SOM
Ethiopia	ETH	South Africa	ZAF
Gabon	GAB	Sudan	SDN
Gambia	GMB	Swaziland	SWZ
Ghana	GHA	Tanzania	TZA
Guinea	GIN	Togo	TGO
Guinea Bissau	GNB	Tunisia	TUN
Kenya	KEN	Uganda	UGA
Lesotho	LSO	Zambia	ZMB
Liberia	LBR	Zimbabwe	ZWE

Chapter 3 Natural Resources, Institutional Quality and Economic Performance in Sub-Saharan Africa: An Empirical Approach

3.1 Introduction

3.1.1 Background

In the continual search for explanations about what affects economic growth and development across countries, Sachs and Warner (SW) (1995) found that resource abundant countries tend to have lower growth rates compared to resource-scarce economies. This has come to be known as the "natural resource-curse". The finding if, of particular interest to African countries cannot be over-emphasised as the continent is richly endowed with both renewable and non-renewable resources and is arguably the poorest continent.

Following the seminal research of SW, the literature on natural resource economics is replete with empirical findings on the relationship between natural resource abundance and economic growth; some empirical findings are not in favour of the resource curse hypothesis while others have criticised the resource curse hypothesis as a methodological artefact.

In general, some of the findings of these studies are that initial conditions of the quality of institutions could determine the possibility of a natural resource curse or blessing. On the one hand, in the face of weak institutions[2] natural resource discovery could lead to civil conflicts as various interest groups may fight to control the resources, especially in ethnically diverse countries (Kolstad and Wiig, 2009).[3] Also, the government may rely so much on the revenues from the sales of natural resources to finance white elephant projects, that other sectors of the economy are neglected. Furthermore, there may be corruption and rent seeking in these countries as easy money serves as disincentives to develop other critical sectors of the economy. On the other

[2] based on World Bank institutional indices

[3] Weak institutions as it is used here denotes low scores for World Bank Institutional indices such as: rule of law, corruption perception index, property rights etc.

hand, strong institutions have been found to help some of the resource-abundant rich countries to manage their economies well (Brunnscheweiler and Bulte (2008) and Brunnscheweiler (2008)). But SW debunked institution as the main causative factor as differing economic growth rates.

A trite question that is yet to be fully addressed is why similarly endowed natural resource abundant African countries differ in terms of economic growth performance empirically. For instance, Botswana is a natural resource abundant African country and is also rich while Nigeria, Congo, and Guinea are rich in natural resources and also poor. Both Botswana and other resource-rich countries listed above have similar initial conditions but had different economic performances over the years. Thus, the analysis of the impact of natural resource abundance on economic growth seems like a paradox.

Given this background, there is the need to learn more on the factors accounting for differing growth performance in resource-rich Sub-Saharan African countries given the quality of political institutions. The rest of the study is grouped into four sections: section two reviews literature on natural resource curse, institutional quality and economic performance; section three, four and five details the empirical approach, results and discussion, and conclusions respectively.

3.2 Literature Review

The review of literature shall be systematically carried out in this order: literature for and against the resource curse hypothesis and the review of literature on institutional qualities and economic performance.

3.2.1 Literature on the Resource-Curse Hypothesis

The literature on natural resource curse hypothesis will be divided into two parts for analytical convenience: literature in favour of the resource curse hypothesis and literature against it. In each subsection, the possible causal factors of resource curse or resource blessings will be explained and I will draw inference at the end of the literature reviewed.

3.2.1.1 Literature in Favour of Resource Curse

On the pessimistic spectrum, several reasons have been adduced as possible transmission mechanisms for natural resource curse.

Firstly, the Dutch disease theory is seen by many researchers as the source of natural resource curse.[4] The phenomenon arises when there is an increase in real exchange, if floating exchange rate regime is adopted, or inflation, if the country adopt fixed exchange rate, as a result of the rise in tax revenues or royalties earned from the export of natural resources. Also, Dutch disease explanation includes the crowding-out of the manufacturing sector of the economy as a result of over-reliance on export of natural resources. In this school of thought, Corden and Neary (1982) developed a model where the booming (natural resources/extractive) sector of the economy leads to real exchange rate appreciation, as the natural resource export induces increased inflow of foreign currencies, and progressive de-industrialisation of the economy. The authors theorised that this is brought by excessive spending of the revenue from the sale of natural resources (usually on unproductive projects) and resource movements, as factors of production are bidded away from other sectors to the booming or natural resource sector. Consequently, this may lead to a current account deficit in the economy when the natural resource boom ends. Similarly, Wijnbergen (1984) developed a two sector model to corroborate the findings of Corden and Neary (1982) that oil producers will be facing a "Dutch-Disease", the crowding-out of the other sectors of the economy by the booming or resource sector. Wijnbergen theorised that the crowding-out of the other sectors by the booming sector will be predominant in countries at the early stage of development except if there is foreign asset accumulation, subsidies to the non-oil sector or adoption of oil-sector. In the same vein, Krugman (1987) writes that Dutch disease for resource-exporting countries may not be a disease after all if they will specialise in the booming sector of

[4] Dutch disease connotes the adverse effects the discovery of natural gas had on the manufacturing sector of the Dutch economy through real exchange appreciation.

the economy or adopt a floating exchange rate regime, as fixed exchange rate may lead to currency appreciation, and this may have a negative effect on other sectors of the economy. Thus the author point out that Dutch disease may lead to the natural resource curse except if there is a deliberate attempt by the social planner to manage the exchange rate; develop other sectors of the economy or specialise in the production of natural resource and utilise the proceed to grow the economy.

Secondly, natural resource curse is also seen to be the effect of the neglect of human capital accumulation in resource-abundant countries. Gylfason (2001) write that natural resource rich countries tend to neglect human capital. Gylfason illustrates his arguments through the graphical relationship between natural capital and education enrolment rate in major resource-rich countries. He corroborated the negative relationship between the two variables by regression analysis and spearman correlation ranks which shows that enrolment rate tend to have a negative relationship with natural capital. The logic of Gylfason's argument is that overconfidence tends to make the resource-rich economies believe that resource rents would continually flow and that to the utter neglect of education sector while resource-poor countries have lower margin of error and tend to grow their economies on ideas, hence the need for education. However, robustness of the econometric estimates are not emphasised in the research. This finding has been supported by Birdsall *et. al.,* (2001) who, in a review of literature, find a negative relationship between resource-rich countries and human capital while holding other factors constant. Conversely, Stijns (2006) cautioned that natural resource abundance may not necessarily lead to the neglect of human capital accumulation by using improved measures of natural wealth using robust tests of indicators of resource abundance. Stijns use various measures of natural resource abundance: subsoil assets, resource-rents, and also various measures of human capital and also use bootstrap correlation technique to show that the findings of Gylfason are not robust across various countries.

Thirdly, the disappointing economic performance of most resource-abundant countries seems to have a link with leadership style. Some literature in this school of thought relates natural resources to authoritarianism in the resource-rich countries (Ross, 2001;Jensen and Wantchekon; 2004). This school of thought has it that natural resources increase the incentive for various interest groups or ethnic fractions to capture power, especially in developing countries and this may lead to civil conflicts or the rise of an authoritarian ruler. Ross (2001) itemise various mechanisms through which oil could hinder democracy: the rentier effect, the repression effect, and modernization effect. Ross believes that rents from oil export could either be used for bribing the stakeholders in the country who could demand for more accountability (rentier effect), or used in repressing the elites (repression effects) and through building state-of-the-art schools, roads, and other project (modernization effect). Ross use pooled time series of 113 countries between the time period of 1971-1997 within an Ordinary Least Square (OLS) framework to investigate the relationship between oil and democracy and found that oil, and other minerals usually impede democracy and that there is positive and significant relationship between oil and authoritarianism. Also, Jensen and Watchenkov (2004) use both random and fixed effects to examine the effects of oil on democratic transition in 46 countries. They find that oil will impede democratic transition unless there are accountability frameworks entrenched in the state. Here, rents from exports of natural resources was analysed to lead to rentier economy, civil conflicts and the underdevelopment of entrepreneurship and innovation which should catalyse long term growth. According to Jensen and Watchenkov (2004), the distribution of resource rents often lead to civil conflicts and eventually leading to autocratic political regimes, especially if the resource is not evenly distributed in the country. This finding is further corroborated by Cuaresma, Oberhofer and Raschky (2011) who find in the study of 106 dictators around the world that the dictators in oil-rich countries tend to stay longer than others that are less endowed in natural resources using data from 1980-2004. A similar explanation to these finding by Al-Ubaydli (2012) views natural resources as strengthening authoritarianism as the autocrats can hamstring the economy with the resource rents while natural resources will be benign in a democratic setting. This natural resource curse hypothesis was examined by Al-Ubaydli using pooled OLS regressions for the period of 1975-2000. Al-Ubaydli (2012) finds that the political system adopted in the country. In this school of thought, Anderson and Aslaksen (2008) considered the period 1990-2000 for 61 countries to find the difference between presidential democracies, parliamentary democracies and non-democratic settings. Within OLS and Instrumental Variable (IV) regression frameworks, the research findings are that resource curse is prevalent in presidential and non- democratic settings while resource blessings is rife in countries with parliamentary constitutional arrangements. So, politics not economics is the problem. Similarly, Kolstad and Soreide (2009) asserts that corruption is the main cause of resource curse. In their review of literature, the authors divides the political economy studies of resource curse into rent-seeking and patronage models of resource-rich economies. Rent seeking according to the authors are when entrepreneurs uses their skills and time to get a part of resource rents while patronage models is when governments bribe interest groups to remain in power. In the same stretch of argument, Barbier (2010) theorized on the relationship between resource revenue and corruption, and then check for empirical validation. In the empirical evidence of Barbier, the demand and supply of bribes are modelled, and a comparison is made between Asian countries and resource-rich countries in Sub-Saharan Africa. Using pooled OLS of 69 countries the author found corruption as the main channel of the resource curse. Also, Williams (2011), in a sample of 105 countries find that the release of information index (which tends to be low as the information of resource sale and how the rents are used are not always available) in resource rich countries contribute immensely to the negative economic performance, using a systems Generalized Method of Moments (GMM) approach. The conclusion of Williams is that the release of information on the natural resources revenue (transparency and accountability) tends to minimise corruptive tendencies of social planners.

Fourthly, Norman (2009) compares the economic performance of 110 countries to investigate the role of rule of law within the context of natural resource curse hypothesis. Using varieties of estimation techniques, the author finds that mineral abundance has a negative effect on the rule of law, especially in developing countries.

Specifically, Carneiro (2005) examines the oil-cycle and tax-spend hypothesis for the Angolan economy using a vector autoregressive model. The findings are that for the Angolan economy, the government's spending correlates with oil revenue. Secondly, the research finds that oil revenue do not respond to innovations in government spending. The research culminated with policy recommendations for diversification of the economy and controlling government spending.

Also, Bjorvatn *et al.,* (2012) finds that governance is the main channel of resource-curse. The authors use the evidence found in the panel of 30 oil -rich countries from 1992-2005 to infer that natural resource abundance can either be a blessing or a curse contingent upon the governance structure. In their words, *ceteris paribus* the level of political fractions would determine whether rents from the sale of natural resources would be beneficial or not.

Fifthly, Van der Ploeg and Poelhekke (2009) argues that the main channel of natural resource curse is volatility of commodity prices and not the reasons adduced in the literature. The arguments put forward are twofold: one, macroeconomic volatility induced by nominal exchange rates and weak financial systems may lead to unstable economic performance. Two, politicians are prone to embark upon ambitious white elephant projects and appropriate more funds to themselves. The authors then provided a cross-country evidence from 1970-2003 to drive home their arguments that volatility is the main channel of poor economic performance of natural resource exporting countries.

Finally, Hodler (2006) develops a model on the political economy of resource curse to test the relative importance of homogeneity or heterogeneity of culture and natural resource curse. The author tested the model using varieties of econometric techniques. The research findings are that countries that have escaped resource curse hypothesis are more homogenous while countries that are heterogeneous have lower incomes as each ethnic fraction fights to increase her own share of resource rents.

3.2.1.2 Literature Against Resource Curse

On the other end of the optimistic spectrum, Alexeev and Conrad (2009), write that the conclusion of Sachs and Warner (2001)[5] may not be accurate. The reasons adduced are that the export of crude oil at commercial quantity started before 1950 and possibly reached a crescendo in the 1990s, hence the starting dates used by Sachs and Warner may be driving the result. The authors also argued that the econometric specifications of most of the literature on resource-curse have issues with endogeneities which were not addressed.

On a critical note, Haber and Menaldo (2011) write that the extant literature that finds a negative relationship between economic performance and resource abundance are usually operationalized by a panel data econometric technique with a shorter time dimension, and often have their results driven by omitted variables bias. In order to correct this, Haber and Menaldo re-estimate the natural resource-curse by using some of the data used by some of researchers in favour of resource-curse hypothesis, especially Ross(2001) using autoregressive distributed lag technique, error correction models and fixed effect regression, cointegration, and refined difference-in-difference estimation. The longitudinal regression between resources and regime types in various countries around the world shows that there is resource-blessing in the countries chosen for estimation and not resource curse.

Also, Brunnscheweiler and Bulte (2008) starts out by debunking the claims adduced by

[5] Sachs and Warner (2001) argued that there is no measurement error in there previous research, that is, the growth determinants (rule of law, terms of trade change, investment and openness) used in their regression suffices.

researchers in favour of natural resource curse as a red-herrings-a piece of information intended to mislead. By re-examining the SW index of natural resource using three stage least square (3SLS) method and Two Stage Least Square (2SLS) which accounts for endogeneities, Brunnscheweiler and Bulte find that conventional wisdom on resource abundance and economic development has been turned upside down: resource abundance can be a blessing both for economic development and institutional quality. Furthermore, Brunnscheweiler (2008) debunk the claim of resource curse in her empirical paper using OLS and 2SLS, arguing that natural resources have positive correlation with real GDP growth in the period 1970-2000 while controlling for institutional quality. Also, part of her research findings is that natural resource abundance do not affect institutional quality negatively. This position was reinforced by Van der ploeg and Poelhekke (2010) who claimed that natural resource curse is a "red herring" and that natural resource is in fact a blessing. The same argument is employed by Norman (2009) citing patchy historical resource data in developing countries and limited data on control variables as possibly the reasons why a negative relationship was found between economic growth and natural resource abundance. Norman use the reserves data and resource export intensity of 1970 within a framework of OLS and 2SLS to find that resource intensity and sub-soil assets are in fact a blessing and not a curse in the 110 countries selected for regression.

In this school of thought, Manning (2004) on resource abundance, human capital and economic growth in a cross section of 80 developing countries found no statistical relationship to support resource curse in the selected countries. The measure of natural resources abundance used by Manning is arable land per capita, which is different from other studies which have used non-renewable resources mostly. The technique employed by Manning is to examine OLS used to examine the relationship between resource abundance and economic growth and that was found to be positive while controlling for regional differences. Additionally, Stijns (2006) use several measures of resource abundance: share of natural capital in national wealth, natural capital/physical capital ratio, subsoil wealth, green capital/physical capita ratio, arable land per capita, etc. and some control variables and bootstrap confidence intervals for correlation coefficients to find that natural resource abundance may not necessarily lead to the neglect of human capital accumulation, thereby debunking the claims of Gylfason (2001) and Birdsall *et al.,* (2001) that inadequate or lack of good education accounts for natural resource curse.

Mehlum, Moene and Torvik (2006) debunks the rent seeking hypothesis of SW (1995) and also the Dutch disease explanation of resource curse. They develop and empirically test a model of grabber-friendly and production-friendly institution claiming that resource curse would only prevail in countries with grabber-friendly institutions but resource curse is not destiny as has been claimed by previous researchers. In the thinking of Mehlum, Moene and Torvik, grabber-friendly institution focuses on rent-seeking behaviour and corruption, while production-friendly institution zeroes in on entrepreneurship. In this same school of thought,Torvick (2009) in a review of literature of political economy of resource curse, itemised factors that will either make resource abundant countries to be winners or losers. According to Torvick, winners are nations that have escaped resource curse such as Norway and Botswana and losers being nations that are still characterised by resource-curse. In the study, many underlining factors for success or failures were adduced such as the savings of rents from income, type of political organisation, strength of institution, resource-type, and age of national industrialisation. Furthermore, Boschini, Pettersson and Roine (2007) in an empirical setting posits that resource curse hinges on institutional quality. Boschini, Pettersson and Roine use various econometric techniques to test the effect of institutions on natural resources and find that natural resource curse is not destiny for resource abundant countries. That is, the resource abundant economies with good institution may make success of their resource rents such as Botswana and South Africa and economies with weak institutions experiences long term lower growth rate.

In the same vein, Manzano and Rigobon (2001) write from a historical perspective that the so-called resource curse hypothesis is debt overhang in resource-rich developing countries. The authors traced the beginning of resource curse in most countries to the huge debt burden of 1970s and 1980s and its multiplier effects on the economy. Re-estimating the effect of natural resource abundance on growth using panel data based on SW(1997) data, the paper found that the natural resource curse effect is present in cross-section but absent in panel data analysis. This was attributed to omitted bias in the cross-section results. The paper concludes that imperfections in credit market is the cause of poor economic performance in the resource-rich developing countries and not natural resource curse.

Rambaldi et al. (2006) examine the validity of resource curse and grouped the methodology for measuring resource curse hypothesis into Sachs and Warner (SW) type, which is essentially the measure of resource intensity as a share of GDP and Gylfason and Zoega (GZ) (2001) type, which is the measure of resource intensity as a share of total capital stock. Rambaldi criticise the previous published work on the ground of the conclusions arrived at, inspite of loss of information in their estimation and, sometimes unsuitable econometric technique. Using cluster analysis the research find that resource curse holds under the SW type and does not hold under GZ type. The study concludes that resource curse is a methodological artefact, as the statistical technique employed by any researcher is what will determine whether there would be resource curse or not.

Basedau (2005), in a review of literature debunks the literature on natural resouce curse as establishing mere statistical relationship between two phenomena in sub-Saharan African without necessarily reflecting causation. The thesis in the study is that whether a country benefit from resource abundance or not is contingent upon country specific characteristics and resource specific characteristics. In his opinion, country-specific characteristics that could undermine the maximal benefit from resource abundance includes relations between groups, political parties, effectiveness of institutions, and industrialization level of the country before resource extraction. In the same vein, the characteristics of oil producers differs from that of diamond and gold, and also differs from that of copper in relation to its pricing, resource rent and demand and supply characteristics. The research concludes that a more sophisticated research design is needed to examine causation between the two phenomena.

3.2.2 Literature on Institutional Qualities and Economic Performance

According to North (1991 p.97) institutions are perceived as:"... humanly devised constraints that structure political, economic, and social interactions. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, and property rights)." Acemoglu et al. (2005) built on this definition by classifying institutions into economic and political institutions. Acemoglu et al. further argued that economic and political institutions are endogenous to economic growth as they both determined by the collective choice of the society and can only by the changed by political power. He further stressed that economic growth empirical investigations are mostly an exercise in distinguishing which countries have good institutions and bad institutions. Given the importance of institutions in determining economic performance, it has become imperative to review the literature on institutions and economic performance with a view to discovering institutional qualities essential for resource-rich African economies.

More recently, Ogilvie and Carus (2014) survey the history of the effects of institutions on economic growth and points out some weaknesses in the literature. Ogilve and Carus raised some crucial questions which every growth modellers must be aware of: how and when nations develop the threshold levels of property rights which engenders economic growth and what institutional quality has fostered growth more than the other institutional quality. On a critical note, Ogilve and Carus assert that property rights which has been used as primary institutional quality arguably has little to do with economic growth. The authors concludes that measures of institutional qualities that have not been much explored should also be explored in examining the effects of institutions on economic growth.

Valeniari and Peluso (2011) investigate the impact of institutional quality on economic growth and development in a panel of 181 countries from 1950 to 2009. The paper review volumes of literature on institution and economic performance and grouped the extant literature into eight categories. The findings of the literature review of these authors is that no consensus exists presently on the type of institutional qualities that engenders growth. In the face of this, the authors concluded that the institutional qualities that help different countries are contingent on the stage of economic development and a host of other factors as the institutional measures chosen for their research have significant impact (both positive and negative) on both developed and developing economies.

Similarly, Sobhee (2012) examine the relationship between quality of institution and economic growth in 30 sub-Saharan African countries and 15 Latin American countries. After reviewing the literature on economic performance and institutions, the author chose Kaufman et al. (2005) institutional measures: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law and control of corruption. The research finds that, while all the indicators chosen have significant relationship with growth performance of the countries; public sector institutional measure have more substantial impact.

More specifically, Butkiewicz and Yanikkaya (2006) examine whether both the rule of law or democratic institutions are important for economic growth or not. The empirical research divides the countries selected for estimation into developed and developing countries and also combined all countries in the sample. Using 3SLS and SUR, the research find that institutional qualities chosen for the research are correlated with economic growth but democracy has no correlation with economic performance.

Lastly, Humphreys and Bates (2005) check what policies and institutions influence African growth patterns in recent years. After chronicling the effects the corrupt political leaders have on African economies, the authors went on to investigate the effects of World Bank- Country Policies and Institutional Assessments (CPIA) and International Country Risk Guide (ICRG) measures on policy choices of 29 African countries. The research discovery is that the growth performance of Africa has been affected by economic and political factors; mobile economic base and political instability.

3.2.3 Summary of Literature Review

The survey of literature on natural resource curse above can be summed up thus: researches that infer statistical relationship between natural resources and economic growth by using only one resource (Ross (2001), Manning (2004),Alexeev and Conrad (2009)); researches that uses many natural resources (Sachs and Warner (2001), Anderson and Alasken (2008)); researches that emphasises on statistical novelty as the main crux of the natural resource curse/blessing (Haber and Menaldo(2011), Brunnscheweiler and Bulte (2008)); and researches on the relationship between institutions and economic performance (Acemoglu et al., (2005) and Sobhee (2012)). This paper is positioned within studies of political institutions as an intervening variable between natural resource abundance and growth performance in the geographical context of Africa.

3.2.4 Contribution of this Study

The essence of the literature survey above is to show that no study has engaged with political institutions as an intervening variable between natural resource curse and economic growth performance within an African context using both non-renewable natural resource, renewable natural resource and total natural resource export. Specifically, in this regards, the natural resources used for regressions in this study are grouped into three for the sake of comparison: total natural resources as percentage of GDP; to measure the scale of natural resources, while oil-rent as percentage of GDP and agricultural export are used for measuring the types of resource export in Sub-Saharan Africa.

3.2.5 Theory to be Tested

Given the above background to this paper; the empirical approach will be predicated on the following theory: the quality of political institution is a mediating variable for the relationship between natural resource abundance and economic growth in Sub-Saharan African countries.

3.3 Empirical Approach

3.3.1 Econometric Approach

Given the objective of this study and theory to be tested, the econometric specification to be used for estimation is:

$$\begin{aligned}\text{Gdppc}_{it} &= \text{cons+}\gamma_1\text{Orpc}_{it-1} + \gamma_2\text{Polity}_{it-1} + \gamma_3(\text{Orpc*Polity})_{it-1} + \\ &\quad \gamma_4\text{Inv} + \gamma_5\text{Gov}_{it-1}\text{+}\gamma_6\text{SSE}\varepsilon_{it} + \alpha_i + \delta_t + \varepsilon_{it},\end{aligned} \tag{3.1}$$

$$\begin{aligned}\text{Gdppc}_{it} &= \text{cons+}\gamma_1\text{Orpc}_{it-1} + \gamma_2\text{RDD}_{it-1} + \gamma_3(\text{Orpc*RDD})_{it-1} + \\ &\quad \gamma_4\text{Inv} + \gamma_5\text{Gov}_{it-1}\text{+}\gamma_6\text{SSE}\varepsilon_{it} + \alpha_i + \delta_t + \varepsilon_{it},\end{aligned} \tag{3.2}$$

$$\begin{aligned}\text{Gdppc}_{it} &= \text{cons+}\gamma_1\text{Agexpc}_{it-1} + \gamma_2\text{Polity}_{it-1} + \gamma_3(\text{Agexpc*Polity})_{it-1} + \\ &\quad \gamma_4\text{Inv} + \gamma_5\text{Gov}_{it-1}\text{+}\gamma_6\text{SSE}\varepsilon_{it} + \alpha_i + \delta_t + \varepsilon_{it}\ ,\end{aligned} \tag{3.3}$$

$$\begin{aligned}\text{Gdppc}_{it} &= \text{cons+}\gamma_1\text{Agexpc}_{it-1} + \gamma_2\text{RDD}_{it-1} + \gamma_3(\text{Agexpc*RDD})_{it-1} + \\ &\quad \gamma_4\text{Inv} + \gamma_5\text{Gov}_{it-1}\text{+}\gamma_6\text{SSE}\varepsilon_{it} + \alpha_i + \delta_t + \varepsilon_{it}\ ,\end{aligned} \tag{3.4}$$

$$\begin{aligned}\text{Gdppc}_{it} &= \text{cons+}\gamma_1\text{Tnpc}_{it-1} + \gamma_2\text{Polity}_{it-1} + \gamma_3(\text{Tnpc*Polity})_{it-1} + \\ &\gamma_4\text{Inv} + \gamma_5\text{Gov}_{it-1}\text{+}\gamma_6\text{SSE}\varepsilon_{it} + \alpha_i + \delta_t + \varepsilon_{it}\ . \end{aligned} \tag{3.5}$$

$$\begin{aligned}\text{Gdppc}_{it} &= \text{cons+}\gamma_1\text{Tnpc}_{it-1} + \gamma_2\text{RDD}_{it-1} + \gamma_3(\text{Tnpc*RDD})_{it-1} + \\ &\gamma_4\text{Inv} + \gamma_5\text{Gov}_{it-1}\text{+}\gamma_6\text{SSE}\varepsilon_{it} + \alpha_i + \delta_t + \varepsilon_{it}\ . \end{aligned} \tag{3.6}$$

3.3.2 Variable Source and Definitions

Gdppc: GDP per person in US $. This data was retrieved from ADI (2013) website and is used as the outcome variable in all the regressions.

Orpc: Oil rent per capita. This variable is also calculated by taking the difference between the value and cost of production of crude oil in US$ divided by the total population. The data is available at WDI (2013) and is used as one of the regressors in the resource-specific regressions.

Inv: Investment share in GDP. This data is used as one of the regressors and is available WDI (2013).

Agexpc: Agricultural export per capita. This is the value of total agricultural export in US $ divided by the total population and is used as one of the main regressors. This data is available at WDI (2013) and is used as one of the independent variables in the regressions below.

Tnpc: Total natural resources rent per capita. This is the value of total marketed natural resources in US$ divided by the total population. This data is available at WDI (2013) and is used as one of the regressors in the regression equations below.

Polity: As a measure of institutional quality, polity measures political regime and characterisations and transitions from 1800-2006. In constructing this index, several factors were incorporated: executive constraints, political participation, political openness and constraints on chief executive. This index is from 0 to 100 with 0 denoting the most autocratic regime and 100 denoting most democratic regime. This data was sourced from Haber and Menaldo (2011).

RDD: Regional Democratic Diffusion: This data is also sourced from Haber and Menaldo (2011) and it measures the percentage of countries in Sub-Saharan African that are democratic at regional level. The score is similar to polity ranging from 0 to 100, with 0 indicating no-democracy and 100 indicating full democracy.

Gov: Government Consumption Share of PPP Converted GDP Per Capita at current prices in Percentage. This data is available at Penn World Table 7.1 and is used as one of the conditioning variables for the regressions reported above.

SSE: Percentage of Total Secondary School Enrolment. This variable is used as a proxy for education, and is available at WDI (2013).

Cons: Constant. The intercept of each regression equation!

In the specifications above, central to the theory to be tested are the signs and sizes of coefficients of γ_1 and γ_3, as the research would like to investigate whether natural resources is a blessing or a curse on it's own, and the role institution plays in the face of increasing natural resource rent. The apriori expectation is for both γ_1 and γ_3 to be positive. This is premised on the fact that democratic institution would promote growth and that natural resource rents should be positively correlated with GDP per capita. Also, investment share of GDP (Inv), government consumption share in GDP (Gov), and secondary school enrolment (SSE) are used as control variables in the regression. The other variables defined in the subsection below. The error term ε_i is assumed to be independent and identically distributed in all the regressions. Furthermore, the i subscript in the specification denotes the individual countries chosen for regression, while t represents the time dimension in years. Lastly, in the specification, allowance is made for time (δ_t) and country-specific effects (α_i) in the Fixed Effects (FE) regression to account shocks common to all countries and spurious business cycle effects.

The empirical models above is standard and has been used extensively in resource-curse hypothesis and has been used by Boschini, Petterson & Roine (2007), Bjorvatn, Farzanegan & Schneider (2012) and Williams (2011). Also, as a method adopted by Bjorvatn, Farzanegan & Schneider (2012), the independent variables are lagged for one year in order to address potential endogeneity in the regressors. Besides the issue of endogeneity, heteroskedasticity and autocorrelation-consistent standard error is chosen for the regression to improve the validity of the estimates.

The panel regression consists of 28 Sub-Saharan African countries selected from 1960 to 2012. A simple and straightforward way to estimate the regressions of equations (3.1) to (3.6) is use OLS, but both measures of institutions, and natural resources per capita are endogenous. This indicates that there may be a reverse causality between the independent variables and the outcome of interest, or omitted variables of some sort. These issues attenuates the use of OLS as the causal inference between the variables may be weakened by either upward or downward attenuation bias. Therefore I lagged all independent variables by one year to resolve the possible endogeneity problem (Bjorvatn, Farzanegan & Schneider 2012, p.1309) and ran pooled OLS regression for sample of selected African countries. Furthermore, looking at the summary statistics in table 1 of the appendix, the spread of the GDP per capita and most of the variables are high, so I took logarithm of all the variables used for regression. Also, FE regressions are carried to compare the results across different estimation techniques and/or for robustness of the regressions carried.

3.4 Results and Discussions

3.4.1 Total Natural Resources

To test the effect of quality of political institutions (polity and RDD) on the economic performance of resource-rich African countries, I ran regressions of all the 6 equations above using both OLS and FE technique with 1 and 3 lags respectively. The logic of the lags is that the higher the lags the more the issue of endogeneity is dealt with.

As stated in subsection 3.3.2 above, the other coefficient that is central to the theory to the tested is γ_3. From table 3.2, all specifications of the interaction term between total natural resources and quality of political institution shows a positive and significant effect. This indicates that good political institutions can aid the positive income effect of natural resources wealth, in line with the findings of other previous researches (Mehhlum, Moene, & Torvik (2006), Haber & Menaldo (2011), Al-Ubaydli (2012), and Bjorvatn, Farzanegan & Schneider (2012)). This is contrary to the findings of Jensen & Wantchekon (2004) that increased resource income and democracy may be mutually exclusive, although measure of democracy is taken to be the dependent variable in their research.

It is also noteworthy in table 3.2 that total natural resources are positively correlated with GDP per capita in all the specifications at 1% significance level. In particular, in the second column of table 3.2, a 1% increase in the size of total natural resources increases GDP per capita by 0.176% in all the 28 Sub-Saharan African countries chosen for this research.

On it's own, the relationship between polity, as a measure of political institution, and GDP per capita is negative but insignificant in all the specifications and thus will not be used for policy recommendation.

The controls used in the regression: investment share of GDP, consumption share of GDP and percentage of total secondary school enrolment are all positive and significant at both 1% and 5% level for both OLS and FE regressions. Government consumption as percentage of GDP is usually negative and significant in some of the literature (Bjorvatn, Farzanegan & Schneider (2012)) but the positive relationship in government consumption and GDP per income have been found in another African-focused exercise (Jensen & Wantchekon (2004)). This shows that government consumption rises with increasing income in the selected African countries.

Similarly, table 3.3 below show the regression results of total natural resources using RDD as measure of political institution. The regression results is similar to the results reported in table 3.2 both in terms of signs and size of significant estimates. Here RDD, a measure of political institution, and GDP per capita is negative and significant in all the specifications, indicating that higher level of political openness may be detrimental to increased income. This finding is similar to the results found by Al-Ubaydli (2012) and Bjorvatn, Farzanegan & Schneider (2012) in their research.

Additional, the constant of all the regressions below (not reported) are positive and highly significant at 1% level.

3.4.2 Agricultural Export

The results displayed in tables 3.4 and 3.5 below shows the regression results using agricultural export per capita as the main independent variable. Row 2 and 3 shows that the relationship with income per capita and agricultural export per capita is positive and highly significant across all specifications indicating that agricultural export is benign in the selected Sub-Saharan African countries. The import of this analysis is that previous papers in this field have highlighted the role of type of resources in the natural resources debate (Boschini, Petterson, & Roine (2007) & Torvik (2009)). The result here shows that non-renewable resource can be a blessing to African countries.

Similar to the regression results of total natural resources, in table 3.4 polity is negative and significantly correlated to income per capita in the selected African countries meaning that higher political openness may be detrimental to economic growth, using OLS regression with 1 and 3 lags. Investment share in GDP per capita, government consumption share and secondary school enrolment also have significant and positive correlation with income per capita. The regression results in table 3.5 with regional democratic diffusion as an institutional variable is similar in signs and size to the regression results displayed in table 3.4 thus same policy implications implies, with the exception of RDD which is negative but insignificant.

3.4.3 Oil Rent

Tables 3.6 and 3.7 show the regression results of regression results of income per capita and oil rent as the main independent variable using both polity and regional democratic diffusion as measures of political institutions. The tables show that the interaction term between the measures of political institution and oil rent all have positive and significant effect on income. This means that higher quality institutions is a blessing. This is in agreement with the findings of Mehhlum, Moene, & Torvik (2006) and Bjorvatn, Farzanegan & Schneider (2012) that resource curse is absent in countries with higher institutions. Also, oilrent have positive and significant effect on income in both tables 3.6 and 3.7 using OLS regression with 1 and 3 lags respectively.

On the basis of comparison, Bjorvatn, Farzanegan & Schneider (2012) find that 1% rise in oil revenue per capita will increase income per capita by 0.13% in 30 oil producing countries in the world from 1992-2005 while this paper find that 1% rise in oil rent per capita will increase income per capita by 0.05% in the 9 major oil exporting countries in Sub-Saharan Africa. The controls of the two regression have similar size and signs of significance.

Using oil as the main natural resource, this study agrees with the finding of Bjorvatn, Farzanegan & Schneider (2012) and Cavalcanti, Mohaddes & Raissi (2012) that oil is a blessing to the countries where they are richly endowed and not a curse.

3.4.4 Robustness Tests

In other to test the robustness of the estimates of the regression above, I excluded government share of consumption from the regression equations and ran the regressions of equations 3.1 to 3.6 again using OLS. From the results displayed in tables 3.8 & 3.9, the signs and size of the estimates are similar to the results we had before hence the robustness of the results. Also, the goodness of fits tests show R^2 of all the regressions ranging from 0.50 to 0.72 with the regression FE regression for agricultural export having the highest R^2. The FE regression also have country and time FE included in all the regressions and all the estimates of the regression are jointly significant.

3.4.5 Conclusion

The objective of this research was to investigate the role institutions play in explaining why similarly endowed African countries perform differently regarding economic growth. The paper examines whether renewable (agricultural export), non-renewable (oil rent), and total natural resources would have differing effects on economic growth performance in the African countries given the political institutions. After reviewing the existing literature on natural resource curse and grouping the literatures into researches that conclude that natural resources could be a curse and adducing various reasons for their conclusions, and the literatures that finds that natural resource curse is a methodological artefact, I used panel data econometrics to test the hypothesis of natural resource curse in 28 Sub-Saharan African countries from 1960-2012 given the institutional qualities of these countries. No previous paper has engaged with the role of political institutions as an intervening variable between growth performance and natural resource endowment in Africa hence the contribution of this paper.

The regression results show that total natural resources on its own was a blessing in all the selected African countries. Also, the interaction term between total natural resources and institutions was positive and significant in the regressions using both FE and OLS regression, denoting that natural resources have a positive scale effect and increasing resource rent in the face of good institutional quality has a beneficial effect on GDP per capita. Similar to total natural resources, agricultural export per capita and oil rent per capita also have positive and significant impact on income in the African countries with similar policy implications as total natural resources.

Therefore, these results seem to debunk the claim that natural resource endowment is a curse in the resource-rich African countries. The institutional factors that promote economic growth as intrinsic in polity score: executive constraints, political participation and political openness should be improved in other to optimise the benefits of natural results endowments. However, excessive political openness can also have a detrimental effect on GDP per capita as also found the research. The policy implication of this is entrenched democratic culture in resource rich African countries would aid economic growth performance.

Lastly, there are some research questions this paper does not address. The paper did not examine which institutional measure is the most important for natural resource-exporting countries, how institutions are formed or on how to invest the rents earned from natural resources in the natural resource exporting countries in Africa. Future studies can look at these areas, in an empirical or experimental setting, with a view to improving the frontiers of knowledge in natural resource economics.

APPENDICES

Table 3.1: Summary Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
gdppc	1391	769.4899	1324.88	37.5165	11113.89
orpc	290	461.344	861.3829	0.009549	5106.28
tnpc	1144	150.8713	499.9579	0.03475	5389.27
agexpc	837	58.25122	115.9051	-292.071	2119.41
inv	1344	17.41765	11.37589	1.29171	75.1887
rdd	1246	10.7452	3.724535	6.81818	22.2222
sse	820	25.38023	21.24306	1.07107	95.6996
gov	1415	11.78776	7.91619	0.813855	52.1046
polity	1267	37.65588	30.0255	5	100

Table 3.2: Panel Data Regressions for Total Natural Resources and Polity with 1 and 3 Lags

	FE(1 lags)	OLS (1 lags)	FE (3 lags)	OLS(3 lags)
Dependent variable: GDP Per Capita				
Total . N .R	0.17607	0.09165	0.12124	0.08826
	(0.0234)***	(0.0179)***	(0.0234)***	(0.0182)***
Polity	-0.01795	-0.04519	-0.02819	-0.01706
	(0.02249)	(0.02987)	(0.02255)	(0.0315)
Total.N.R*Polity	4.58e-06	0.0000305	-5.94e-07	0.0000275
	(2.30e-06)**	(4.18e-06)***	(2.30e-06)	(4.15e-06)***
Investment	0.04849	0.14075	0.0392	0.1796
	(0.03168)	(0.03814)***	(0.0318)	(0.0404)***
Govt. Consump	0.06411	0.08201	0.10022	0.0723
	(0.03899)	(0.03302)***	(0.0391)**	(0.0393)*
Secondary School	-0.03894	0.51680	0.11826	0.49599
	(0.04195)	(0.0250)***	(0.0420)***	(0.0271)***
R^2	0.58	0.573	0.518	0.5318
Country FE	Yes	No	Yes	No
TimeFixed Effect	Yes	No	Yes	No
Observation	672	672	667	667
Prob>F	0.0000	0.0000	0.0000	0.0000
Legends: * p<0.1; **p<0.05; *** p<0.001				

Table 3.3: Panel Data Regressions for Total Natural Resources and Regional Democratic Diffusion with 1 and 3 Lags

	FE(1 lags)	OLS(1 lags)	FE (3 lags)	OLS(3 lags)
Dependent variable: GDP per capita				
Total N.R.	0.1634	0.05238	0.1136	0.04277
	(0.0253)***	(0.01634)***	(0.0248)***	(0.0172)**
RDD	-0.2542	-0.17295	-0.2785	-0.08186
	(0.1231)***	(0.06977)***	(0.1211)***	(0.0717)
Total N.R*RDD	0.0000149	0.0000816	2.20e-06	0.0000797
	(5.53e-06)***	(6.53e-06)***	(5.43e-06)	(7.21e-06)***
Investment	0.06541	0.1221	0.04984	0.15109
	(0.0328)**	(0.0371)***	(0.03219)	(0.04012)
Govt. Consump	0.07028	0.0831	0.10281	0.06921
	(0.04089)*	(0.0321)***	(0.0402)**	(0.0368)*
Secondary Sch	-0.02589	0.551746	0.103269	0.5255
	(0.04281)	(0.02716)***	(0.0420)**	(0.0282)***
R^2	0.5426	0.5526	0.5012	0.5640
Country FE	Yes	No	Yes	No
Time FE	Yes	No	Yes	No
Observation	665	665	665	665
Prob>F	0.0000	0.0000	0.0000	0.0000
Legends: * p<0.1; **p<0.05; *** p<0.001				

Table 3.4: Panel Data Regressions for Agricultural Export and Polity for 1 and 3 lags

	FE(1 lag)	OLS(1 lag)	FE(3 lag)	OLS(3 lag)
Dependent variable: GDP per capita				
Agric. Export	0.06027	0.0660	0.06101	0.063881
	(0.0141)***	(0.0189)***	(0.0145)***	(0.02023)***
Polity	0.0167	-0.1152	-0.03445	-0.09084
	(0.0247)	(0.0419)***	(0.02539)	(0.04287)**
Agric*Polity	0.0000118	0.0000308	9.57e-06	0.0000312
	(4.85e-06)***	(0.0000134)***	(5.03e-06)***	(0.0000132)***
Investment	0.07657	0.1764	0.03015	0.18843
	(0.03745)**	(0.04945)***	(0.03868)	(0.05155)***
Govt. Cons	0.06997	-0.07212	0.11218	0.08611
	(0.04528)	(0.04437)	(0.04682)***	(0.0479)*
Secondary Sch.	0.00574	0.5558	-0.06804	0.5138
	(0.05086)	(0.03306)***	(0.05225)	(0.03324)***
R^2	0.7429	0.5426	0.6831	0.4650
Country FE	Yes	No	Yes	No
Time FE	Yes	No	Yes	No
Observation	394	397	392	392
Prob>F	0.0000	0.0000	0.0000	0.0000
Legends: * p<0.1; **p<0.05; *** p<0.001				

Table 3.5: Panel Data Regressions for Agricultural Export and Regional Democratic Diffusion for 1 and 3 lags

	FE (1 lag)	OLS(1 lag)	FE(3 lags	OLS(3 lags)
Dependent variable: GDP per capita				
Agric. Export	0.0653	0.03193	0.06639	.0324994
	(0.01469)	(0.01740)***	(0.0146)****	(0.0193)
RDD	-0.06152	-0.12908	-0.14577	-0.02882
	(0.2151)	(0.09493)	(0.2189)	0.0971
Agric. Ex*RDD	0.000045	0.00022	0.0000256	0.00021
	(0.0000195)***	(0.0000483)***	(0.000019)	(0.0000485)***
Investment	0.08208	0.17667	0.0454	0.1827
	(0.03821)***	(0.04936)***	(0.0389)	(0.05061)***
Govt. Consump	0.09121	-0.07407	0.1257	0.09982
	(0.045005)**	(0.04388)	(0.04581)***	(0.04829)**
Secondary Sch	-0.02387	0.5616	-0.0708	0.5127
	(0.05275)	(0.0332)***	(0.0536)	(0.0339)**
R^2	0.7125	0.5458	0.6606	0.54
Country FE	Yes	No	Yes	No
Time FE	Yes	No	Yes	No
Observation	389	389	389	389
Prob>F	0.0000	0.0000	0.0000	0.0000
Legends: * p<0.1; **p<0.05; *** p<0.001				

Table 3.6: Panel Data Regressions for Oil and Polity with 1 and 3 lags

	FE(1 lags)	OLS (1 lags)	FE (3 lags)	OLS (3 lags)
Dependent variable: GDP per capita				
Oilrent	0.04002	0.0554128	0.082628	0.06305
	(0.02867)	(0.0180)***	(0.0247)***	(0.0183)***
Polity	-0.1662	-0.1421	-0.21492	-0.09024
	(0.0654)**	(0.0676)**	(0.0564)	(0.0716)
Oilrent*Polity	0.000016	0.0000178	9.08e-06	0.0000114
	(3.65e-06)***	(5.79e-06)***	(3.15e-06)***	(6.32e-06)*
Investment	0.1931	0.33195	0.15689	0.4335
	(0.07860)***	(0.09271)***	(0.0678)**	(0.1019)**
Govt. Cons	0.09828	0.05918	0.1081	0.07619
	(0.09806)	(0.06620)	(0.08458)	(0.07646)
Secondary sch	0.2767	0.6830	0.2614	0.6063
	(0.1396)*	(0.10554)***	(0.1204)**	(0.1111)***
R^2	0.6949	0.4897	0.7272	0.4588
Country FE	Yes	No	Yes	No
Time FE	Yes	No	Yes	No
Observation	166	166	166	166
Prob>F	0.0000	0.0000	0.0000	0.0000
Legends: * p<0.1; **p<0.05; *** p<0.001				

Table 3.7: Panel Data Regressions for Oil and Regional Democratic Diffusion with 1 and 3 lags

	FE (1 lag)	OLS(1 lag)	FE(3 lags)	OLS (3 lags)
Dependent variable: GDP per capita				
Oilrent	0.05945	0.0278	0.09691	0.03019
	(0.0296)***	(0.0174)	(0.0259)***	(0.0178)
RDD	-1.7028	0.0520	-0.96888	0.3018
	(0.42785)***	(0.1946)	(0.3754)**	(0.1987)
Oilrent*RDD	0.0000238	0.000062	0.0000102	0.0000515
	(7.79e-06)***	(7.82e-06)***	(6.84e-06)	(8.12e-06)**
Investment	-0.0918	0.30935	-0.090475	0.44733
	(0.08082)	(0.1022)***	(0.0709)	(0.1143)***
Govt. Consump	0.1848	0.06075	0.16900	0.0666
	(0.10209)*	(0.06336)	(0.0895)*	0.0706
Secondary Sch	0.25529	0.53508	0.2419	0.4441
	(0.1471)*	(0.0997)***	(0.1291)*	(0.1033)
R^2	0.6688	0.5664	0.6935	0.5679
Country FE	Yes	No	Yes	No
Time FE	Yes	No	Yes	No
Observation	166	166	166	
Prob>F	0.0000	0.0000	0.0000	0.0000
Legends: * $p<0.1$; ** $p<0.05$; *** $p<0.001$				

Table 3.8: Regression without Government Expenditure using 3 Lags with Polity as Institutional Variable

	(1)	(2)	(3)
Total N.R	0.09156	-	
	(0.0180)***	–	
Agric.Export	-	0.0655	
	-	(0.0199)***	
Oil rent	-		0.06327
	-		(0.0185)***
Polity	-0.01094	-0.0899	-0.09003
	(0.03167)	(0.04307)**	(0.0716)
Total N.R*Polity	0.0000266		
	(4.15e-06)***		
Agric. Export*Polity	-	0.0000294	
	-	(0.0000134)**	
Oil Rent*Polity	-		0.0000112
	-		(6.43e-06)*
Investment	0.178127	0.19852	0.4622
	(0.04083)***	(0.05179)***	(0.0977)***
Govt. Consumption	-	-	-
	-	-	-
Secondary Sch. E	0.4785	0.5283	0.6149
	(0.0264)***	(0.0327)***	(0.1064)***
Observation	667	392	166
R^2	0.5288	0.4611	0.4554
Legends: * $p<0.1$; ** $p<0.05$; *** $p<0.001$			

Table 3.9: Regression without Government Expenditure using 3 Lags with RDD as Institutional Variable

	(1)	(2)	(3)
Total N.R	0.04441		
	(0.0171)**		
Agric.Export	-	0.03242	
	-	(0.0186)***	
Oil rent	-		0.03040
	-		(0.0178)
RDD	-0.0633	-0.06516	0.3245
	(0.0708)	(0.09557)	(0.1954)
Total N.R*RDD	0.0000791		
	(7.18e-06)***	-	
Agric. Export*RDD	-	0.0002113	
	-	(0.0000488)***	
Oil Rent*RDD			0.000051
			(7.95e-06)***
Investment	0.1480	0.194527	0.47622
	(0.04071)***	(0.0508)***	(0.1095)***
Govt. Consumption	-	-	-
	-	-	-
Secondary Sch. E	0.50792	0.5337	0.4485
	(0.0278)***	(0.0338)***	(0.09932)***
Observation	665	389	166
R^2	0.5616	0.5022	0.5319
Legends: * p<0.1; **p<0.05; *** p<0.001			

Table 3.10: List of African Countries Used for Regression

Total Natural Resources	**Agricultural Export**	**Oil Rent**
Angola	-	Angola
Benin	Benin	-
Bostwana	Botswana	-
BurkinaFaso	BurkinaFaso	-
Burundi	Burundi	-
Cameroon	Cameroon	Cameroon
Central African Republic	Central African Republic	-
Congo Democratic REP	Congo Democratic REP	Congo DR
Congo	Congo	Congo
Cote D'Ivoire	Cote D'Ivoire	Cote D'Ivoire
Gabon	Gabon	Gabon
Kenya	Kenya	-
Madagascar	Madagascar	-
Malawi	Malawi	-
Mali	Mali	-
Mauritania	Mauritania	-
Mauritius	Mauritius	-
Mozambique	Mozambique	-
Niger	Niger	-
Nigeria	Nigeria	Nigeria
Rwanda	Rwanda	-
Senegal	Senegal	Senegal
Sierra Leone	Sierra Leone	-
South Africa	South Africa	South Africa
Togo	Togo	-
Uganda	Uganda	-
Zambia	Zambia	-
Zimbabwe	Zimbabwe	-

Chapter 4 Malaria and Economic Growth in Africa: Investigating Reciprocal Relationship

4.1 Introduction

4.1.1 Background

In Africa, malaria is one of the most worrisome infectious disease. Malaria is a parasitic disease transmitted by five species of parasite (plasmodium falciparum, plasmodium vivax, plasmodium ovale, plasmodium malariae and plasmodium knowles). Of this, the most deadly and most prevalent in African region is plasmodium falciparum and vivax (Gallup and Sachs, 2001). The transmission of malaria have been suggested to be principally caused by the climate and ecological conditions of the malaria-endemic areas (Gallup and Sachs, 2001).

Goodman et al., (2000) documents that the effect of malaria disease is mostly felt in children, pregnant women, immigrants and on the workforce with the attendant economic effects. In the report, malaria disease in Sub-Saharan Africa was associated with increased household and public expenditure on malaria treatment, control and prevention; decreased labour productivity, decreased children school's attendance and cognitive performance; effects on land use, and its effects on physical work capacity.

Climate affects the biological processes which makes it convenient for malaria parasite to transmit disease. Among other things, climate affects human biting rate, mosquito propagation, probability of mosquitoes' survival and human vulnerability to malarial infection (Kovats et al. 2003). Malaria is a climate-sensitive tropical parasitic disease, hence climate plays a dominant role in its propagation, transmission and spread. Specifically, mosquitoes breed in marshes, dam, and pool of water; thus, rainfall plays a dominant role in its propagation. Also, relative humidity which is affected by the amount of rainfall is important for the survival of mosquito.

WHO (2013) estimates that about 3.5 billion people are possibly at risk of malaria disease and another 219 million malaria morbidity cases and 660,000 malaria mortality in 2010 and almost 90 percent of these occurred in Africa.[6] Additionally, the World Bank reports that 16 percent of deaths of African children are due to malaria disease and that malaria disease treatment costs $12billion a year. Similarly, WHO (2012) estimates that 90 percent of malaria mortality and 80 percent of malaria cases of the total malaria mortality and morbidity in the world were of people living in the Africa and the most severely affected are the children under the age of five and pregnant women.

Although malaria is principally caused by anopheles mosquitoes, its transmission and incidence on humans can also be exacerbated by non-availability of insecticides, public health infrastructure, land use change and environmental sanitation. WHO also estimates that Nigeria and Democratic Republic of Congo (DR Congo) account for 40 percent of global malaria deaths. Also, Nigeria, India and DR Congo account for 40 percent of malaria cases globally.

The governments of developing countries are faced with the challenge of reducing malaria cases in their regions. Attempts were made in the mid-twentieth century to eliminate malaria by developing insecticides (e.g. DDT) which recorded moderate success in the Asian countries; and malaria treatment drugs like chloroquine (Greenwood and Mutabingwa, 2002). This project was abandoned in Africa in 1969 for reasons associated with inadequate funding and technical know-how. Perhaps, this account for the increased rate of malaria morbidity and mortality in Africa in the following years until international health and environmental agencies such as Roll Back Malaria (RBM). RBM's four cardinal points of action are: easy accessibilities to malaria treatments; distribution of mosquito-treated nets; preventing malaria cases in pregnant women and children and malaria epidemic monitoring and response system.

Recently, World Malaria Report (2014 p.34) estimates that 128 million people were infected with malaria falciparum in 2013, and the two countries with the highest number of infection in

6 http://web.worldbank.org

the world are Nigeria and Democratic Republic of Congo. Given the rate of malaria infection in sub-Saharan Africa coupled with the fact that 90 percent of malaria morbidity occurs in Africa; there is the need to generate more academic insights on malaria-income relationship in Africa with a view to shaping practical policies.

4.1.2 Malaria and Income: Correlation and Causality

Most of the macroeconomic studies on malaria disease and economic growth in Africa have focussed on the question of correlation between malaria and national income and the effects of malaria incidence on foreign direct investment, education and health, population growth, labour productivity, trade and savings. On the other hand, microeconomic studies of malaria focus on out-of-pocket costs of malaria and efficiency of policies geared towards malaria eradication (Bloom and Canning, 2005).

WHO (2012) asserts that malaria is correlated with poverty. WHO estimates that malaria deaths are highest in countries with lowest Gross National Income (GNI) per capita. That is, countries with the highest number of people living below US$1.25 a day per person are the worst hit with malaria mortality. The report further states that malaria is prevalent in children of the poorer population within countries and also in rural areas. These are indices to link poverty with malaria incidence.

Conversely, Gallup and Sachs (2001) reason whether malaria is a cause or a consequence of poverty. By taking cues from malarious countries that are also rich in terms of high GNI per capita of almost $10,000 (Oman and United Arab Emirates), the authors conclude that malaria is chiefly caused by ecology and climate and not necessarily bad economic conditions. The reasons adduced are the following: poverty may be the cause of unsafe drinking water, unkempt housing, poor hygiene and substandard sewage treatment but none of these may lead to malaria incidence. Gallup and Sachs further argued that the nations in the temperate region that had eliminated malaria based much of the success on eco-climatic factors and efficient organisation rather than financial resources. On the flip side, Gallup and Sachs also agreed that it takes a considerable financial resources in low-income countries to reduce malaria incidence like investment in mosquito treated nets, anti-malaria drugs and labour costs.

From Figures 4.1 and 4.2 in the appendix below, it is evident that there might be a two-way causality between malaria and per capita income in the selected African countries. The two graphs shows dual causality but other factors (ecology, climate and hygiene system) that impinge on malaria cases in Africa has not been accounted for.

From Figure 4.1 below, it is evident that there is a negative relationship between income and malaria. Taking logarithm of malaria cases as the dependent variable, the graph shows that income falls as malaria cases rises in African countries for the period of 1990 to 2011. Also, Figure 4.2 shows the negative relationship between malaria and income. In the graph, taking logarithm income per capita in Africa as a dependent variable, there is evidently a negative relationship between malaria and income. Consequently, it is needful to investigate reciprocal relationship between the variables.

The relationship between malaria disease and income may be complex or spurious, as income growth may reduce malaria disease, and malaria disease (owing to cost of prevention and treatment) may also reduce income. The crux of the possible reciprocal relationship between income and malaria are the causal pathways.

Recently, Datta and Reimer (DR) (2013) investigates a two-way causality between malaria and national income to resolve this divergence in opinion. DR (2013) probed whether increasing rate of economic development would help reduce malaria incidence in a sample of 100 countries using data for 17 year time period. DR (2013) develop a utility model of consumption and health status where utility rises with consumption, but at a diminishing rate; and utility also declines with malaria at a diminishing rate. The model was expounded by including various factors that are responsible for malaria disease and economic outcome in a simultaneous equation framework. The simultaneous relationship used for the estimations accounts for reverse causality and the findings of the research is that increased national income un-associated with human capital, increases monies spent for malarial treatment, prevention and, therefore contributes to the negative relationship between malaria and income. On the basis of policy analysis, the findings of DR (2013) contradicts the prediction of Gallup and Sachs (2001). The point of divergence is malaria control suggested by the former and malaria elimination suggested by the latter, drawing from the experience of the rich temperate region.

For instance, Teklehaimanot and Mejia (TM)(2008) of Malaria Program, Earth Institute at Columbia University write that climatic and ecological conditions favours the transmission of *plasmodium falcimodium* and *anopheles gambiae.* According to TM (2008), at both microeconomic and macroeconomic level, the use or absence of insecticide- treated bednets, as well as health expenditure per capita which includes monies spent for both treatment and prevention of malaria disease also affect malaria cases. These factors, in addition to the poverty level of most of the African countries where malaria is rife is what keeps malaria disease in reinforcing cycles. More specifically, TM states that mortality of children under the age of five in Tanzania after fever is 39 percent higher among the poorest than in the least poor. Lastly, the TM states that the poorest are also 2.5 times less likely to receive medical treatment in African countries than in other poor regions.

Given this background, the objectives of this study are: to expand and augment the DR model and include additional models that of particular relevance to Africa. Then the analysis would be repeated using the DR database and the African database. The commonalities and differences between the estimates of DR estimates and the African- focused exercise would form the basis for discussion and policy recommendations in this paper.

The remainder of this paper is organised as follows: section 4.2 expands and augments the workhorse model of DR (2013); section 4.3 details the empirical approach to be adopted and describes the data, section four explains the results of the regression and section five concludes the work.

4.2 Model of Malaria and Income

DR (2013) develop a household utility model of health status (represented by malaria incidence) and consumption where malaria is declining function of utility, albeit at a diminishing rate, and consumption rises with utility, also at a diminishing rate. DR further modelled the private investment in malaria treatment and prevention as $i,$ but this was not accounted for in the empirical investigation. I argue that malaria prevention in Africa which accounts for 90 percent of malaria morbidity and mortality is different from malaria treatment.

Specifically, it has been established in the literature that insecticide-treated bednets/ long-lasting insecticidal nets are effective preventive tools which directly affects malaria disease incidence in Africa (Berthelemy *et al., (*2013); Choi *et al.*, (1995); and Hawley *et al.,* (2003). In this regard, WHO (2014) reports that 49 percent of the population at risk of malaria in Africa in 2013 had access to insecticide-treated nets in their household, in comparison to 3 percent access in Africa in 2004. The report further states that a total of 427 million insecticide-treated nets had been distributed to different African countries since 2012. Inspite of the importance of insecticide-treated nets in preventing malaria-sickness occurrence in Africa, it was not accounted for in the DR model.

Also, I argue in this paper that private investment of household for treatment of malaria disease cannot be proxied by investment as a percentage of Gross Domestic Product (GDP) but health expenditure per capita (HEPC) which is the average of out–of-pocket expenditure for all households in the country.

The relationship between malaria incidence, insecticide-treated nets, and income level are in this respect: health expenditure per capita increases with increased malaria cases per million as the monies may be spent on physicians, treatment of the malaria disease and purchasing insecticides-treated nets to prevent future occurrence. Furthermore, the purchase of insecticide treated bednets increases as malaria incidence increases, as insecticide-treated nets is expected to prevent future occurrence of malaria disease. Moreso, WHO (2014) reports that insecticide treated nets are distributed to areas with the highest malaria incidence, and income level decreases with increased malaria incidence.

Therefore, the augmented form of household utility function u is taken to be a function of consumption c , health status which is represented in this model as sickness s induced by malaria disease, and the preventive insecticide-treated nets/long-lasting insecticide treated nets $t.$

$$u = u(c, s). \tag{4.1}$$

In this form, $u_c \succ 0, u_s \prec 0,$ and the second derivatives yields $u_{cc} \prec 0,$ $u_{ss} \succ 0.$This indicates that utility increases with consumption on the one hand. On the other hand, utility declines with the occurrence of malaria-induced sickness and at a diminishing rate. Similarly, the household budget constraint is given as:

$$c + pi + qj = y, \tag{4.2}$$

where j is the private investment of household on malaria prevention, especially in the purchase of insecticide treated nets, i is the private investment of household on treatment of malaria-induced sickness, p is the price ratio of i to the price index of other goods and q is the price ratio of j to a price index of other goods. Lastly, y is the household income.

Similar to the model of DR, I also assume that the household output or income in a typical African country is contingent on labour l,fixed capital k,malaria-induced sickness $s,$ and other exogenous factors influencing income G.Taken together, the household income function is:

$$y = f(l, k, s, G). \tag{4.3}$$

Here f_l, $f_k \succ 0$, $f_s \prec 0$ and $f_{ll}, f_{kk} \prec 0$, $f_{ss} \succ 0$. This indicates that labour, capital, increases with household income but in a declining rate and sickness declines with household income and also in a diminishing rate.

Malaria-induced sickness is related to private prevention of malaria disease j (which is principally monies spent in buying insecticide treated nets, drugs, insecticides and other forms of defensive health expenditure),private treatment of malaria disease when it eventually occurs i and other exogenous climatic, geographic, and demographic factors H :

$$s = s(i, j, H). \tag{4.4}$$

In this specification, s_i,$s_j \prec 0, s_{ii}, s_{jj} \succ 0,$ indicating that malaria sickness declines with prevention and treatment and at a diminishing rate. It is also assumed that malaria treatment and malaria prevention are separable in theory, but may be merged in practise as there may not be data on these.

Incorporating equations (4.4) into (4.3) yields:

$$y = f(l, k, s(i, j, H), G), \tag{4.5}$$

and substituting (4.5) into (4.2) and re-arranging yields:

$$c = f(l, k, s(i, j, H), G) - pi - qj. \tag{4.6}$$

The household utility maximisation problem can be formed by incorporating (4.4) and (4.6) into (4.1) with to view to choosing the optimal level of private investment in malaria prevention j

and it's treatment when there is occurrence of malaria-induced sickness i.This is given as:

$$\text{Max}_{i,j}\ u(f(l,k,s(i,j,H),G)-pi-qj,s(i,j,H)). \tag{4.7}$$

The first order conditions are:

$$\frac{\partial u}{\partial c}\left[\frac{\partial f}{\partial s}.\frac{\partial s}{\partial j}-q\right]+\frac{\partial u}{\partial s}\left[\frac{\partial s}{\partial j}\right]=0,\text{and }\frac{\partial u}{\partial c}\succ 0,\frac{\partial f}{\partial s},\frac{\partial s}{\partial j},\frac{\partial u}{\partial s}\prec 0, \tag{4.8}$$

$$\frac{\partial u}{\partial c}\left[\frac{\partial f}{\partial s}.\frac{\partial s}{\partial i}-p\right]+\frac{\partial u}{\partial s}\left[\frac{\partial s}{\partial i}\right]=0,\ \text{and }\frac{\partial u}{\partial c}\succ 0,\ \frac{\partial f}{\partial s},\frac{\partial s}{\partial i},\frac{\partial u}{\partial s}\prec 0. \tag{4.9}$$

Equations (4.8) and (4.9) can be re-arranged to show that:

$$\frac{\partial f}{\partial s}.\frac{\partial s}{\partial j}+\frac{\partial u}{\partial s}/\frac{\partial u}{\partial c}.\frac{\partial s}{\partial j}=q, \tag{4.10}$$

$$\frac{\partial f}{\partial s}.\frac{\partial s}{\partial i}+\frac{\partial u}{\partial s}/\frac{\partial u}{\partial c}.\frac{\partial s}{\partial i}=p. \tag{4.11}$$

The re-arrangement of equations (4.10) and (4.11) shows that the marginal benefits of malaria prevention and treatment equals their respective marginal costs, where p and q are taken as the marginal costs of malaria treatment and prevention respectively. Additionally, $\frac{\partial f}{\partial s}.\frac{\partial s}{\partial j}$ and $\frac{\partial u}{\partial s}/\frac{\partial u}{\partial c}.\frac{\partial s}{\partial j}$ are taken to be marginal benefits derived from prevention while $\frac{\partial f}{\partial s}.\frac{\partial s}{\partial i}$ and $\frac{\partial u}{\partial s}/\frac{\partial u}{\partial c}.\frac{\partial s}{\partial i}$ are marginal benefits of malaria treatment if it eventually occurs. At the elementary level, this theoretical derivation is in agreement with the principle of consumer choice. It's been established by DR model and other relevant literature that there is a reciprocal relationship between malaria-induced sickness and household income. That is,

$$\frac{\partial y}{\partial s}=\frac{\partial f(l,k,s(i,j,H),G)}{\partial s}\prec 0. \tag{4.12}$$

Also, given that private investment of malaria prevention is different from private investment on malaria treatment, from equation 4.2, we have $i = \frac{y-c-qj}{p}$, and $j = \frac{y-c-pi}{q}$.Coupling this with equation 4.7 gives:

$$\frac{\partial s}{\partial y} = \frac{\partial s(i,j,H)}{\partial j}.\frac{\partial j}{\partial y} \prec 0, \tag{4.13}$$

$$\frac{\partial s}{\partial y} = \frac{\partial s(i,j,H)}{\partial i}.\frac{\partial i}{\partial y} \prec 0. \tag{4.14}$$

Given this theoretical background, I shall re-estimate the two-way relationship between income and malaria using equations (4.3) and (4.4). The practical estimation issues of these theoretical derivations are explained in the section below.

4.3 Empirical Approach

4.3.1 Functional Form

The functional form of equations (4.4) and (4.5) is linear relationship between dependent and independent variables. The estimable form of the equations are given below:

$$\begin{aligned} GDPPC_{it} &= \beta_o + \beta_1 M_{it} + \beta_2 HEPC_{it-1} + \beta_3 CAP_{it-1} + \beta_4 LAB_{it} + \beta_5 UFM_{it} \\ &\quad + \beta_6 INS_{it} + \beta_7 CST_{it} + \beta_8 SWO_{it} + \beta_9 TRND_t + \xi_{it}, \end{aligned} \tag{4.15}$$

$$\begin{aligned} M_{it} &= \beta_o + \beta_1 GDP_{it-1} + \beta_2 HEPC_{it-1} + \beta_3 CST_{it} + \beta_4 TEMP_{it} + \beta_5 PHY_{it} \\ &\quad + \beta_6 IMUNE_{it} + \beta_7 INS_{it} + \beta_8 LAT_{it} + \beta_9 SWO_{it} + \beta_{10} TRND_t + \epsilon_{it}, \end{aligned} \tag{4.16}$$

$$\begin{aligned} ITN_{it} &= \beta_o + \beta_1 M_{it} + \beta_2 GDP_{it} + \beta_3 HEPC_{it-1} + \beta_4 CST_{it} + \beta_5 TEMP_{it} + \beta_6 IMUNE_{it} \\ &\quad + \beta_7 INS_{it} + \beta_8 LAT_{it} + \beta_9 SWO_{it} + \beta_{10} TRND_t + \varepsilon_{it}. \end{aligned} \tag{4.17}$$

Equation (4.15) shows the determinants of income as proven above, and equation (4.16) shows the determinant of malaria disease in the chosen African countries. In equation (4.15), k, l, and s are proxied by malaria cases per million (m), capital (cap) and labour respectively. A proxy for investment at the household level is Health Expenditure Per Capita (HEPC),. As has been argued above, it is expected that health expenditure per capita (HEPC) will rise in response to increased malaria cases per million population, hence a positive correlation is expected between malaria cases and HEPC. Also, institutions, nearness to coast, under five mortality and openness index are also included as it has been proved by previous studies as been relevant for income per capita growth (DR 2013). In equation (4.16), the recursive relationship between income and malaria used in DR (2013) was also adopted to facilitate effective comparison. The additional variables added to equation (16) which distinguishes this regression from DR are HEPC and the percentage of household protected by insecticide-treated nets (ITN).

The variables used for the specifications above are defined below, and ξ_{it}, ϵ_{it} and ε_{it} are error terms for equations 4.15, 4.16 and 4.17, and is expected to be independent and identically distributed. The variables above are all in logarithmic form in order to reduce the spread, with the exception of trend variable (TRND) and index of Sachs-Warner openness (SWO). Also, the subscript i in the equations represents the various countries used for regression while t stands for year. In contrast to the specifications of DR (2013), the right hand side of equations 4.15, 4.16, and 4.17 are without interaction terms, as this specification is consistent with many economic studies of malaria (Gallups and Sachs, 2001; and McCarthy, 2000$).$

In addition, equation 4.17 shows that we can also run a regression of malaria prevention using ITN. The import of this cannot be over-emphasised as the use of insecticide-treated nets has been proven to be an effective way for preventing malaria disease infection (Berthelemy *et al.* 2013). To this end, WHO (2013) reports ITN either through personal purchases or through governments free distribution, as one of the indicators for combating malaria infection.

It is also worthy of mention that the measure of institution chosen by DR (2013) ranges from

-2, denoting low quality, to +2 denoting high quality. The measure chosen in this work ranges from 0 to 10, indicating that the effect of openness on economic outcome in this paper will have a higher impact, on a percentage basis than the measure chosen by DR (2013).

4.3.2 Data,Variables Definition and Summary Statistics

The source of data and definition of variables as used in this paper are explained in this section below:

Malaria cases per million population (M): Malaria cases is used as the dependent variable on the one hand and the main independent variable on the other hand in the examination of possible reciprocal between malaria disease and income in African countries. The data for malaria cases are retrieved from World Malaria Report (2013) from the period of 1990 to 2011. This data is arrived at by dividing the malaria cases reported in each country by the total population and multiplying it by one million.

Gross Domestic Product Per Capita (GDPPC): Purchasing Power Parity (PPP) converted GDP per capita relative to the United States, G-K method, at current prices is retrieved from Penn world table 7.0 from 1990 to 2011 and used as one of the main variables to investigate the possible reciprocal relationship between income and malaria diseases in Africa.

Percentage of Children Under 15 (CHLD): This variable is used as one of the predictor variable and is retrieved from WDI (2014). The variable is used as it has been established in the brief review of literature that malaria affects children and pregnant women the most in Africa.

Health Expenditure Per Capita (HEPC): The per capita health expenditure in the selected African countries from the period of 1990 to 2011 is used as one of the explanatory variable as it involves expenditure on both prevention and treatment of all diseases including malaria. The apriori expectation is that the higher the malaria cases per million population, the higher the health expenditure per capita, as this includes monies spent for malaria treatment. The data for this is also retrieved from African Development Indicators (2013).

Latitude(LAT): The values of latitude of the country as it is measured in this paper ranges from 0 to 1 where 0 is the equator . This variable proxies geographical factor impinging on malaria cases.The data is retrieved from Quality of Governance (2013).

Temperature(TEMP): Data for annual mean temperature of the African countries is retrieved Mitchell *et al.* (2003). The annual mean temperature is calculated as the average of the maximum and minimum temperature of the countries from January to December in a year.

It100km (CST): Amount of territory within 100km of the coast can affect the reproduction of malaria parasite reproduction. This data is retrieved from Acemoglu *et al.* (2001).

Avexpr(INS): This variables literally means average protection against expropriation risk, that is, protection against repudiation of contracts by the governments of the host country. This measure is used as one of the institutional indices in the selected African countries. The measures ranges from 0-10 with 0 indicating no protection and 10, maximum protection against expropriation risk. This data is sourced from Acemoglu *et al.* (2001). It is also worthy of mention that the measure of institution chosen by DR (2013) ranges from -2, denoting low quality, to +2 denoting high quality. The measure chosen in this work ranges from 0 to 10, indicating that the effect of openness on economic outcome in this paper will have a stronger effect, on percentage basis, than the institutional measure chosen by DR (2013).

Investment(CAP): Investment share of converted GDP per capita at current prices is chosen as one of the determinants of economic growth. The data was retrieved from Penn world table 7.0 from 1990 to 2011 for the 43 African countries in this research.

SWopen(SWO): Sachs and Warner Index of openness was retrieved from Sachs and Warners (1995). The index 1 is for trade openness and 0 for a state of autarky.

Climatic Dummy (CLIM): This is the dummy variable used to identify the climatic region a country belongs. 1 represents tropical or sub-tropical region while 0 represents temperate or desert region.

Immune(IMUNE): This is the percentage of the population immunized against diphteria, pertussis and tetanus. This is to make the population less vulnerable to infectious disease and is chosen as one of the proxies for malaria prevention. The data was retrieved from World Development Indicators (WDI) (2013).

Physicians (PHY): Physicians per thousand of populations representing the number of staffs skilled in the treatment of malaria disease. This data is retrieved from WDI (2013).

Labour(LAB): Percentage of workforce in the population. This is used as one of the independent variable as malaria is predicted to affect productivity negatively in the background to the study. This data is retrieved from WDI (2013).

Percentage of people protected by Insecticide-Treated Bednets (ITN): The percentage of people protected (distributed or sold) by ITN in the African countries is used to infer protection from malaria parasites at household level. This data is retrieved WHO (2013).

Under Five Mortality(UFM): Percentage of under-5 mortality in the selected African countries. The data is retrieved from ADI (2013) but the percentage is own calculation.

Trend (TRND): This variable is used in the same fashion as DR (2013) to capture the time effects.

Table 4.1: Summary Statistics

Variable	obs	Mean	Std. Dev	Min.	Max
trnd	946	11.5	6.347645	1	22
gdppc	934	1136.896	2246.336	64.3562	27818.6
hepc	946	53.22121	90.10533	3.80563	1236.15
lat	924	0.139495	0.11787	0	0.673088
temp	945	25.71175	3.621192	17	32.4
ins	770	5.951949	1.102016	3.63636	8.27273
cst	748	0.147491	0.1469001	0	0.570964
cap	942	21.06515	12.66316	-34.02	117.35
m	944	100527.7	126714.3	3.09166	1800000
lab	946	39.16957	8.586188	0.70444	53.6464
swo	792	0.25	0.4332863	0	1
phy	893	0.155572	0.1957284	0.008	1.207
chld	946	43.65576	3.892521	27.1201	49.9203
clim	946	0.9069767	0.2906187	0	1
itn	880	57.6	30.235339	0	10
ufm	946	13.44742	5.348756	2.13	31.37
imune	934	67.5	21.68476	10	99

Table 4.2: Summary Statistics of DR(2013) for 100 countries

Variable	obs	Mean	Std. Dev	Min.	Max
trnd	1700	9	4.900421	1	17
gdppc	1700	3478.118	3255.577	74.83	18682.5
m	1700	50052.58	120916.3	0	2700000
lat	1700	0.200604	0.14495	0	0.67309
temp	1696	23.93226	4.748326	5.38213	34
ins	1697	6.068665	1.3394	1.63636	8.63636
cst	1697	0.326221	0.319371	0	1
swo	1563	0.387716	0.487385	0	1
chld	1700	41.76394	7.306443	20.614	69.2639
phy	1551	0.7438	1.00689	0.0038	5.192
lab	1264	67.62263	11.79975	35.3	91.3
cap	1645	21.43823	11.70604	0.75997	88.0044
clim	1700	0.66	0.473848	0	1
imune	1649	65.63311	23.96213	2	99
atr	1528	15.56461	10.82804	0.71	105.36
malfal94	1632	46.22273	42.51996	0	100
le	1700	59.97468	9.32171	35.7927	77.8958
hepc	1663	155.6505	159.4415	10.2044	851.536
itn	1564	43.29923	34.80866	0	100
ufm	1697	104.3278	66.6551	5.3	334.5

4.3.3 Econometric Strategy

In order to facilitate effective comparison between this paper and the publication of DR in 2013, three systematic strategies would be employed. First is difference in datasets, second is difference in model specification and lastly, difference in econometric techniques. For the datasets, the DR (2013) use datasets of 100 countries around the world for the period of 1985-2001 (17 years) while the African focused exercise I embark upon is from 1990-2011 for 43 African countries, thus the DR (2013) dataset is broader in countries and shorter in years in relation to the African focused regressions which is longer in years (22) but shorter in countries' dimension. The list of 100 countries used for regression for DR (2013) and the 43 African countries are detailed in tables 4.9 and 4.10. A few details stand out from the summary statistics tables above in tables 4.1 and 4.2: average malaria cases per million in the DR (2013) datasets is 50,052 while the average malaria case in the 43 African countries I have chosen is 100,528.

Similarly, national income per capita in the DR dataset is $3478 while the average national income in the African focused exercise is $1136. Hence malaria cases per million population in the 43 African countries is much more than the average malaria cases in the 100 countries of DR datasets while the average income in the DR dataset is higher than the average income in the malaria datasets. This will affect the size of estimates of both malaria cases and income in the comparison below. The climatic dummy variable in the DR dataset shows 66 percent are from tropical region while the remaining 34 percent while the database for the African countries show that 91 percents of the 43 countries are from tropical or subtropical region while the remaining 9 percent are either from temperate or desert region. The results section shall also detail various model specifications and econometric techniques for both the DR dataset and the dataset for the 43 African countries used for comparison. For instance, the econometric technique used for all the regressions include Ordinary Least Square (OLS), Two Stage Least Square (2SLS), Three Stage

Least Square (3SLS), and Seemingly Unrelated Regression Model (SUR).

4.4 Results

The estimation results in tables 4.3 to 4.7 show variations of model specifications, datasets and econometric techniques. In all the tables 'DR' indicates a global dataset of countries where malaria is rife: 100 countries for 17 years, while AFR is the dataset for 43 African countries for 22 years. Thus, the time dimension in the African database is longer than in the DR database but the countries' dimension is longer in the DR database than the African database. The comparison shall be systematically carried out in this manner: comparison of results using various econometric techniques with the inclusion of insectide-treated nets and other variables, and comparison of datasets without insecticide-treated nets.

4.4.1 Comparison of Results Using Different Econometric Models

The starting point of the comparison between the global estimates of malaria-income nexus of 100 countries for 17 years, and the 43 African countries for 22 years is the joint estimation of equations 4.15 and 4.16 using multivariate regression model (OLS), 2SLS, 3SLS and SUR. The model fits the data well as the R^2 for the 8 regression results displayed in tables 4.3 and 4.4 ranges from 0.68 to 0.77.

Using multivariate regression model, the second and third columns of table 4.3 shows that the coefficient of malaria cases per million population is -0.0357 for the DR database while it is -0.0618 for the African database. This indicates that a 1% rise in the number of malaria cases per million in the DR database would reduce income by 0.0357% while reducing income by 0.0618% in the African database. This is the expected size and signs of estimates and show that the effect of malaria incidence on income is stronger in African countries. These estimates are different than zero at 1 percent level.

The same multivariate regression model shows that health expenditure per capita (HEPC) and share of investment in GDP per capita (CAP) all have a positive and significantly related to GDP per capita using the DR database with the coefficients 0.0522 and 0.0818 respectfully. This shows that both defensive expenditure and expenditure on curing malaria disease has a effect of increasing income through better health status. However, the percentage of labour force in population is negatively related to income in both the DR database and the African countries' regression, contrary to apriori expectation. Also, as expected, the percentage of under five mortality (UFM) in the selected African countries are negative and significantly related to income, with coefficient of 0.6744 in the DR database and 0.7306 in the African countries. These estimates are informative as it shows that under-five mortality has more damaging effect on income using the African database than in the global database of 100 countries. Most importantly, columns 2 and 3 of table 4.3 also shows that a 1% rise in percentage of people protected by insecticide-treated nets (ITN) will reduce income by 0.0856% using the DR database and 0.0773%. The possible explanation for this is that the expenditure of purchasing nets on its own reduces the monies left for household in spending on other goods and services thus the negative relationship.

The second equation (equation 4.16) in table 4.3 quantifies the lagged effect of income on malaria, and shows that the relationship is negative and significant at 1 percent level. The coefficient for lagged GDP in table 4.3 for columns 2 and 3 are 0.7290 and 0.6250 for the DR database and the African database. As explained above, this means a 1% rise in income per capita, holding constant other effects, will be associated with a 0.729% reduction in malaria cases using the DR database and 0.625% using the database for 43 African countries. These are different from zero at 1% statistical significance. In table 4.3, just below the estimate of lagged GDP per capita is HEPC which is positively related to malaria cases per million, and statistically significant for the African database at 1% level but the estimate is not different from zero for the DR database. The sign of HEPC is positive probably because the increase in malaria cases also is associated with increased monies spent for treatments and prevention. More so, the percentage of household protected by insecticide-treated nets (ITN) is also positively related to malaria cases per million. Also, nearness to coast (CST), temperature (TEMP), percentage of children under 15 (CHLD) are positive and significantly related to malaria cases while the number of physicians per thousand population and latitude (LAT) is found to reduce malaria cases per million. The coefficient of the intercept is negative and significant at 1% level. However, the null hypothesis of no-endogeneity was rejected in this table using Hausman test. Thus the results of the 2SLS is both consistent and efficient. Furthermore, the measure of institution (INS) is positive and significantly related to malaria cases per million using the African database while the estimates is not different from 0 using the DR database. In all, the second equation of joint estimation of equations 4.15 and 4.16 gives the same result estimates for OLS and 2SLS for both the DR database and African database.

Table 4.4 compares joint estimation equations 4.15 and 4.16 using 3SLS estimation and SUR for both the DR database and the African database. Before proceeding with the estimation results using 3SLS, I checked for the validity of the instruments used for regression by regressing M_{it} on all the exogenous variables in the first stage of the regression and found that M_{it} is a valid instrument, given that its R^2 is 0.96 for the African database and 0.99 for the DR database. On the other hand, the predicted value of $GDPPC_{it}$ is also taken to be the instrumental variable for $GDPPC_{it}$. Regressing $GDPPC_{it}$ on all the exogenous variables gives R^2 of 0.59 for the DR database and 0.45 for the African database.

The coefficient of malaria cases per million in columns 2 and 3 of table 4.4 are -0.0889 and -0.3469 for DR database and African database respectively. This indicates that a 1% rise in malaria cases per million will be associated with 0.0889% income reduction in the DR database for 100 countries in various regions of the world while a 1% rise in malaria cases per million will reduce income to the tune of 0.3469% using the African database. The other estimates are similar to what was displayed in table 4.3 in terms of signs and sizes of the estimates.

Also in table 4.4, quite tellingly from columns 2 and 3 of the second equation (equation 16), a 1% increase in GDP per capita (or income) will decrease malaria cases per million by 1.5537% using the DR database and 1.3345% by African database using the 3SLS econometric estimation. Furthermore, a 1% increase in GDP per capita in column 4 and 5 of the second equation displayed in table 4.4 will reduce malaria cases per million by 1.1742% using the DR database and by 0.9494% using the African database for the SUR econometric estimation.

In sum, in tables 4.3 and 4.4, there is a negative and significant reciprocal relationship between malaria and income using both the DR database and the African database for OLS, 2SLS, 3SLS and SUR econometric estimators. In all the comparative regressions, income growth is estimated as the most important driver of the negative reciprocal relationship between GDP per capita and malaria cases per million in all the four regressions which include estimates for insecticide-treated nets (ITN), and other explanatory variables. In all, the income effect is estimated to be more in the DR database comprising of 100 countries for 17 years than the 43 African countries for 22 years. Hausman specification tests displayed in tables 10 and 11 shows that 2SLS and 3SLS are preferred estimators for the DR database and OLS and 3SLS preferred for the African focused regression.

In table 4.5, as part of the regression estimates that includes insecticide-treated nets, I ran four OLS regressions for equations 4.15 and 4.16 using African and DR database. The results estimate for both DR database and African database also shows that there is reciprocal relationship and the signs and sizes of the estimates are similar to the estimates arrived at using joint estimation. Thus, the policy implications of the estimates arrived at will be the same as have been explained above.

Given the emphasis on insecticide-treated nets in malaria-income nexus, I also estimated the determinants of insecticide-treated nets both in levels and in lagged-term and the results are displayed in table 4.6. The result of the OLS regressions shows that malaria rises with insecticide-treated nets. The OLS regression using DR database indicates that a 1% rise in malaria cases per million will lead to a 0.1341% rise in the household protected by insecticide-treated nets and a 1% rise in malaria cases per million will lead to 0.0758% rise in the household protected by insecticide treated nets using the African database. In the same vein, the coefficients of malaria cases per million in lagged term is also positive and significant both for the DR database and the African database. Also, the OLS regression in levels for DR database shows that increase in under-five mortality (UFM) and Latitude (LAT) will increase insecticide-treated nets both in levels and in lagged term. However, the R^2 for the regressions are 0.12 and 0.36 for DR and African database.

4.4.2 Comparison of Results Using Different Empirical Models

In this subsection, I compare both the DR database and the African database without insecticide-treated net (ITN) and some other variables using 3SLS estimators. Columns 2 and 3 of equation 4.15 in table 4.7 shows that 1% increase in malaria cases per million will lead to 0.05277% and 0.2560% reduction in income using DR and African database respectively. This is similar in size and signs to the regression estimates which includes insecticide-treated nets. The table also shows that a 1% rise in Health Expenditure Per Capita (HEPC) will lead to a 0.07166% and 0.4896% increase in GDP per capita using the DR and African database respectively. This is intuitive because monies spent for malaria prevention and cure will lead to increased productivity and thereby increasing income. The other estimates that are statistically significant in column 2 and 3 of table 4.7 are similar in sign and size with the exception of trend variable (TRND) with opposing signs and also significant.

The second model specification that excludes insecticide-treated nets (ITN), labour (LAB) and share of investment in GDP (CAP) of equation 4.16. The sign and size of malaria cases per million in DR and African database are similar to the regression results of the first specifications with 0.0924 and 0.2985 for DR and African database respectively. This shows that the reciprocal effect of malaria and income is well established in all the specifications.

To round out the robustness checks and comparative exercise, the second equation (equation 4.17) of the joint estimation of 3SLS in table 4.7, column 2 and 3 shows that a 1% rise in GDP per capita will be associated with 1.2338% and 1.8019% reduction in malaria cases per million using the DR database and African database respectively. The table further shows that increase in nearness to coast (CST) and temperature (TEMP), climate index (CLIM) also increases malaria cases per million while the number of physicians per 1000 population will decrease malaria cases million.

Columns 4 and 5 of the regression results of equation 4.16, as part of the joint estimation of 3SLS in table 4.7 shows that a 1% increase GDP per capita will lead to reduction in malaria cases per million using both DR and African database by 1.3817% and 1.8045% respectively. Since the signs and size of the other estimates in columns 4 and 5 are similar to the regression results reported in this subsection, similar policy implication implies, to avoid repetition.

Two interesting finds in the comparative exercise in this section and in the section where different econometrics models where used are these: firstly, income growth is the most important driver of the negative reciprocal relationship between income and malaria cases per million in all the four regressions which exclude estimates for insecticide-treated nets (ITN), and other explanatory variables (Labour and investment share of GDP). Secondly, the income effect is estimated to be more in the African database comprising of 43 countries for 22 years than the global estimates of 100 countries for 22 years. In the earlier subsection where different econometric models were used with the inclusion of insecticide treated nets and other variables, the income effect is more using the DR database than in using the African database.

4.4.3 Diagnostics

The diagnostic tests for the regression estimates are displayed at the end of each regression results table. Using lmcovreg3 and lmareg3 command in stata 14, I test for Breusch-Pagan LM diagonal tests and system autocorrelation for both 2SLS, 3SLS, and SUR. I fail to reject the null hypothesis of no-heteroskedasticity in all the regression estimates, both for 2SLS, 3SLS, and SUR. Hence, I use standard errors that is consistent with heteroskedasticity.

Also, the Durbin-Watson tests for all the regressions displayed in the tables below are below 1 indicating there may be serial correlation in the regression. The goodness of fits of the estimates also shows that the explanatory variables fit the dependent variable well as the estimates from tables (with the exception of regression results in table 4.6).

4.4.4 Comparison to other Published Work

In this subsection, I compare the estimates of malaria-income regressions with similar results obtained by researchers in the field of health economics. Gallup and Sachs (2001) use malaria exposure index in 1994 as representing malaria cases, and the studies find that exposure to malaria falciparum in 1994 makes the countries where it is rife to grow 1.3% lesser than others that are free of malaria and that a 10% reduction in malaria is associated with increased growth rate of 0.3%. However, Packard (2009) doubts the estimates of Gallup and Sachs given that indices and not real malaria estimates are used for the regression. However, this study use real estimates of malaria cases per million population and found that a 1% increase in malaria cases per million population (with the inclusion of insecticide-treated nets as one of the explanatory variable) will be associated with 0.035% reduction in income using the DR database and 0.0617% reduction in income using the African database, as displayed in table 4.3 below.

Similarly, Egbedewe-Mondzozo et al. (2011) examine the impact of malaria cases per 1000 in a cross-section of 25 African countries (and for 10 years) and find that a 1% increase in income per capita reduces malaria cases per 1000 by 0.0008%. This study is different from the research of Egbedewe-Mondzozo in three distinct ways: first, the number of African countries in this study is 43 over 22 years period; while Egbedewe-Mondzozo use semi-parametric technique, the estimation techniques of this work are: OLS, 2SLS, 3SLS, and SUR. Thirdly, the findings of this study is that a 1% increase in income will be associated with 0.6205% reduction in malaria cases per million population.

4.5 Conclusion

This paper compares the estimation of DR (2013) based on 100 countries around the world over 17 years (1985-2001), with 43 African countries over 22 years (1990-2011). The basis of the comparison are that, over 90 percent of malaria mortality and morbidity in the world occurs in these 43 countries. Also, essential variables that are reported by the World Malaria Report as been crucial to malaria incidence in these countries are excluded from their analysis, namely: insecticide-treated nets and health expenditure per capita. This study adds additional insight to the literature examining the impact of insecticide treated nets on the reciprocal relationship between malaria and income. Therefore, I expand and augment the DR model and include additional variables relevant for malaria-income analysis before re-estimating the equation and comparison the regression estimates.

Expectedly, this paper finds a statistically significant reciprocal relationship between malaria and income in agreement with the findings of DR (2013). Furthermore, in the comparative exercise where different econometric models where used as the basis of comparison with the inclusion of insecticide treated nets and other explanatory variables such as labour and investment share in GDP; the paper finds that income is the most important driver of the negative reciprocal relationship between malaria and income. Secondly, this approach also finds that the effect of income on malaria is stronger when the DR (2013) database is used than when the African database is used.

On the contrary, the comparison based on different model specification without variables like insecticide-treated nets, and labour and capita also finds that income is the most important driver of the negative reciprocal relationship, however, the effect of income on malaria is now stronger using the African database than when the DR (2013) database is used for estimation.

Other research findings is that increase in malaria cases will also lead to increase in the demand for insecticide-treated nets or the percentage of household protected by insecticide treated nets as displayed in table 6. This is plausible as World Malaria Reports (2013) advocates for more practical malaria prevention tools, in countries where malaria is rife, like insecticide-treated nets. Furthermore, closeness to the equator (LAT) is found to increase the supply of insecticide-treated nets. This is interesting because Congo DR which is along the equator has the country with the second largest malaria cases Africa.

Policy recommendations are for increased efforts at economic growth in Africa as this is found to be the highest driver of malaria reduction in contrast to the submission of Gallup and Sachs. Efforts should also be made to increase the supply of physicians in the countries where malaria cases is rife in order to reduce the severity of, or cure to the malaria disease for those infected. Lastly and most importantly, there should be a more effective distribution of insecticide treated nets in the African countries where malaria is rife.

Figure 4.1: Malaria vs Income (1990-2011)

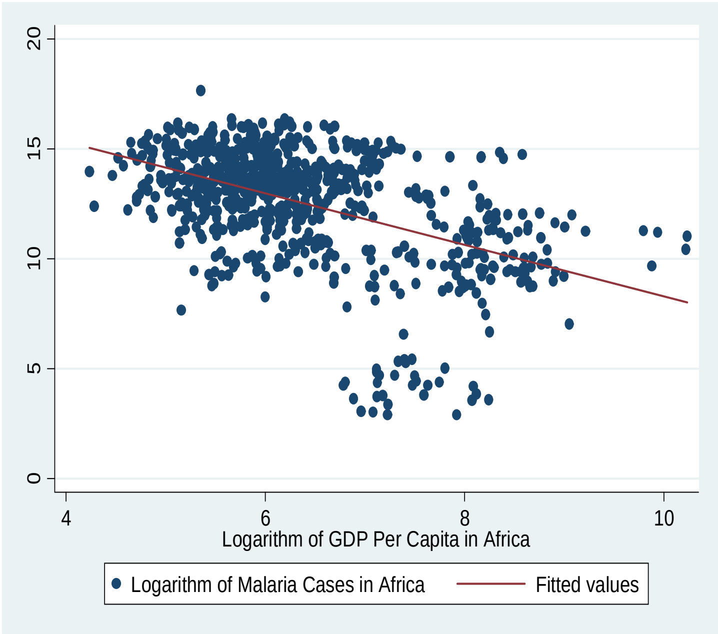

Figure 4.2: Income vs Malaria (2011)

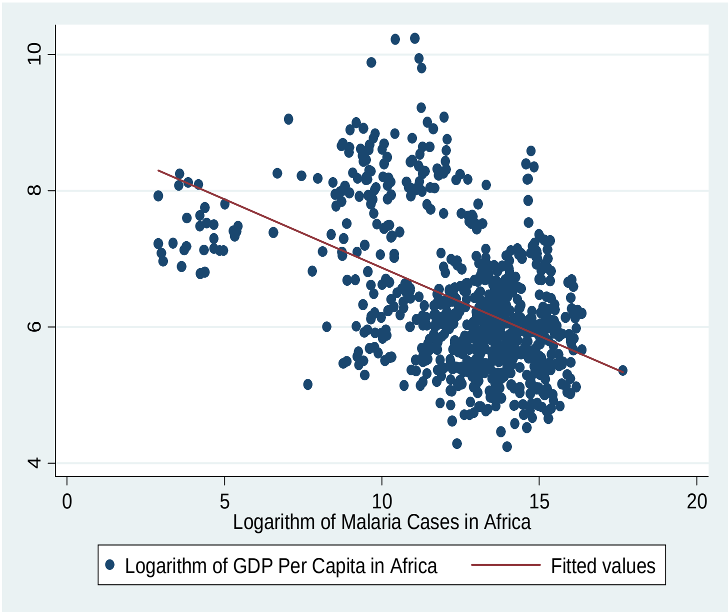

Table 4.3: Comparison of Regression results using DR database and African-Focused Regression

Equation 16, dependent variable $GDPPC_{it}$				
	DR (OLS)	AFR(OLS)	DR (2SLS)	AFR(2SLS)
Variables				
M_{it}	-0.03573***	-0.06175***	-0.0844***	-0.3476***
$HEPC_{it-1}$	0.05215***	0.6545***	0.0404***	0.6378***
CAP_{it-1}	0.08179***	-0.03644	0.05211	0.0692
LAB_{it}	-0.6864***	-0.6869***	-0.6156***	-0.5585**
ITN_{it}	-0.08564***	-0.0773***	-0.0779***	-0.0254***
UFM_{it}	-0.6744***	-0.7304***	-0.6026***	-0.4241***
INS_{it}	0.7933***	0.4695***	0.7368***	1.1031***
CST_{it}	0.0485**	0.04542	0.037***	0.1600***
SWO_{it}	-0.2473***	-0.07379	-0.2428***	-0.0429
$TRND_{t}$	-0.0088**	0.0026	-0.0101**	0.0136***
Intercept	12.8354***	8.8116***	12.5457***	9.2055***
Equation 17, dependent variable M_{it}				
GDP_{it-1}	-0.7290***	-0.6205***	-0.7290***	-0.6205***
$HEPC_{it-1}$	-0.0056	0.3317***	-0.0056	0.3317***
ITN_{it}	0.1592***	-0.0705	0.1592***	-0.0705
CST_{it}	0.2699***	0.3112***	0.2699***	0.3112***
$TEMP_{it}$	1.4945***	0.1255	1.4945***	-0.1255
PHY_{it}	-0.4974***	-0.2396***	-0.4974***	-0.2396***
$IMUNE_{it}$	0.8862***	0.7283***	0.8862***	0.7283***
INS_{it}	0.5047	1.7925***	0.5047	1.7925***
LAT_{i}	-0.6316***	-0.0917*	-0.6316***	-0.0917*
$CHLD_{it}$	3.5268***	3.3422***	3.5268***	3.3422***
$CLIM_{i}$	0.6446***	0.5189**	0.6446***	0.5189
$TRND_{t}$	0.0011	0.0246***	0.0011	0.0246***
Intercept	-10.6421***	-5.3489***	-10.6421***	-5.3489***
N	782	466	782	466
R^2	0.72	0.77	0.71	0.6881
Durbin-Watson	-	-	0.0958	0.7823
Breusch-Pagan	-	-	104.69	201.47

Table 4.4: Comparison of Regression results using DR database and African-Focused Regression

Equation 16, dependent variable $GDPPC_{it}$				
	DR (3SLS)	AFR(3SLS)	DR (SUR)	AFR(SUR)
Variables	Equation 15, dependent variable GDP_{it-1}			
M_{it}	-0.0889***	-0.3469***	-0.0685***	-0.1482***
$HEPC_{it-1}$	0.0425**	0.6447***	0.04661**	0.6443***
CAP_{it-1}	0.1061***	0.0138	0.09512***	-0.0159
LAB_{it}	-0.5212***	-0.3638*	-0.6068***	-0.6283***
ITN_{it}	-0.0729***	-0.0343	-0.0782***	-0.0648***
UFM_{it}	-0.5729***	-0.4606***	-0.6238***	-0.6788***
INS_{it}	0.7693***	1.1109***	0.7469***	0.6548***
CST_{it}	0.0485**	0.1686***	0.03459	0.6548***
SWO_{it}	-0.2422**	-0.0747	-0.2497**	-0.0799
$TRND_t$	-0.0102**	0.0124***	-0.0096**	0.0052
Intercept	11.8354***	8.7644***	12.2491***	9.0548***
Equation 17, dependent variable M_{it}				
GDP_{it-1}	-1.5537***	-1.3345***	-1.1742***	-0.9494***
$HEPC_{it-1}$	0.03305	0.8530***	0.0316	0.5636***
ITN_{it}	0.05563	-0.0569	0.0900*	-0.0831
CST_{it}	0.3361***	0.3855***	0.3046***	0.3216***
$TEMP_{it}$	1.7793	-0.4001	1.6972***	-0.2374
PHY_{it}	-0.4164***	-0.1141***	-0.4601*	-0.1973***
$IMUNE_{it}$	1.0945***	0.5552***	1.0328***	0.7426***
INS_{it}	1.0685***	2.4598***	0.7930**	2.0599***
LAT_i	-0.6399***	-0.0788*	-0.6514***	-0.0976*
$CHLD_{it}$	2.0228***	1.7323***	2.7118***	2.9254***
$CLIM_i$	0.1985	0.1805	0.3984**	0.4356***
$TRND_t$	-0.0130	0.0248***	-0.0062	0.0211**
Intercept	-0.6628	2.7034*	-5.5732**	-1.4139
N	782	466	782	466
R^2	0.72	0.687	0.687	0.76
Durbin-Watson	0.0988	0.7781	0.0977	0.7249
Breusch-Pagan	104.6994	201.47	29.5962	24.2121

Table 4.5: Comparison of DR and African-Focused OLS Regression

Equation 16, dependent variable $GDPPC_{it}$				
	DR (OLS)	-	AFR (OLS)	
M_{it}	-0.0284***		-0.047***	
$HEPC_{it-1}$	0.0668***		0.6424***	
CAP_{it-1}	0.06399*		-0.0103	
LAB_{it}	-0.7311***		-0.7673***	
ITN_{it}	-0.0964***		-0.0796***	
UFM_{it}	-0.7109***		-0.7767***	
INS_{it}	0.7309***		0.4793***	
CST_{it}	0.0222		0.01569	
SWO_{it}	-0.2482***		-0.0821*	
$TRND_t$	-0.0079*		0.0035	
Intercept	12.8545***		8.9556	
N	852		504	
R^2	0.736		0.778	
Equation 17, dependent variable M_{it}				
		DR(OLS)	-	AFR(OLS)
$GDP_{i,t-1}$		-0.5913***		-0.6205***
ITN_{it}		0.1822***		-0.0705
$HEPC_{it-1}$		-0.1553***		0.3317***
CST_{it}		0.1649**		0.3112***
$TEMP_{it}$		1.1853***		-0.1255
PHY_{it}		-0.5246***		-0.2396***
$IMUNE_{it}$		0.5331***		0.7283***
INS_{it}		0.2213		1.7925***
LAT_{it}		-0.5932***		-0.0917
$CHLD_{it}$		3.7255***		3.3422***
$CLIM_i$		0.8496***		0.5189**
$TRND_t$		-0.0107		0.0246***
Intercept		-9.0063***		-5.3489
N		852		466
R^2	-	0.5265	-	0.3786

Table 4.6: Comparison of Regression Results for Insecticide-Treated Nets

	DR(OLS)	AFR (OLS)
Variable	Equation 18, dep. var. ITN	
M_{it}	0.1341***	0.0758*
$HEPC_{it-1}$	-0.0485	-0.5032***
CST_{it}	-0.0725	-0.2862***
$TEMP_{it}$	0.0084	0.3209
$IMUNE_{it}$	0.1606	0.6223***
UFM_{it}	0.2892***	0.1341
LAT_{it}	0.2483***	0.2596***
INS_{it}	0.0933	-0.8991***
$TRND_{t}$	0.0121	0.01494***
Intercept	0.2479	0.0149**
N	1163	495
R^2	0.12	0.359
Regression with lagged ind. variables		
Equation 18, dep. var. ITN		
$M_{i,t-1}$	0.1392***	0.0977**
$HEPC_{i,t-1}$	-0.0568	-0.5014***
$CST_{i,t-1}$	-0.0727	-0.3020***
$TEMP_{i,t-1}$	0.0938	0.3407
$IMUNE_{i,t-1}$	0.1198	0.6196
$UFM_{i,t-1}$	0.2603***	0.1204
LAT_{it-1}	0.2518***	0.2640***
INS_{it-1}	0.0585	-0.9182***
$TRND_{t}$	0.0109	0.0149**
Intercept	0.3363	1.8732
N	1,159	495
R^2	0.1204	0.3682

Table 4.7: Comparison of Regression results using DR database and African-Focused Regression Uisng Different Model Specifications

Equation 16, dependent variable $GDPPC_{it}$				
	DR (3SLS1)	AFR(3SLS1)	DR (3SLS2)	AFR(3SLS2)
Variables	Equation 16, dependent variable : GDP			
M_{it}	-0.05277***	-0.2560***	-0.0924***	-0.2985***
$HEPC_{it-1}$	0.07166***	0.4896***	0.0659***	0.4997***
CAP_{it-1}	0.1582***	-0.0624	-	-
LAB_{it}	-0.7439***	-0.4608*	-	-
ITN_{it}	-	-	-	-
UFM_{it}	-0.5878***	-0.2859**	-0.6065***	-0.1460
INS_{it}	0.8349***	1.2411***	0.6681***	1.2948***
CST_{it}	0.0189	0.2491***	0.01939	0.2586***
SWO_{it}	-0.1204***	0.0952*	-0.1270***	0.05625
$TRND_{t}$	-0.0096**	0.02537***	-0.0120***	0.0262***
Intercept	11.7858***	7.9534***	9.8869***	6.0575***
Equation 17, dependent variable M_{it}				
GDP_{it-1}	-1.2338***	-1.8019***	-1.3817***	-1.8045***
$HEPC_{it-1}$	0.0458	0.9089***	0.03785	0.9288***
ITN_{it}	-	-	-	-
CST_{it}	0.2838***	0.5928***	0.2634***	0.6097***
$TEMP_{it}$	1.1431***	1.5061***	1.1620**	1.2251***
PHY_{it}	-0.7327***	-0.4056***	-0.6643***	-0.4373***
$IMUNE_{it}$	0.9987***	0.0401	0.7173***	0.0184
INS_{it}	1.1796***	3.0349***	1.2449***	2.9642***
LAT_{i}	-0.4909***	-0.2148***	-0.4222***	-0.1949***
$CHLD_{it}$	1.7071***	1.3833**	1.5372***	1.2246*
$CLIM_{i}$	1.1302***	0.9904**	1.2229***	0.9261***
$TRND_{t}$	-0.0048	0.0574***	-0.0087	0.0563***
Intercept	-0.7676	1.31003	2.2773	3.0599
N	875	549	1080	549
R^2	0.67	0.628	0.598	0.59
Durbin-Watson	0.1074	0.4078	0.1697	0.4006
Breusch-Pagan	68.726	213.06	368.9390	246.15

Table 4.8: List of the 100 Countries used for DR Estimation

Afghanistan	Cote'Divoire	Korea	SaoTome
Algeria	Djibouti	Kyrgyzstan	Saudi Arabia
Angola	Dominican R	Laos	Senegal
Argentina	Ecuador	Liberia	Sierra Leone
Armenia	Egypt	Madagascar	Solomon Islands
Azerbaijan	El Salvador	Malawi	Somalia
Bangladesh	Equitoria Gu	Malaysia	South Africa
Belize	Eritrea	Mali	Sri-Lanka
Benin	Ethiopia	Mauritania	Suriname
Bolivia	Gabon	Mauritius	Swaziland
Bostwana	Gambia	Mexico	Syria
Brazil	Georgia	Morocco	Tajikistan
BurkinaFaso	Ghana	Mozambique	Tanzania
Burundi	Guatemala	Nepal	Thailand
Cambodia	Guinea	Nicaragua	Togo
Cameroon	Guinea Bissa	Niger	Turkey
CapeVerde	Guyana	Nigeria	Turkmenistan
Central Afr. R	Haiti	Oman	Uganda
Chad	Honduras	Panama	Uzbekistan
China	India	Pakistan	Vanuatu
Colombia	Indonesia	Papa New G	Venezuela
Comoros	Iran	Paraguay	Vietnam
Congo DR	Iraq	Peru	Yemen
Congo	Kenya	Phillipines	Zambia
Costa Rica	Korea DR	Rwanda	Zimbabwe

Table 4.9: List of 43 Countries used for African-Focused Regression

Algeria	Congo	Kenya	Sao Tome
Angola	Cote Divoire	Liberia	Senegal
Benin	Congo DR	Madagascar	SierraLeone
Botswana	Equitoria Guinea	Malawi	South Africa
BurkinaFaso	Eritrea	Mali	Swaziland
Burundi	Ethiopia	Mauritania	Tanzania
Cameroon	Gabon	Mozambique	Togo
Cape Verde	Gambia	Namibia	Uganda
Central Afr. R	Ghana	Niger	Zambia
Chad	Guinea	Nigeria	Zimbabwe
Comoros	Guinea-Bissau	Rwanda	

Table 4.10: Hausman Specification Tests for African Focused Regression

Null Hypothesis of Regression	Alternative Hypothesis	Chi-Square statistics
2SLS is both consistent	2SLS is inconsistent;	27.63***
and efficient; OLS is	OLS is consistent	
consistent but inefficient		
2SLS is both consistent	2SLS is inconsistent	6.07
and efficient; 3SLS is	3SLS is consistent	
consistent but inefficient		
OLS is both consistent	OLS is inconsistent	322.75***
and efficient; 3SLS is	3SLS is consistent	
consistent but inefficient		

Table 4.11: Hausman Specification test for DR database

Null Hypothesis of Regression	Alternative Hypothesis	Chi-Square statistics
2SLS is both consistent	2SLS is inconsistent	28.84***
and efficient; OLS is	OLS is consistent	
consistent but inefficient		
2SLS is both consistent	2SLS is inconsistent	28.16***
and efficient; 3SLS is	3SLS is consistent	
consistent but inefficient		
3SLS is both consistent	3SLS is both consistent	23.73***
and efficient; OLS is	and efficient; OLS is	
consistent but inefficient	consistent and inefficient	

Acemoglu, D., S. Johnson and J.A. Robinson (2001). The Colonial Origins of Comparative Development: An Empirical Investigation, *The American Economic Review* 91 (3):1369-1401

Acemoglu, D.,S. Johnson & J.A.Robinson (2005). Institutions as a Fundamental Cause of Long Run Growth. In Aghion, P and S.N. Durlauf (Ed.), *Handbook of Economic Growth.* Vol (1): Elsevier DOI:10.1016/51574-0684(05)01006-3.

Adger, W.N., S. Agrawala, M.M.Q Mirza, C.Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit. and Takahashi (2007): Assessment of adaptation practices, options, constraints and capacity. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), M.L.Parry, O.F.Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press,Cambridge, UK 717-743

African Development Indicators (2013). African Development Indicators 2012/2013, available at https://openknowledge.worldbank.org/bitstream/handle/10986/13504/9780821396162.pdf?sequence=1

Alexeev, M & R.Conrad (2009). The Elusive Curse of Oil. *The Review of Economics and Statistics,* 91(3):586-598

Al-Ubaydli, O. (2012). Natural resources and the trade off between authoritarianism and development. *Journal of Economic Behaviour & Organisation,* 81:137-152.

Andersen, J.J., & S. Alaksen (2008). Constitution and the resource curse.*Journal of Development Economics* 87:227-246.

Aslaksen, S. (2011). Corruption and Oil: Evidence from Panel Data, available at:

http://www.sv.uio.no/econ/personer/vit/siljeasl/corruption.pdf

Barbier, W. B. (2010). Corruption and the Political Economy of Resource- Based Development: A Comparison of Asia and Sub-Saharan Africa. *Environ Resource Econ*, 46:511-537.

Basedau, M. (2005). Context Matters-Rethinking the Resource Curse in Sub-Saharan Africa. *Working Paper Global and Area Studies* p.1-46.

Benhin, J.K.A (2008). South African crop farming and climate change: An economic assessment of impacts. *Global Environmental Change*, 18(4):666-678

Berthelemy, J., J. Thuilliez, O. Doumbo., and J. Gaudart (2013). Malaria and protective behaviours: is there a malaria trap? *Malaria Journal* 12:200

Birdsall, N., Pinckney, T. & Sabot, R. (2001). Natural Resources, Human Capital, and Growth. In R.M. Auty (Ed.), *Resource Abundance and Economic Growth* 57-75. Oxford: Oxford University Press.

Bjorvatn, K & K. Selvik (2008). Destructive competition: Factionalism and rent-seeking in Iran. *World Development,* 36(110):2314-2324

Bjorvatn, K., Farzanegan, M.R & F. Schneider (2012). Resource Curse and Power Balance: Evidence from Oil-Rich Countries. *World Development,* 40(7):1308-1316.

Bloom, D.E and D. Canning (2005). Health and Economic Growth: Reconciling the Micro and Macro Evidence. *CDDRL Working Paper* 42:1-27

Boschini, A.D., Petterson, J & J.Roine (2007). Resource Curse or Not: a Question of Appropriability. *The Scandinavian Journal of Economics*, 109(3):593-617.

Braulke, M (1982). A Note On Nerlovian The Nerlovian Model of Agricultural Supply Response. *International Economic Review,* 23(1):241-244.

Brunnschweiler, C.N. (2008). Cursing the Blessings? Natural Resourse Abundance, Institutions, and Economic Growth. *World Development*, 36(3):399-419.

Brunnschweiler, C.N. & E.H. Bulte (2008). The Resource Curse Revisited and Revised: A tale of Paradoxes and Red Herrings. *Journal of Environmental Economics and Management,* 55(3):248-264.

Butkiewicz, J.L. & H. Yanikkaya. (2006). Institutional quality and economic growth: Maintenance of the rule of law or democratic institutions, or both? *Economic Modelling:* 23:648-661

Carneiro, F.G. (2005). The Oil Cycle, The Resource Curse and the Tax-Spend Hypothesis: A VAR analysis. *World Bank,* p.1-15.

Cavalcanti, T.V., K.Mohaddes & M.Raissi. (2012). Growth, Development and Natural Resources: New Evidence Using a Heterogenous Panel Analysis. *Cambridge Working Paper in Economics,* 0946.

Choi, J and P.G. Helmberger (1993). How Sensitive are Crop Yields to Price Changes and Farm Programs? *Journal of Agricultural and Applied Economics.* 25(7):237-244

Choi, H.W., J.G. Breman, S.M. Teutsch, S. Liu, A. H. Hightower, and J.D. Sexton (1995). The

Effectiveness of Insecticide-Impreganted Bed-Nets in Reducing Cases of Malarial Infection: A Meta-Analysis of Published Results. *American Journal of Tropical Medical Hygiene* 52:377-382

Cline, W.R (1996). The Impact of Global Warming on Agriculture: Comment. *The American Economic Review* 86(5):1309-1311.

Corden, W.M. & J.P. Neary.(1982). Booming Sector and De-Industrialisation in a Small Open Economy. *The Economic Journal,* 92(368):825-848.

Cuaresma, J.C ., Oberhofer, H., & P.A. Raschy (2011). Oil and the Duration of Dictatorship. *Public Choice,* 148:505-530.

Datta, S.C and J.J. Reimer (2013). Malaria and Economic Development, *Review of Development Economics* 17:1-15

Deschenes, O and M. Greenstone (2007). The Economic Impacts of Climate Change: Evidence from Output and Random Fluctuations in Weather, *The American Economic Review* 97(1): 354-385

de Janvry, A. and E. Sadoulet (2011). Agriculture for Developemnt in Sub-Saharan Africa: An Update. *African Journal of Agricultural and Resource Economics*

Egbedewe-Mondzozo, A., M. Musumba, B.A. McCarl, and X. Wu (2011). "Climate Change and Vector-borne Diseases: An Economic Impact Analysis of Malaria", *International Journal of Environmental Research and Public Health,* 8:913-930

EM-DAT (2013). The International Disaster Database. Available at: http://www.emdat.be/database

Fisher, A.C., W.M. Hanemann, M.J. Roberts, and W. Schlenker (2012). The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather: Comment, *The American Economic Review* 1(1): 1-25

Food and Agriculture Organization (FAO) (2000). *Two Essays on Climate Change and Agriculture: a developing country perspective*, FAO Economic and Social Development Paper, Rome, Italy.

Food and Agriculture Organization of the United Nations Statistics Division (FAOSTAT)(n.d) FAO Agricultural Statistics, available at http://faostat3.fao.org/home/E on December 03, 2015

Huang, H and M. Khanna (2010). An Econometric Analysis of U.S. Crop Yield and Cropland Acreage: Implications for the Impacts of Climate Change, Selected Paper for Presentation at the Agricultural & Applied Economic Association, AAEA, CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010.

Gallup, J.L and J.D.Sachs (2001).“The economic burden of malaria. *America Journal of Tropical Medical Hygiene*, 64(1,2):85-96

Goodman, C., Coleman, P. and A. Mills (2000). *Economic analysis of malaria control in Sub-Saharan African* . London School of Hygiene and Tropical Medicine. Mimeo.

Greenwood, B and T. Mutabingwa (2002). Malaria in 2002. *Nature,* 415:670-672

Gurr, T.R., Jaggers, K. & W.H. Moore (1990). The Transformation of the Western State: The Growth of Democracy, Autocracy, and State Power since 1800. *Studies in Comparative International Development*, 25(1):73-108.

Gylfason, T. (2001). Natural Resources, Education and Economic Development. *European Economic Review* ,45:847-859.

Gylfason, T. & G.Zoega. (2001). Natural Resources and Economic Growth: the Role of Investment. *CEPR Discussion Papers* 2743.

Haber, S & V. Menaldo. (2011). Do Natural Resources Fuel Authoritarianism? A Re-appraisal of the Resource Curse. *American Political Science Review* 105(1):1-26.

Hawley, W.A., P.A. Phillips-howard, F.O. Terkuile, D.J. Terlouw, M.S. Kolczak and A.W. Hightower (2003). Community-wide effects of permethrin-treated bed nets on child mortality and malaria morbidity in western Kenya. *American Journal of Tropical Medical Hygiene* 68:121-127

Hodler, R. (2006).The curse of natural resources in fractionalized countries., *European Economic Review,* 50:1367-1386.

Humphreys, M. & R. Bates. (2005). Political Institutions and Economic Policies: Lessons from Africa. *British Journal of Political Science,* 35(3):403-428.

Seers, D. (1969). The Meaning of Development. *IDS Communications* 44: 1-26

IPCC(2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* A Special Report of Working Group I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J.Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.K, Plattner, S.K. Allen, M. Tignor, and P.M Migley (eds.)]. Cambridge University Press, Cambridge, UK, and NewYork, NY, USA, 582 pp.

Isik, M. and S. Devadoss. (2006). An Analysis of the Impact of Climate Change on Crop Yields and Yield Variablity. *Applied Economics* 38:835-844

Jensen, N & L.Watchekon. (2004). Resource Wealth and Political Regimes in Africa. *Comparative Political Studies* 37:816

Kaiser, H.M., S.J.Riha, D.S. Wilkes, D.G. Rossiter, and R.K Sampath (1993). A Farm-Level Analysis of Economic and Agronomic Impacts of Gradual Warming, *American Journal of Agricultural Economics* 75:387-398

Kaufmann, D., Kraay A. & M.Mastruzzi (2005). Governance Matters IV: Governance Indicators for 1996-2004, *World Bank Policy Research Working Paper Series*, No. 3630

Kaufmann, R.K and S.E. Snell (1997) A Biophysical Model of Corn Yield: Integrating Climatic and Social Determinants. *American Journal of Agricultural Economics,* 79(1): 178-190

Kolstad, I & T.Soreide(2009). Corruptions in Natural Resource Management: Implications for Policy Makers. *Resource Policy,* 34:214-226.

Kolstad, I & A. Wiig. (2009). Its the rent, stupid! The political economy of the resource curse. *Energy Policy,* 37:5317-5325.

Kovats, R. S., Ebi, K., and B. Menne (2003). Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change. *Health and Global Environmental Change Services,* World Health Organisation, WMO.

Krugman, P. (1987). The Narrow Moving Band, the Dutch Disease, and the Competitive Consequences Of Mrs Thatcher: Notes on Trade in the Presence of Dynamic Scale Economies. *Journal of Development Economics*, 27:41-55.

Lobell, D and M. Burke (2010). On the use of statistical models to predict crop yield responses to climate change. *Agricultural and Forest Meteorology* 150(11):1443-1452

Manning, A. (2004). Human Capital as a Transmission Mechanism of the Resource Curse. *The Park Place Economist*, 12(1):75-86.

Mano, R. and C. Nhemachena (2007). Assessment of the Economic Impacts of Climate Change on Agriculture in Zimbabwe: A Ricardian Approach. *Policy Research Working Paper* WPS4292:1-41.

Manzano, O & R. Rigobon .(2001). Resource Curse or Debt Overhang? *NBER Working Paper,* 8390(04): 41-70.

McCarthy, F.D., H.Wolf, and Y. Wu (2000) “The Growth Costs of Malaria” NBER Working Paper Series 7541:3-31

Mehlum, H., Moene, K. & R. Torvik. (2006).Institutions and the resource curse. *The Economic Journal* 116:1-20.

Mendelsohn, R., W.D.Nordhaus. and D. Shaw (1994). The Impact of Global Warming on Agriculture: A Ricardian Analysis. *The American Economic Review* 84(4):753-771.

Mendelsohn, R., W.Nordhaus and D.Shaw. (1996). Climate impacts on aggregate farm value: accounting for adaptation. *Agricultural and Forest Meterology* 80:55-66.

Mitchell, T.D., Carter, T.R., Jones, P.D., Hulme, M. and M. New. (2003). A Comprehensive Set Of High-Resolution Grids of Monthly Climate for Europe and the Globe : The Observed Record (1901-2000) and 16 Scenarios (2001-2100). *Journal of Climate*

Mundlank, Y., D.F. Larson and R. Rita (1997) The Determinants of Agricultural Production: A Cross-Country Analysis. *World Bank Policy Research Working Paper* 1827

Nafziger, E W (2006). *Economic Development.* 4th Edition. London: Cambridge University Press

Norman, C.S. (2009). Rule of Law and the Resource Curse: Abundance versus Intensity. *Environ Resource Econ,* 43:183-207.

North, D.C.(1991). Institutions. *Journal of Economic Perspectives,* 5(1):97-112

Ogilve, S and A.W.Carus. (2014). Institutions and Economic Growth in Historical Perspective. In *Handbook of Economic Growth,* Vol.2A, ISSN 1574-0684, http://dx.doi.org/10.1016/B978-0-444-53538-2.00008-3

Packard, R.M. (2009). Roll Back Malaria, Roll in Development? Reassessing the Economic Burden of Malaria.*Population and Development Review,* 35:53-87

Penn World Table 7 (2015). Penn World Table. Available at http://www.nsd.uib.no/macrodataguide/set.html?id=28&sub=1 on October 02, 2015

Quiqqin, J. and J.K. Horowitzn (1999). The Impact of Global Warming on Agriculture: A Ricardian Analysis: Comment. *The American Economic Review* 89(4):1044-45.

Rambaldi, A.N., Hall, G. and R.P.C.Brown. (2006). Re-testing the Resource-Curse Hypothesis Using Panel-Data and an Improved Measure of Resource Intensity. available at http://ageconsearch.umn.edu/bitstream/25289/1/cp060275.pdf on February 12, 2013.

Ramirez-Villegaz, J and A.Challinor (2012). Assessing Relevant Climate Data for Agricultural Application. *Agricultural and Forest Meteorology.* 161:26-45.

Rosegrant, M.W and T.S. Thomas (2012). Climate Change Impact on Key Crops in Africa: Alternative Scenarios Using Biophysical and Economic Models. Available at: http://www.fao.org/fileadmin/templates/est/meetings/climate_2013/Rosegrant_-_FAO_presentation.pdf.

Ross, M.L (2001). Does oil hinder democracy? *World Politics,* 53:325-36.

Sachs, J.D. & A.M. Warner.(1995). Natural resource abundance and economic growth. NBER Working Paper Series 0946.

Sachs, J.D.& A.M. Warner.(1997). Natural resource abundance and economic growth. Available at: http://www.cid.harvard.edu/ciddata/warner_files/natresf5.pdf

Sachs, J.D & A.M. Warner. (2001).The curse of natural resources. European Economic Review, 45:827-838.

Schlenker, W and D.B. Lobell (2010). Robust negative impacts of climate change on African agriculture .Environmental Research Letters 5., doi:10.1088/1748-9326/5/1/014010

Seo, S.N. and R. Mendelsohn (2008a) A Structural Ricardian Analysis of Climate Change Impacts and Adaptation in African Agriculture. Policy Research Working Paper 4603:1-30

Seo, S.N. and R. Mendelsohn (2008b). Measuring impacts and adaptations to climate change: a structural Ricardian model of African livestock management. Agricultural Economics 38:151-165

Seo, S.N., R. Mendelsohn, A. Dinar, R. Hassan, and P. Kurukulasuriya (2008). A Ricardina Analysis of the Distribution of Climate Change Impacts on Agriculture across Agro-ecological Zones in Africa, Policy Research Working Paper, WPS4599

Sobhee, S.K. (2012). Quality of institutions and economic growth in developing economies. Available at SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2176542.

Stijns, J. (2006). Natural Resource Abundance and Human Capital Accumulation. World Development, 34(6): 1060-1083.

Teklehaimanot, A and P. Mejia (2008). Malaria and Poverty, Annals of the New York Academy of Science 1136:32-37.

The Quality of Governance Institute (2013). Data, retrieved from http://www.qog.pol.gu.se/data/ on 24th December, 2013.

Thornton, P.K., P.G.Jones, Alagarswamy et al (2009). Spatial Variation of Crop Yield Response to Climate Change in East Africa, *Global Environmental Change* 19(1):54-65

Thornton, P.K., Jones, P.G., Ericksen, P., and Challinor, A. J (2010). Agriculture and food systems in sub-Saharan Africa in a four-plus degree world. *Philosophical Transanctions of The Royal Society* 369:117-136

Todaro, M.P. and Smith. S.C (2012). *Economic Development.* 11th Ed. Addison-Wesley Press

Torvik, R. (2009).Why do some resource-abundant countries succeed while others do not?. *Oxford Review of Economic Policy*, 25(2):241-256.

Trimmer, C. P. (1997). Farmers and Markets: The Political Economy of New Paradigms. *American Journal of Agricultural Economics* 79:621-627

UNFCCC (n.d) Climate Change, available at https://unfccc.int/2860.php on December 03, 2015.

Valeriani, E & S. Peluso (2011). The Impact of Institutional Quality on Economic Growth and Development: An Empirical Study. *Journal of Knowledge Management, Economics and Information Technology,* 6:1-25.

Van der Ploeg, F. & S.Poelhekke.(2009). Volatility and the natural resource curse. *Oxford Economic Papers*, 61:727-760.

Van der Ploeg, F. & S. Poelhekke. (2010).The pungent smell of "red herrings": Subsoil assets, rents, volatility and the resource curse. *Journal of Environmental Economics and Management,* 60:44-55.

Wijnbergen, S.V. (1984). The 'Dutch Disease': A Disease After All?. *The Economic Journal,* 94:41-55.

Williams, A. (2011). Shining a Light on Resource Curse: An Empirical Analysis of the Relationship Between Natural Resources, Transparency and Economic Growth. *World Development,* 39(4):490-505.

World Bank (2013) *World Development Indicator 2013.* Available at http://data.worldbank.org/data-catalog/world-development-indicators on October 02, 2015.

World Health Organization .(2012). *World Malaria Report 2012.* Geneva

World Health Organization .(2013). *World Malaria Report 2013.* Geneva

World Health Organization .(2014). *World Malaria Report 2014.* Geneva