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Modelling Food Security in Africa Using Panel Data Analysis.

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DECLARATION

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the Research Project contains no material previously published or written by another person except where due reference is made in the Research Project itself.

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This Research Project has been submitted for examination with my approval as the Supervisor.

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Abstract

The study seeks to determine the most important variables that drive food security in Africa. It uses panel data analysis to model food security in Africa. Data from agricultural sector is analyzed alongside food imports and exports, economic empowerment and population growth rates in Africa. The results show increase in agricultural exports and GDP per capita increases food security while increase in food aid reduces food security in the long run. This is consistent to previous studies which modelled food security using indices made up of economic and social variables (Nyirenda-Jere & Kazembe, 2014). Past studies also show a lot of improvement in the various farming practices used in Africa in achieving food security. The continent produces a lot of food but most of it goes to waste during harvest, transportation, storage and cooking. Secondly, the continent has a lot of idle land that can produce food enough to export hence governments can invest more in developing such land. The purpose of this research is to investigate the possibility of attaining zero hunger in Africa by 2030. This is done by evaluating the effort put in place and its results against Zero Hunger indicators and to show how resources can be used efficiently to feed all inhabitants of Africa. Most institutions give a lot of money to support agriculture in Africa yet the methods used by farmers and distributors are mostly outdated and inefficient.

Key words: Panel Data Analytics, smart farming, Food security, food imports, agriculture education

Chapter 1: Introduction

1.1 Background of the Study

Agriculture has seen the success of green revolution and food security Asian developing countries (Pingali, 2012). Less than ten African countries invest more than 10% of their national budgets into the agricultural sector yet the sector plays a key role in economic development (Goyal & Nash, 2016). Over 54% of Africa's workforce depend on the agricultural sector for income and employment as shown in figure 1 below (FAO, Food and Agriculture Organization of the United Nations, 2020). This represents people who earn their living from working in crop and animal farms. Agricultural farm produce is exported to other continents and earns African countries valuable foreign exchange that is used in the purchase of necessities which are not produced locally. The agriculture sector also provides food and raw material to other sectors of the economies. The success of non-agricultural industries depend on quality food to feed their workers with the necessary nutrients to allow them achieve their maximum output levels.

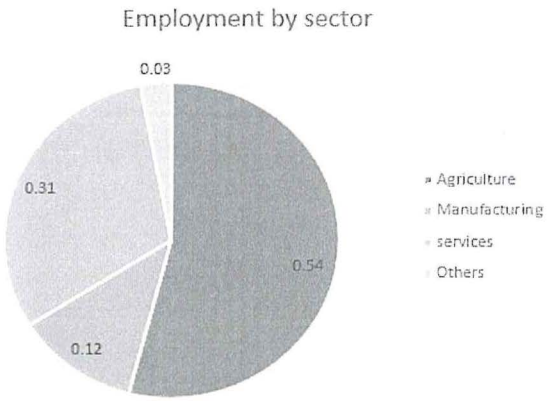

Figure 1 Employment structure in Africa: Source Ahebe, 2014)

Large scale farmers may have huge cash surpluses and they can invest the money locally to boost the gross domestic product. Their savings and expenditures cause liquidity in the financial markets which makes the markets more efficient. Research confirms that the multiplier effect of agriculture is high in other non-agricultural sectors. Rural areas have been opened through a vast network of

transport and communications channels that have been built to transport farm produce from rural areas to the densely populated urban areas.

1.2 Key concepts

Sustainable agriculture is farming using methods that ensures food security of the current generation without compromising that of the future generations (Velten, Leventon, Jager, & Newig, 2015). It includes methods that conserve soil and nutrients and further expands into organic agriculture which involves the use of minimal synthetic chemicals, fertilizers and genetically modified organisms in food production and regenerative agriculture which is the conservation and rehabilitation of farmlands to its original state and productivity. Advancements in technology have led to the creation of genetically modified organism (GMO) also known as a transgenic organism which is any organism whose genetic material has been modified using genetic engineering techniques. GMOs are the source of genetically modified foods and can be used to sustainably feed the current generation.

Food security is a state where everyone in a country has access to enough nutritious food to lead a healthy and happy life (Pérez-Escamilla, Gubert, Rogers, & Hromi-Fiedler, 2017). Achieving hunger eradication means providing food to those in need. People access food by buying, producing it themselves or both. In developing countries most people get food from their farms, the animals they keep and from fishing. Most Africans live as small holder farmers. The average small farm size less than 2 hectares. They can therefore be helped by being trained on how to produce more or better food and improving their access to markets where they can buy inputs and sell their produce.

Food accessibility means people should have enough purchasing power to get food. This is determined by the price of food and the amount of income. An individual's real income must enable them to afford food in the right amounts to sustain them and make them lead healthy lives. This means they should be living above the International Poverty Line. The International Poverty Line is a monetary threshold under which an individual is considered to be living in poverty. The World Bank puts the current threshold is $ 1.90 per day. Supply chains should be supported with good transport infrastructure to ensure food that leaves farms arrive in the markets in due time for consumers to purchase.

Food quality is the nutritional status of food that is of acceptable standards and beneficial to one's health/ for consumption. The quality of food depends on the food chain which is the whole process that food takes from the farmer, to the stores, to processing and distribution to the markets, and finally to the consumer.

1.3 Problem Statement

The 2007/2008 financial crisis was a shock to the agriculture sector which also served as a wake-up call that we need to invest more in this sector (Trostle, 2008).Food insecurity, according to FAO, is still a major humanitarian problem in today's developing countries. Over 234 million people live under extreme poverty and hunger in Africa alone. In addition to high cases of hunger in Africa, many more people suffer from micronutrient deficiencies (Kumssa, 2015). Improving food security and nutrition is key in ensuring economic development in Africa.

The main question then is how Africa can use its money, land, labor and expertise to improve the food security situation. By supporting entrepreneurs that operate in the agricultural sector, governments cannot only create demand for farm produce but also boost consumers' access to food thus improving their economic incomes and nutritional outcomes respectively. It also involves empowering small holder farmers as they produce the most food (Herrero, Wirsenius, Henderson, & Rigolot, 2015). The research will therefore aim to find out what challenges food companies/entrepreneurs/farmers face and then to find their solution.

1.4 Research objectives

(i) To determine which variable is most relevant in explaining and improving food security in Africa using panel data analysis.

(ii) To determine the significance of international food aid in making Africa food secure.

(iii) To determine non-agricultural economic sectors with the highest multiplier effect on agriculture.

1.5 Research Questions

(i) Which variable is most important in explaining food security in Africa?

(ii) How does international food aid affect food security in Africa in the long run?

(iii) Which economic variables have the highest multiplier effect on agriculture?

1.6 Food pricing over time

Africa has in the past experienced severe fluctuations in food prices that even doubled over certain periods including between 2006 and mid 2008 in some regions due to severe drought (AfDB, 2011).Undernourishment has also been a huge challenge facing Africans. Progress has however been made in reducing those who are undernourished from 33% in 1990 to 23% in 2015 (FAO, IFAD, & WFP, The State of Food Security in the World, 2015). Despite all these, Africa still remains to be the region with the most undernourished population. This is caused by inaccessibility food in the right amounts and of desired quality.

In Africa, food inflation has been higher and more volatile compared to non-food and non-fuel inflation compared to other regions experiencing similar economic growth rates. Countries like India and Brazil experienced alarming surges in food prices in 2012. Two years, the same trend was seen in Africa due to oil shocks and lack of sufficient rainfall. Data from Food and Agriculture Organization(FAO) and Organization for Economic Co-operation and Development (OECD) show that food prices appreciate faster in Africa compared to the rest of the world (as shown in fig 2). This is caused by the huge demand and the unsurprisingly low supply of food in the continent which make food prices out of reach for many households.

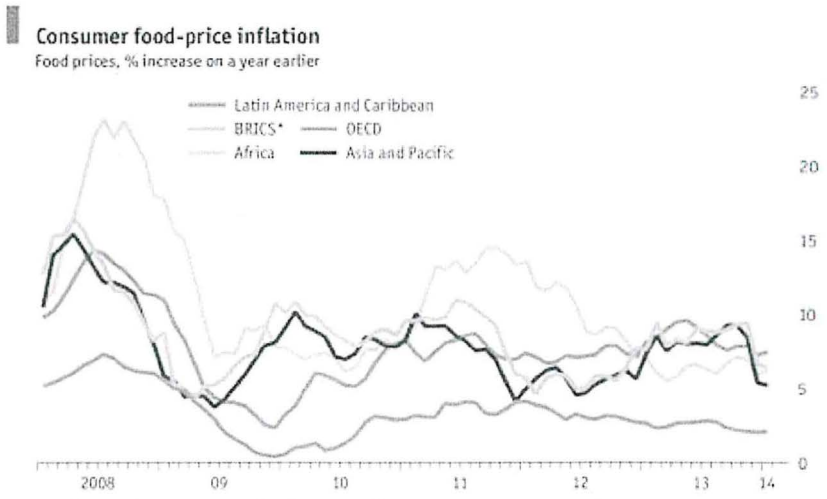

Figure 2: Consumer food price inflation; Sources: FAO and OECD

1.7 Scope of the study

The population of Africa is projected to double by 2050 reaching close to 2.5 billion inhabitants (Haub & Kaneda, 2013). This shows that Africa is a huge market and is the fastest urbanizing continent in the world (Güneralp, Lwasa, Masundire, Parnell, & Seto, 2017). The continent is still a net food importer with yearly imports of over $ 35 billion yet this is food that can easily be produced within its borders (FAO 2017). However, the GDP growth rates for African countries are among the highest recorded expansions in the world averaging 2.8 percent per annum. The expected ten year growth in per capita income is shown in figure 3 below.

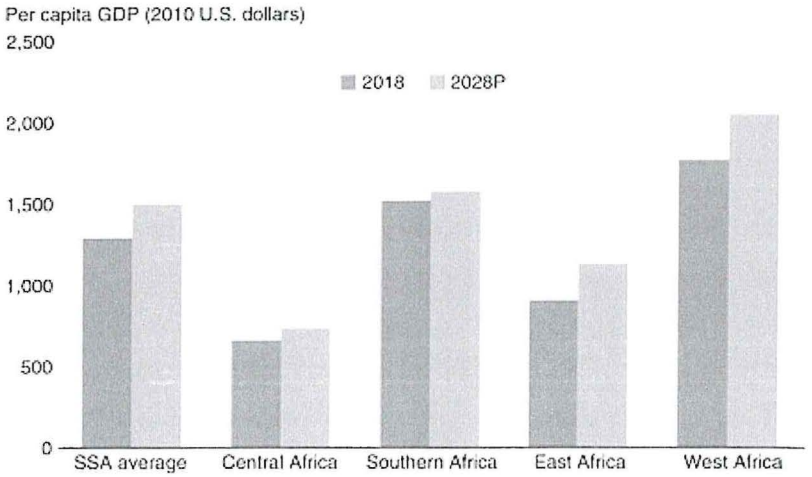

Figure 3: Per capita income in Sub Saharan Africa. Source: USDA, Research Service

The agricultural sector contributes significantly to the GDP of the African economies (Świerczyńska, 2017) and the European Union Parliamentary Research Service (EUPRS) estimates this contribution to be 17% as shown in the pie chart in figure 4. However, the agricultural sector remains largely undeveloped or underdeveloped in these countries. Poor and outdated farming practices have led to low quality outputs, huge loses and low yields to farmers. Agriculture not only contributes to the economy through produce sales but also by being the chief and only source of food to the people. According to the 2019 World Bank Demographics Report, Africa has population of 1.22 billion with more than 50% of the people depending solely on the agricultural sector for employment and food.

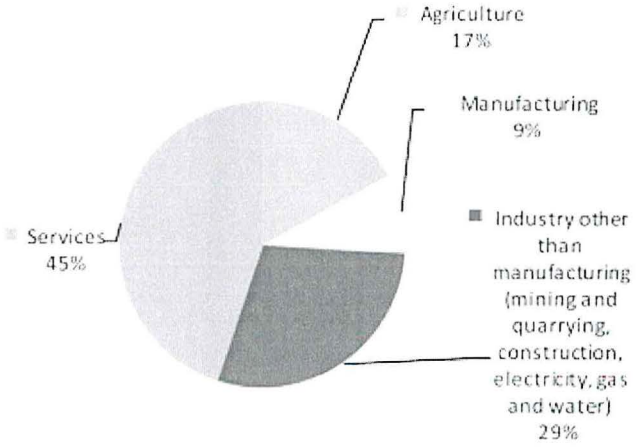

Figure 4: Africa Composition of GDP by Sectors; Source: AfDB, Data Portal, 2015

Africa has one of the highest poverty rates in the world. World Bank's 2019 report titled 'Accelerating Poverty Reduction in Africa' shows a substantial decline in the share of Africans living under extreme poverty (under US $ 1.90) to have fallen from 54% in 1990 to 41% in 2015. However, the nominal value increased from 278 million to 413 million people in the same period driven by the high population growth rates that has negated the poverty reduction efforts.

Poverty hinders a person's ability to get food in the right amounts and quality (The Impact of Poverty, Food Insecurity, and Poor Nutrition on Health and Well-Being, 2017).

1.8 Significance of the Study

This research project aims to understand how Africa can ramp up food production and be food secure by 2030 through the analysis of historical data and agricultural practices. This is essentially reducing the gap between what is currently produced and what should be produced and making the approximately 27.4% of the population in Africa, classified as severely food insecure, have sufficient food.

The historical trend of primary crops and meat from sheep, goats, poultry and beef shows that total food production in Africa has been growing but at a very slow rate of less than one per cent per year. According to FAO this is alarming considering the fact that food production growth rate is not statistically different from population growth rate which raises concerns about Africa's ability to self-insure against food insecurity (Mulangu, Chauvin, & Porto, 2012). A lot of produced food

goes to waste during storage and transportation hence the food growth rate should exceed the population growth rate.

Native African crops like yams and cereals like sorghum and millet (pearl and finger) are major staple foods in Africa. These are supplemented by several imported cereals like wheat, rice and maize. In total, cereals are grown over an area of 98.6 million hectares (ha) producing 162 million tons of cereal. Breads and a common African food called fufu (in West Africa) or ugali (in East Africa) are derived from these crops.

Maize is the most-produced cereal worldwide (Ranum, Pena-Rosas, & Garcia-Casal, 2014). In Africa, Maize farming has overtaken traditional cereals. In addition, maize is also very important as feed for farm animals. Ninety per cent of the total maize production is white maize. Maize production in Africa is very low: while the average yield worldwide is approximately 5.5 tons/hectare/year, production in Africa stagnates at around 2 tons/hectare/year. Africa covers more than 3 billion hectares, 1.3 billion hectares is agricultural land but only 252 million ha is arable meaning that only 19.36% of the land is used for farming (Macauley, 2015).

Chapter 2: Literature review.

2.1 Introduction

Food insecurity is a ticking time bomb that might in the near future cause great humanitarian crisis, the effects of which will be hard to reverse (Fawole, Ilbasmis, & Ozkan, 2015). A lot of research has been done to review food insecurity in Africa (Misselhorn & Hendriks, 2017). These studies show disturbing food insecurity patterns in Sub Saharan Africa. Hunger in this region is caused by several factors such as: underdeveloped markets, wars, conflicts, political instability, adverse climatic conditions and poverty. Globally, food insecurity is a health nightmare leading to the loss of over 300,000 lives annually (Drammeh, Hamid, & Rohana, 2019). In Africa, hunger and malnutrition cause more than 50% of child mortality.

Densely populated areas in the region face higher risks of hunger and starvation given the strain applied to the existing resources and infrastructure to produce enough food for everyone. An example is Nigeria with a population of 206 million as of 2020 (Worldometer, 2020). Nigeria has 13.40% of its citizens living below the required food intake to meet the continuous dietary energy requirement. Zambia is however among the worst hit in the world by food insecurity, having this figure at 46.70% (World Bank, 2020).

2.2 Empirical literature review

Policy holders must look for easily defined or measured indicators to design programs that will reach the food insecure and to fight food insecurity using data analysis (Staatz, D'Agostino, & Sundberg, 1990). These researchers used indicators such as food supply and its correlates such as rainfall patterns. The researchers found that a multilevel approach from individuals, households, regions and finally nations and aggregate this indicators to get a clearer picture of how many people are food insecure. Their conclusion was that national and regional indicators are poor predictors of household and individual indicators. This research paper uses the same line of thought in suggesting policy should be aimed at the micro institutions for effective hunger prevention at the macro levels.

(Ramakrishna & Demeke, 2005) Used household data to construct a food balanced sheet and a food security index which enable the study of food scarcity using a logit model. A food balance sheet shows a clear picture of a country's food supply pattern during a given period. From their survey study, they concluded that a multivariate approach is best suited to explain food security.

This study relates to their study by using multivariate panel data analysis to study food security in mainland Africa.

FAO has in the past noted that food insecurity emerges as a predictor of under-nutrition, showing the need of multi-sector strategies in fighting food insecurity and the various forms of malnutrition. The report used child stunting, child wasting, exclusive breastfeeding of children below 6 months and anemia in women of child bearing age as indicators of malnutrition. Instead of an index, this study uses variables at their level form to isolate individual changes. However, it borrows the statistical methods that were used by FAO to interpret the output.

The FAO food energy deficiency index measures hunger as the proportion of the population with individual energy consumption level below the standard nutritional requirements. The requirements include proteins, carbohydrates, minerals, vitamins and water. The FAO index uses per capita availability of food, inequality in energy intakes and country energy requirements by gender and age group to measure hunger (Napoli, Muro, & Mazziotta, 2011).

Agriculture has played a key role in the economic development of many countries globally as it has been the chief source of food and employment during their development stages (Khanna & Solanki, 2014). In Africa, a lot of people are moving to cities where there are no farmlands. This will lead to high demand in the urban area food markets. Khanna and Solanki used socioeconomic and migration data to analyze the impact of mass movements to food security. They found out that rural to urban migration in search of white collar jobs reduce food production hence food insecurity for the urban dwellers. Using a similar line of thought, this study focuses on population changes over time in contrast to the researcher's spatial movements. This is to have a dynamic view of population growth on food availability.

2.2.1 Role of agriculture in economic development

Africa has huge resources and an expansive land suitable for agriculture (Oluwatayo & Ayodeji, 2018). However, most countries practice rain dependent agriculture which leads to severe economic fluctuations mostly in the negative domain given that climate change significantly determines agricultural output via rainfall.

Development economics literature states that a country has to undergo several stages of development before its citizens can live comfortable lives, affording basic needs and move up the Maslow's hierarchy of needs. In the early stages of development, the agricultural sector dominates

income and employment opportunities hence the sector is very crucial. Later, these roles diminish as the economy and nation industrialize (Diao, McMillanDani, & Rodrik, The Recent Growth Boom in Developing Economies: A Structural-Change Perspective, 2019). Only 8% of Africans live in middle income countries where the average national income is more than 10 times that of Africans living in low income countries.

Currently, agriculture supports 54% of Africa's labor force by offering employment. World Bank national accounts and OECD data files show the value of agricultural output contribution to Sub Saharan Africa GDP stood at 15.67% in 2018. Unfortunately, there has been a downward trend for this value with a high of 21.28% in 1994 followed by a decline that saw an all-time low of 15.14% in 2014.

2.3 Theoretical literature review

Food insecurity is an often an ill-defined concept which is difficult to measure, and by attempting to measure hunger itself, its individual constituents and causes are often ignored. This paper discusses two major theoretical approaches to food security; Sen's Entitlement Approach and Food availability Decline (FAD).

Sen's [1]entitlement approach holds that famine is a socio economic problem rather than a food availability problem. It states that developing countries have sufficient food produced but many people are still hungry. The underlying cause is therefore poverty which hinders people's ability to access quality and sufficient food. (Asenso-Okyere, Anum, Osei-Akoto, & Adukonu, 1998) State that household income, assets, food prices, demographic factors, health, sanitation, education, cultural norms and old feeding habits hinder equal access to food. This approach has however been criticized as only focusing on one final end: food. Food security is only a part of livelihood security which in itself is a complex function of economic, social and political variables (Attanasio & Davis, 1996).

Food availability Decline (FAD) approach is a conventional explanation on the possible causes of famines. Its key assumption is that the cause of all famines is the decline on food availability to offset fluctuations in production and prices (Devereux & Maxwell, 2001). Therefore, given a

[1] **Amartya Sen** is an Indian economist who was won the 1998 Nobel Prize in Economic Sciences for his contributions to welfare economics and social choice theory and for his interest in the problems of society's poorest members. Sen is best known for his work on the causes of famine, which led to the development of practical solutions for preventing or limiting the effects of real or perceived shortages of food.

steady growth in food supply that is significantly higher than population growth, food insecurity will be offset in the long run. In Africa however, food supply growth has been unable to feed the ever increasing population. Caution should be taken when using this approach as few large farms can produce a lot of food and in increasing quantities yet the food can only be exported or consumed by a few people living in urban areas.

(Yaro, 2006) Noted that food insecurity and increased impoverishment of people in developing countries constitutes a huge challenge for social scientists whose theories have tried to catch up with diversity, dynamism and international integration. Several researchers have tried theorizing food insecurity over the last few decades. This research focuses on two main theories: Food availability Decline and Sen's entitlement approach. In Africa, food insecurity seems to be an intractable problem which requires a lot of effort to solve.

2.3.1 Government expenditure on food production.

Monitoring public spending is important as public spending instruments are useful in promoting industrial and agricultural development and also reducing hunger (Diao, Hazell, Resnick, & Thurlow, 2006). Historical data shows that African countries need to increase their budgetary allocation to agriculture (Fan, Omilola, & Lambert, Public Spending for Agriculture in Africa: Trends and Composition, 2009).

African leaders have in the past signed and ratified programs that aim to boost investment and expenditure in their countries. The Maputo Declaration of 2003 is a good example where the African Union heads of states pledged to allocate at least 10% of their national budgets into agriculture. Other programs such as the Comprehensive Africa Development Programme (CAADP), set goals of achieving a certain optimum growth rate in agriculture (CAADP requires 6% growth rate).

However, majority of the administrations remain complacent in implementing the Maputo declaration and CAADP recommendations. They instead opt for a wait-and-see approach, only unveiling food security strategy roadmaps when there are severe pandemics such as drought, floods and global health pandemics such as Ebola and the novel corona virus (covid-19).

Since agriculture and poverty are closely correlated in Africa, governments have been using their monies to create jobs in the agricultural and supporting sectors where people can earn their livelihoods (Fan, Johnson, Saurkar, & Makombe, 2008).

In Sub Saharan Africa, the number of people suffering from malnutrition, starvation, under nutrition and hunger is over 240 million (Sasson, 2012). The Food and Agriculture Organization of the United Nations has projected this number to increase into the near future thus many African governments have tried prioritizing agriculture in their public spending. The World Bank continues to hold that boosting agricultural productivity can alleviate poverty and speed up economic growth and development.

FAO recommends immediate, short term and medium term responses to national and continental food crises. The share of central governments' agricultural expenditure has declined from an average of 3.66% in 2001 to 3.03% in 2017 in Africa (FAO, 2019). However, some countries have shown a significant investments with Malawi and Ethiopia averaging 16.4% and 9.0% respectively between 2012 and 2016. Africa has maintained an Agriculture Orientation Index (AOI[2]) of less than 0.5 showing a lower investment into agriculture by the African countries which does not match the higher benefits the economies derive from the sector.

2.4 Research Gap

A lot of work has already been done in tackling food insecurity in Africa. These studies and solutions can be further enhanced using big data analytics to predict future food production and population growth rates hence reduce the number of people living under extreme poverty and hunger in Africa by 2030. Data can inform policies that empower small holder farmers to build digital profiles that can increase access to farm inputs, produce markets and agriculture extension

[2] SDG Indicator 2.a.1 – Agriculture Orientation Index (AOI) for Government Expenditures, compares the central government contribution to agriculture with the sector's contribution to GDP. An AOI less than 1 indicates a lower orientation of the central government towards the agriculture sector relative to the sector's contribution to the economy, while an AOI greater than 1 indicates a higher orientation of the central government towards the agriculture sector relative to the sector's contribution to the economy.
Source: http://www.fao.org/economic/ess/investment/expenditure/en/

services offered by the government. At a macro level, nations can use data to transform agriculture through funding appropriate programs and use optimum irrigation technologies.

2.5 Conceptual framework

The following conceptual framework shows the hierarchical interaction of different variables in making countries attain food security successfully.

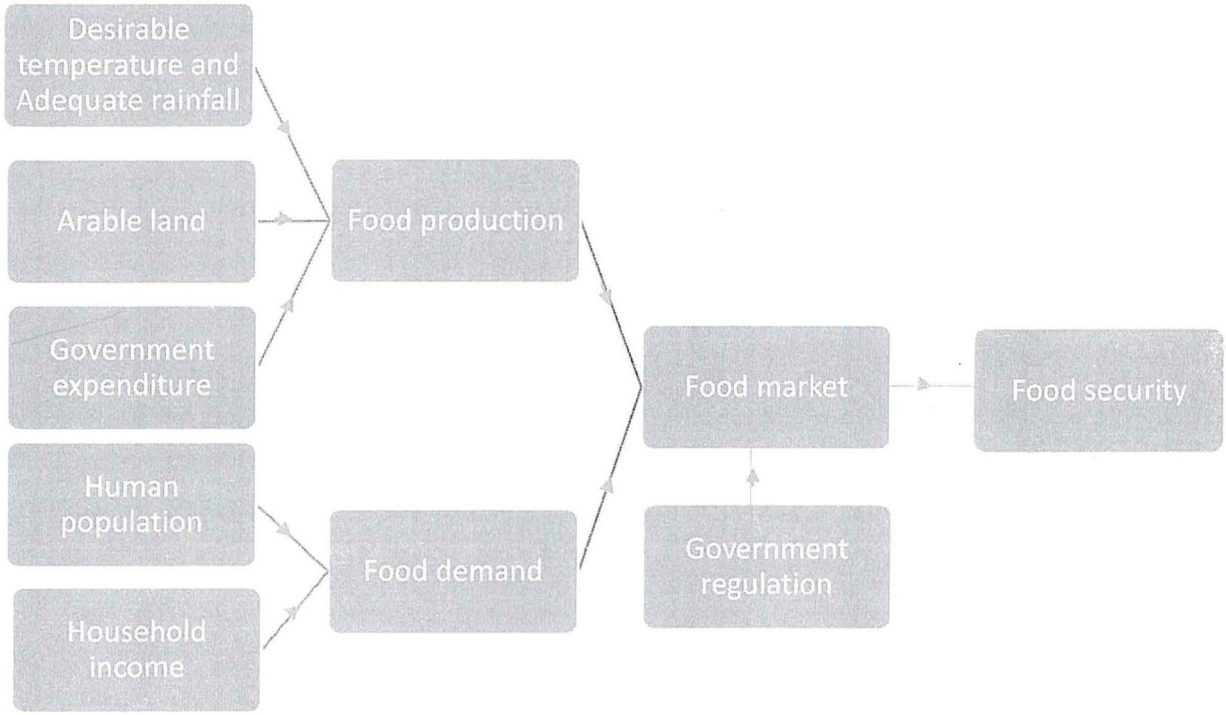

Figure 5: Conceptual framework: Source: Researcher generated

Chapter 3: Research Methodology

3.1 Introduction

This chapter describes the modelling of food insecurity using ordinary least squares regression analysis. It covers data collection methods, population sampling and model selection.

3.2 Research design

This research study has been carried out quantitatively; using a logical sequence of sampling, data collection, data analysis and discussion of results respectively. This study seeks to find the various economic, social and geographic variables that affect food production in Africa. . (Wilde & Nord, 2005) Use panel data approach to study food security as it caters for multiple confounding factors. Panel data analysis is used to study various cross sections represented by the chosen countries across a period of 36 years (1980 – 2015). This is the model that has been chosen for this research study.

Food availability is the dependent variable whereas food exports, food aid, GDP per capita and yield are the main independent variables. The dependent variable will be measured as the total agricultural food production per person in a country.

3.3 Population and sampling

Africa is the main region of study. It is divided into four heterogeneous regions which differ in geographical, social and economic characteristics. Food insecurity elements are included together with the measurable variables that drive food production in four African regions (North, East, South and West Africa. The countries in those regions were chosen given their population, general climatic conditions and their level of development in terms of agriculture.

Published secondary data will be obtained from government, academic and private research institutions. The organizations include: Food and Agricultural Organization of the United Nations (agricultural datasets), World Bank Group (historical climate data) and United Nations Statistics Division (UNSTATS) for demographic data.

3.4 Diagnostic checks

3.4.1 Unit root test

A stationary time series is one which has a stable probability distribution over time. It has a constant mean and variance (covariance stationarity). To understand the relationship between two or more variables, we need to have stability over time. This also ensures we avoid having a spurious regression which makes the results hard to interpret and understand. To make the model suitable for prediction, the variables should be stationary. A non-stationary series can be differenced to make it stationary. A series is said to be integrated of order d if it has to be differenced a minimum of d times to make it stationary.

For panel data, stationarity tests include the following three tests: First is the Levin–Lin–Chu Test.Levin, Lin, and Chu (2002) propose a test which has the null hypothesis as each panel contains a unit root. This test compensates for the low power of individual and separate unit root tests for the variables. Secondly is the Im-Pesaran-Shin Test developed by Im, Pesaran, and Shin (2003). This test allows a more general alternative hypothesis by allowing some individual series to have a unit root. It however diminishes the power of the test but it is a simpler approach as the test statistics are simply averaged after being calculated for each variable. The average value is asymptotically normally distributed hence a standard normal table can be used. Lastly, the Fisher test sums the log p-values which is asymptotically a Chi-square with 2n degrees of freedom. The Fisher Test will be used for this study considering that it can be used for both balanced and unbalanced panel data sets.

3.4.2 Normality test

A normality plot is first drawn to visualize the distribution. Secondly, the distribution of sample probabilities are computed and the two are compared. If they differ substantially, there is a high likelihood that the data set does not follow a normal distribution. Normality is important for analysis as it determines the measures of central tendencies and the statistical methods and parametric tests that will be used.

3.4.3 Cointegration test

Cointegration tests are used to determine whether series have a stable, long-run relationship. In the presence of cointegration the series wander together and have a long-run equilibrium

relationship. I carry out Madalla Wu test to establish if the variables are cointegrated and if they are integrated of different orders.

3.5 Model specification

This research considers a model where agricultural food production is a function of economic, geographical and political variables and that food production can be predicted using several independent variables. Given the complexity of food production, it is hard to find one best model. However, in this research I choose panel data analysis as it considers the spatial and inter temporal effects of independent variables which is consistent with previous application of panel data to study food security (Staatz, D'Agostino, & Sundberg, 1990).

Suppose that at each time, t, a country's food production is determined using a set of k regressors. The panel data multivariate regression analysis, using ordinary least squares, can be done by taking the individual years as the unique observations for the model. For each year (t) and each cross section (i) the general equation is given as:

$$y_{i,t} = b_0 + \sum_{t=1,i=1}^{t=T,i=N} b_i x_{i,t} + e_{i,t}$$

Where: $y_{i,t}$ is the annual food availability per capita

$x_{i,t}$ is the independent variable at time t as per table 1 below

3.5.1 Description of variables

The independent and dependent variables will be measured and defined as shown in the next page:

Variable	Variable name	Measurement
Food exports	ExportD	2005 US dollars (Millions)
GDP per capita	Gdp_capD	2005 US dollars/person
Total Food aid	aidD	Grain equivalent (1000 Metric tonnes)
Yield	yieldD	Metric tonnes/Hectare
Food Availability per capita	Food_capD	Kg/capita/year

Table 1: Description of Variables

Food exports and GDP per capita are measured in US dollars. Constant prices are used to remove the impact of inflation and the year 2005 is used as a base year. Total food aid is measured the weight of its grain equivalent. Quantity/mass is the only dimension considered for food aid hence it is measured in metric tonnes. Farm yield is calculated as the total amount of food produced divided by the land area. Finally, food availability per capita is measured as the amount of food in kilograms that one person in a certain country receives over a period of one year.

The hausman test is used to choose between a fixed effects model and a random effects model.The model with the lowest information criteria is chosen as the information criteria accounts for residual sum of squares and penalizes the addition of more variables through the loss of degrees of freedom.

Chapter 4: Data Analysis and Discussion of Results

4.1 Introduction

This research study consists of four unique panels and one panel which is an aggregation of the first four. These panels contains data from different African regions including: North Africa, East Africa, Southern Africa and West Africa. Panel unit root and normality tests were first done to find out if standard statistical methods can be used for inference.

4.2 Summary Statistics

Three variables (ExportD, aidD and yieldD as explained in table 1) have positive excess kurtosis while food_capD has negative kurtosis. gdp_capD has a distribution closest to the normal distribution because its negative excess kurtosis is a small value. All variables are skewed to the right since they all have positive skewness values. Using growth rates, the data moves closer to following a normal distribution as opposed to level forms. A table containing summary statistics is shown below.

Statistic	*ExportD*	*Gdp_capD*	*aidD*	*YiedD*	*Food_capD*
Count	*336*	*336*	*336*	*336*	*336*
Mean	*9,719.15*	*1,108.58*	*23.55*	*2.67*	*185.42*
Stdev	*13,521.93*	*985.73*	*42.25*	*1.7*	*49.55*
Skewness	*1.85*	*1.05*	*2.82*	*1.83*	*0.9*
Kurtosis	*5.76*	*2.7*	*11.44*	*10.84*	*1.82*
range	*64,038.52*	*3,696.26*	*242.14*	*14.62*	*196.25*

Table 2: Summary statistics

Export of agricultural products and food aid have very high standard deviations compared to their mean values. This shows that these two variables have very high variation over time and cross sections. To make them stable, logarithm forms are used as outlined in the previous section. This transformation also allows for the use of econometric methods as it reduces the impact of outliers in the interpretation of results.

This inferential statistical tests are important in using the underlying related distributions to infer population parameters from the sample. All variables have positive skewness meaning they have heavy tails to their right. Figure 6 below shows the three major forms of skweness with the extremes being positive and negative skewness. The graph with zero skewness represents a normal

distribution. Figure 7 shows the distribution of food aid which is positively skewed. The tail is heavy on the right meaning more values lie above the mean.

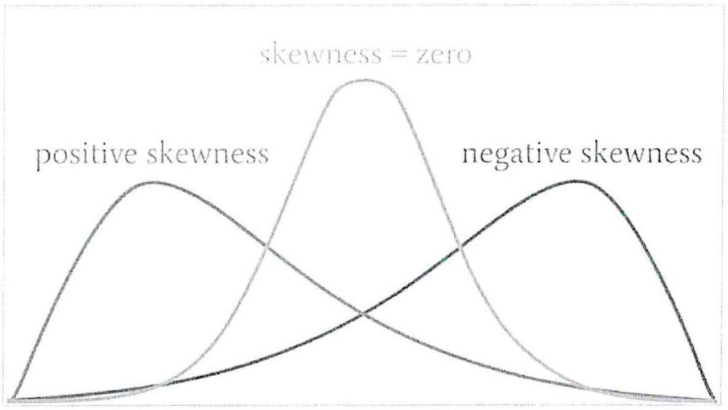

Figure 6: positive skewness, skewness, and negative skewness, Source: Kolin (2020)

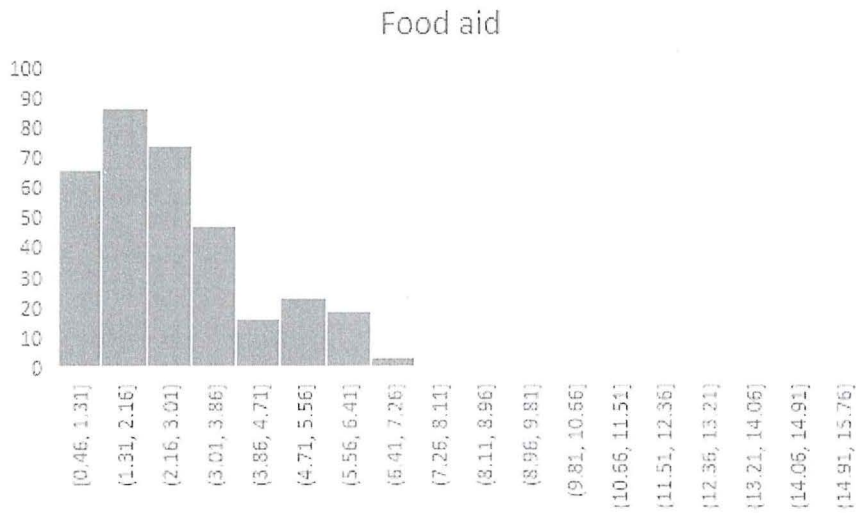

Figure 7: Food aid distribution; Source: Researcher generated

4.3 Diagnostic checks

4.3.1 Stationarity Test

Im, Pesaran and Shin (IPS) test was used because it provides a flexible and simple unit root test. It slows some panels to be non-stationary in the alternative hypothesis and then uses the average test statistic to evaluate the null. This test is used because the panel is strongly balanced and the

test allows for the simultaneous testing of both stationary and non-stationary series. The test's hypotheses are listed below:

H_0: all series have a unit root.

H_{C1}: some series are stationary.

Four lags of the time series are used to get rid of autocorrelation. The summary output is shown on table 3.

	Variable (level form)	T-stat	p-value
1	Food exports	5.544	1
2	GDP per capita	3.362	0.9996
3	Food aid	-1.682	0.0463**
4	Yield	1.94	0.9738
5	Food availability per capita	1.32	0.9066

* significant at 1%
** significant at 5%
*** significant at 10%

Table 3: Stationarity test (Level form)

From the summary results on table 3 above, all data series contain unit root at the level form but they become stationary when transformed into percentage change as shown in table 4 below. These growth rates are therefore used for the remainder of this chapter.

	Variable (growth rate)	T-stat	p-value
1	Food exports	-2.2114	0.0135*
2	GDP per capita	-1.672	0.0473*
3	Food aid	-2.2642	0.0118*
4	Yield	-2.4273	0.0076**
5	Food availability per capita	-3.31	0.0005**

* significant at 1%
** significant at 5%
*** significant at 10%

Table 4: Stationarity test (log form)

4.3.2 Multi-collinearity test

Given that a multiple regression will be used, any high inter correlations between one or more independent variables and the dependent variable will lead to the statistical significance of the former to be undermined. Variance inflation factor (VIF) is used to test for multicollinearty in multiple regression. The table below shows the summary of the test.

Variable	VIF	1/VIF
gdp_capD	1.52	0.6599
exportD	1.43	0.6969
yieldD	1.27	0.7861
aidD	1.03	0.9725
Mean VIF	1.31	

Table 5: VIF Multicollinearity test

All VIF values are less than 10 hence no multicollinearity between any regressor and food availability per capita.

4.3.3 Test for Heteroscedasticity

The Breusch Pagan test is used to test if the error terms have a constant variance. The summary of the test is shown below:

H_0: Residuals have constant variance

H_a: Residuals have non constant variance.

Chi^2 (1) = 52.84

Prob > chi^2 = 0.000

Decision rule: reject the null hypothesis if the p-value is less than 0.05. The results of the test show the error terms are heteroscedastic since the null is rejected at 5% level of significance.

4.4 Discussion of results

The hausman test is used to choose between a fixed effects and a random effects model. The test is based on the following hypotheses;

H_0: Random effects is consistent and should be preferred.

H_{C1}: Fixed effects is consistent and should be preferred.

	Coefficients			
	(b)	(B)	(b-B)	rt(Vb-VB)
	fixed	random	difference	S.E
export	0.058	0.0588	-0.0007	0.0026
gdp_capD	0.0908	0.0911	-0.0003	0.0056
aidD	-0.0114	-0.0114	-0.0001	0.0008
yieldD	-0.0061	-0.0041	-0.0019	0.0057

Where: b = consistent under H0 and Ha
B = inconsistent under Ha, efficient under H0

H0: difference in coefficients not systematic
chi2(4) = 0.38
pvalue = 0.9844

Table 6: Hausman Test

Given the test's p-value is more than 5%, the null hypothesis fails to be rejected hence a random effects model is used. This model assumes that there are infinite regressors that may affect the dependent variable value which will be observed. It also allocates a different intercept for each cross section. The random effect is therefore treated as part of the error term since it is thought to have randomly occurred from a group of infinite possible intercepts.

Random effects model uses generalised least squares (GLS) estimators to reduce the effects if serial correlation. It is also more efficient in the presence of heteroscedasticity compared to Ordinary Least Squares estimators. Running a random effects model, the following summary results are obtained.

	Variable	Coefficient	Standard error	p-value
1	ExportD	0.0588	0.0103	0.000***
2	Gdp_capD	0.0911	0.0207	0.000***
3	aidD	-0.0114	0.0035	0.001***
4	yieldD	-0.0041	0.0239	0.864
5	constant	0.00005	0.0058	0.993

* significant at 1%
** significant at 5%
*** significant at 10%

Table 7: Random Effects Model Output

The regression is done at the log-log form hence the coefficients show the percentage change in the dependent variable given a one percent change in the independent variable.

Performing a Wald test, the model is jointly significant with a p-value of 0%. The Wald test is uses maximum likelihood estimation to test for joint significance of a model. By definition of random effects, the correlation between the regressors and the error term is assumed to be zero. This is further confirmed by the zero standard deviation of unobserved heterogeneity.

All variables except yield are statistically significant in explaining food availability per capita in Africa. Agricultural produce exports have a significant positive effect on food security of the exporting country. International trade and food security dimensions of availability, accessibility, utilization and stability interact together in a complex manner. The positive effect arises when countries that want to gain more foreign exchange through food exports simultaneously develop the local food chain hence more people get access to food. Governments can also work deliberately to produce more food to feed local workers who produce and add value to agricultural produce before they are exported.

GDP per capita is a measure of goods and services produced in a country in one year and which adjusts for population. This variable has a significant and positive effect on food security. The results show a one percent increase in GDP per capita leads to a 9.1% increase in food availability per capita. Most food in Africa is produced by many smallholder farmers and any improvement in their economic power enables them to employ better labour and equipment in food production. This in turn makes the whole process more efficient and more food is produced. However, this requires economic growth rates to be higher than population growth rates.

Food aid sent by international donors to African countries has a significant negative effect on food security. Aid incentivises the local administrations to be lax in creating buffer food produce and building sufficient local production capacity. Food aid in itself makes the recipient more food secure but it is the huge incentive of not supporting local farmers that negates the positive impact.

Governments classify households as food secure if all members can access sufficient food all the time to live happy lives (Wilde & Nord, 2005). A similar definition has been used in this study with food availability per capita measuring the amount of food in kilograms that is available to a person over one year. These two studies use longitudinal data to gain insights on how different factors interact at the individual and household level to achieve food security. Micro-level policies targeting small holder farmers are found to be more effective in producing more food compared to national macro level policies such as the irrigation of large tracts of land.

(FAO, Food and Agriculture Organization of the United Nations, 2020) Develop an index using several food security indicators to determine whether a country is food secure or not. In this study I use variables before they are aggregated into an index to get a feel of how individual variables drive food security. In both studies, multivariate panel data analysis is used to study the spatial and temporal effects of independent variables on food availability per capita. Furthermore, both studies report consistent results under the analysis and descriptive statistics sections. This consistency shows the relevance and accuracy if the model chosen by the researchers.

Chapter 5: Policy Implication

This study can be used to inform policy, educate the population on better food handling practices, development of modern farming and irrigation systems and the development of a food safety net for the vulnerable in the society. The following recommendations are made to policy makers from the findings of this study. Research grants should be made to local universities and research institutions to help find solutions that best fit the African continent. This will enable more research about socioeconomic factors that drive food security and can be used by the executive to make food security a reality.

The entire food cycle needs to be made more efficient by employing the latest technology in the production, storage, distribution and consumption of food. Losses should be minimized to acceptable low levels. This will in turn increase profits for farmers who can use it to purchase better equipment and employ skilled labor. Consumers also benefit as the reduction in food wastage leads to them paying less. Efficiency in the food chain ensures that food quality is maintained and will remain nutritious until it reaches the end consumer.

Governments should subsidise firms exporting agricultural produce as they are observed to have a positive effect on the local food production. This can be done through expansionary fiscal policies that are aimed at reducing costs along the food chain and its supporting industries. This will reduce input costs to farmers and later cheaper food to the end consumer. Transfer payments to the poor will enable them purchase sufficient food that is also nutritious. These macroeconomic policies should target export oriented farmers because the results indicate they are more likely to increase the amount of local food production in the process of exporting food.

Chapter 6: Recommendations and Conclusion

6.1 Room for more research

Researchers have not been keen on the application of dynamic panel data models and dynamic panel autoregressive models. This extends to social sciences like economics and real life issues like food security. This research opens a door to possible advancement of the basic random effects panel data model it used. Future research work can be done in future using more advanced models that correct for unobserved heterogeneity and allow for the modelling of partial adjustments of variables. Panel vector autoregressive models allows models to have a mixture of both endogenous and exogenous variables. This helps in reducing heterogeneity bias that arises from the omission of important variables.

6.2 Limitations of the Study

The findings of this research were constrained by data and design problems that could not be eliminated completely. The sample size was limited due to the effects of cross sectional dependence. Countries from different African regions had to be dropped from the study if their variables had high correlations with those from other regions. This was established using Pesaran's cross sectional dependence test.

Secondly, gaps in the cross sections and holes in the time series made it hard to carry out diagnostic checks that need strongly balanced panels. This problem was however sorted using statistical methods from literature which suggests using moving averages if the number of missing data points is small. Lastly, the field of panel data is still at its developing stages with few studies using it in studying food security. Most software packages lack advanced panel methods which make it time consuming for to develop user defined functions and packages.

6.3 Conclusion

Food security is attained by making sure sufficient food that is of acceptable quality is accessed by everyone when they need it. This study concludes that ramping up agricultural exports will in the process lead to increased production of food for the local markets. Furthermore, foreign exchange earned from cocoa, tea, coffee and tea exports can be used to import modern machinery that will make farming more efficient.

Secondly, local small holder farmers need to be empowered so that they can produce more food. This can be done by giving grants, loans and agricultural extension services. Economic empowerment also plays a big role in ensuring farmers focus on food production rather than inefficiently moving from one economic activity to another. Macroeconomic policies such as tax reductions and increased government spending lead to economic growth which further leads to more food production and availability.

Food aid to African countries has eroded the oversight roles of administrative institutions. Many African countries have been over dependent on food aid hence they are not able to secure their citizens when the aid is either delayed or withdrawn. A lot of farmers have been driven out of business and lost their livelihoods due to the influx of free or heavily subsidised food from donors. In the long run, such countries become more dependent on aid and are worse of in terms of food security as shown in the findings in the previous chapter.

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