Essays on Smallholder Crop-Choice and Food Security

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Chisom L. Ubabukoh

Economics, School of Social Sciences

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Abstract

The aim of the second chapter is to examine the factors which determine the crop choices of small-holder farmers in Nigeria and how these choices affect productivity and welfare outcomes. Using the two-rounds of LSMS panel data from Nigeria in 2010/11 and 2012/13; the paper starts by re-examining the old arguments surrounding whether small-holder farmers are indeed "efficient-but-poor". We find that smallholders are generally efficient in their allocation of resources (after estimating household crop productivity by stochastic frontier analysis) but are not necessarily rational in their crop choices because even when some crops are found to be more productive than others, the less productive crop is often chosen. To figure out why, a treatments effect model is employed to determine farmer selection into the choice of a type of crop in the first stage; and subsequently the impact of their choices on productivity and poverty. We find that access to free inputs, non-farm income and the use of seeds from the previous growing season are important determinants of crop choice. The third chapter aims to examine the effect of the choices smallholder farmers make in terms of what crops they grow on the food security outcomes of the households. This issue is studied using the household level panel data available from the World Bank's Living Standards Measurement Study (LSMS) and different specifications of propensity score matching models. The empirical estimates suggest that smallholders who grow cash crops have significantly more diverse food options available to them as well as a greater amount of overall food consumption but a greater severity of food shortage when food is scarce. However, there is no effect of crop choice on the total number of days in a week without food. Furthermore, when there are significant effects, these effects are reduced when the access to export markets and fluctuations in international food prices are considered as instruments. The conclusion is that if the policy objective is to improve food security, a careful examination has been carried out on the pre-existing conditions of the households before a crop choice recommendation can be made. In addition, cash crop production should only be encouraged when an adequate support can be provided to link the farmers to the international market and if there can be some government-backed price stabilization measures. The fourth chapter examines the determinants of food availability at the national level from the perspective of food imports in African countries. The system-GMM method is adopted for this purpose to account for the endogeneity of variables in a dynamic model. The results show that past import levels, food aid, armed conflicts, food price fluctuations, as well as overall income per capita levels were some of the influential factors for food-security sufficient food imports.

Declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Copyright Statement

Dedication

To my lovely wife and to the fulfilment of purpose.

Acknowledgements

There are a lot of people who deserve thanks for their support towards the completion of my PhD. First, I would like to thank God Almighty, the Father and maker of all things for His sufficient grace.

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Chapter 1

Introduction

1.1 Overview

This thesis is a study of several themes including crop choice, agricultural productivity, poverty, and food security from different perspectives and it involves analysing the inter-relationships between them.

The next chapter examines crop choice in detail with emphasises on what determines the type of crop a smallholder farm household chooses to produce and how this choice influences the poverty and agricultural productivity outcomes of the household if at all. From a layman's perspective, it might appear that farmers decide what crops they choose to grow entirely by chance or at random but if farmers are assumed to be rational economic agents every decision they make regarding their farms including what crop they choose to grow should be as technically efficient as possible. But does this assumption hold in reality? Are farmers always truly at the productivity frontier? Obviously, the answer is no but this does not negate economic rationality, which also includes a wide range of considerations apart from strict productivity. Thus, one of the goals of this chapter would be to figure out what the other factors are that go into the decision-making process of farmers when they determine their crop production. The chapter starts out by analysing the various agricultural productivities of farmers who grow different categories of crops and it was determined that all other things being equal, some crops were associated with higher productivities than others. If this was the case though, why then would any farmers make the decision to produce the "lower productivity" crop at the start of the planting season if given an open choice? The analysis of the paper uses the selection bias correction by Greene (2010) to study the differences in choice between farmers who are similar in every other way (for example, similar levels of income, age, education, household size etc) apart from the crop they have chosen to grow in the years of study. The answer suggested by the chapter emphasises the roles of tradition (proxied for by how much of the new season's planting was done by seeds retained from the previous season) and the amount of non-farm income the farm household possesses. It is no surprise that these are some of the same variables which are important in determining the level of risk aversion the household possesses. In other words, if there was the security of some non-farm income, there is likely to be a greater appetite for growing higher productivity albeit more risky crops with the reverse also being the case. Papers that have analysed these issues have come up with different results. For example, Delarue et al. (2009) discovered that farmers who produced cotton had better welfare outcomes than those who did not; also, Loveridge et al. (2003) discovered a positive but weak relationship between being a coffee producer and the consumption outcome of the household. However, Maertens and Swinnen (2009) found that the welfare of rural households was vastly improved by their participation in food crop production. The findings of this paper contributes to this debate by providing new evidence of this interrelationship.

The third chapter picks up from this to study what the impacts of these crop choices are on the food security outcomes of the households who grow the different categories of crops. This chapter makes the division between cash crop and non-cash crop production. Following from a narration of the history of the food security definition, for this study, four dimensions of household food security are identified: food consumption per household member in kcal, squared difference in the mean food consumption, the household dietary diversity score (HDDS) and the number of days without food within the recall period of the last 7 days prior to the survey. A major contribution of this chapter is the use of the squared difference in the mean food consumption variable as a measure of food security because it allows one to account for the severity of food deprivation at the lower end of the food consumption distribution. In the literature, the relationship between the choice to grow cash crops and food security outcomes varies widely based on the differences in the specific crops studied, the geographical spread of the research areas, and the existing local structures (Dewalt, 1993; Sharma, 1999; Kiriti & Tisdell, 2004). Jones & Gibbon (2011), Komarek (2010), Pierre-Louis et al. (2007), Von Braun (1995), Kennedy et al. (1992) find that growing cash crops provides a better access to nutrition and better food consumption outcomes. On the other hand, Kiriti & Tisdell (2004), Kanyamurwa et al. (2013), Collins (1962), Dewey (1979); FAO (1987), Fleuret & Fleuret (1980), Haaga (1986) showed that cash cropping actually had a negative effect on per capita food availability in certain situations. After the utilization of some propensity score based matching procedures, the results of this chapter showed that there were significant average effects of growing cash crops on the farmers that did in both the food quality and food quantity indicators. Also, if a particular farm household already possessed worse outcomes than the average household's food security, then there was a greater likelihood for that household to be even worse off if they chose to grow cash crops.

The next chapter takes a macro-economic view on these issues by examining an aspect of national food security. The premise of this chapter is that if that there are two major ways a country can provide for its food requirements: domestic food production and importation of food (if/when there are shortfalls in production), and the country is not able to fill up these gaps with trade, then there would result in poorer nutrition and more food insecurity over time as food consumption would have to be reduced. The chapter goes on to analyse what factors are important in the consideration of how much food imports a country makes to supplement shortfalls in domestic production. In the literature, some of the identified predictors of food import include food shortages (Porkka et al., 2017), general food price levels (FAO, 1995; Safoulanitou & Ndinga, 2010; Astou, 2015), smuggling, food reserves, the "Dutch disease" phenomenon (Collier, 1988; Fielding & Gibson, 2013; Timmer, 2014), urban bias, changing tastes and preferences (Kearney, 2010), population (Adger, 2003) and armed conflicts (Misselhorn, 2005). The results of this chapter agrees with most of the established literature but it especially sought to explain the main reasons behind the recurrent massive food shortages in Africa. The chapter suggests that in order to maintain a good level of sustained provision of food, when there are shortages in domestic production, the difference should be matched by corresponding food imports. When this gap is not covered, because of the several points stated earlier, this would result in a shortage in the availability of food at the national level. This point underlines the importance of studying the determinants of food imports.

1.2 Crop Choice Facts and Figures

Different regions of the world have different preferences in terms of the types of crops they favour growing. Of course, a large part of this choice is made up by the natural effects of climatic, topographic and geographic conditions of the regions, but even within the regions when farmers have a free choice between more restricted samples, there are also revealed preferences for specific products over others. A part of the next chapter of this thesis deals with answering the question of why this may be the case.

The information contained in this section was obtained from the Food and Agricultural Organisation's statistics database (FAOSTAT) for the year 2018. Going by the value of agricultural products in current US dollars, the most popular crop worldwide is rice with an output value of $337 trillion, after this is maize with $232 trillion worth produced. This is followed by wheat, potatoes and tomatoes with production values of $167 trillion, $111 trillion and $95 trillion respectively with cereals as a group particularly dominant with over $790 trillion in production value. However, in Africa the most popular crop choice by this same measure is cassava, followed by maize, yams, wheat and rice with values of $17 trillion, $13 trillion, $11 trillion, $7 trillion, and $6 trillion respectively with a cereal production value of $38 trillion. By way of comparison in Asia, the most popular crops are rice, wheat, maize, vegetables, and sugarcane with values of $315 trillion, $100 trillion, $83 trillion, $76 trillion, and $60 trillion respectively with a cereal production value of $511 trillion.

It is often taken for granted that the crop a farmer chooses to grow is a random event, but this thesis re-examines this notion using new household data from Nigeria.

Table 1: Top 10 crops produced in Africa by production value in 2016

Crop	**Gross Production Value (current million US$)**
Cassava	17198.98
Maize	13344.27
Yams	10546.64
Wheat	7058.57
Rice	6471.15
Vegetables	6096.54
Bananas	5787.64
Potatoes	5606.88
Tomatoes	5470.36
Sorghum	4719.64

Source: Food and Agricultural Organisation's statistics database (FAOSTAT), 2018

1.3 Facts on Food Security in Africa

In addition to crop choice, the other major theme in this thesis is food security and the importance of this concept: that there should be sufficient, nutritious and accessible food for all at all times cannot be over-emphasized as this forms the foundation of the physiological needs of man as espoused by Maslsow (1954). Food is a subject that affects everyone regardless of economic status or other considerations. The fundamentals and explanation of the food security challenge is extensively discussed within the thesis but briefly, it is important to note that food security is not concerned solely about the availability of sufficiently large quantities of food but also the access to this food (especially economically by the ability of purchase) and the utilization of the available food in a safe and proper manner to obtain the optimal nutrition and utility thereof.

The world is experiencing a food crisis; about 795 million people are currently unable to afford a basic 1,800 calories a day (this amount is insufficient for a medium level of activity according to the FAO publication: The State of Food Insecurity in the World, 2014). The International Food Policy Research Institute (IFPRI) Global Hunger Index (2014) states that malnutrition especially during the first 1,000 days of life may result in permanent stunting, or reduced productivity and health throughout adulthood and unfortunately over 2 billion people are not getting sufficient nutrition. By 2050, food production would need to be doubled to feed the 2 billion people which are estimated to be added to the world population. This statistic is all the more troubling considering that the current highest population growth rates occur in those regions which are the most food insecure (population growth rates in sub-Saharan Africa, North Africa, and South-Central Asia are 2.66%, 1.74%, and 1.18% respectively).

Due to the size and importance of the food problem, the international community via the United Nations have made the elimination of hunger by 2030 one of the key components of the Sustainable Development Goals (SDGs). Some progress has been made towards the achievement of this goal. For example, the above quoted number of malnourished people (795 million) is an improvement from the about 930 million people between 2000 and 2002. In addition, the stunting rate has declined from 33 percent in 2000 to 23 percent in 2016. However, a lot still has to be done to reduce the absolute numbers of food insecure individuals and households in the world.

The question regarding what effects, if any, a farmer's choice of crops has on his/her household's food security is examined in chapter 4 of this thesis. This is followed by an examination of some of the macro-level determinants of national food security in Africa from the perspective of food imports in chapter 5. The expectation is that by the end of this thesis, the reader would have gained a more robust understanding of the general issues relating to crop choice, agricultural productivity, and food security in the African (or developing country) context as well as some specific knowledge on the methods and techniques commonly used in the analysis of similar questions.

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Chapter 2

"Why do Farmers Grow the Crops they Do?" The Impact of Crop Choice on Agricultural Productivity and Poverty

Summary

The aim of this paper is to examine the factors which determine the crop choices of small-holder farmers in Nigeria and how these choices affect productivity and welfare outcomes. Using the two-rounds of LSMS panel data from Nigeria in 2010/11 and 2012/13; the paper starts by re-examining the old arguments surrounding whether small-holder farmers are indeed "efficient-but-poor". We find that smallholders are generally efficient in their allocation of resources (after estimating household crop productivity by stochastic frontier analysis) but are not necessarily rational in their crop choices because even when some crops are found to be more productive than others, the less productive crop is often chosen. To figure out why, a treatments effect model is employed to determine farmer selection into the choice of a type of crop in the first stage; and subsequently the impact of their choices on productivity and poverty. We find that access to free inputs, non-farm income and the use of seeds from the previous growing season are important determinants of crop choice.

JEL classification: D24, I32, N57, 013, 033

Keywords: Agricultural Productivity, Poverty, Crop Choice, Stochastic Frontier Analysis, Treatment Effects Model, Nigeria

2.1. Introduction

The main purpose of this research is to investigate the relationship between the choices of smallholder farmers regarding which crops to grow and the productivity and welfare outcomes of the farm households. Their productivities are also analysed to determine the nature of the differences between farmers who grow different types of crops. Additionally, the specific characteristics and properties of the subgroups of farmers within the sample are also examined to determine if any useful information can be obtained, and an attempt is made to identify the determinants of such choices. The data to be used comes from the two waves of Nigeria's General Household Survey-Panel (GHS-Panel), which is part of the World Bank's Living Standards Measurement Study – LSMS.

Furthermore, an attempt will be made to link this idea with the growing literature on the effects risk attitudes of farmers have on their investment decisions (especially regarding the crop they choose to grow). Dercon and Christiaensen (2011) have shown that the less income a farmer has, the more risk averse he or she will be, and the more risk averse a farmer is, the less likely he or she will be to invest more in his or her farm operation or to adopt new technology.

Producing cash-crops has, for the most part been traditionally looked upon as the forte of large-scale commercial farmers, but in more recent times, there have been arguments that perhaps smallholder farmers could also take advantage of the large international market these products have and synergize their efforts to raise overall productivity[1] and improve their incomes. Thus, this research proposes to study these arguments in closer detail – Do smallholder farmers who engage in the production of crops which are mostly export-oriented experience significant productivity differences from those that don't, and do they have better welfare outcomes?

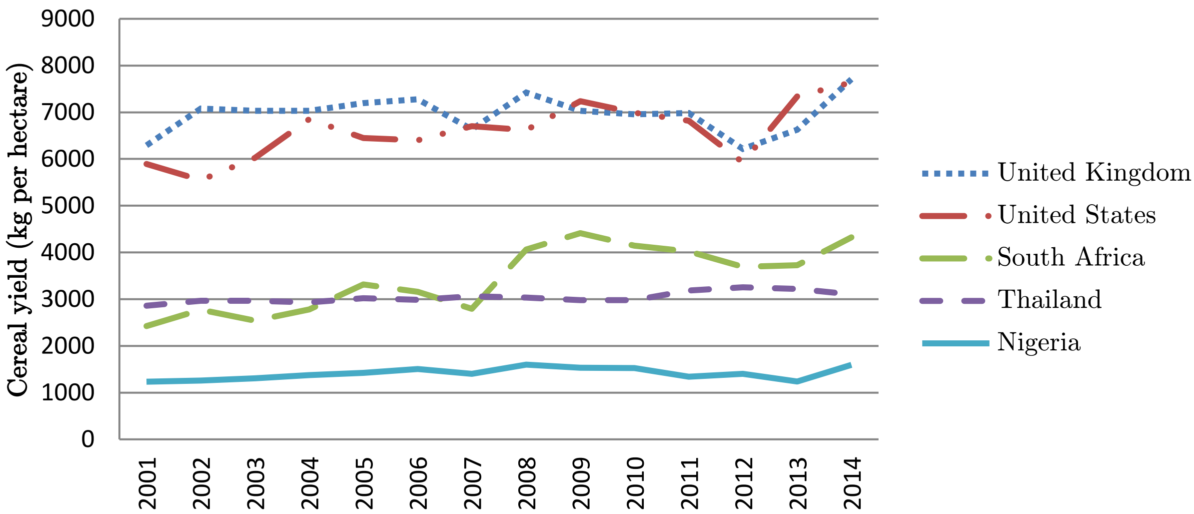
Nigeria is an appropriate country to use as a case study because it is a country where the agricultural sector is trapped in a cycle of low productivity. Nigeria may be classified as a lower-middle-income country (by the World Bank definition) with a national GDP of $375.8 billion as at 2017 (which is about half a percent of the global economy), an estimated population of 190.9 million people, and a gross national per capita GDP of $1,968 (World Bank, 2018). The average growth rate of GDP between 2007 and 2014 was 6.09%, which is higher than several countries in Africa and even Europe who barely managed to average 5% within the same

[1] Productivity here is defined as total factor productivity or output after inputs have been accounted for.

time frame, but there has been a sharp decline in the growth rate since then to an average of 0.63% between 2014 and 2017 due to a period of recession in 2016.

Despite the long period of high economic growth, about 67% of the population lives on less than $2 a day (World Bank, 2016) and in 2017 overtook India as the country with the largest amount of absolute poverty in the world; with a large proportion of the poor engaged in agriculture. Agriculture accounts for about 40% of the country's GDP and employs about 65% of the people (World Bank, 2016). Thus, the agricultural sector is important in determining the quality of life and welfare of a large proportion of people in the country. However, it has lagged behind other sectors and the rest of the world in terms of productivity. To illustrate this, the graph below shows agricultural productivity of a few countries, proxied by cereal yields in kg per hectare, from which it is clear that, Nigeria is not doing as well as it could be.

Figure 1: Time Trend of Cereal Yield for Selected Countries



Source: Author's drawing from World Development Indicators (WDI), 2016 database

The low agricultural productivity in Nigeria could be due to many factors ranging from poor soil quality due to erosion, pollution and leaching, to the scarcity and high cost of inputs. Others may be the continued use of crude implements, and traditional (non-modern) farming practices. However, this paper intends to show that all other things being equal, the type of crop a farmer chooses to grow, even at the same levels of technology is important for the outcomes of that household in terms of productivity (technical efficiency) and poverty.

To illustrate this further, below is a table of selected crops, the area of land planted with the crop, their prices, the average output in tonnes and their average revenues per hectare.

Table 1: Selected Crops with Outputs, Prices and Expected Revenues

Crop	Land Area ('000 ha)	Output ('000 metric tons)	Avg. Price per kg (Naira)	Avg. Revenue per ha ('000 Naira)
Yam	3236.16	37328.17	76.07	877.45
Cassava	3481.88	42533.17	65.31	797.79
Cocoyam	520.12	2957.09	80.00	454.83
Cotton	398.56	602.44	230.22	347.99
Melon	469.7	507.34	123.06	132.92
Rice	2432.64	4472.51	72.03	132.43
Maize	4149.33	7676.85	64.65	119.61
Guinea corn	4960.13	7140.96	73.08	105.21
Beans	2859.77	3368.24	83.03	97.79
Groundnut	2785.17	3799.15	69.02	94.15
Soyabeans	291.38	365.06	60.03	75.21
Millet	4364.16	5170.45	58.53	69.34

Source: Nigerian Bureau of Statistics (NBS), 2009

It is clear that some crops give more revenue than others (this, of course, does not include input and production costs, for which some crops would also have higher costs of production than others, thus narrowing the profit margins[2]), but this gives a general idea of the motivation. If there are crops that yield higher revenues, and importantly, a farmer is free to choose among all these crops equally, all other things being equal (like weather and soil variability), why would he choose to grow a crop that provides a smaller profit margin than the other crops? And by how much would choices of this kind impact on their productivity and household welfare? These are the questions we set out to answer in the paper.

This research is important for several reasons. Firstly, from studying the productivity of farmers in Nigeria, it would be clearer where opportunities exist for improvements and the important factors which when increased (or reduced as the case may be), would result in the highest productivity increases. This is especially important since as more countries and charity organisations channel a large part of their foreign aid investment into agriculture (Addison & Tarp, 2015), they need to know where the greatest gains could be achieved. Should the focus be more on moving the technological frontier forward with innovation, or to try to raise

[2] This is however taken into account in our computation of productivity, and the analysis shows that there are indeed productivity differences between crops, even after accounting for all input and production costs. Some economists would refer to this particular aspect of analysis as implying allocative efficiency, which is the position of this paper as well.

allocative efficiency on the current frontier by encouraging better use of inputs, or perhaps a combination of both?

Also, understanding the reasons why farmers choose to grow the crops they do could help policymakers know where to focus when trying to promote the production of certain crops, for which they believe their country has a comparative advantage and where they feel the largest national gains could be achieved, perhaps in terms of a reduction in foreign exchange expenditure or for food security. For example, whenever a new government comes into power in Nigeria, it would often seek to come up with an overarching agricultural agenda for the agricultural sector, encouraging the production of certain crops which it deems more "important" (Iwuchukwu & Igbokwe, 2012). This paper could help improve the choice of such crops.

In addition, poverty and food security is a major concern for many sub-Saharan African countries and the cropping decision of these countries could have far-reaching implications for national food security. If the production of certain crops can improve the welfare outcomes of the farmers or reduce the food insecurity in bad seasons, this knowledge would be important. The argument of crop choice being a likely proxy for a measure of risk aversion could be important for researchers who face the daunting task of planning field experiments and using methods from behavioural economics or psychology to estimate the risk aversion of farmers.

It is only when the drivers of productivity or poverty perpetuation are properly linked and analysed that progress could be made in determining the possible ways that special interventions could be used in solving these problems. For example, according to Karlan et al. (2013), the unavailability of credit may not be biggest problem to the productivity question, in the sense that, even if all farmers had access to equal amounts of credit, not all farmers may decide to make use of the necessary amounts to raise their overall productivity. They argue that in this way, risk attitudes might potentially be even more important, bringing up agricultural self- or micro-insurance as a vital piece of the puzzle. Because if farmers take out large loans but cannot predict with any certainty what their output is likely to be, it could be likened to them just taking on a really big gamble. Could it be that the type of crop a farmer decides to grow is a form of self-insurance? This illustrates the importance of studying what types of crops farmers plant, why they choose those crops, and what effects such seemingly innocuous choices could have.

Technically, this research is original because it creates variables that measure crop choice directly, rather than relying on proxy. It is not based on only one-crop divisions. For example, Delarue et al. (2009) groups cotton farmers in one category and everyone else in the other category and analyses what the determinants for growing cotton are. Other papers like Loveridge et al. (2003) and Murekezi and Loveridge (2009) have compared coffee farmers with others and tobacco farmers with others. The limitation to these studies is that they neglect the fact that there are several crops that possess similar characteristics which can be studied and analysed together. Thus, for example, it could be much better in terms of policy to study crops that are roots and tubers together, rather than only potatoes. Crop groupings as are used in this paper have been used in relation to productivity, but not in relation to household welfare. However, the effects of these crop choices on household welfare are also analysed.

Furthermore, this paper is to our knowledge, the first attempt at studying productivity based on a Stochastic Frontier approach and poverty in Nigeria using the available waves of data from the Living Standards Measurement Study (LSMS). Our study is also unique as it relates to the types of crops grown by the farmers in Nigeria.

The results show that access to free inputs, non-farm income, the use of seeds from the previous growing season, household size, gender and the different regional differences are the main determinants of crop choice. Also, the choice influences the productivity and poverty of the households, although not in the ways that may be expected. In addition, commercialization was found to be important for poverty alleviation, but not for productivity improvements.

The rest of this paper is laid out as follows. Following this introduction, there will be a brief literature review highlighting some of the work that has been done on productivity of smallholders and the effects of decisions to grow a crop on productivity and welfare. Thereafter, the economics behind the methodologies to be used are developed, starting with how the key crop choice variables are defined in this paper. The data section, results and analyses are then presented. Following this, there is a general discussion of risk aversion and how this could be related to crop choice.

2.2 Literature Review

2.2.1 Agricultural Productivity in Nigeria

To measure technical efficiency, two groups of methods can be employed: parametric and non-parametric methods. Among the parametric methods, stochastic frontier models are the most common. For Nigeria, these models have been used to compute farmer efficiency for a large variety of crops including rice, wheat and cassava, among others. Stochastic frontier methods are also applied in this paper, not for specific crops here, but for all the comparable farmers in the sample; in addition, we are able to make a more detailed analysis due to the availability of panel data. The difference between the parametric (like the Stochastic Frontier Analysis or SFA) and non-parametric methods is that whilst production functions are of a specified form for parametric analysis, there is no such restrictive functional form employed for the non-parametric method. An example of the non-parametric approach is the data envelopment group of models (Charnes, 1978). Models of this kind rely instead on the data rather than predetermined functional forms of the production functions (Ajibefun, 1998). In addition to the above, some other studies have used some partial measures of productivity like yield per hectare in their analysis.

Adeyemo et al. (2010) compute an average technical efficiency (TE) score of 0.89 for cassava farmers in Ogun state, Ebong et al. (2009) do the same for food crop farmers in Akwa Ibom and recover an average TE of 0.81. In the South-East region, Onyenweaku & Ohajianya (2009) calculate an efficiency score of 0.65 for rice farmers in Ebonyi state. Finally, Amaza et al. (2005) do the same for food crop producers in Borno and calculate an average score of 0.68. Papers like these are an indication of the range of calculated efficiency scores, but this paper carries out a nationwide analysis using data from the nationally representative panel household survey of Nigeria. To the best of our knowledge, this is the first time both waves of this dataset have been combined to perform an SFA for efficiencies, thus this should make a useful contribution to the literature.

2.2.2 Crop Choice, Productivity and Welfare

In the reviewed papers below, household welfare was measured by domestic household per capita consumption. Using national household surveys from Mali, Delarue et al. (2009) studied the relationship between cotton production and household consumption and discovered that cotton producers consumed an average of 9 percent more food than non-cotton producing households where food consumption is a proxy for total consumption. The previously stated result was the difference between an aggregation of large and small cotton and non-cotton farmers. When they were disaggregated, it was found that the largest cotton producers consumed up to 22 percent more than the smallest cotton producers. Delarue et al. (2009) reports correlations though, rather than the suggestion of any causal relationships as is attempted by this paper. Loveridge et al. (2003) do something similar for Rwanda, but with coffee, and discovered a positive but weak relationship between coffee production and consumption outcomes of the households. They speculated that this relationship could be explained by the low prices for coffee in the world market as at the time of the survey, which was in

2001. Murekezi and Loveridge (2009) use the same methodology to compare the 2001 season data of Rwanda to that of 2007, to assess the impact of policy reforms and they found that technology could be a factor in the efficiency of cash-cropping among smallholders because those that used modern techniques spent 15 percent more on food and 17 percent more on all goods than the traditional producers. However, in addition to the methodology of Murekezi and Loveridge (2009), this paper also takes into account differences in production technologies by distinguishing crops that have vastly different methods of production from each other in one of the classifications for crop choice (i.e tubers and roots as against the other types of crops). Similarly, Maertens and Swinnen (2009) found that the welfare of rural households was vastly improved by their participation in high-yield vegetable exports in Senegal, while Cuong (2009) finds that commercial crops have positive poverty-reducing effects on rural households in Vietnam.

2.3 Defining Crop Choice

The idea that is intended to be examined here under crop choice is the cash-crop vs food-crop debate in order to attempt answering the question regarding whether one type of crop had quantitatively better production and welfare outcomes than the other. Normally, a cash crop is defined as an agricultural crop that is grown primarily for sale in order to make a profit. The term is often used to differentiate such crops from subsistence or food crops, which are grown primarily for the family of the farmer. However, in most developing countries, the understanding of the term 'cash-crop' is often related specifically to crops for export and the demand for such products from developed countries (especially for industrial purposes) and not necessarily just crops that are sold at the local level. According to the US Environmental Protection Agency, cash crops are typically purchased by organisations or commercial entities separate from the farm[3]. Given these definitions, if crops were to be divided by such a straight classification, it would be quite confusing and perhaps impossible to empirically test, especially when faced with the real data. This is also important as this paper intends to group similar crops together rather than study farmers who grow an isolated crop against all the others. The following are some of the reasons why this cash-crop/food-crop classification might be problematic.

Firstly, when cash crops are mentioned, the first picture that comes to the mind of a listener is that of tree cash-crops such as cocoa, coffee, palm oil, rubber etc. However, one of the objectives of this paper was to identify what determined the choice of crop planted and if tree crops are used in the analysis, this purpose

[3] See: "Ag 101: Crop Glossary" (2009), US Environmental Protection Agency.

would be defeated. This is because if we are trying to measure the effect of a planting choice on productivity and thence on welfare or poverty, it is necessary that the entire life cycle of the crop be captured within the year of interest. If tree cash crops are included, there would hardly be a basis for comparison with other farm households who do not produce these crops, mostly because a tree crop takes a relatively longer time to start producing output from when it is grown, and as such the inputs used for this would not be captured at all in our measure for productivity (which accounts for all the agricultural inputs and outputs within the production year under consideration). In addition to this, many of such trees could have even been planted by a previous generation, hence nullifying the premise that a choice has been made by the household to grow that tree crop. To be properly formal, tree cash-crops should be compared with tree food crops and annual cash crops with annual food crops. Therefore, excluding all the farm households with livestock and tree crops listed as their primary output was the first thing that was done in creating the crop choice variable. This ensures that the focus will be restricted to annual crops (those crops that can complete a life cycle within a year).

The second reason why a cash-crop vs food-crop categorization might be impractical is that going by the formal definitions, it would be difficult to allocate one crop solely to one category, apart from a few strictly non-edible crops like cotton and rubber. For example, take a crop like cassava. This is one of Nigeria's largest agricultural exports, with an average of over 45,000,000 metric tons exported per year on average, making the country the largest exporter of the product in the world. This crop is often used in industry to produce ethanol and other biofuels. However, cassava is also the raw material for a major local staple food – *'garri'*, which is consumed by most households in the country. Would this crop then be classified as a cash crop or a food crop?

For these reasons, this paper creates 3 different ways in which crops could be classified without too many of these same problems:

1. **Crop-Choice Group 1 (C_1) –** by the most exported crops (most exported crops vs. others),
2. **Crop-Choice Group 2 (C_2) –** by type (tuber and root crops vs. others),
3. **Crop-Choice Group 3 (C_3) –** a continuous variable for the degree of crop commercialization (how much a crop is sold or marketed vs. how much of it is consumed within the household).

It is important to mention that these are by no means an exhaustive list of ways in which crops could be classified. The point here is to simply illustrate that such divisions could be helpful to tell a story about the types of crops a farmer chooses to grow, depending on what the interest of the researcher is. For example, if a researcher is interested in the differences between farmers who choose to grow vegetables as against those who don't, or perhaps those who grow cereals as against those who don't, the sample could be so divided to investigate this.

2.3.1 Crop-Choice Group 1 (C_1) – Classification by the most exported crops (most exported crops vs. others)

To create the variable for the first category by most exported crops, data from the FAO was examined to determine which crops were the most exported ones in Nigeria, and the farmers who grew the top 5 crops (and listed them as their primary product output) were classified as Crop-Choice group 1 ($\mathbf{C_1}$) households. The purpose of this variable is to capture those farm households who grow crops that are the most likely ones to be exported. As can be seen from table 2 below, 11.06% of the sample planted one of the five crops in the first wave and 7.14% planted these in the second wave. The crops used here are as follows:

Table 2: List of crops classified as $\mathbf{C_1}$ (by most exported)

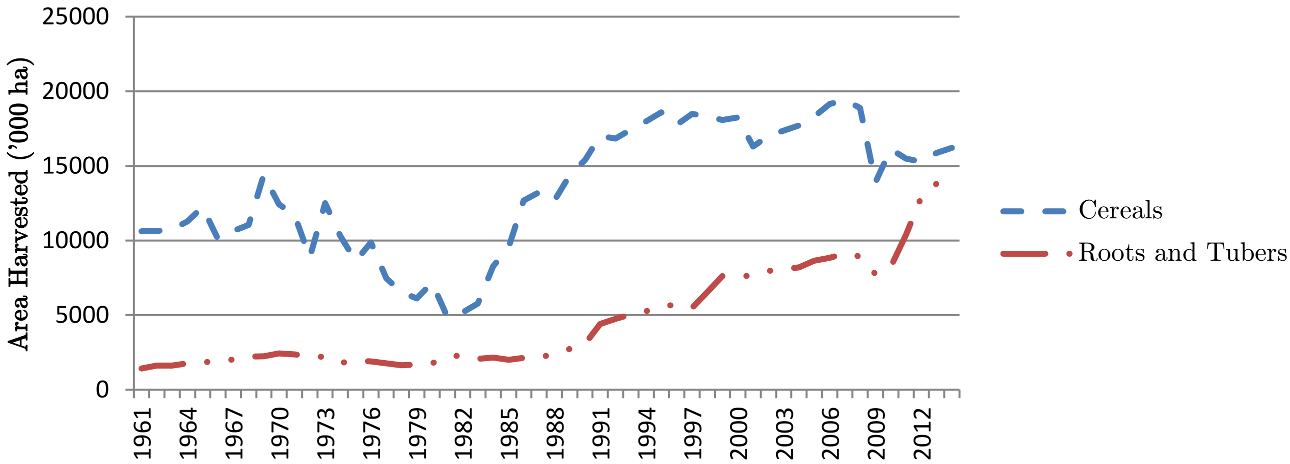
Crops ($\mathbf{C_1}$)	Export ('000 metric tons)	% of sample (wave 1)	% of sample (wave 2)
Cassava	42,533.17	10.42	6.48
Sugarcane	1,429.57	0.04	0.04
Cotton	533.31	0.16	0.19
Ginger	167.29	0.08	0.08
Sesame seed (Beni-seed)	127.60	0.36	0.35
Total	44790.94	11.06	7.14

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

2.3.2 Crop-Choice Group 2 (C_2) – Classification by type (tuber and root crops vs. others)

For the second division, crops have been grouped by type, with tuber and root crops on the one hand against the others. This classification is important because root and tuber crops have long been recognised as particularly important to the agriculture and food security of many countries especially those in sub-Saharan Africa. According to the Commission for Africa Report (2010), these types of crops are an important component of the diet for 2.2 billion people in developing countries, and in Nigeria, they were traditionally a store of wealth as you could tell how rich a person was by the size of his or her yam barn, for example (Obidiegwu and Akpabio, 2017). To illustrate this further, Figure 2 shows that even though cereals like rice and maize have in the past been allocated more land for production by farmers than roots and tubers, this gap has been closing steadily as more and more land area is allocated to the latter. In fact, there has been an upsurge in the production of tubers from around 2006.

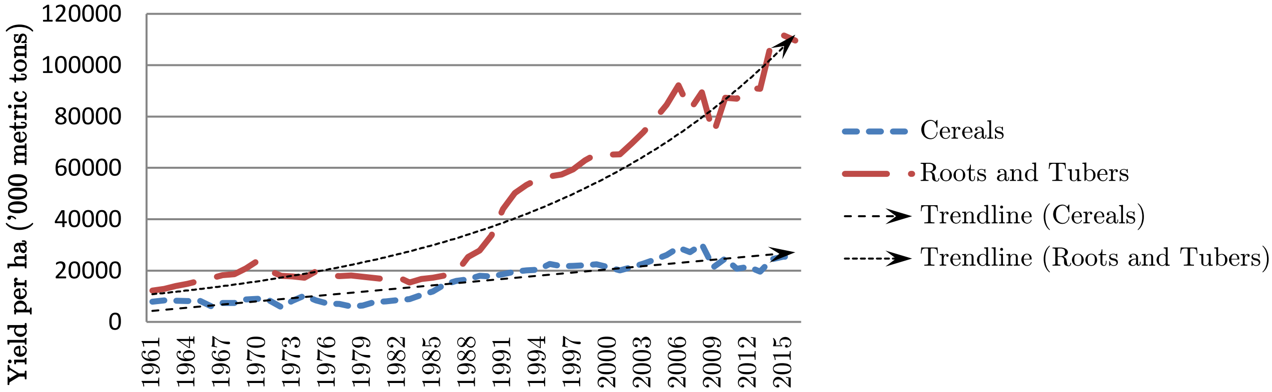
Figure 2: Time Trend of Area Harvested for Cereals, Roots and Tubers in Nigeria



Source: Author's drawing from FAOSTAT database, 2016 database

Figure 3 tells a similar story for yield, except that in this case, the data shows that roots and tubers have for long been a higher yielding crop type than cereals, and this productivity gap has increased dramatically over the last three decades. These diagrams just go to show how important crop divisions of this kind can potentially be.

Figure 3: Time Trend of Yield/Ha for Cereals, Roots and Tubers in Nigeria



Source: Author's drawing from FAOSTAT database, 2018 database

However, as important as tuber and roots crops are, they have not been given as much attention as they deserve in policy making. One reason could be that in comparison to crops like wheat and rice, tuber crops are bulky, have higher water content and thus relatively shorter shelf lives (CIP Report, 2014). This constrains the development of innovations in their value chains, as well as the expansion of production and delivery at scale to processors and the markets.

Having noted the above, four Consultative Group for International Agricultural Research (CGIAR)[4] organisations came together in 2011 to form a whole new research group devoted to the study and development of these often-neglected crops – the Roots, Tubers and Bananas (RTB) research programme. According to the RTB website (rtb.cgiar.org), the goal of the programme at launch was "to mobilize complimentary expertise and resources" in ensuring that sufficient research is devoted to improving the production outcomes and value-chain of these products.

In this paper, the crops classified under this category are as shown in Table 3.

Table 3: List of crops classified as C_2 (by being a tuber or root)

Crop	% of sample (wave 1)	% of sample (wave 2)
Yam	21.51	23.17
Cassava	10.42	6.48
Cocoyam	1.49	1.71
Groundnuts	1.79	1.45
Potatoes	0.58	0.64
Ginger	0.08	0.08
Total	35.87	33.53

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

2.3.3 Crop-Choice Group 3 (C_3) – Classification by the Household Commercialization Index (HCI)

Finally, an index for the degree of commercialization of crop produce per household was used to capture the extent to which a farm household's crop production was oriented towards commercial agriculture. Following from Govereh et al. (1999) and Von Braun et al. (1995), which lay a standard in measuring commercialization; this can be calculated by taking the percentage of the value of

[4] The four organisations are: International Potato Center (CIP), which leads the research program, Bioversity International, the International Center for Tropical Agriculture (CIAT), the International Institute of Tropical Agriculture (IITA) – together with the French Agricultural Research Centre for International Development (Cirad), which also represents INRA, IRD and Vitropi.

the entire agricultural crop product in the year which is explained by the gross value of crops sold. This computation will result in a number between 0% and 100% in which a household with a HCI of 0% is one with none of its total crop product sold; while a household with an index of 100% will be one with all its crop output sold.

$$HCI = \left[\frac{gross\ value\ of\ crop\ sales}{gross\ value\ of\ all\ crop\ production}\right] x\ 100 \tag{1}$$

This is a neat way of transforming the binary crop choice variable into something that is continuous and shows the range of possibilities between just the choices of which crops to produce. In addition, this variable allows for interactions to be made (with the other crop choice variables) to produce new parameters with interesting interpretations[5]. However, the limitations to the use and interpretation of this variable must be noted because it tends to give more weight to farms with smaller output who might sell a higher percentage of their output for whatever reason. To illustrate, if we consider a simple case where a farm household grows 5 stands of cassava, harvests and sells all 5; he would be classified as fully commercialized (100%), as opposed to a situation where a farmer grows 20 stands and sells 5. In the second case he would be measured as only semi-commercialized (with 25% on the index), even though they have both sold the same amount of crop. These notwithstanding, this measure is a useful one in describing agriculture in developing countries like Nigeria, because the smaller the farm, the more likely it is that they would be consuming a larger proportion of their total output at home for subsistence reasons rather than selling them (except for cases of higher value–added crops like cut flowers or vegetables) (Govereh et al., 1999).

2.4 Methodology

2.4.1 Stochastic Frontier Analysis (with Greene Correction for Selection Bias)

In this study, we estimate the technical efficiency of crop production, for which the aggregation of data at the household level is employed; each observation representing a unique productive entity. Technical efficiency in this sense can be defined to be the ratio of the produced output of a farm household over the maximally possible output, given a set level of inputs. In order to achieve this,

[5] For example, interacting commercialization with the most likely to be exported crops would create a variable that represents how much of these crops are actually sold as opposed to consumed at home. This would disaggregate the farm households growing this crop to some extent.

farm households had to be compared against some "ideal" farm as a benchmark, which is often done in the literature through some form of frontier analysis. There are two major ways a production possibility frontier function may be estimated: the non-parametric Data Envelope Analysis (DEA), which was first proposed by Charnes et al. (1978), and the parametric Stochastic Frontier Analysis (SFA) independently proposed by Aigner et al. (1977) and Meeusen & Van den Broeck (1977).

There are pros and cons to the use of either of the models and the choice would depend on the research setting and what the researcher is trying to achieve. For the stochastic frontier model, its major disadvantage is that it requires ex-ante assumptions to be made on the functional form of the frontier function i.e. either linear, quadratic, Cobb-Douglas and so on (Bogetoft and Otto, 2011). In this case, if a wrong functional form is assumed, the estimated parameters are biased. But for the data envelope model, which is deterministic, a disadvantage is that there is no stochastic error term representing the measurement errors of unobservable parameters; hence every deviation from the production frontier is explained by technical inefficiency.

In agricultural research, there are many possible important stochastic shocks (for example, disease infestation, weather, motivation of the farmers or even luck) that could be experienced by the farm households and thus must be accounted for (Coelli and Battese, 1996). The SFA model does this by partitioning the stochastic error term into two: systemic random/stochastic error to account for statistical noise and an inefficiency component (Battese and Coelli, 1992). Another advantage the SFA has over the DEA model is that it can be tested with conventional statistical tests due to its parametric nature (Singh et al., 2001). This explains why the SFA is employed in most agricultural studies estimating efficiency by frontier and why this method is also used here.

Aigner et al. (1977) and Meeusen & Van den Broeck (1977) show how the error term in a stochastic frontier model can be split into: v_i, the stochastic error term and u_i, the inefficiency error term. To illustrate, the base model (without specification) takes the form:

$$ln(Y_i) = ln(f(\boldsymbol{X}_i)) + v_i - u_i \quad with\, u \geq 0 \tag{2}$$

v_i is either positive or negative and is assumed to be normally distributed with mean zero and constant variance, as it represents an unsystematic stochastic effect related with measurement errors and random influences (e.g luck, drought, flood, or other weather shocks, as earlier mentioned) while u_i is non-negative and either assumed to be half-normal or truncated normally distributed, measuring technical inefficiency, i.e the stochastic shortfall of output from the most efficient farm on the production frontier (Coelli and Battese, 1996).

In the above specification, Aigner et al. (1977) and Meeusen & van den Broeck (1977) used cross-sectional data for their analysis, but since 1977, more advances were made in the technical application of the method. Pitt & Lee (1981) first provided an extension using panel data. This addition makes it possible to test for unobserved heterogeneity among the different production entities. Following from this, the next major extension was Greene (2010) where it was argued and demonstrated that selection bias could make a significant difference if ignored in the computation of a production frontier. This paper makes use of Greene (2010) selection correction model in its estimation of the stochastic frontier model and the following analysis because the decision of farmers to grow one kind of crop instead of another is determined by some latent or unobserved characteristics which needs to be controlled for. If this is not done, this effect would show up as technical inefficiency rather than a bias.

Three conventional inputs are used in the computation of the agricultural production frontier function. These are *land* (total agricultural land area under cultivation), *labour* (total wage expenditures for labour including family labour[6]) and *inputs* (intermediate input costs like seed, fertilizer, pesticides, cost of irrigation, and costs to rent farm equipment/machinery). To gain some perspective on the results of this analysis, it may be useful to examine the nature of land distribution in Nigeria, especially as it relates to agriculture.

In Nigeria, land is an important aspect of the lives of people. It goes beyond just being an economic asset or factor of production to being an integral part of the social and cultural lives of the people. Several land tenure systems had been in use in the past colonial history of the country but the system in current use was promulgated as the Land Use Act of 1978. This law was an attempt to bring different land tenure systems together into a single federally regulated programme. According to Chikaire et al. (2017), customary land (or land residing under the control of traditional structures) may be obtained either by outright purchase, inheritance, rent, allocation, lease, pledge, gift and exchange.

Chikaire et al. (2017) showed that purchase was one of the easiest means of acquiring agricultural land. However, these sales are almost always compelled by the economic needs of the seller because there is a natural reluctance to dispose permanently of landed assets due to the intention of leaving them as an

[6] Family labour is costed by multiplying number of hours supplied by family members with the going market wage rate per hour.

inheritance for their children. Following from this, inheritance is also considered an important source of farm lands. Inheritance in this sense is a customary land transfer to heirs when the landowner passes on. When land has been acquired through either of these means, the new landowner has complete freedom to use the land as he/she pleases.

The other ways to acquire agricultural land are less popular and often have conditions attached to the land use. When land is acquired by rent, the farmer's control is limited to the agreements reached with the landlord regarding how to make use of the land including what crops to be planted and what buildings that can be put up. Pledge and lease options are alternative ways to rent, where a delayed payment agreement is reached. Land may also be obtained via government (community or state) allocation.

In terms of land distribution, Nigeria has a total land area of over 910,000 km^2 out of which about 80% has been determined to be usable for agricultural purposes. With 80% of the rural population being farmers, only 33% of the arable land is in use. This limitation is caused by the small and inefficient public investment in the sector as well as a need to reform the distribution of non-customary land, which is under the sole authority of the state government (Mabogunje, 1992; Fabiyi & Idowu, 1993).

In an ideal case, there would also be a variable for capital (depreciated cost of machinery and buildings), but this is not included here due to data constraints. However, this should not be a problem, because most smallholders in Nigeria usually own neither of these, apart from small implements like hoes and shovels and the farmers that want to mechanize would tend to rent the machines for the required period of time rather than buy them (these rental costs are included in the inputs variable already). These inputs are used to produce the output y_{it} defined as total revenue generated at the farm (including by-products). The Cobb-Douglas[7] model is employed here to fit the production frontier:

$$ln(Y_{it}) = \beta_0 + \beta_1 ln(land) + \beta_2 ln(labour) + \beta_3 ln(inputs) + v_{it} - u_{it} \quad (3)$$

Because of the non-symmetry of the conventional error term, ε_{it}, the expected value is defined here as, $E(\varepsilon_{it}) = -E(\varepsilon_{it}) \leq 0,\ \varepsilon_{it} = v_{it} - u_{it}$. Here the estimation by ordinary least squares (OLS) will provide inconsistent estimates of the

[7] Cobb-Douglas models without restriction and with restrictions (where the parameters are forced to be homogenous) were tried, but there was no significant difference. The time varying decay (TVD) estimation is also used as it most closely simulates a fixed effects regression, as against the time invariant (TI) version.
The Cobb-Douglas model is used in several similar studies on agricultural productivity such as: *Murillo-Zamorano (2004); Jiang and Sharp (2015); and Kumbhakar and Lovell (2003)*

parameters apart from the intercept. Moreover, the OLS estimation cannot extricate the technical efficiency component from its normal residual error.

The maximum likelihood estimation (MLE) however can be used, as this selects values of the model parameters that produce the distribution most likely to have produced the observed data by maximizing the likelihood function; in addition, we would like the efficiency estimates to fall between 0 and 1. For this to work, we assume that the technical inefficiency error term (u_{it}) has a positive half-normal distribution and that u_{it} and v_{it} are independent. This is useful because the standard deviation of the distribution can concentrate efficiencies near zero or spread them out (with a zero cut off) (Aigner et al., 1977; Street, 2003).

Technical efficiency can then be derived for each farm household. It is the ratio of the output y_{it} over the stochastic frontier output when $u_{it} = 0$. The resulting technical efficiency would have a value between 0 and 1 and gives information about how far away the observation data points are from the production frontier:

$$TE_{it} = \frac{y_{it}}{exp(x_{it}\beta + v_{it})} = \frac{exp(x_{it}\beta + v_{it} - u_{it})}{exp(x_{it}\beta + v_{it})}) = exp(-u_{it}) \tag{4}$$

2.4.2 Treatment Effects Model

In this section, the intuition behind solving the problem of a potential selection bias in the creation of the key variables is discussed. Firstly, why should we suspect that the categorical variables we have created for crop choice ($\mathbf{C}_1$ and $\mathbf{C}_2$) might be biased by self-selection? This is because it is highly unlikely that farmers have chosen a particular crop to produce entirely at random, especially when they have chosen a crop with reduced productive capacity when they have been given an equal opportunity to grow one with higher productivity possibilities. It is far more likely that there are certain unobservable characteristics that influence their decision to produce these types of crops, and that these would lead to the key variables being endogenous, as they become correlated with the error term of the main equation.

To try to mitigate these problems, we implement a treatment effects model, similar to the Heckit method (Heckman, 1979). It involves the use of a control function with an endogenous treatment variable which is the self-selection into the choice of crop a farm household has made. In addition, crop choice is likely to be an endogenous determinant of poverty and productivity. In this case, we are fortunate that we have panel data and thus can demean the data and control for the time invariant characteristics of the sample.

The treatment effects model estimates the effect of an endogenous binary treatment, T_{it} (in this case crop choice), on a continuous, fully observed outcome variable, Y_{it} (in this case productivity and poverty in separate models); conditional on vectors of explanatory variables, $\boldsymbol{X}_{it}$ and $\boldsymbol{Z}_{it}$ (which would include exclusion restrictions). This can be modelled in the following way as our desired result:

$$Y_{it} = \beta T_{it} + \eta \boldsymbol{X}_{it} + \mu_i + \nu_{it} \tag{5}$$

In this case, β would be the parameter of interest as the average net effect of being treated on the outcomes, μ_i would be the unobservable time fixed effect and ν_{it} is the error term. However, since T_{it} is endogenous, we would first need to model the selection into treatment. This could be written as:

$$T_{it}{}^{*} = \gamma \boldsymbol{Z}_{it} + \varepsilon_{it} \tag{6}$$

The selection into treatment $T_{it}{}^{*}$ in this model is a function of ε_{it}, which is correlated with ν_{it}, the error term in the outcome equation of Y_{it} above. Thus, $T_{it}{}^{*}$ is actually an unobserved latent variable (what is observed in the data is simply the choice, but not the underlying activity). The assumption is made that this is a linear function of the exogenous covariates $\boldsymbol{Z}_{it}$ and a random component ε_{it}. The relationship between the observed T_{it} and the latent $T_{it}{}^{*}$ can be defined in this way:

$$T_{it} = \begin{cases} 1, & if \quad T_{it}{}^{*} < 0 \\ 0, & if \quad T_{it}{}^{*} \geq 0 \end{cases} \tag{7}$$

The problem here is that estimating equation 6 directly by OLS would only be consistent if there is no correlation between ν_{it} and ε_{it} (notationally, this correlation is represented by ρ; so ideally, we want $\rho = 0$) (Green, 2008). But in this case, ρ is not zero, thus a different method would have to be used to estimate the coefficients consistently. More formally, if we assume that the treatment T_{it} is normally distributed, the expected conditional outcome of productivity and poverty (Y_{it}) could be written in this way:

$$E[Y_{it}|T_{it}, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}] = \eta \boldsymbol{X}_{it} + \beta T_{it} + \mu_i + E[\nu_{it}|T_{it}, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}] \tag{8}$$

$$= \eta \boldsymbol{X}_{it} + \beta T_{it} + \mu_i + \left[\rho_1 \sigma_{v_1} \{\phi(\gamma \boldsymbol{Z}_{it}) / \Phi(\gamma \boldsymbol{Z}_{it})\} | T_{it}, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}\right] P(T_{it} = 1 | \boldsymbol{X}_{it}) + \left[\rho_0 \sigma_{v_0} \{-\phi(\gamma \boldsymbol{Z}_{it}) / 1 - \Phi(\gamma \boldsymbol{Z}_{it})\} | T_{it}, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}\right] [1 - P(T_{it} = 1 | \boldsymbol{X}_{it})]$$

Thus, the expected outcomes for participants and non-participants have been disaggregated. The expected outcome for the treated would be:

$$E[Y_{it} | T_{it}, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}] = \eta \boldsymbol{X}_{it} + \beta T_{it} + \mu_i + \left[\rho_1 \sigma_{v_1} \{\phi(\gamma \boldsymbol{Z}_{it}) / \Phi(\gamma \boldsymbol{Z}_{it})\} | T_{it}, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}\right] \tag{9}$$

And the expected outcome for the non-treated would be:

$$E[Y_{it} | T_{it}, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}] = \eta \boldsymbol{X}_{it} + \mu_i + \left[\rho_0 \sigma_{v_0} \{-\phi(\gamma \boldsymbol{Z}_{it}) / 1 - \Phi(\gamma \boldsymbol{Z}_{it})\} | T_{it}, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}\right] \tag{10}$$

Here, $\rho_1 \sigma_{v_1}$ represents the covariance between v_i and ε_i for the treated, $\rho_0 \sigma_{v_0}$ represents the covariance between v_{it} and ε_{it} for non-treated, $\phi(\gamma \boldsymbol{Z}_{it})$ is the marginal probability of the standard normal distribution at $\gamma \boldsymbol{Z}_{it}$ and $\Phi(\gamma \boldsymbol{Z}_{it})$ is the cumulative distribution function of the standard normal distribution at $\gamma \boldsymbol{Z}_{it}$. Equations 9 and 10 above include the "Inverse Mills Ratio" to control for the possible sample selection bias. The difference between the expected outcomes of the treated and non-treated becomes:

$$E[Y_{it} | T_{it} = 1, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}] - E[Y_{it} | T_{it} = 0, \boldsymbol{X}_{it}, \boldsymbol{Z}_{it}] = \beta + bias\, from\, selection \tag{11}$$

In this case, it is expected that there is a positive bias on the OLS estimates (that it overestimates the impact of crop choice on productivity and poverty), as ρ is positive. The coefficients are estimated by maximum log likelihood as this provides consistent estimates. The usual log likelihood equations are as follows:

$$lnL_{it} \begin{cases} ln\Phi \left\{ \dfrac{\gamma \boldsymbol{Z}_{it} + (Y_{it} - \eta \boldsymbol{X}_{it} - \beta)\, \rho / \sigma}{\sqrt{1 - \rho^2}} \right\} - \dfrac{1}{2} \left(\dfrac{Y_{it} - \eta \boldsymbol{X}_{it} - \beta}{\sigma} \right)^2 - \ln\left(\sqrt{2\pi\sigma}\right), & \boldsymbol{Z}_{it} = 1 \\ ln\Phi \left\{ \dfrac{-\gamma \boldsymbol{Z}_{it} - (Y_{it} - \eta \boldsymbol{X}_{it})\, \rho / \sigma}{\sqrt{1 - \rho^2}} \right\} - \dfrac{1}{2} \left(\dfrac{Y_{it} - \eta \boldsymbol{X}_{it}}{\sigma} \right)^2 - \ln\left(\sqrt{2\pi\sigma}\right), & \boldsymbol{Z}_{it} = 0 \end{cases} \tag{12}$$

So in reduced form, there are two stages of regression; the first stage is the regression to estimate the probability of being treated, or for a farmer choosing to grow a type of crop, conditional on $\boldsymbol{Z}_{it}$; the inverse mills ratio was computed from the residuals and used in the second stage – an impact regression of the $\boldsymbol{X}_{it}$ and the IMR as an extra regressor to deflate the selection bias on productivity and poverty. The $\boldsymbol{Z_{it}}$ vector of variables used in the first stage would include selection restrictions, which are parameters that influence choice but do not "directly" influence productivity or poverty, and as such would not belong in the main impact equation of interest. Instruments that will satisfy the exclusion restrictions which have been used here are the amount of stored seed from the previous season used in planting the current season, and the amount of free seeds received by the farmer and used in planting. The distance of plot from the nearest extension provider was tried but proved a little problematic due to trying to find a proper distance proxy for this and multicollinearity issues[8]. Non-farm income has also been used as an instrument for the productivity equation, but not from the poverty equation, as this is directly related to the mean per capita household expenditure. Non-farm income is important because it accounts for the fact that rich farmers may choose more productive but risky crops, while the less well-off ones may choose lower yielding crops but with a higher degree of security.

For the $\mathbf{C_3}$ variable (the variable representing the Household Commercialization Index (HCI)) and its interactions, a different model is used in estimating its effects, mostly because this is a continuous variable (rather than a binary one), and hence, presents us with more opportunities to use a wider range of the data. A Fixed Effects (FE) model or a Correlated Random Effects (CRE) model can normally be used to address any endogeneity due to unobserved time invariant characteristics. The FE method addresses potential biases by using the variation in commercialization within a household over the two time periods to identify the causal effect of crop commercialization on productivity (Wooldridge, 2002).

However, a potential limitation of the use of the fixed effects model in this case is that we are unable to properly recover the coefficients on the time invariant observable characteristics such as regional dummies and when they are reported, must be interpreted with caution[9]. This can be an issue when important variables affecting productivity such as gender are time invariant. One other way suggested in correcting this is with the Correlated Random Effects (CRE) model. This model addresses endogeneity due to unobserved time invariant factors but still makes it possible to recover the coefficients on time invariant observed variables (Wooldridge, 2010; Sheahan et al., 2013).

[8] Defining what exactly the nearest extension provider is has been tricky. Proxying for this by using distance to the nearest major town with 20,000 plus residents was tried, but this was highly correlated to the rural/urban area variable, as well as being directly correlated to poverty. Other proxies that were tried include distance to nearest major road and distance of plot to town centre, but could not produce very useful results. This could be revisited in the future though.

[9] This in fact renders some of the reported results uninterpretable.

The estimation of production frontiers was done using nLOGIT 6 and other computations were done on STATA 14. The next section describes the form and sources of data used.

2.5 Data

2.5.1 General description of data source

For this analysis, the Nigerian General Household Survey-Panel (GHS-Panel) for 2010/2011 and 2012/2013 is used, which is the most recent official comprehensive household survey for Nigeria and is part of the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) series from the World Bank. The panel version of the GHS was conducted by the Nigerian Bureau of Statistics (NBS) in collaboration with the Federal Ministry of Agriculture and Rural Development (FMA&RD), the National Food Reserve Agency (NFRA), the Bill and Melinda Gates Foundation (BMGF) and the World Bank. It covers all the 36 states of the country including the Federal Capital Territory (FCT), Abuja. They used a two-stage probabilistic sampling technique to select clusters (or neighbourhoods) at the first stage and households at the second stage. Clusters were selected from each of the 36 states that the country has and from the capital city. Sampling was carried out on both urban and rural Enumeration Areas (EAs) and is thus nationally representative. According to the accompanying documentation, this panel component was created to focus on getting better information on the role of agriculture in households' economic well-being and draws heavily on the Harmonized Nigerian Living Standard Survey (HNLSS) and the National Agricultural Sample Survey (NASS).

For the GHS-Panel, 5,000 households were surveyed out of 22,000 in the cross-sectional part. The survey for each wave was done in two stages: the post-planting period (lean season), once in 2010 and once in 2012 and the post-harvest period, once in 2011 and once in 2013. In addition, the post-planting survey includes the 22,000 cross-sectional households while the post-harvest survey includes just the 5,000 households in the panel sample. The original objective was for the GHS-Panel to be repeated every two years while the normal Cross-Section component would continue to be carried out annually as it is currently done.

There are three detailed questionnaires contained in the survey, which cover a wide range of socioeconomic topics: the Household Questionnaire, the Agricultural Questionnaire and the Community Questionnaire. These questionnaires contain information on education, the observations' demographic characteristics, labour market, migration, credit and savings, household assets, non-farm enterprises, household food and non-food expenditures, food security and other non-labour income.

The household questionnaire in particular contains variables dealing with consumption, cash and non-cash income, savings, assets, food security, health, education, vulnerability and social protection. The agricultural questionnaire was only administered to the subset of the sample that was involved in non-aquatic agricultural activity, and included information on land size, agricultural inputs, access to extension services and production and marketing figures for main crops and livestock. The fishery questionnaire is not used because it does not provide the any information on crops planted, which is the focus of this research. Finally, the community questionnaire contains community or village-level data provided by several knowledgeable residents about community characteristics such as physical infrastructure, access to public services, economic activities and local retail prices of essential goods and services.

2.5.2 Descriptive Statistics

Table 4: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
Primary output is C1 crop	0.11	0.32	0	1
Primary output is C2 crop	0.35	0.47	0	1
Household Commercialization Index (C3)	48.22	7.36	0	80.40
ln(Total Food Auto-Consumed in HH)	10.75	1.21	1.78	13.94
ln(output)	10.98	1.72	0	15.59
ln(land)	8.89	1.73	0	13.04
ln(labour)	4.26	5.30	0	16.73
ln(inputs)	7.01	4.41	0	14.25
Age of HH Head	50.09	15.10	16	110
Marital Status of HH (Married=1)	0.75	1.71	0	1
Religion of HH Head (Christian=1)	0.53	0.55	0	1
Gender of HH Head	0.89	0.31	0	1
Number of adult males in household	1.36	0.93	0	11
Number of adult females in household	1.54	0.89	0	7
Number of dependent males in household	1.69	1.62	0	16
Number of dependent females in household	1.51	1.47	0	11
Household size	6.11	3.13	1	31
Literate (Can read and write=1)	0.47	0.49	0	1
Years of education of HH Head	3.89	3.24	1	13
Rural	0.89	0.32	0	1
Mean per capita expenditure (MPCE) in naira	448408.6	290725.4	33907.57	2975185

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

Before discussing the econometric results, it is important to provide a brief review of the statistics regarding the characteristics of the sample respondents and variables used in the econometric model. Accordingly, Table 4 presents descriptive statistics of some variables used for this study. The mean age of the household heads in the sample is about 50 years and about 89% of the farm households are headed by males. In addition, the sample is almost 90% made up by households in the rural areas and 75% of the household heads are married.

With regards to educational status, about 47 percent of the sample are literate and can at least read or write, and the average length of time in formal education is about 4 years. The mean household size in the sample is about 6 individuals with averages of about 1 adult male, 2 adult females, 2 dependant males and 2 dependant females.

2.6 Results and Analysis

2.6.1 Agricultural Productivity in Nigeria

Table 5 shows the results of the crop productivity estimation of farm households in Nigeria, using the methods previously outlined in the methodology section. The Cobb-Douglas specification applied here does not force the coefficients to add up to one. This could be done by imposing constant returns to scale constraints on the maximum likelihood estimation of the production function, but there was no convergence in using this method and the estimates would not be very different. The result shows that all inputs are significantly important in the production function, but labour and land jointly contribute about 84% to output, with coefficient estimates 0.372 and 0.470 respectively.

Table 5: Results of the Stochastic Frontier Analysis model

	Cobb-Douglas (Time Varying Decay-TVD)	
	Coefficient	SE
Constant	3.016	43.130
lnLand	0.372***	0.013
lnLabour	0.470***	0.004
lnInput	0.110***	0.005
Sigma^2	1.975	0.039
Gamma	0.163	0.023
Sigma_u^2	0.322	0.048
Sigma_v^2	1.652	0.052
lnSigma^2	0.680***	0.019
ilgtgamma	-1.633***	0.171
Mu	4.387	43.131
Statistics		
No. of obs.	5192	
No. of groups	3045	
Wald chi^2	1359.16***	

Note: *** represents significance at 1% alpha

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

Other inputs, which includes seeds, fertilizer, equipment etc., has a coefficient of 0.110. These results are indicative of the kind of agriculture Nigeria practices. The agricultural system is more labour intensive than capital intensive, which is typical for traditional developing economies. This also shows that there might be potential for an overall frontier improvement by increasing capital intensity whilst releasing the extra labour to other productive industries, as proposed by Lewis (1954). Sigma_v^2 is the estimate of the σ_v^2, Sigma_v^2 is the estimate of σ_u^2, gamma is the estimate of $\gamma = \sigma_u^2/\sigma_S^2$, and sigma^2 is the estimate of $\sigma_S^2 = \sigma_v^2 + \sigma_u^2$. Due to the restrictions on gamma, the optimization is parameterised in terms of its inverse logit, and this estimate is reported as ilgtgamma. Likewise, because Sigma^2 must be positive, the optimization is parameterised in terms of $\ln(\sigma_S^2)$ or lnsigma^2. Mu is the estimate of μ, which is the mean of the truncated-normal distribution. The Wald test verifies the overall significance of the explanatory variables in the production function model and this is significantly different from 0 in the results.

From the results, the overall productivity of the farmers averages about 68%. This is not very different from some of the other estimates that have been obtained by some other more crop specific studies (e.g. 89% by Adeyemo et al. (2010), 81% in Ebong et al. (2009), 65% in Onyenweaku & Ohajianya (2009), and 68% in Amaza et al. (2005)). This is also about the average obtained by studies designed to test the Schultz hypothesis of the efficient small farmer[10].

Although, these productivity numbers are not too bad, there is a lot of room for improvement, even at the current levels of technology. Since non-labour variable inputs are a significant determinant of productivity, it is likely that the choice of crops grown itself is a source of inefficiency. Some evidence of this may be found in studying Table 6, which shows the cross-tabulation of the crop choice variables and the average productivities of households. It will be noticed that there are, on average, higher productivities figures for households who grow either export-oriented crops or tubers and roots. These differences range from 1.5% to about 5%. However, cross-tabulations should not provide any evidence on causality, as they hide many possible explanatory variables for the differences. These differences are however tested in the following sections to see if they are significantly different from zero, using the distributional assumptions, utilizing the panel time framework, and controlling for other extenuating characteristics.

[10] Theodore Schultz won the Nobel prize in economics in 1979 mostly for his work on the economics of agriculture. Schultz (1964) formulates the hypothesis that small-scale farmers in developing countries were "poor-but-efficient" implying that they made the best decisions in allocating their scarce resources by responding to price incentives.

Table 6: Cross tabulation of crop choice variables and average technical efficiency

		C_1		Difference between 1 & 0	C_2		Difference between 1 & 0
		1	0		1	0	
TE	t = 1	0.660	0.640	0.020	0.666	0.651	0.015
	t = 2	0.644	0.611	0.033	0.670	0.620	0.04

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

By way of further analysis, Table 7 shows the variation in productivity across the sample by gender and age of the household head as well as household land size, just using the first wave alone (similar results are obtainable from the other wave also). The last row gives an overall productivity of each column division. Each of these variables provides useful information. Males in the sample are more productive than females with an average productivity of 66% as opposed to 62%. Following what we would expect, the most productive age range is between 20 and 60, and productivity appears to reduce as land size increases (as in Imai et al, 2015). Furthermore, in general most of the proportions of the sections fall within the 50-75% range of productivity.

Table 7: Productivities of different segments of the population by the characteristics of the household heads (from Wave 1)

	Male	Female	Age (<20)	Age (20-60)	Age (>60)	Land size (<1ha)	Land size (1-5ha)	Land size (5-10ha)	Land size (>10ha)
Productivity (<25%)	4%	15%	7%	2%	7%	9%	5%	11%	2%
Productivity (25-50%)	24%	35%	19%	9%	12%	19%	20%	19%	40%
Productivity (50-75%)	62%	48%	65%	70%	66%	69%	65%	65%	46%
Productivity (>75%)	10%	2%	9%	19%	15%	8%	10%	5%	12%
Overall Average Productivity	66%	62%	64%	70%	66%	69%	69%	64%	63%

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

2.6.2 Impact of crop choice on productivity and poverty

This section reports the results of the treatment effects model to estimate the determinants of crop choice and hence the impact of this choice on productivity and poverty, proxied for by mean per capita consumption expenditure (MPCE). Following from the above analysis, this section tests whether the productivity and welfare differences between the two groups of farmers are significantly different from zero; after controlling for household characteristics these are reported in Tables 8 and 9 respectively.

Table 8: Treatment Effects Model Results for the Selection of Crop equation and the impact of Crop Choice on Productivity (Technical Efficiency)

	C₁ – Farmer chose a commonly exported crop		**C₂** – Farmer chose a tuber/root crop	
	Selection	Impact	Selection	Impact
	(1)	(2)	(3)	(4)
Crop Choice		0.0014 (0.005)		0.045*** (0.004)
Age of HH Head	0.01 (0.35)	0.0010* (0.0006)	0.019 (0.45)	0.001 (0.001)
Age Square of HH Head	-0.022 (0.22)	-0.0000 (0.0000)	-0.022 (0.22)	-0.000 (0.000)
Education of HH Head	2.02e-05 (1.81e-05)	-0.0136*** (0.0028)	2.02e-05 (1.01e-05)	-0.012*** (0.003)
HH Size	0.128* (0.008)	-0.808*** (0.280)	0.129* (0.007)	0.003*** (0.001)
Sex of HH Head	0.233*** (0.054)	0.766*** (0.316)	0.235*** (0.054)	0.028*** (0.007)
Rural	-0.22 (0.34)	0.005 (0.004)	-0.22 (0.34)	0.007 (0.004)
Female Share	-7.55e-05 (0.00)	-0.002 (0.001)	-7.05e-05 (0.00)	-0.002* (0.001)
Married	0.118* (0.063)	0.000 (0.001)	0.118* (0.063)	-0.000 (0.001)
Region1 (NW)	0.167 (0.209)	-0.008* (0.004)	-0.181 (0.150)	-0.006 (0.004)
Region2 (NC)	1.074*** (0.187)	0.036*** (0.004)	1.557*** (0.123)	0.019*** (0.004)
Region3 (SW)	1.737*** (0.212)	0.003 (0.007)	1.738*** (0.161)	-0.011 (0.007)
Region4 (SE)	1.031*** (0.192)	-0.020*** (0.005)	2.284*** (0.132)	-0.049*** (0.005)
Region5 (SS)	2.207*** (0.193)	0.003 (0.006)	2.885*** (0.157)	-0.031*** (0.006)
Free Inputs#	0.677*** (0.023)		0.334*** (0.033)	
Non-farm income#	0.118* (0.0638)		0.11** (0.062)	
Previous year's seeds#	0.420* (0.10)		0.484*** (0.064)	
Constant	-2.384*** (0.495)	0.588*** (0.018)	-2.538*** (0.419)	0.592*** (0.017)
N	2422	2422	2422	2422
R^2	0.21		0.345	
Time Dummies	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; # Exclusion restrictions

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

This analysis is done using the two categorical crop choice variables as previously defined; columns 1 and 2 being results using **C₁**, and columns 3 and 4 being results using $\mathbf{C}_2$. Columns 1 and 3 in both tables are the results of the first stage selection into treatment equation, determining the probability of being treated (growing $\mathbf{C}_1$ and $\mathbf{C}_2$). However, since these are drawn from probabilistic functions and not from linear probability modelling, the coefficients cannot be directly interpreted as probabilities, but with p-values indicating significance and direction of signage indicating direction of effect. Columns 2 and 4 are the results of the impact equation of the second stage, showing the average treatment effect on the treated.

The exclusion restrictions used for the productivity equation are the amount of free inputs used in production, the amount of non-farm income the household possesses and the amount of seeds used from the previous growing season, whilst for the poverty equation, only the free inputs and previous year's seeds are used because non-farm income is directly related to household expenditure, as previously explained in the methodology section. These variables were positive and significant in determining participation to growing export-oriented crops and tubers or roots.

For the use of previous year's seeds variable, the data shows that the greater the amount of primary inputs like seeds that were saved from the previous year, the more likely it would be for that farm household to plant the same crop in the next growing season. The rationale behind the use of this variable was from informal discussions with local farmers and other people who had knowledge of the sector; and a constant theme that emerged as a major driver of the decision-making process of the farm household in choosing a crop to plant is the idea of tradition and culture. Farmers may not make a deep study of the different options available to them each growing season, if they already know enough about one crop from their years of experience working with and producing a particular crop. To help mitigate the perpetuation of potentially less productive traditional practices, extension services were introduced. It would have been interesting to see how access to extension services would affect the crop choice of the farmers, but this variable has not been included because a good proxy for this that worked could not be found, as explained in the method section. Nonetheless, many other studies have examined this and found that extension played an important role in the productivity of farmers (e.g. Imai et al, 2015).

The amount of free agricultural inputs received was significant at the 99% confidence level in all the regressions run. This indicates that at the point where farmers decide on the crop to produce, there is scope to influence their decisions by the amount of free agricultural inputs they are given. The coefficient is also positive indicating a positive relationship. What this implies is that the more inputs received, the more likely the households would be to choose to produce tuber or root crops and more export-oriented crops. It might not be immediately obvious why this is the case, but one possibility is that this relationship exists because some types of crops require a greater initial investment to get going and these free inputs act as a buffer to reduce the costs (or risks) of planting those crops they believe could be more profitable.

Table 9: Treatment Effects Model Results for the Selection of Crop equation and the impact of Crop Choice on Poverty (log MPCE)

	C_1 – Farmer chose a commonly exported crop		C_2 – Farmer chose a tuber/root crop	
	Selection (Probit)	Impact	Selection (Probit)	Impact
	(1)	(2)	(3)	(4)
Crop Choice		-0.183** (0.066)		-0.161*** (0.022)
Age of HH Head	-0.007 (0.019)	0.008 (0.007)	0.019 (0.45)	-0.001 (0.003)
Age Square of HH Head	0 (0)	0 (0)	-0.022 (0.22)	0 (0)
Education of HH Head	-0.036 (0.095)	0.067 (0.037)	2.02e-05 (1.01e-05)	0.090*** (0.017)
HH Size	0.128* (0.008)	0.152*** (0.008)	0.129* (0.007)	0.079*** (0.004)
Sex of HH Head	0.233*** (0.054)	-0.300** (0.096)	0.235*** (0.054)	-0.004 (0.044)
Rural	-0.22 (0.34)	0.011 (0.057)	-0.22 (0.34)	-0.142*** (0.026)
Female Share	-7.55e-05 (0.00)	-0.079*** (0.016)	-7.05e-05 (0.00)	0.009 (0.008)
Married	0.118* (0.063)	-0.085*** (0.017)	0.118* (0.063)	-0.056*** (0.008)
Region1 (NW)	0.560* (0.270)	-0.118* (0.052)	-0.181 (0.150)	-0.267*** (0.024)
Region2 (NC)	1.266*** (0.257)	-0.221*** (0.056)	1.557*** (0.123)	0.060* (0.027)
Region3 (SW)	1.276*** (0.289)	-0.038 (0.087)	1.738*** (0.161)	0.019 (0.041)
Region4 (SE)	1.277*** (0.263)	-0.239*** (0.061)	2.284*** (0.132)	-0.159*** (0.032)
Region5 (SS)	2.471*** (0.263)	-0.087 (0.080)	2.885*** (0.157)	0.140*** (0.039)
Free Inputs#	0.677*** (0.023)		0.334*** (0.033)	
Previous year's seeds#	0.420* (0.10)		0.484*** (0.064)	
Constant	-2.706*** (0.619)	11.084*** (0.235)	-2.538*** (0.419)	12.069*** (0.109)
N	2422	2422	2422	2422
R^2	0.214		0.365	
Time Dummies	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; # Exclusion restrictions

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

The major other significant determinants of crop choice are the regions in which the household resides, the size of the household and the gender of the household head. The regions are obviously important because some crops grow better in some areas than others, and the simple imposition of topological or geographic constraints could influence the determination of crop produced. It is worth noting that within each crop choice division are crops that are capable of being grown profitably anywhere in the country, although with a distribution of productivities. The size of the household being significant and negative appears to indicate that the larger a household is, the less likely they are to plant tubers, roots or exportable crops. This is possibly due to the fact, as mentioned earlier, that different crops would require different capital outlays and the head of a larger household may be more reluctant to put up this sum. The association of this result to risk attitudes of the farm household, as well as the other variables is discussed briefly in a later section.

On the impact of the choice on productivity, there is a mixed result. Using $\mathbf{C}_1$ as measure of crop choice shows no statistically significant effect to productivity at all, but $\mathbf{C}_2$ is significant. This result is to be expected given the trend described earlier in Figure 3, which showed roots and tubers having dominance over cereals and fibres in productivity. However, the difference between the productivities of the farm households who engage in the more export-oriented crops is not that different from the rest.

From Table 9 however, both $\mathbf{C}_1$ and $\mathbf{C}_2$ have a significant effect and are important in explaining the differences in the poverty outcomes of the two groups of farmers, but in a strange direction. Their coefficients are negative implying that the farmers who have grown these types of crops have lower mean household expenditures on the average. One possible explanation for this might be that cassava, which is a crop that features in both $\mathbf{C}_1$ and $\mathbf{C}_2$ divisions, is the raw material for a major staple food in Nigeria, and as such, a lot of the produce is consumed within the household itself. If this is the case, such self-consumption would not be reflected in the household expenditure variable, therefore underestimating the real valuation of the welfare situations of the two groups of farm households. In the next section, the commercialization index is examined to clarify the dichotomy between home use and marketing of produce.

2.6.3 Impact of crop choice and commercialization on productivity and poverty

In this section, the results of the fixed effects and correlated random effects models to estimate the impact of commercialization and its interactions with the categorical choice variables on productivity and poverty are reported in Tables 10 and 11 respectively. Columns 1 and 2 are the results for both models with commercialization only; columns 3 and 4 are for the impact of commercializing the export-oriented crop grown; and columns 5 and 6 are for the impact of commercializing tuber and root crops.

The results show that the household index of commercialization is not a significant determinant of productivity, but of poverty. This is a bit surprising because one might expect that the more commercialized a farm household is, the better its productivity should be due to the monetary incentives in producing the most output possible with the lowest amount of inputs.

Table 10: Results of Impact of Crop Commercialization with Crop Choice on Productivity

	FE	CRE	FE	CRE	FE	CRE
	(1)	(2)	(3)	(4)	(5)	(6)
C3 – Commercialization	-0.011 (0.057)	0.067 (0.037)				
C3*C1 – by export and commercialization			0.014 (0.05)	0.00844 (0.34)		
C3*C2 – by tuber/root crop and commercialization					0.035*** (0.004)	0.055*** (0.004)
Age of HH Head	0.096*** (0.027)	0.008 (0.007)	0.096*** (0.027)	0.008 (0.007)	0.096*** (0.027)	0.008 (0.007)
Age Square of HH Head	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Sex of HH Head	-1.740 (1.025)	-0.300** (0.096)	-1.740 (1.025)	-0.300** (0.096)	-1.740 (1.025)	-0.300** (0.096)
Education of HH Head	0.096 (0.095)	0.067 (0.037)	0.096 (0.095)	0.067 (0.037)	0.096 (0.095)	0.067 (0.037)
HH Size	0.747*** (0.045)	0.152*** (0.008)	0.747*** (0.045)	0.152*** (0.008)	0.747*** (0.045)	0.152*** (0.008)
Rural	0.01 (0.35)	0.019*** (0.01)	0.01 (0.35)	0.019*** (0.01)	0.01 (0.35)	0.019*** (0.01)
Female Share	-0.022 (0.22)	-0.050 (0.041)	-0.022 (0.22)	-0.050 (0.041)	-0.022 (0.22)	-0.050 (0.041)
Married	2.02e-05 (1.81e-05)	0.358 (0.041)	2.02e-05 (1.81e-05)	0.358 (0.041)	2.02e-05 (1.81e-05)	0.358 (0.041)
Region1 (NW)		-0.808*** (0.280)		-0.808*** (0.280)		-0.808*** (0.280)
Region2 (NC)		0.766*** (0.316)		0.766*** (0.316)		0.766*** (0.316)
Region3 (SW)		-0.001 (0.00)		-0.001 (0.00)		-0.001 (0.00)
Region4 (SE)		-0.299 (0.270)		-0.299 (0.270)		-0.299 (0.270)
Region5 (SS)		-0.087 (0.080)		-0.087 (0.080)		-0.087 (0.080)
Constant	10.23*** (0.326)	11.095*** (0.229)	10.23*** (0.326)	11.095*** (0.229)	10.23*** (0.326)	11.095*** (0.229)
R^2	0.09	0.35	0.09	0.35	0.09	0.34
N	2422	4844	2422	4844	2422	4844
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

These results show however, that the incentives to the household head of increasing productivity to keep his family fed are greater than the incentives from doing so for the sake of the possible monetary value of his goods. This is an interesting result with potentially far reaching policy implications. It means that if the government is interested in increasing productivity, food security should be prioritised instead of commercialization as a policy focus. This ties in with the previous story of the efficient small farmer as well (if we are to take the more commercialized farms as farms with larger farm land holdings, even though we know, as was noted in the definitions, that the commercialization index may not be directly correlated with land size). It is possible that some inefficiencies arise as costs increase when workers have to be hired and supervised.

On the other hand, commercialization is an important determinant of poverty (significant at the 99% confidence level). Thus, if poverty alleviating policy is on the agenda, commercialization would be a policy to push forward and implement. It is not clear however, how these two relationships come together. From the coefficients of the interactions, it appears they simply echo and amplify the effects of the commercialization variable.

Table 11: Results of the Impact of Crop Commercialization with Crop Choice on Poverty

	FE	CRE	FE	CRE	FE	CRE
	(1)	(2)	(3)	(4)	(5)	(6)
C3 – Commercialization	-0.142*** (0.026)	-0.056*** (0.008)				
C3*C1 – by export and commercialization			0.019* (0.00766)	0.0178*** (0.006)		
C3*C2 – by tuber/root crop and commercialization					-0.095* (-0.021)	-0.161*** (0.022)
Age of HH Head	0.096*** (0.027)	-0.001 (0.003)	0.096*** (0.027)	-0.001 (0.003)	0.096*** (0.027)	-0.001 (0.003)
Age Square of HH Head	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Sex of HH Head	-1.740 (1.025)	0.090*** (0.017)	-1.740 (1.025)	0.090*** (0.017)	-1.740 (1.025)	0.090*** (0.017)
Education of HH Head	0.096 (0.095)	0.079*** (0.004)	0.096 (0.095)	0.079*** (0.004)	0.096 (0.095)	0.079*** (0.004)
HH Size	0.747*** (0.045)	-0.004 (0.044)	0.747*** (0.045)	-0.004 (0.044)	0.747*** (0.045)	-0.004 (0.044)
Rural	0.01 (0.35)	-0.142*** (0.026)	0.01 (0.35)	-0.142*** (0.026)	0.01 (0.35)	-0.142*** (0.026)
Female Share	-0.022 (0.22)	0.009 (0.008)	-0.022 (0.22)	0.009 (0.008)	-0.022 (0.22)	0.009 (0.008)
Married	2.02e-05 (1.81e-05)	-0.056*** (0.008)	2.02e-05 (1.81e-05)	-0.056*** (0.008)	2.02e-05 (1.81e-05)	-0.056*** (0.008)
Region1 (NW)		-0.267*** (0.024)		-0.267*** (0.024)		-0.267*** (0.024)
Region2 (NC)		0.060* (0.027)		0.060* (0.027)		0.060* (0.027)
Region3 (SW)		0.019 (0.041)		0.019 (0.041)		0.019 (0.041)
Region4 (SE)		-0.159*** (0.032)		-0.159*** (0.032)		-0.159*** (0.032)
Region5 (SS)		0.140*** (0.039)		0.140*** (0.039)		0.140*** (0.039)
Constant	5.198*** (1.233)	11.095*** (0.229)	5.198*** (1.233)	11.095*** (0.229)	5.198*** (1.233)	11.095*** (0.229)
R^2	0.13	0.25	0.23	0.25	0.13	0.24
N	2422	4844	2422	4844	2422	4844
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

2.7 Extension: Distributional Effects of Choice by Quantile Regressions

2.7.1 Model

As an extension to the previous analysis, quantile regressions are also done for a pooled sample of both waves of data to see the effects of crop choice on different quantiles of the poverty (MPCE) distribution, conditional on the control variables. The reason why this analysis is relevant is that it allows for a much richer characterization and description of what is actually going on in the data and can show if there are different effects of crop choice across the spectrum, and what nature these effects are. In addition, there is some flexibility here for modelling the data with heterogeneous conditional distributions; this would therefore produce a median regression (50^{th} quantile) that is often more robust to outliers.

The quantile regressions are described by the following equation:

$$y_i = \boldsymbol{x}_i'\beta_q + \varepsilon_i \tag{13}$$

Where β_q is the vector of unknown parameters (coefficients) associated with the q^{th} quantile, y_i is the mean per capita household expenditure (poverty variable), $\boldsymbol{x}_i$ are the explanatory variables including the crop choice variables and ε_i is the stochastic error term.

The quantile regression minimizes $\sum_i q|\varepsilon_i| + \sum_i(1-q)|\varepsilon_i|$ [11], a sum that gives the asymmetric penalties $q|\varepsilon_i|$ for underprediction and $(1-q)|\varepsilon_i|$ for overprediction.

The q^{th} quantile regression estimator, $\widehat{\beta_q}$ minimizes over β_q the objective function:

$$Q(\beta_q) = \sum_{i:y_i \geq \boldsymbol{x}_i'\beta_q}^{n} q|y_i - \boldsymbol{x}_i'\beta_q| + \sum_{i:y_i < \boldsymbol{x}_i'\beta_q}^{n} (1-q)|y_i - \boldsymbol{x}_i'\beta_q| \tag{14}$$

where $0 < q < 1$

[11] As opposed to OLS, which minimizes: $\sum_i {\varepsilon_i}^2$ (sum of squares of model prediction).

The standard conditional quantile is assumed to be linear and for the jth regressor, the marginal effect is the coefficient for the qth quantile:

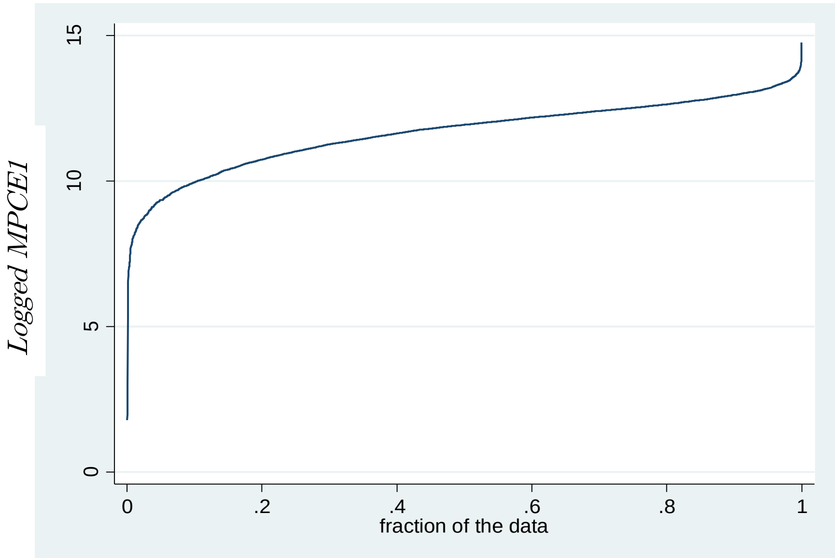
$$\frac{\partial Q_q(y|x)}{\partial x_j} = \beta_{qj} \tag{15}$$

In this way, we can interpret the coefficient or quantile regression parameter β_{qj} estimates as the change in a specific quantile q of the dependent variable y produced by a one-unit change in the independent variable x_j. As is normal in quantile regressions, there are two kinds of significance of importance: the first being if the effect on each quantile value is significantly different from zero; and the second, to check if they are different from a normal OLS, which would indicate that there are differences in the effect to different segments of the population. The three quantiles reported in the table are the 20th, the 50th and the 90th.

2.7.2 Results

Figure 4 is a plot showing the MPCE across different fractions of the sample. It can be seen that the bottom 20% have the worst poverty outcomes, with most of the rest around the average, while the top 10% have slightly better outcomes. This picture motivates the need to study the peculiarities of those households which fall within different quantiles of the mean expenditure distribution.

Figure 4: Quantile plot of MPCE



Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

From the four regressions run on the pooled sample with both the **C**$_1$ and **C**$_2$ crop choice variables, what can be seen from Table 12, is that there is not a significant difference between the coefficients from the quantile regressions and the OLS estimates for crop choice. This result can also be inferred from Figure 5, a plot showing the estimated marginal effects of the different variables on the conditional quantiles of MPCE. It can be seen that the 95% confidence intervals band around the quantile function overlaps mostly with the 95% confidence interval band for the OLS regression, except for a little bit from around the 80th quantile.

Table 12: Cross-sectional quantile estimation results for pooled cross-section

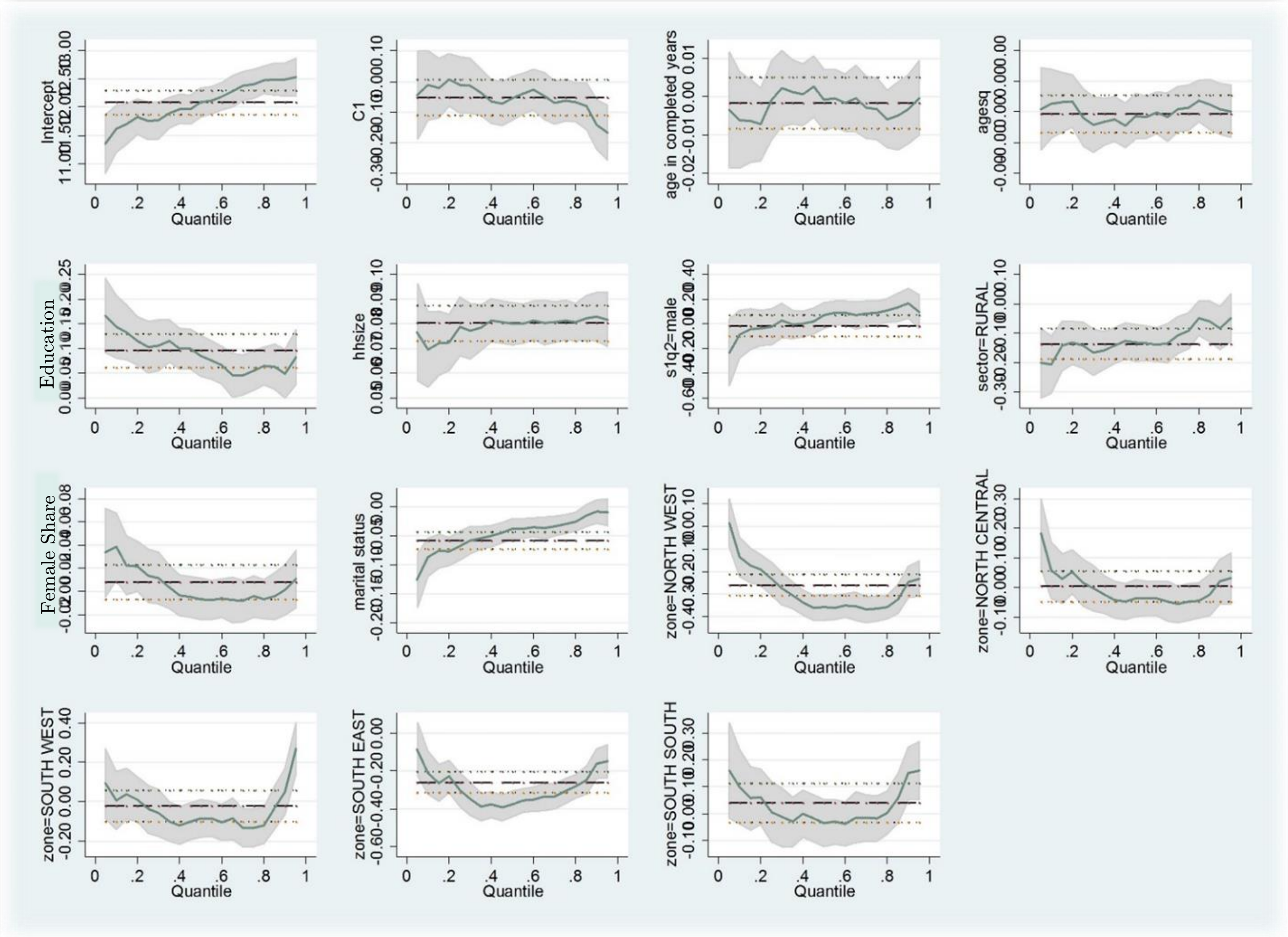
	C$_1$ – Farmer chose a commonly exported crop				**C**$_2$ – Farmer chose a tuber/root crop			
	Quantile Regressions				Quantile Regressions			
	0.20	0.5	0.90	OLS	0.20	0.5	0.90	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crop Choice	0.005 (0.043)	-0.055 (0.036)	-0.061 (-0.034)	-0.052 (0.030)	-0.163*** (0.037)	-0.176*** (0.026)	-0.128*** (0.027)	-0.161*** (0.022)
Age of HH Head	-0.007 (0.005)	-0.001 (0.004)	-0.003 (0.004)	-0.002 (0.003)	-0.007 (0.006)	0.000 (0.004)	-0.002 (0.004)	-0.001 (0.003)
Age Square of HH Head	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
Education	0.115*** (0.025)	0.085*** (0.020)	0.056** (0.019)	0.096*** (0.017)	0.097*** (0.028)	0.080*** (0.020)	0.057** (0.021)	0.090*** (0.017)
HH Size	0.072*** (0.005)	0.080*** (0.004)	0.081*** (0.004)	0.080*** (0.004)	0.074*** (0.006)	0.080*** (0.004)	0.081*** (0.004)	0.079*** (0.004)
Sex of HH Head	-0.034 (0.063)	0.068 (0.052)	0.089 (0.050)	-0.015 (0.044)	-0.000 (0.072)	0.062 (0.050)	0.120* (0.053)	-0.004 (0.044)
Rural	-0.132*** (0.038)	-0.132*** (0.031)	-0.092** (0.029)	-0.136*** (0.026)	-0.161*** (0.043)	-0.125*** (0.030)	-0.098** (0.032)	-0.142*** (0.026)
Female Share	0.022* (0.011)	-0.007 (0.009)	-0.004 (0.008)	0.008 (0.008)	0.023 (0.012)	-0.005 (0.009)	-0.007 (0.009)	0.009 (0.008)
Married	-0.078*** (0.011)	-0.038*** (0.009)	-0.030*** (0.009)	-0.058*** (0.008)	-0.071*** (0.012)	-0.040*** (0.009)	-0.028** (0.009)	-0.056*** (0.008)
Region1 (NW)	-0.192*** (0.034)	-0.359*** (0.028)	-0.365*** (0.027)	-0.260*** (0.024)	-0.196*** (0.039)	-0.367*** (0.027)	-0.005 (0.011)	-0.267*** (0.024)
Region2 (NC)	0.052 (0.038)	-0.037 (0.031)	-0.049 (0.029)	0.004 (0.026)	0.117** (0.045)	0.009 (0.031)	-0.269*** (0.036)	0.060* (0.027)
Region3 (SW)	0.011 (0.058)	-0.085 (0.048)	-0.134** (0.046)	-0.022 (0.041)	0.084 (0.067)	-0.046 (0.047)	0.013 (0.041)	0.019 (0.041)
Region4 (SE)	-0.229*** (0.041)	-0.374*** (0.034)	-0.307*** (0.032)	-0.259*** (0.029)	-0.110* (0.052)	-0.268*** (0.036)	0.074 (0.061)	-0.159*** (0.032)
Region5 (SS)	0.061 (0.053)	-0.036 (0.044)	-0.017 (0.042)	0.040 (0.037)	0.183** (0.063)	0.083 (0.044)	0.154** (0.057)	0.140*** (0.039)
Constant	11.832*** (0.155)	12.081*** (0.128)	12.404*** (0.122)	12.083*** (0.109)	11.818*** (0.178)	12.073*** (0.124)	12.467*** (0.160)	12.069*** (0.109)
R^2				0.821				0.833
N	4,786	4,786	4,786	4,786	4,786	4,786	4,786	4,786

Note: Robust standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

What is more interesting however, are the conditional marginal effects of some of the other variables on the quantiles of MPCE. Education has much higher significant associations with the MPCE of households at the bottom of the expenditure distribution than in the OLS case; and this can also be seen from the marginal plots diagram where the confidence interval bands for the lower quantiles is higher than the normal. This is an interesting result for proponents of education as a valid tool to raise the poorest households out of poverty the quickest. The actual quantile function line for household size also appears to be different from the OLS, but the confidence boundaries at that end of the distribution are higher, leading to substantial overlap. Finally, marital status is another variable of interest because the quantile regression shows that the head of household being married is more important to the welfare situation of that household, the poorer that household is. This could explain why in many poorer countries, marriages are contracted as a form of social security (Charsley and Liversage, 2013). Thus, finding a way to raise incomes might be a viable option to consider when thinking about tackling the problem of forced marriages and child brides.

Figure 5: Estimated marginal effects on the conditional quantiles for MPCE with $\mathbf{C}_1$



Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

2.8 Corollary: Crop Choice and Risk Aversion

As a corollary to the discussion of results above, a careful examination of these results reveals a pattern that appears to emerge. This pattern is regarding the apparent similarity between the reasons why a farm household would choose to grow one crop instead of another and that household's vulnerability to risk. It has been shown extensively in the literature that vulnerability to risk is a dominant feature of the poor's livelihood, and this is particularly so for small farmers in sub-Saharan Africa (Fafchamps, 2009). This is because when there are shocks to the production function, it could have a ripple effect on their incomes, assets, and hence the health and education of the next generation; especially as they have so little to begin with, and thus a lower margin for error.

So, the point here that is hypothesised is that the household's desire to mitigate risks and protect themselves from adverse shocks could affect their production decisions. When risk aversion is to be computed for farmers (as in Binswanger, 1980 for his ICRISAT data project), it is normally done by applying psychological and game techniques via field experiments. This would involve the farmers making a choice between lotteries of sorts and this information would then be aggregated to produce an index of risk aversion. Similarly, the choice of which crop to produce could be likened to a range of lotteries each with their own distribution of expected returns. And the farmer would then choose the lottery that gives him the highest anticipated earnings. A similar idea is known and has been used in application for the adoption of new or modern agricultural technology, but as far as we are aware, has not been expressly applied to the type of crop a farmer chooses to grow.

The channel through which this works is that farmers who are fearful of the uncertain return of growing a new (different) type of crop might just be content to keep growing the crop they have always grown, simply because they know from experience what the output they would get at the end of the growing season is likely to be. And this information gets reinforced from year to year to such a point that it would take a great effort indeed to break the aversion to try something new. This is as opposed to the prospect of "shooting in the dark" and expecting the best, even though they may have heard on radio or been visited by extension agents who have tried to convince them that there is a crop they could grow which would be more productive. The next paragraphs present some literature and anecdotal evidence to buttress this theory.

To start with, it is important to differentiate agricultural shocks from risk (even though some papers like Portner (2008) use them interchangeably). Following the book by Fafchamps (2003), he states that shocks could affect welfare and behaviour because they are often times unanticipated and as such, suitable precaution could not be taken against it. These could include severe weather disruptions like floods or droughts or unexpected influx of pests. This is in a sense similar to the idea of uncertainty; where the distribution of outcomes is unknown at the start of decision making. In contrast, although risk also involves unknown outcomes, the distribution of these outcomes can be predicted ahead of time. In other words, when people understand a shock is more likely to occur, any option that amplifies this likelihood becomes a riskier prospect. This difference is subtle but important because people can only adjust their behaviour ahead of time in response to risks and not shocks, for which they would have to respond after the fact.

There is surprisingly little research on the direct effects of actual risk attitudes on farm household behaviour. Most of the literature use shocks of different kinds as a proxy for risk because the effects are relatively easier to demonstrate econometrically than an index of risk aversion, which is not a concept that can be measured with completely assurance. For example, Portner (2008), Alderman et al. (2006) show the effects of weather shocks on agricultural yields and on nutrition and height of children respectively. Kurosaki and Fafchamps (2002) use a survey from Pakistani dairy farmers to show that the crops they plant are consistent with their desire to cover some of the feeding requirements of their cattle and hence reduce their risk exposure.

Studies from behavioural economics, that do use measures of risk aversion, often find that males, who have more family burden and are less educated tend to have higher levels of risk aversion as opposed to the female, younger, single, and more educated individuals. It turns out that these characteristics, represented by gender, household size and education, are also significant determinants of the crops that farmers chose to grow. If it is the case that there is actually correlation between crop choice and risk aversion as we suspect, it might be possible to simply use the type of crop a farmer has grown at the start of the growing season as a proxy for his risk appetite instead of conducting expensive and often misleading field experiments to measure risk aversion directly. Also, this would be making use of a decision the farm household head had already made at the start of the season, rather than a spur of the moment answer to a set of questions in an interview or lottery game.

2.9 Conclusion

The intention of this research was to examine the arguments on whether or not smallholder farmers in Nigeria who produce certain types of crops (export-oriented crops and roots and tubers) experience any significant productivity and welfare differences to those who do not, and to examine the factors which determine the crop choices of these farmers. Using the two-rounds of LSMS panel data from Nigeria in 2010/11 and 2012/13; we started by re-examining the old arguments surrounding whether small-holder farmers are indeed "efficient-but-poor". It is reported that although smallholders were generally efficient in their allocation of resources (after estimating household crop productivity by stochastic frontier analysis), they were not necessarily rational in their crop choices because even when some crops are found to be more productive than the others, the less productive crop was often chosen. To figure out why, a treatments effect model was employed to determine farmer selection into the choice of a type of crop in the first stage and the impact of their choices on productivity and poverty in the second stage. It was discovered that access to free inputs, non-farm income, the use of seeds from the previous growing season, household size, gender and the different regional differences were the main determinants of crop choice. Also, the choice influenced the productivity and poverty of the households in different ways. While the choice of tuber and root crop improved productivity, they were found to actually reduce poverty outcomes (mean per capita household expenditure). In addition, commercialization was found to be important for poverty alleviation, but not for productivity improvements.

These results have several important implications for policy. First, this paper suggests that farm household crop choices are not random, but can be predicted by economic modelling. This means that there are factors which could be changed in order to influence the eventual choice of crop planted. So, if a government makes a determination that the promotion of cash crops for example would be of benefit, it may decide to increase the amount of free inputs given to the farmers or provide some micro-finance to enable the farmers develop subsidiary businesses, which would provide other streams of income. Secondly, the results indicate that crops grown for export purposes attract better financial benefits to the farmer and has poverty alleviating effects (albeit with reduced total factor productivity, at least initially mostly due to farmer inexperience and the lack of mechanization). Furthermore, educating farmers on the marketing opportunities for their products, if it results in greater commercialization would also have positive welfare effects.

There may not be enough evidence to suggest that all smallholders should switch from producing one type of crop to another, but the implications of crop choices by smallholder farmers having the effects reported could be that these different types of farm households may need to be targeted differently in terms of social welfare or aid. And depending on the poverty alleviation strategy of the government, it is possible that it could require far less effort to lift these groups of farmers out of poverty (rather than a one-size-fits-all approach). Also, agricultural extension could be utilised to get more people within areas of comparative advantage to switch to these high productivity crops in order to improve their welfare outcomes.

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Chapter 3

The Impact of Crop Choice on Food Security

Summary

The aim of this study is to examine the effect of the choices smallholder farmers make in terms of what crops they grow on the food security outcomes of the households. This issue is studied using the household level panel data available from the World Bank's Living Standards Measurement Study (LSMS) and different specifications of propensity score matching models. The empirical estimates suggest that smallholders who grow cash crops have significantly more diverse food options available to them as well as a greater amount of overall food consumption but a greater severity of food shortage when food is scarce. However, there is no effect of crop choice on the total number of days in a week without food. Furthermore, when there are significant effects, these effects are reduced when the access to export markets and fluctuations in international food prices are considered as instruments. The conclusion is that if the policy objective is to improve food security, a careful examination has to be carried out on the pre-existing conditions of the households before a crop choice recommendation can be made. In addition, cash crop production should only be encouraged when an adequate support can be provided to link the farmers to the international market and if there can be some government-backed price stabilization measures.

Keywords: Crop Choice, Food Security, Propensity Score Matching, Nigeria

3.1 Introduction

This paper seeks to establish, using a new dataset from Nigeria, how important the choice of the type of crop to grow is to the food security outcomes of small-holder farming households. For example, does the choice to grow cash crops make them more food-secure than if they had produced food crops? Or would it perhaps have the opposite effect of reducing their food security instead? It is also possible that this choice of crop makes no difference at all and there may be other extenuating circumstances that make one choice more effective in ensuring food security under certain conditions.

To study this issue, we use a two-period panel from Nigeria to analyse and compare the situations of the farming households who grew cash crops as opposed to those who did not. The food security outcome variables are compared to their counterfactuals or what could have been if each farm household chose to grow the other type of crop. The first step is to make the farmers in the data sample as similar to each other as possible by eliminating those farmers who had zero probability of growing cash crops, either due to their regional placement, income level, or any other demographic or socio-economic classifiers. Then the rest of the households are given a probability score which indicates how likely it is for each farm household to choose to grow a cash crop. These were achieved using propensity score matching (PSM) techniques. Following this, fixed effects and instrumental variable regressions are run using these propensity scores in order to obtain the true effect of growing cash crops on the food security outcome of the farmers who chose to produce those crops (i.e. the average treatment effect on the treated, ATT).

The results show that on average, farmers who grew cash crops had significantly better food security outcomes than those who did not in both the food quantity and quality measures of food security used. There was no effect of crop choice on the number of days the household went without food, however among the households with lower total food consumption, the severity of this lack of food was magnified among those who produced cash crops. In one of the specifications using the Household Food Dietary Diversity Score (HDDS) as a component of food security, the crop choice effect of cash crop production was up to 2.3%. However, the effect was reduced to 1.3% with a decline in significance when price volatility and the access of the farmer to export markets were taken into consideration along with the choice of crop.

The issue of food security has been on the front burner in recent times, especially after the United Nations (UN) highlighted the threat of massive global hunger and inaugurated a high-level task force to implement new strategies in dealing with the problem at the turn of the last decade (UN, 2009). Worldwide, there are about 842 million people who suffer from hunger (approximately about 12% of the world's population). Out of these, 227 million live in Africa. According to world hunger statistics (FAO, 2015), it is estimated that 9 million people die of hunger each year. At the UN Sustainable Development Summit in September 2015, the UN came together to agree on new global goals that would come into effect after the expiration of the Millennium Development Goals (MDGs). These objectives (now known as the Sustainable Development Goals or SDGs) were proposed to be the major drivers of new development policy for the next few decades.

The second of these goals is to eliminate world hunger in totality and malnutrition in all forms by 2030. Agriculture, being the single largest employer in the world with about 40% of the world's population employed in the industry, was proposed to be a ready vehicle to achieving this goal. As lofty as this goal may seem, great strides have already been made towards its attainment, nevertheless Africa in particular is still some way off the target. This has drawn continuous robust debate in the literature as to the best means for the achievement of this goal, especially in developing countries.

Even though most economists and development experts would agree that food security is an important subject, there is hardly any consensus as to the avenues through which this problem may be solved on a global scale. Over the years, many strategies and ideas have been proffered as solutions to food insecurity and many remedial programmes have been undertaken, with mixed results.

Based on the development experiences of China, Brazil, Thailand and Vietnam, a study by the International Food Policy Research Institute (Fan & Polman, 2014) suggested that the second goal of eliminating hunger was perhaps even more relevant than the first goal of ending poverty by 2030, which some may see as being less realistic. Three major pathways proposed and debated as avenues to achieving Goal 2 were:

1. Agriculture-led
2. Social Protection and Nutrition Intervention-led and
3. A combination of these approaches

If an agriculture-led approach is to be successfully canvassed, there is still wide scope for research as to the means by which the explosion in agricultural productivity and the incomes of smallholder farmers required would come.

This paper joins this discussion by analysing the narrow question of what types of crops should be focused on if the objective of an agriculture-led solution to food insecurity is being considered. The main gap in the literature arises from the fact that there have been insufficient case studies on the effects of growing one type of crop in favour of another specifically on food security outcomes. As is discussed in the following sections, the ones that do exist show differing results. For example, while Kuma et al. (2018) using a sample of 1600 smallholder coffee farmers in Ethiopia, have shown that coffee income was associated positively with food security of the farmers, Achterbosch et al. (2014) suggest that any advantages to cash crop production are well-tied to the prevention of the economic and environmental risks they are often associated with.

Nigeria as a study area is appropriate in this case because apart from it being a large country in terms of population and land area, it is also quite influential in both the regional economy of West Africa and the general African economy. This size, influence and potentials though are widely considered not to have translated to improvements in the welfare of the people. This is evidenced by the fact that according to World Bank (2018), in 2017, over 70% of the population were below the $1.25 a day poverty line (taking over from India as the country with the most poor people in the world in absolute numbers), as at 2017 (World Bank, 2018), the life expectancy is 53 years, which is low in comparison to similar economies like Ghana (63 years), South Africa (62 years), and Mexico (77 years). In addition to these, many of the people lack a fundamental access to (especially through the inability to pay for) adequate food and nutrition, thereby leading to the large spread of malnutrition and stunting among children and adults (UNDP, 2011).

Food insecurity in Nigeria has not always been a problem though. In the 1940s and early 1950s, local food systems were efficient and relatively stable with the different regions of the country competing against each other on the massive production and export of different food and cash crops. At this time, the type of crop being produced could be generally accepted to be irrelevant because all crops produced had a ready market and the entire food value chain including trade and marketing was more efficient. Food crops like yams and millet could be sold for food around the country, while cash crops like cocoa and cotton could be exported for the income to purchase the food crops from other parts. Due to the relatively low population, and a strong exchange rate, Nigeria's agricultural products could be both enough for foreign trade and domestic consumption with the ability to easily import any redundancies. After the discovery of oil in 1956 however, the agricultural sector became increasingly destabilized due to the rapid influx of oil money. This led to the almost complete neglect of the sector and a corresponding rapid rise in population growth as incomes improved (meaning that there were more mouths to be fed with declining food resources). The combination of these factors meant that the country gradually became a net food importer; the worsening of which has led to the current somewhat acute food security challenge.

This study examines the agricultural sector in Nigeria and tries to determine if the choice of farmers to grow cash crops or food crops have played any important roles in the said decline of food security or if said choices have caused no difference in effect at all. The study is important for several reasons. Firstly, from a policy perspective, it provides a framework for crop choice analysis as it relates to solving the food insecurity problem. Due to the limit of resources, it could enable governments make intelligent decisions on what type of crops to channel their scarce resources to, either in terms of subsidies, supply of inputs or general government intervention policy. Also, the paper provides a further insight into some of the other factors which play prominent roles in determining different aspects of the food security outcomes of smallholder farm households. Finally, some insight into the interactions between the crop produced and some auxiliary elements like international prices and export opportunities are examined.

The rest of this paper is laid out thus: following this introduction, there will be a brief literature review highlighting how the history of food security has evolved over time, the measurement of food security and some of the work that has been done on the relationship between food security and cash cropping; thereafter the variables to be used in the analysis are explained, then the data with an explanation of the variables used, the results and analyses are presented.

3.2 Literature Review

3.2.1 Brief History of Food Security

"Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

\- *World Food Summit (1996)*

The definition above is currently the most widely accepted and used definition of food security. However, there has been a long history and vast disagreements over time over what food security actually was and how it should be studied and measured.

The concept of food security was first formally discussed as a problem that needed to be solved globally at the Hot Springs Conference of Food and Agriculture in 1943. Here, the idea that there should be a secure, adequate and suitable supply of food for everyone was developed (United Nations Conference on

Food and Agriculture: Text of the Final Act, 1943). Following from this, the USA and Canada as major donor countries set up bilateral agencies in the 1950s with the role of organising for the shipping of agricultural surpluses overseas to the countries that needed them. This was borne out of the ideal that surplus food resources should not be wasted but redistributed.

By the 1960s, attention began to shift away from gifting food aid overseas to the promotion of indigenous self-sufficiency due to the concern that the food aid recipient countries would eventually lose the ability (and willingness) to be food autonomous (a form of food import dependence) if the situation continued. This new policy shift resulted in the Food for Development concept and in 1961, the formation of the World Food Programme (WFP) to bring the notion of food security (as then defined) into practical realisation. The first development programme under the auspices of the WFP was launched in Sudan in 1963.

It is worth noting that until this point in most of the developing world, there was relative food abundance, but this was to change in 1972-5 with a food crisis which was marked by wild fluctuation of food supplies and prices (Gerlach, 2015). To counteract this, more food aid and the recognition of how important agricultural insurance schemes were became a lot more widespread in order to forestall the bottlenecks to steady food supplies to food aid recipient countries and coordination among donor agencies and organisations was greatly improved.

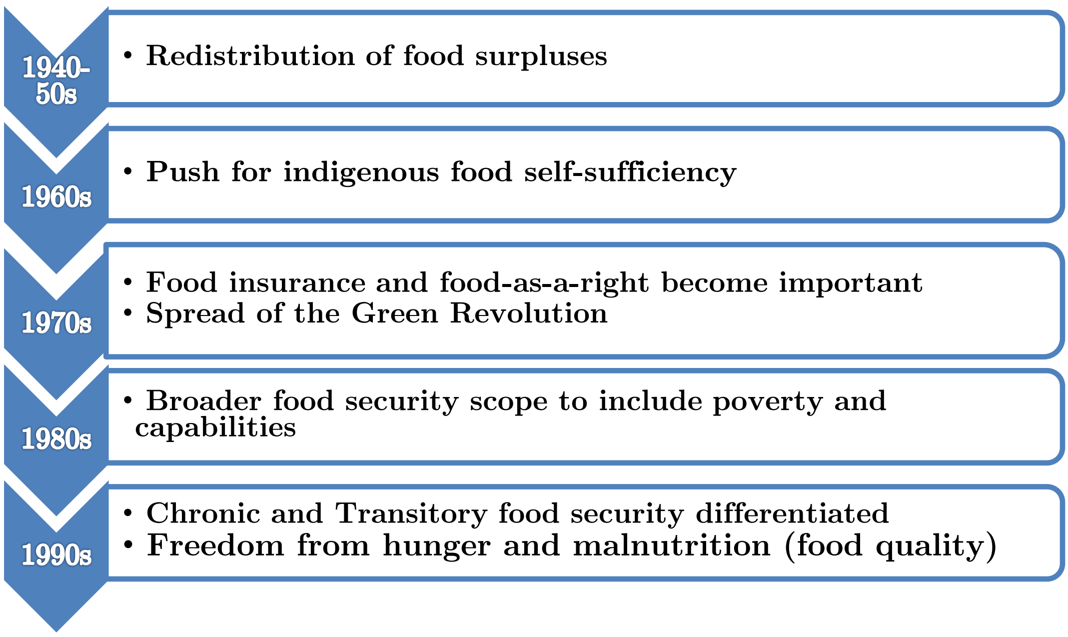


Figure 1: The progression of food security policy (by world view)

Source: Author's construction

Following the food crisis, a World Food Conference was called in Rome in 1974 to explicitly discuss what the world's response will be to subsequent occurrences of food crises and how to forestall them on a more sustainable basis. It was at this conference that the right to food for every man, woman and child was expressed and a clarion call was put out for the international community, developed countries and everyone in a position to help to ensure hunger is eradicated in the world.

In the 1970s, the overarching view on food insecurity was that it was basically a problem related to the shortage of food supply caused by a variety of factors such as adverse weather and other agricultural shocks which directly impact on the ability of countries to produce sufficient food on a consistent basis. This is why the ignition of a "Green Revolution" was such a big idea at the time; it was believed that this agricultural revolution would ensure price stability both on a national and international level. Throughout the 1980s, most of the developing world[1] including countries like Mexico, India, Pakistan, Thailand and the Philippines who grew primarily cereals did indeed experience a massive improvement in food production.

Notwithstanding the successes of the Green Revolution, the primary problem of intermittent incidences of famine was not solved for the most part. It was at this point that the narrative began to shift away from deficiencies in food supply towards deficiencies in purchasing power of specific groups. In this period, food security began to be defined to include the economic as well as the physical aspects of food supply. Poverty and welfare began to be focused on more because there was the understanding that even when food was available, if the people did not have the resources to purchase food, there would still not be food security. This is the economic meaning of access to food component of food security. Also in 1981, eventual Nobel prize winner, Amartya Sen's book: Poverty and Famines was published. A major point of the book being that starvation was not a property of there not being enough food to eat, but it was more about some people not having enough food to eat (Sen, 1981). In other words, the food was available, but not everyone has the ability to purchase what they need.

Following from this, although the emphasis on access to food and poverty/welfare of people became widespread, international organisations began to recognise the need for food stability or sustainability as well. This led to the introduction of the time element in the food security definition. In 1986, the World

[1] It is worth noting that sub-Saharan Africa for many reasons did not experience the full impact of the Green Revolution like many of the other countries in the developing world and these same factors may be part of the reason why food security remains a prevalent concern.

Bank published a report on "Poverty and Hunger", and this report clarified the importance of differentiating between chronic and transitory food insecurity. Chronic insecurity existed where the problems surrounding food were more or less permanent while transitory insecurity existed where the problems were only temporary and soon resolved, the former obviously being the more serious case. Chronic insecurity basically involved the situation where food was going to be scarce in supply for an extended period, probably due to a collapse in the domestic supply or some external shock to cause a high risk of famine. This time component is the reason why in the above quoted definition for food security the following phrase is included: "…all people, at all times, have physical and economic access…" (World Food Summit, 1996).

Finally, the last component of food security as expressed in the definition above is food quality. In the 1990s, attention was drawn to the fact that inasmuch as food in sufficient quantities was necessary to solve the food problem, the quality of the food which was available was equally important. This is because food insecurity was also understood to include malnutrition, both under-nutrition (evidenced by gauntness, stunting, and a variety of nutrient/vitamin deficiency sicknesses) and obesity due to the consumption of cheap, low quality food (as opposed to obesity due to bad choices, which is not caused by lack, but perhaps by lack of information and discipline). Furthermore, the lack of some of the many other micro-nutrients needed for health was classified under this category. In the 1996 World Food Summit's definition, the following phrases were included: "…access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." There was also expressed interest in how food was utilized within the household, once it was adequately available and households had economic access to it. People had to have knowledge and information on how to utilize food to maximize the delivery of nutrition.

These different components of food security are often studied separately depending on the interest of the researcher to determine how they all fit into the larger picture and towards reaching some further enlightenment on how to solve this very important problem. The next section deals with the different ways in which food security has been measured in the literature.

3.2.2 Measurement of Food Security

Food security has been measured in a wide variety of ways. The specific indices chosen by a researcher would depend on several factors such as the specific component interested in, whether he/she is considering actual insecurity or vulnerability, qualitative or quantitative indices, and whether the study is to be carried out at the macro-, meso- or micro- level (country, intermediate/community or household level). Due to the differences in definitions and understandings of the concept of food security, over 450 different indicators have been proposed.

However, in order to reach some consensus on this subject, the Food and Agricultural Organisation (FAO) held a Scientific Symposium on the Measurement and Assessment of Food Deprivation and Undernutrition in 2002 and the outcome of this was the fine-tuning of measures to focus on an assessment of how the world was progressing towards the fulfilment of Goal 1 of the Millennium Development Goals (MDG) and specifically, Target 3 (FAO, 2002). Goal 1 was to eradicate extreme poverty and hunger, while Target 3 was to halve the proportion of individuals suffering from hunger in the period between 1990 and 2015. This symposium propounded on five main methods (actually, systems) of analysis focusing on different aspects of the food security question ranging from food availability and food intake to nutritional outcomes and hunger perception.

Household Income and Expenditure Surveys

International agencies and organisations from time to time initiate national surveys seeking different types of relevant information depending on what they are interested in. The World Bank's Living Standards Measurement Study (LSMS) is an example of such which seeks to gather regular comprehensive information on different aspects of the lives and lifestyles of the people in the countries where the surveys are carried out. Many countries also carry out their own domestic surveys for the purpose of information gathering and planning. As a part of these types of surveys, there is often a section dealing with food; the amounts of food acquired (as opposed to actually consumed) and as to how these foods were acquired. It is also common to find questions regarding the monetary value of food acquired and the questions on the types or classes of foods.

According to the FAO (2002) document, the main sources of this information would normally include:

1. Food purchased
2. Food received as gifts (either as payment from labour or from family and friends living outside the household)
3. Food produced at home (auto-consumption of food)

The information from these surveys is used to calculate the amount of food available to the households for the period of recall[2] measured in kilocalories. This

[2] The period of recall is the length of time over which the interviewer asks the respondent to try to remember details regarding the information sought. It varies depending on the survey creators and type, but 1 year is a commonly used standard for this class of measures.

figure is then divided by the number of adults (or adult equivalents[3]) in the households to obtain the kilocalorie per household member or individual measure.

In the use of these measures, one should be careful to interpret the indicators for what they are: as food available to the household per household member rather than actual food or energy intake. This distinction is important even though they convey similar information, because it may be more difficult for people to remember the precise details of everything the family had eaten, but perhaps easier to remember where and when and how much food they had obtained. Following from this, another likely problem is that there may not be consistency among all respondents because some of them might erroneously include food receipts prior to the recall period if that was a source of a large part of their consumption. A major advantage of this class of measures however, is the fact that the food insecurity analysis is done at the direct micro household level, which some may argue is the most important, as this allows for certain policy analyses that cannot be done with macro-level measures. The specificity of the data may also be a disadvantage though because the averaged data from one country may not be directly comparable with another.

Food Consumption Measure

Using the same surveys as before, different questions could be asked to obtain a food consumption (or intake) measure of food security. This would indicate an estimation of how much food each member of the household actually consumed over the period of recall. The nutrient and energy content of each consumed food could also be calculated. The focus on consumption rather than acquisition of food is the main difference between this class of measures and the previous case. Although this is a more accurate measure because it captures food or energy actually consumed, it could be more difficult for households to remember all the meals consumed over a longer period of time. This is why questions that intend to capture this measure often have relatively short recall periods of a few days.

Qualitative Measures

When the United States was designing a survey in 1995 to measure food insecurity and hunger in the country, a new module was included. The objective of this module was to measure hunger using new, more practical dimensions dealing primarily with how hunger affects the lives of people and hunger outcomes

[3] Since children would be expected to consume less than adults, the use of an adult's equivalents conversion scale can be useful to compare like with like. They are normally obtained by dividing the household's kilocalories by a fraction, depending on how many children are in the household rather than as whole individuals.

(Andrews, Bickel & Carlson, 1998). Modules of this kind have now become quite main-stream in national household surveys and they have the advantage of being able to be used to predict vulnerability or the likelihood of households to either exit from or to fall into food insecurity. The major areas that are assessed in a qualitative food security measure include:

1. If food consumption has reduced recently for adults in the household
2. If food consumption has reduced recently for children in the household
3. If there is increased anxiety about food availability
4. If there is a reduction in food quality or a perception of inadequate food quality.

Based on the results, a scale of food security could be drawn up ranging from only a slight worry about food to highly severe. The households could then be classified into:

1. Food Secure – When almost no evidence of food insecurity is present.
2. Food Insecure without hunger – When food consumption of the household may not reduce in quantity or frequency, but there is a reduction in food and dietary quality, as well as a replacement of normal foods with more quantities of inexpensive food.
3. Food Insecure with moderate hunger – When the food consumption of adults in the household has reduced and they have experienced incidences of hunger due to rationing of food.
4. Food Insecure with severe hunger – When food consumption in the household is severely reduced with children experiencing hunger physically and adults experience much reduced energy intake and severe hunger.

In each of the above categories, there could be further scales of severity, and the cut-offs for the categories could be set based on the perception of severity. Even though the premise of measuring the perceptions of respondents to the future state of their food security is useful, this measure could be critiqued as being too subjective, both from the perspective of the respondents (as some may respond with an over-exaggeration of their condition for many reasons) and from the researcher (who is tasked with dividing up the scores into varying degrees of hunger severity by his/her intuition). Some studies that have used variations of this include Ashiabi (2005), Cook et al. (2004), and LeBlanc, Kuhn & Blaylock (2005).

<u>Anthropometric Indicators</u>

Anthropometry refers to the science of measuring the human individual in different ways. Regarding food security, anthropometric indicators refer to the measures that deal with how hunger and food insecurity have affected the physical appearance of the people concerned. According to WHO (1995), anthropometric indicators show hunger as what results from the interaction between poor diet and disease. Some of these indicators which have been commonly used include low height-for-age (stunting), low weight-for-age (being underweight), low weight-for-height (wasting) for children under the age of five. It is less common in the literature for anthropometric measures to be used in the analysis of adults since the different genetic make-ups of individuals make an objective analysis less informative[4].

These measures rely on the fact that as a means of predicting hunger, undernutrition rates could play an important role due to its established correlation with factors like mortality, poor productivity and morbidity. These undernutrition rates could also be used to analyse the condition regarding how moderate or severe the hunger is in malnourished children.

The United Nations Children's Fund (UNICEF) annually publishes a State of the World's Children report which contains anthropometric information on global child hunger and malnutrition in order to make assessments on the current state of the situation and on how much progress is being made towards solving the problem. Countries could use this information as a gauge to determine how far they have gone towards their implementation of SDG hunger-specific policy.

Despite the obvious advantages of these indicators, which include the fact that they measure the impact of hunger on the physical lives of children, they also raise some problems in analysis. For example regarding time frame, short-term problems in food security may not show up on anthropometric indicators. It would take some time before a lack of food begins to lead to weight loss and wasting. Furthermore, it may not always be the case that these negative outcomes are as a result of hunger. Stunting for example could be due to genetic or other environmental factors including poor mother nutrition and sanitation which could have led to the incidences of some sickness or disease. This limits the uses of this class of measures for wider macro-level comparisons.

Multidimensional Indicators

As an alternative to the measures discussed above, some multidimensional approaches to measuring food insecurity have also been attempted. These measures attempt to make a combination of both the causes and effects of food insecurity

[4] Signs of malnutrition can obviously still be observed in adults with deficiencies in different nutrients, but this anthropometric information cannot be used comparatively in analysis due to genetic differences.

and try to capture multiple dimensions at the same time. While they have the advantage of being more comprehensive in terms of how much information they convey, there are also a few disadvantages of this. Firstly, they have the property of obscuring direct information provided by the important individual measures. Also, they are often data-intensive requiring a large amount of information on different components to arrive at an index, and if the different pieces of information required are missing (for individual countries say), it would greatly diminish the reliability of the index in the comparison of countries or individuals. Any errors in measurement or estimation of the individual components could also create a magnification or mis-specification effect. The following are some examples of these multidimensional indices.

The *FAO* index

The *FAO* index was introduced in 1987 (FAO, 1987), in a publication of the fifth World Food Survey. There was a large time gap from this report till the next one, coming about nine years later in 1996. Following this World Food Summit of 1996, the decision was made to begin the publication of this index annually for all developing countries in the series: *The State of Food Security and Nutrition in the World*[5]. This index measures food insecurity as the proportion of a country's population whose per capita energy consumption falls below a pre-set standard for nutrition. The inability to meet these basic energy requirements would often cause an inability to maintain proper body weight and a deficiency in energy for normal work duties[6].

The FAO index is measured using a combination of three main parameters: the per capita availability of food, inequality of energy intake and the pre-determined country, age and sex specific energy requirements. The first step in the computation of this measure is to estimate per capita calorie intake which is based on the FAO's country Food Balance Sheets. Following from this, the distribution of calories among the people is calculated in order to determine the gap in food provision, much like the Foster-Greer-Thorbecke (FGT-1)[7] poverty measure. The coefficient of variation of energy expenditure is calculated, assuming it follows a log normal distribution. The third step is to choose a cut-off point and then count the number of people in food insecurity.

[5] This is otherwise known as the SOFI – State of Food Insecurity report, for short.

[6] These observable outcomes such as being underweight are treated as the results or outcomes of food insecurity rather than insecurity itself in this measure.

[7] This is also known as the poverty-gap measure because it examines income (or expenditure) gaps among the population to determine the threshold for the incidence of poverty.

The advantage that this index has is that it is relatively easy to calculate as the data on food availability are readily available as well as the internally developed national "Food Energy Requirements"; and it can be calculated for each country for the purpose of comparison. There are several problems with this measure as well though. The first is that food availability may not be the best predictor of mortality and stunting according to Svedberg (2000). Also, due to the way it is computed it is not sensitive to differences along the hunger distribution scale, thus an improvement in the situation of the most food-deprived people may not indicate any change in the index numbers. In addition, since food availability data is averaged over three years for this measure, it may not be sensitive to short-term fluctuations in food security caused by missed incidences of drought or violent conflict. Finally, as noted above the energy requirement cut-offs are quite arbitrary. They are obtained by aggregating sex and age specific minimum caloric requirements using the proportion of these different segments in the population as weights (Neiken, 2003). If there were slight changes in these cut-offs however, the poverty figures could vary a lot. One point of novelty is that we attempt to solve some of these issues by introducing a modification of the squared poverty gap measure as one of the component measures of food insecurity. Here, the severity of food shortages becomes important and the distance of households from the country-specific calorie cut-off is magnified.

The Global Hunger Index (GHI)

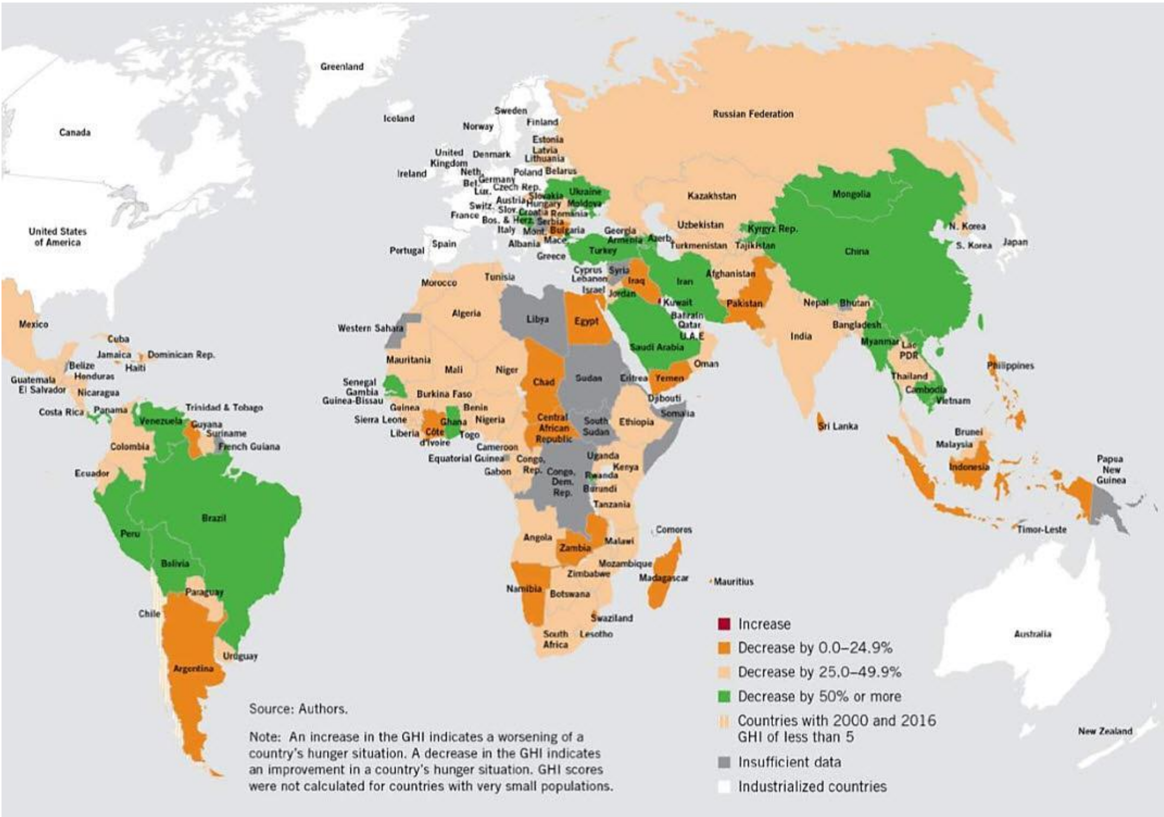
The Global Hunger Index was first published in 2006 by *Welthungerhilfe*, a German non-profit organisation (NPO), and in 2007 joined by *Concern Worldwide*, another NPO from Ireland. The measure has subsequently been adopted and developed by the International Food Policy Research Institute (IFPRI). The index is updated annually with a Global Hunger Index report (IFPRI/Welthungerhilfe/Concern, 2007).

It was set up to follow global, regional and national hunger trends and the progress being made towards eliminating hunger. The index combines three indicators in its formation: the FAO estimate of the proportion of the population without enough access to food, WHO's estimate of the proportion of under-age-5 children who are underweight, and UNICEF's numbers on child mortality under 5. An average of these indices is taken, and countries are then classified according to their scores.

The index ranks countries on a 100-point scale, where the lowest possible score of 0 means that there is no hunger (best score) and the highest score of 100 is the worst. In between these, there are arbitrary thresholds used for analysis. A score less than 10 means “low hunger”, between 10 and 19.9 represents “moderate hunger”, between 20 and 34.9 the score represents “serious hunger”, between 35 and 49.9 indicates “alarming hunger” and finally, scores above 50 reflect a state of “extreme hunger”.

Advantages of this measure include the relative reliability of the data forming the components and the ability to use it for macro-level comparison. However, as a measure, it reacts poorly to short-term fluctuations in food supply and nutrition.

Figure 2: Map of Change in Global Hunger Index Scores 2016



Source: Global Hunger Index Report 2016 (IFPRI, 2016)

<u>The Action Aid Hunger Scorecard Index</u>

ActionAid is a UK-based non-governmental organisation (NGO) whose stated objective is to support women and girls to understand their rights and to be empowered (Action Aid, 2009). The organisation’s index measures hunger outcomes and the commitments made to eradicating hunger at the national level. It includes the amount of the country’s investment in agriculture and social protection, as well as the legal aspects of right to food. The different components are weighted differently according to their perceived importance and for each nation, their index score is a measure of what the country has achieved as a ratio of potential achievement.

The advantage of this index is in the multiple components it brings together, but it allows the possibility of double-counting or mis-specification. Also, the idea of potential achievement may not be objective.

In this paper, we make use of a few different measures which are appropriate for the household survey data we have and the analysis that is being carried out. In the variables section, the measures used will be specified including a justification for why they are appropriate and how they were implemented. In the next section, the literature on crop choice and food security is examined.

3.2.3 Crop Choice and Food Security

In the literature, the relationship between the choice to grow cash crops and food security outcomes varies widely based on the differences in the specific crops studied, the geographical spread of the research areas, and the existing local structures (Dewalt, 1993; Sharma, 1999; Kiriti & Tisdell, 2004).

In sub-Saharan Africa, cash-crop production has often been touted as a means to reduce poverty and improve food security (Jones & Gibbon, 2011), it is still unclear the precise conditions under which these ends can be achieved at the level of the household. Komarek (2010) showed that vanilla production had a positive correlation with the ability of the producers to access and purchase food. Also, Pierre-Louis et al. (2007) found positive association between diet diversity and the production of peanuts in Mali. Using anthropometric indicators for cardamom producers in New Guinea, rice farmers in Gambia, and potato farmers in Rwanda, it is shown that the producers of these cash crops experienced better outcomes (Von Braun, 1995; Kennedy et al., 1992). It is important to note that food or nutrient intake is not the only influencer of anthropometric food security measures (like stunting and wasting), with quality of health also being important. Furthermore, Kuma et al. (2018) using a sample of 1600 smallholder coffee farmers in Ethiopia, have shown that coffee income was associated positively with the food security of those farmers.

On the other hand, using a survey of 137 female respondents (63 of which were wives of a male household head) from a district in Central Kenya, Kiriti & Tisdell (2004) showed that cash cropping actually had a negative effect on per capita food availability in the male-headed households, but had the opposite positive effect on the female headed households. Their argument was that since husbands had control over cash income, they were able to influence food purchases by sacrificing food for other expenses. Also, Kanyamurwa et al. (2013) use a cross-sectional comparative survey of 190 female coffee producers and 191 female food crop producers in a rural district of Uganda and obtain the result that coffee producers had more assets, greater income, made better use of markets, and had greater access to inputs. However, there was no significant difference in health care and the coffee producers had poorer dietary outcomes and greater food stress. They also had to work longer hours to obtain their economic returns. This paper sounds a cautionary note to the blind promotion of cash-crops. Some other papers have taken a similar posture that despite higher incomes and more assets, the actual food consumption of cash crop farmers are not significantly different (or superior) to subsistence farmers (Collins, 1962; Dewey, 1979; FAO,1984; Fleuret & Fleuret, 1980; Haaga, 1986). Going even further, from a survey of 29 different villages, Schofield (1979) found that those villages which were purely subsistent experienced significantly higher nutrient intake than the more semi-cash villages and they were better fed. Kumar (1977) also finds something similar.

Anderman et al. (2014) makes an analysis of some of these contrasts in results. Thus, with these mixed results, there is no clear expectation as to the eventual impact of crop choice on actual food security (even though there seems to be a consensus that growing cash crops improves incomes and amount of assets).

3.3 Variables

3.3.1 Food security

In this paper, food security is the dependent variable and it is measured in four different ways in order to capture different aspects or dimensions of the food security problem among the households in the study area.

Food Consumption per capita

As discussed earlier, this is a commonly used measure of food security due to the simplicity in its application. The household survey questionnaire within the World Bank's Living Standards Measurement Study (LSMS) conducted in Nigeria included questions on the specific foods the households consumed over the recall period of the week prior to the interview and the quantities of these foods were estimated. This survey was undertaken in the after harvest season, so there should be no issues of seasonal hunger. This includes both food obtained as gifts, obtained from the market, or converted to home use from domestic production. This was then converted to kilocalories of food and divided by the number of household members to obtain per capita food consumption numbers. By this measure, a higher food consumption score would indicate a greater level of food security. It measures the quantity of food available for consumption by the household in calories.

Squared Difference from mean of Food Consumption per capita

After computing the food consumption per capita measure above for each household, the mean of the entire sample was then calculated, and each household's score is differenced from this mean and squared. The households above the mean are given a score of 0, while those below have exponentially larger scores based on how far off from the mean the household is. This measure is an indication of the severity of the food deprivation suffered by the household because it exaggerates differences from the average Nigerian food calorie consumption. It is also a food-quantity food security measure.

This is similar to the Foster-Greer-Thorbecke (FGT-2)[8] poverty measure. In poverty measurement, this formulation allows one to vary the amount of weight that one puts on the income (or expenditure) level of the poorest members of society. In this case, it allows for greater weight to be placed on the households with lower quantities of food consumption. The implication of this is that the situation of the households which are most food deprived is better represented.

Another reason why this measure is useful in this case is due to the fact that greater quantities of consumed food is not always equivalent to better nutrition. As a matter of fact, the Engel curve (which is a representation of the fact that when income improves, the proportion of income spent on food generally decreases) gives expression to the fact that with improved financial capacity, it is more likely that the household would make some changes to their diet, replacing cheap high carbohydrate content foods with a more expensive protein-based diet. For such households, food consumption per capita measures in calories may not give an accurate representation of overall health. When a household is able to consume above the minimum food energy requirement, it is not expected that there would be a continuous increase in caloric food consumption. However, for the households who are not able to afford the basic minimum energy requirements for food, every extra calorie available for consumption makes a difference. Thus, providing the same amount of food aid for example, would have differing effects along the distribution of households without basic nutrition. This measure accounts for this and allows food intake (or availability) to have differing levels of importance to different households depending on the initial level of the severity of their food deprivation.

[8] This is also known as the poverty-severity measure because it takes into account the inequality among the poor.

Number of days in past week without food

As the name indicates, this measure contains the simple record of the number of days in the past week of recall which the household has had no food. This is a weighted average of all the individuals in the household with children having a higher weight of 0.75 and adults having a weight of 0.25. This weighting system is used because this paper makes the assumption that it is a more serious food security issue for a child to go a day without food than an adult, due to their different nutritional requirements and deficiency tolerances. This simple measure of food security neither captures the quantity nor quality of food available (as is done by the other measures), but it is a measure of the daily regularity of food supply within each household. Here, when the number of days without food is higher, this is an indication of a worse food security outcome.

Household Dietary Diversity Score (HDDS)

In constructing the HDDS, the procedures laid out by Arimond & Ruel (2004), Steyn et al. (2006) and Arimond et al. (2009) were followed. Information on household-level food consumption was obtained from the food module of Nigeria's Living Standards Measurement Study (LSMS) dataset where questions are asked regarding the households' consumption of some specific classes of foods. The respondent is asked about the frequency with which the foods within each group are consumed over the past week (the immediate past seven days). We then summed up these consumption frequencies, and any group frequency value above seven (7) is capped at seven.

Table 1: Food Groups and Weights used in calculating the HDDS

Food Group	**Weight**
Cereals, tubers and root crops	2
Meat and Fish	4
Milk	4
Oil/Fats	0.5
Fruit	1
Vegetables	1
Pulses and nuts	3
Sugar	0.5
Condiments	0

Source: World Food Programme (2018)

Following this, the obtained frequency values are multiplied with the food group weights contained in table 1. The weights are based on the nutrient profile of the food groups as set by the World Food Programme (WFP). Thus, the food groups with the higher weights are adjudged to be the groups representing a better quality of food consumption. When the weighted frequency values for each of the food groups is summed up, this would represent the HDDS for that household. As an alternative to the previous variables measuring food security, this one captures the quality of food available to the household because a more diverse (well-balanced) diet with better all-round food quality is desirable as a target in achieving food security.

3.3.2 Crop Choice

For the key independent variable: cash crop, a dummy variable is created for if the main product produced by the household is any of the following: Palm Oil, Sesame Seed (Beniseed), Cotton, Cocoa, Guinea Corn, Ginger, Gum Arabic, Shea nuts, Soya Beans, Sugarcane, Tobacco, Coffee or Cassava. If a household belongs to this set, they would have a value of 1 and 0 otherwise. These crops were chosen because from the national statistics, they are the most exported crops from Nigeria. A sensitivity analysis was carried out to see if the results change drastically with the exclusion of any one of the crops and there was no significant difference. Thus, this group was deemed to be sufficiently different. The propensity scores obtained from the two created groups also support this hypothesis. In addition, an attempt was also made to include farmers who indicated that they grew these cash crops as either primary or secondary product, but there was no clear delineation of groups by propensity scores in this way.

3.3.3 Price Volatility of Exports

This is a measure of the volatility of agricultural prices faced by the farm households in Nigeria on the international market. The variable is the first difference of a calculated index by the FAO and it is obtained from a detailed trade matrix from each country. The unit values (in US dollars) of imported foods are differenced using a Laspeyres-type formula to create the index (FAO, 2018). It represents a sense of the assuredness the farmers would have about what the price level will be in the next year for their products rather than the actual price levels in the current period. This variable, along with distances to borders, serves as an instrument because there is no apriori expectation for the price volatility to vary positively or negatively with the level of food security (measured in the four ways as detailed above) except through the channel of crop choice.

Even if the actual price levels are related to the food security outcomes, the argument made here is that the price volatility (i.e how the price changes over time, increases as well as decreases) should not have a direct effect. Because for example, assuming the agricultural prices are high one year and low the next, one may expect food security to decline the first year and increase the next year; however, there may not be a clear expectation about the effect of the volatility itself on the food security measures. So in the example, if volatility is high, one may not be able to readily predict if food security would be high or low. In order words, the volatility could influence the farmers to either plant cash crops or food crops but is not expected to directly affect how much food is consumed by calories, the number of days without food or the food diversity of the households. Also the interaction with distance for instrumentation could further reduce any contention about validity.

3.3.4 Access to Export Market

Whether the household head has knowledge about marketing opportunities in the international markets is captured by this variable. This dummy variable is the answer to the questions "Are you aware of export opportunities for your product?" and "If yes, are you aware of *how* to take advantage of it?" irrespective of if there was actual contact with said market but includes simply the knowledge of what opportunities exists for export. To proxy this, contact with extension agents and belonging to an agricultural association were tried with no significantly different results.

3.3.5 Distance to Nearest Border

The household panel dataset reports the distances of surveyed households from the nearest international border posts. According to the survey documentation, this data was obtained by a combination of Global Positioning System (GPS) data, Google Earth and other map sources. The justification for the use of this variable is as an instrument for cash crop production (as an interaction with price volatility) is that it is hypothesised that the closer a farm household is to an international border, the more likely it would be to grow cash crops due to the reduced transaction costs of transportation, logistics etc., but it is not expected that this variable would influence food security directly. Other measures of distance (such as distance to towns with a population of over 20,000) which were also considered were found to be weak, due to a noted correlation with food security. This outcome was probably because as the households got closer and closer to the cities, the income levels and thus some food security variables (food consumption per capita) of the households improved.

3.3.6 Others

Other demographic and socio-economic variables such as age and marital status of the household heads, number of male and female dependents and number of children in the household were also included as controls in order to obtain propensity scores as well as in the matching analysis.

3.4 Methodology and Empirical Specification

The main objective of this paper is to test the hypothesis that small-holder farmers who grow cash crops have significantly better food security outcomes than those who do not. This can be represented by the basic equation below:

$$FS_{it} = \beta_0 + \beta_1 CashCrop_{it} + \beta_2 ExpMkt_{it} + \beta_3 \boldsymbol{X}_{it} + \varepsilon_{it} \tag{1}$$

Where:

- FS_{it} is the food security variable
- $CashCrop$ is cash crop dummy
- $ExpMkt$ represets household's access to export market
- $\boldsymbol{X}_{it}$ is a vector of household characteristics
- ε_{it} is idiosyncratic error which varies with time

However, a simple regression of this basic form is likely to suffer from a number of specification problems including the non-randomness of selection into treatment and reverse causality. These are discussed in more detail below. To mitigate these issues a range of econometric models have been estimated as suggested by related literature.

The main econometric models used in this paper include: (a) a Propensity Score Matching (PSM) model without fixed-effects as a baseline, (b) a Propensity Score Matching (PSM) model with fixed-effects (with time and household fixed effects), and (c) a Propensity Score Matching (PSM) model with instrumental variables, to address any possible endogeneity issues.

3.4.1 Ordinary Least Squares Model

Equation 1 above as defined, is the model to be estimated. This model is proposed to be used a baseline upon which the other models are built and compared. The unobservable fixed effect in an ordinary least squares model (OLS) which captures household specific heterogeneity is potentially correlated with the explanatory variables and thus would need to be controlled for. If this is not done, the coefficient estimates produced by regression would be inconsistent due to a bias from omitted variables. One way of correcting this problem is by the use of a fixed-effects model (Murtazashivili & Wooldridge, 2008). At the same time, this is also a way of controlling the potential endogeneity of crop choice as shown from the previous chapter where a better-off farmer could be more likely to grow cash crops, but we go on to use other techniques to further diminish the possibility of these biases influencing the results.

3.4.2 Propensity Score Matching with Fixed Effects (PSM-FE)

The main problem with using the vanilla FE model described above is one of incomplete information, because we only observe whether a farmer has planted cash crops or not, and the respective food security outcomes, but we cannot observe the food security of the cash-crop households if those same households grew food crops instead, thus a proper counterfactual is lacking for each of the groups. Also as previously stated, the decision a farmer makes on the type of crop to produce is not a random decision. This explains why a simple comparison between the food security outcomes of cash crop farmers against food crop farmers is likely to yield an incorrect result.

To explain the problem more formally, we make use of the Roy-Rubin model (Roy (1951), Rubin (1973a, 1973b, 1974)), otherwise known as the potential outcomes framework. Here, the main elements are the individual farm households, the treatment (whether the household grew cash crops) and the potential outcomes (Y). In the case of a binary treatment variable, as we have here, the treatment indicator D_i would equal one ($D_i = 1$) if household i was treated and zero ($D_i = 0$) otherwise. Thus, the potential outcomes could be defined as $Y_i(D_i)$ for each household i, where $i = 1, \ldots,$ N and N denotes the total population. This would mean that there are two potential outcomes for each household: either $Y_i(1)$ or $Y_i(0)$. Using the information we have thus far, we could write an equation for the treatment effect for a household i (τ_i) as:

$$\tau_i = E(Y_i(1) - Y_i(0)) \tag{2}$$

This means that τ_i represents the expected value of the difference in outcomes of a household if that household grew cash-crops or if it did not.

However, out of these two potential outcomes for the same household, only one of them can be possible at any one time. Thus, the household treatment effect, τ_i

cannot be obtained and we would have to make do with estimating the average treatment effects on all the treated (ATT).

The ATT can be defined in the following way using this framework:

$$\tau_{ATT} = \mathrm{E}[\mathrm{Y}(1) - Y(0)|\mathrm{D} = 1] \tag{3}$$

In the case of the ATT, the same issue stated above exists here – the actual counterfactual mean outcome for the households that grow cash crops ($\mathrm{Y}(0)$) is not observed. However, in this case, since this is an average effect, it is possible to seek for a substitute that could perform a similar function to the unobserved counterfactual. One possibility could be to use the mean outcome of the households that grew food crops, ($\mathrm{E}[\mathrm{Y}(0)]$). This is however not a strictly good idea because it is likely that the variables which influence the decision to grow cash crops are also variables which influence the food security outcomes (Caliendo and Kopeinig, 2005). In practical terms, what this means is that even if all the farmers grew food crops and none grew cash crops, there could still be a difference in food security between the two virtual groups of farmers (in this hypothetical scenario, the difference between the two groups should be zero since one of the groups is an empty set), leading to a kind of self-selection bias. Further transformations of equation 3 would lead to the following specification which could now be defined as:

$$\mathrm{E}[\mathrm{Y}(1)|\mathrm{D} = 1] - \mathrm{E}[\mathrm{Y}(0)|\mathrm{D} = 0] = \tau_{ATT} \underbrace{+ \mathrm{E}[\mathrm{Y}(0)|\mathrm{D} = 1] - \mathrm{E}[\mathrm{Y}(0)|\mathrm{D} = 0]}_{Self-Selection\ Bias} \tag{4}$$

With random assignment to treatment, such as in Randomized Control Trials (RCTs), this condition is satisfied by construction, and thus a treatment effect can be directly identified. In cases like that of the subject of this paper, there would have to be some further identifying assumptions made in order to solve the problem of missing counterfactuals.

The first of these assumptions is the Conditional Independence Assumption (CIA), otherwise known as *Unconfoundedness* (Rosenbaum & Rubin, 1983). The idea here is to assume that given a set of covariates **X** which are not influenced by the decision to grow cash crops, the potential outcomes are independent of assignment to treatment. This can be formally written as:

$$Y(0), Y(1) \perp D|\boldsymbol{X}, \qquad pr(D = 1|\boldsymbol{X}) \epsilon\ (0,1) \tag{5}$$

where $\mathbf{X}$ is some multidimensional conditioning set and $\perp$ denotes independence.

The implication of this assumption is that the choice to grow cash crops is solely based on certain characteristics that can be observed and that variables which influence both choice of crop and food security outcomes are observed. This is obviously a strong condition, but there is good evidence from the data that this might be satisfied. More discussion on this would be made in the discussion of the results. However, in order to account for the possibility that this condition is unfulfilled, the specifications in the following paragraphs of doing the same analysis with propensity scores and instrumental variables are applied.

Fallout from this assumption is that when the vector $\mathbf{X}$ is of a high dimension, conditioning on all relevant covariates is limited (Rosenbaum and Rubin, 1984). Rosenbaum and Rubin (1984) therefore suggest the use of what they called "balancing scores". They showed that the potential outcomes would be independent of treatment conditional on some balancing score b($\mathbf{X}$), if they were also independent of treatment conditional on the covariates $\mathbf{X}$. An example of such a balancing score is the propensity score, which can be defined as:

$$P(D = 1|\boldsymbol{X}) = P(\boldsymbol{X}) \tag{6}$$

In terms of this research, this means that the probability for a farm household to grow cash crops given the observed covariates $\mathbf{X}$ of the household, is the balancing propensity score: $P(\boldsymbol{X})$. Therefore, the CIA assumption can be rewritten based on the propensity score thus:

$$If\ Y(0), Y(1) \perp D|\boldsymbol{X}, \qquad pr(D = 1|\boldsymbol{X})\ \epsilon\ (0,1)$$

$$and\ 0 < P(\boldsymbol{X}) < 1\ for\ all\ \boldsymbol{X} = x$$

$$then\ Y(0), Y(1) \perp D|P(\boldsymbol{X}) \tag{7}$$

The second assumption required in order to solve the problem of the missing counterfactuals is normally known as the Common Support assumption. This further condition is one that emphasises overlap between groups. It can be represented as:

$$Pr(D = 1|\boldsymbol{X}) < 1 \tag{8}$$

The main implication of this assumption is that it ensures that households with the same $\mathbf{X}$ values have a positive probability of both growing cash crops and food crops. It drops households who have zero probability of taking on the treatment, as well as households who would always take treatment with a probability of 1 (Heckman, LaLonde, & Smith, 1999). Therefore, this matching method properly identifies a restricted control group that better approximates the treatment group based on the pre-treatment attributes of the households.

Given these two assumptions, the propensity score matching (PSM) estimator for ATT can be written as:

$$\tau_{ATT} = \mathrm{E}[\mathrm{Y}(1)|\mathrm{D} = 1, \mathrm{P}(\mathbf{X})] - \mathrm{E}[\mathrm{Y}(0)|\mathrm{D} = 0, \mathrm{P}(\mathbf{X})]$$

$$= \mathrm{E}[\mathrm{Y}(1) - \mathrm{Y}(0)|\mathrm{P}(\mathbf{X})] \tag{9}$$

In essence, this PSM estimator is the mean difference in food security outcomes of the two groups over the common support area and weighted appropriately by the propensity score distribution of the households.

After creating propensity scores for growers of cash-crops and food crops in each year, the fixed-effects estimation technique was also implemented to control for the time-invariant factors that would influence the food security variables. In the first stage, a logit regression is carried out to determine selection into treatment, and then based on the obtained propensity scores, the two groups are matched using different techniques.

3.4.3 Propensity Score Matching with Instrumental Variables (PSM-IV)

The model described above addresses specification issues regarding household-specific heterogeneity which do not vary over time between the now matched treatment and control groups. This would include things like differences in soil quality, topography, regions etc. However, if we suspect that the choice to grow cash crops is endogenous (i.e $Cov(CashCrop_{i,t}, \epsilon_{i,t}) \neq 0$) due to factors which do vary with time such as the amount of the stored seeds used in production (as was established in the previous chapter), then the coefficient estimates might still be inconsistent and would need to be controlled for. To address this, the same model as specified above is re-estimated, but this time using the instrumental variable approach.

Heckman, Ichimura & Todd (1997) explain that the average treatment effect can also be identified through an instrumental variable, Z under these conditions:

$$\mathrm{E}(\mathrm{Y}|\mathrm{Z},\mathbf{X}) = \mathrm{E}[\mathrm{Y}(0)|\mathbf{X}] + \mathrm{E}[\mathrm{Y}(1) - Y(0)|\mathrm{X}]P(Z,\boldsymbol{X}) \tag{10}$$

$$\mathrm{Var}[\mathrm{E}(\mathrm{D}|\mathrm{Z},\mathbf{X})|\mathbf{X}] \neq 0 \tag{11}$$

where $P(Z,\boldsymbol{X}) \equiv Pr(D = 1|Z,\boldsymbol{X})$.

According to Heckman et al. (1997) when the Y is estimated here by OLS on a constant term and the $P(Z,\boldsymbol{X})$ term, it would yield $\mathrm{E}[\mathrm{Y}(1) - Y(0)|\mathrm{X}]$ as a Wald-type estimator. Thus, the conditioning variable D in the previous equations is replaced by Z.

This formulation would work when the instrument Z is a discrete variable just like the treatment (D). If Z is not a natural dummy, it could be transformed into one by the use of a threshold above which there is a switch from 0 to 1. If we assume a discrete Z, in this case given $\boldsymbol{X}$, $P(Z,\boldsymbol{X})$ would take on discrete values. Following the procedure laid out by Ichimura and Taber (2001), if the assumptions of equations 10 and 11 above are satisfied, one can theoretically condition on these two arguments:

$$P(\boldsymbol{X}) = E[P(Z,\boldsymbol{X})|\boldsymbol{X}] \tag{12}$$

$$Q(\boldsymbol{X}) \equiv E[P^2(Z,\boldsymbol{X})|\boldsymbol{X}] \tag{13}$$

This is a simplifying statement because it should be noted that if Z is D, then $P(Z,\boldsymbol{X}) = D$ and the two statements $E[P(Z,\boldsymbol{X})|\boldsymbol{X}]$ and $E[P^2(Z,\boldsymbol{X})|\boldsymbol{X}]$ reduce to $E[D|\boldsymbol{X}]$, which is the propensity score[9]. The implication of this is that in the special case where Z is a dummy and Z and X can be used as instruments for D, the method can be seen as a generalisation of the standard propensity-score matching

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[9] Note that $\frac{Cov[Y,[P(Z,\boldsymbol{X})|\boldsymbol{X},\ Q(\boldsymbol{X})]}{Var[P(Z,\boldsymbol{X})|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]}$
$= (E[Y\,P(Z,\boldsymbol{X})|P(\boldsymbol{X}),\ Q(\boldsymbol{X})] - E[Y|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]E[P(Z,\boldsymbol{X})|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]) \times (Var[P(Z,\boldsymbol{X})|P(\boldsymbol{X}),\ Q(\boldsymbol{X})])^{-1}$

Also, $E[Y\,P(Z,\boldsymbol{X})|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]$
$= E[E(Y(0)|\boldsymbol{X})P(Z,\boldsymbol{X})|P(\boldsymbol{X}),Q(\boldsymbol{X})] + E[E(Y(1) - Y(0)|\boldsymbol{X})|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]$
$= E[Y(0)|P(\boldsymbol{X}),Q(\boldsymbol{X})]P(\boldsymbol{X}) + E[Y(1) - Y(0)|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]Q(\boldsymbol{X})$

Similarly, $E[Y|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]$
$= E[Y(0)|P(\boldsymbol{X}),\ Q(\boldsymbol{X})] + E[Y(1) - Y(0)|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]P(\boldsymbol{X})$

And $Var[P(Z,\boldsymbol{X})|P(\boldsymbol{X}),\ Q(\boldsymbol{X})] = Q(\boldsymbol{X}) - P^2(\boldsymbol{X})$

Therefore, $\frac{Cov[Y,[P(Z,\boldsymbol{X})|\boldsymbol{X},\ Q(\boldsymbol{X})]}{Var[P(Z,\boldsymbol{X})|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]}$
$= E[Y(1) - Y(0)|P(\boldsymbol{X}),\ Q(\boldsymbol{X})]$.

technique (much in the same way the OLS can be seen as a special case of the two-stage least squares).

To implement the strategy, the mean of $\mathrm{Y}(1) - \mathrm{Y}(0)$ conditional on $P(\boldsymbol{X}) = E[P(Z, \boldsymbol{X})|\boldsymbol{X}]$ and $Q(\boldsymbol{X}) \equiv E[P^2(Z, \boldsymbol{X})|\boldsymbol{X}]$ is estimated by the sample version of:

$$\frac{Cov[Y,\ [P(Z, \boldsymbol{X})|\boldsymbol{X}, Q(\boldsymbol{X})]}{Var[P(Z, \boldsymbol{X})|P(\boldsymbol{X}), Q(\boldsymbol{X})]}$$

This is quite similar to the kernel-based matching estimator suggested in Heckman et al. (1997, 1998).

The first-stage model to be estimated is therefore specified as follows:

$$CashCrop_{it} \ = \ \beta_0 \ + \beta_1 Z_{it} \ + \beta_2 \boldsymbol{X}_{it} \ + \delta_t + \lambda_i + \ \varepsilon_{it} \tag{14}$$

Where: Z_{it} is the instrument for crop choice, $\boldsymbol{X}_{it}$ is a vector of controls, δ_t is the time effect, λ_i is the household fixed effect and ε_{it} is the error term.

The instrument being made use of here is the product of the average FAO international food price indices for 2010 and 2012 first differenced and the distance of the household from the nearest international border crossing:

$$Z_{it} \ = \ price\ volatility\ x\ distance\ to\ border$$

As earlier discussed, this continuous variable is first discretized in order for it to be used as an instrument for the dummy variable signifying treatment in this case: crop choice. This is done by averaging this variable over $Q(\boldsymbol{X})$ as defined above in equation 13 (i.e $Q(\boldsymbol{X}) \equiv E[P^2(Z, \boldsymbol{X})|\boldsymbol{X}]$). In practical terms, the instrument is used in the first stage logit equation along with other covariates to determine the probability of choosing to grow cash crops, and then the propensity scores obtained are squared and used to discretize the instrumental variable. The division is based on the Mahalanobis or distance kernel matching technique as suggested by Heckman et al. (1997). The farmers who have similar propensity scores of crop-choice and the Z index outcomes are grouped. According to Ichimura and Taber (2001), this could lead to some loss of efficiency in the discretising process, but it adds the advantage of controlling for any remaining heterogeneity contained within the crop-choice variable itself.

This variable works as an instrument because it creates a time varying parameter which is exogenous to the original regression ($Cov(z, \varepsilon) = 0$), and it is correlated with the choice of growing cash crops ($Cov(z, cashcrop) \neq 0$. This correlation still holds after the discretisation procedure. In addition, it does not belong in the original model to be estimated. The price volatility index is the source of time variation (if it is assumed that the households do not move between survey periods).

This distance component of the instrument is also exogenous to the original regression because there is no apriori expectation that food security outcomes would be related with distances from the closest borders. In other words, households living closer to an international border are not expected to have significantly more or less food expenditure, number of meals a day and/or food diversity than households that live further away. This is also reflected in the relatively low calculated correlation score of 0.03 between the instrument and number of meals per day and 0.06 between the instrument and the household food consumption score. However, the instrument is also shown to be highly correlated with the choice of crop that households grow. Thus, it qualifies as a strong instrument for crop-choice (further evidence for this is provided in the results below). The rest of the method proceeds as described above.

3.5 Data

In this paper, we utilize the two- period Nigerian General Household Survey – Panel (GHS-Panel). This survey was conducted for the 2010/11 and 2012/13 agricultural seasons. It is the most comprehensive household survey panel for Nigeria and is part of the World Bank's Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) series. It was conducted as a collaboration between the Nigerian Bureau of Statistics (NBS), the Federal Ministry of Agriculture and Rural Development (FMA&RD), the National Food Reserve Agency (NFRA), the Bill and Melinda Gates Foundation (BMGF) and the World Bank.

It is nationally representative as it covers all 36 states of the country and the Federal Capital Territory (FCT). According to the survey documentation, a two-stage probabilistic sampling technique was used to select clusters (or neighbourhoods) at the first stage and then the households to be included were selected in the second stage. Clusters were selected from the states and the FCT, and sampling was done in both urban and rural Enumeration Areas (EAs). The survey had both cross-section and panel components in the two waves, but we make use of the panel portion because if focuses more on the agricultural decisions of smallholder farmers during the planting season and after harvest and the extra information allows for the use of better econometric methods. The questionnaires draw heavy inspiration from the Harmonized Nigerian Living Standard Survey (HNLSS) and the National Agricultural Sample Survey (NASS).

For the GHS-Panel, 5,000 households were surveyed out of the 22,000 in the full sample. As mentioned above, the survey for each wave was done in two stages: during the post-planting period once in 2010 and once in 2012; and during the post-harvest period once in 2011 and once in 2013. Furthermore, the post-planting survey was done for the entire 22,000 households in the cross-sectional dataset, but the post-harvest survey was done to give further information about the 5,000 households in the panel dataset.

The GHS survey consists of three detailed questionnaires that cover a wide range of socioeconomic topics and concerns. They are: the Household Questionnaire, the Agricultural Questionnaire and the Community Questionnaire. These questionnaires contain information on the farmers and the communities they reside in such as: their demographic and migration characteristics, education, credit and savings, household assets, labour market outcomes, entrepreneurship and non-farm enterprises, household food and non-food expenditures, food security and many other topics.

We have used the household questionnaire to obtain information on the demographic and food security variables required for this research. There are quite a few questions which deal directly with how much food is consumed within the farming households, the quality, diversity and frequency of this food, the sources of this food, and for if the households ever felt they were in danger of going without food for stretches of time. The module with the agricultural questionnaire was also used to obtain information on the crops the farmers grow on their fields and if this has changed over time. It also includes many other variables which have been used as controls in this research.

This dataset has many advantages which include its comprehensiveness, the fact that it has repeat observations for each farm household, its representativeness, and its focus on agricultural households. According to the data documentation, there is also only a negligible amount of attrition in the sample.

3.6 Results and Analysis

3.6.1 Descriptive Statistics

Table 2 presents the first stage logit estimates used in the formation of the propensity scores which were the foundation for matching. The common support restriction was imposed on all specifications in the estimation of the propensity scores thus allowing households with the similar characteristics of confounding factors to be evaluated with a similar level of probability of selection into treatment (Heckman, Ichimura et al. 1997). The logit model has an average McFadden pseudo R^2 value of around 0.29 and significant chi-square values.

Table 2: Estimation of the propensity scores (first-stage logit specification)

Logit Specification	**HDDS**	**Food Consumption per capita**	**Squared Difference of food consumption per capita**	**Days with no food**
	Coefficients			
	(1)	(2)	(3)	(4)
Household per capita expenditure	0.221*** (0.028)	0.221*** (0.028)	0.221*** (0.028)	0.223*** (0.028)
Married	-0.009* (0.004)	-0.009* (0.004)	-0.009* (0.004)	-0.011** (0.004)
Rural	0.095 (0.121)	0.073 (0.121)	0.073 (0.121)	0.075 (0.122)
Household size	-0.029 (0.025)	-0.029** (0.065)	-0.030** (0.070)	-0.021 (0.026)
Sex of household head (Male=1)	-0.014 (0.202)	-0.034 (0.202)	-0.034 (0.202)	-0.001 (0.203)
Number of dependents	0.028 (0.033)	0.030 (0.034)	0.029 (0.034)	0.018 (0.034)
Age of household head	0.002 (0.001)	0.001 (0.001)	0.001 (0.001)	0.002 (0.001)
Educational level of household head (log)	0.591*** (0.110)	0.653*** (0.213)	0.620*** (0.812)	0.620*** (0.812)
Farm size	-0.001 (0.002)	-0.001 (0.003)	-0.001 (0.003)	-0.001 (0.003)
Price Volatility x Distance to border (km)#	0.001*** (0.00)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Access to export market	-0.10*** (0.046)	-0.10*** (0.046)	-0.10*** (0.046)	-0.19*** (0.046)
McFadden Pseudo R^2	0.290	0.250	0.251	0.29
Model chi-square	176.56***	177.71***	177.35***	180.96***
Log likelihood ratio	-1840.398	-1841.735	-1841.912	-1800.198
No. of observations	2904	2904	2908	2844

Note: Standard errors in parenthesis. *Significant at 10% level **Significant at 5% level ***Significant at 1% level

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

3.6.2 Propensity Score Matching Estimates

After balancing, the descriptive tests reported in Table 2 show a marked reduction in differences between the treated and control group in the means of several covariates. Figure 3 shows how closely the pseudo counterfactual group matches the treated group when common support is maintained.

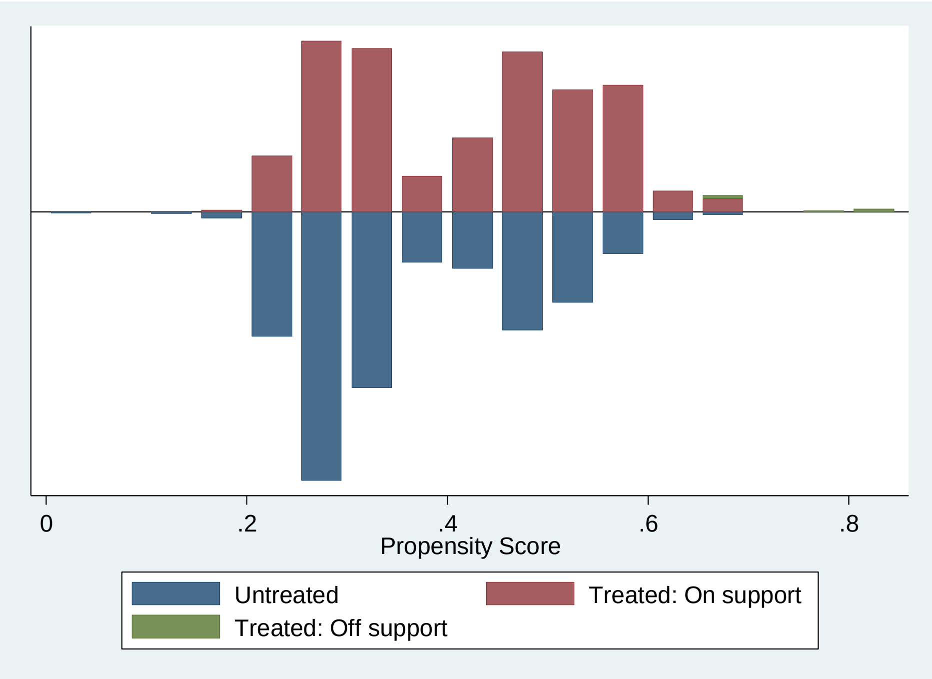

Figure 3: Propensity score distribution and common support after matching. Note: "Treated: on support" indicates the observations in the cash crop group that have a suitable comparison. "Treated: off support" indicates the observations in the cash crop group that do not have a suitable comparison. *Source:* Author's calculation.

Table 3 presents some descriptive information on some of the variables included in the analysis regarding the differences between the farm households who grew cash crops and those who did not, as well as the level of significance of these differences.

The results show that there are no significant differences between the two groups as it relates to the food consumption per capita and the number of days in the past week without any food. However, there is a significant difference as it regards the squared difference from mean food consumption per capita and the household dietary diversity score. Other results show an average household size of about 6 members; the average age of the household head of about 52 with all of these showing a significant difference between the cash crop and non-cash crop groups.

Table 3: Differences in characteristics between cash-crop and non-cash crop farming households on balancing

	Wave 1			Wave 2		
	Cashcrop	Non-cashcrop	Difference (%)	Cashcrop	Non-cashcrop	Difference (%)
Food consumption per capita (log)	11.071	11.098	-0.002	11.014	11.001	0.001
Squared difference from mean of Food consumption per capita (log)	20.445	20.384	0.003	20.349	20.231	0.006
Number of days in past week without food	0.095	0.043	1.209	0.071	0.075	-0.053
Household Dietary Diversity Score	55.691	55.576	0.002	55.483	54.889	0.011
Household size	6.453	6.062	0.065	6.371	6.424	-0.008
Sex of household head (Male=1)	0.837	0.910	-0.080	0.886	0.885	0.001
Number of dependents	3.019	3.295	-0.084	3.176	3.120	0.018
Age of household head	54.795	50.108	0.094	53.431	51.853	0.030
Educational level of household head (log)	23.263	18.860	0.233*	19926	20499	-0.028*
Farm size (ha)	1.404	2.223	-0.368	1.321	1.694	-0.220
Distance to border (km)	365.003	303.063	0.204*	365.003	303.063	0.204*
Access to export market	0.660	0.442	0.493	0.755	0.330	1.288
No. of observations	1104	1806	-0.389	660	2281	-0.711

* Indicates that the differences between cashcrop and non-cashcrop farming households are statistically significant at the 95% level (the t-test is used for differences in means).

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

It also shows that the average number of dependents is 3 per household and there was an average of 85 percent of the sample being households headed by males. The average age of the head of the household was between 52 and 53, with the households choosing to grow cash crops being headed by slightly older people. This difference in age being significant might indicate that farm households with more experience in farming are the ones that are more likely to be capable of shouldering the extra risk associated with the "high-risk, high-return" cash crop sector. This is against the argument that younger farmers may want to be trendier in their choice of crop.

3.6.3 Results

There are four tables (Tables 4, 5, 6 and 7) which present the results of the model estimations for the four different indicators of food security considered in this paper: the household dietary diversity score, the food consumption per capita, the squared difference from mean of food consumption per capita, and the number of days with no food respectively.

Table 4: Average treatment effects on the treated (ATT) of Crop Choice on *log (Household Dietary Diversity Score, HDDS)*

Matching algorithms	Without fixed effects (1)	With fixed effects (2)	With IV (3)
NNM[a]	0.018*** (0.005)	0.015** (0.004)	0.011** (0.006)
KBM[b]	0.019*** (0.121)	0.019** (0.121)	0.019** (0.121)
RBM[c]	0.023*** (0.006)	0.020*** (0.006)	0.012** (0.004)

Note: Absolute values of bootstrapped standard errors in parenthesis. *Significant at 10% level **Significant at 5% level ***Significant at 1% level. a NNM = single nearest neighbour matching with replacement, common support. b KBM = kernel-based matching with band width 0.06, common support. c RBM = radius-based matching with radius 0.03, common support.

The first columns of results are the pooled specifications without fixed effects, fixed effects are added in the second columns and the third columns are with the use of instruments as described above. The tables report the average treatment effect of growing cash crops on the food security outcomes of those farming households using the nearest neighbour, kernel based, and radius based matching techniques.

For the household dietary diversity score, the results indicate that growing cash crops improves the dietary diversity of foods consumed within those households significantly by an average of about 1.5%. Using the kernel based matching technique; the effect is 1.9% across the different model specifications. Even though this may appear to be a small effect in terms of absolute amounts, the persistent significance of this result across the different models cannot be ignored. The implication of this result is that farming households who grow cash-crops are more likely to consume a more diverse diet, the antithesis of which is that the households who grow food crops are more restricted in their choices. This result is expected because the farmers who grow food crops may be constrained to consume more quantities of the particular crop(s) which they produce as against the alternative of selling them in the market in order to purchase a more balanced food mix. In this sense, if the crop that was being grown is of limited household use but greater industrial use, there would be greater pressure to sell in order to purchase food for domestic consumption. However, with the use of instrumentation, the effect of crop choice on food diversity is reduced, albeit still significant.

Table 5: Average treatment effects on the treated (ATT) of Crop Choice on *log (Food Consumption per capita)*

Matching algorithms	Without fixed effects (1)	With fixed effects (2)	With IV (3)
NNM[a]	0.621*** (0.0387)	0.221*** (0.028)	0.220*** (0.028)
KBM[b]	0.095 (0.221)	0.073 (0.121)	0.073 (0.121)
RBM[c]	0.014 (0.302)	0.034 (0.202)	0.024 (0.22)

Note: Absolute values of bootstrapped standard errors in parenthesis. *Significant at 10% level **Significant at 5% level ***Significant at 1% level. a NNM = single nearest neighbour matching with replacement, common support. b KBM = kernel-based matching with band width 0.06, common support. c RBM = radius-based matching with radius 0.03, common support.

Table 5 shows the results for the impact of growing cash-crops on the food consumption per household member food security indicator. The analysis indicates significant effects of cash-crop production on the overall food consumption levels of the farming households (when divided by the number of individuals in the household) only using the nearest neighbour matching specification. This parametric result may be expected because from the naïve comparison between cash-crop and food-crop groups, there was an indication of significant differences using this measure of food security. However, this effect is not noticed in any of the other matching specifications, which may be a surprising result because of the papers that have hypothesised that growing cash crops could improve farmer welfare and thus the overall food consumption (Von Braun, 1995; Kennedy et al., 1992; Kuma et al., 2018). But these results indicate that even though there may be income improvements (which is not directly measured here), such extra income may not be normally spent on a higher total caloric intake of food, but rather on a greater diversity of the food mix. The pattern that appears (in conjunction with the previous result) is that even though growing cash-crops may not be a consistently major determinant of the overall quantity of food available for consumption, the models predict cash-crop production to have positive effects on the overall quality of nutrition available to the household consistently. It is also possible that any improvement in incomes are spent on things totally different from food, for example on more leisure activities.

Table 6: Average treatment effects (ATT) of Crop Choice on *log (Squared Difference from mean of Food Consumption per capita)*

Matching algorithms	Without fixed effects (1)	With fixed effects (2)	With IV (3)
NNM[a]	0.131*** (0.04)	0.110*** (0.028)	0.094*** (0.05)
KBM[b]	0.073*** (0.011)	0.058*** (0.009)	0.057*** (0.005)
RBM[c]	0.145*** (0.022)	0.034*** (0.022)	0.034*** (0.05)

Note: Absolute values of bootstrapped standard errors in parenthesis. *Significant at 10% level **Significant at 5% level ***Significant at 1% level. a NNM = single nearest neighbour matching with replacement, common support. b KBM = kernel-based matching with band width 0.06, common support. c RBM = radius-based matching with radius 0.03, common support.

The squared difference from the sample mean food consumption score as a measure of food security was intended to capture the severity of household food shortfalls from the average household's food consumption. Thus, in strict comparison to the "average household", in a sense it incorporates how much the choice of crop affects inequality of food consumption. In order to account for the severity in actual shortfalls in dietary energy requirements, this measure was also replaced with the squared difference of per capita household consumption from the recommended minimum national energy requirements (measured in kcal/individual) in the same analysis, with no significant difference. From Table 6, the effects of cash-crop production here are positive and significant. The results show that for households below the average, growing cash-crops would cause a more severe gap to develop between them and the typical household in terms of food consumption. Using the nearest neighbour matching technique and fixed effects, this effect is 11%, but drops to 9.4% with the use of instrumentation. The implication of this result is that for those households which are already below average in food consumption (among the sample), the choice to grow cash-crops could worsen their food consumption situation faster than growing food crops. This result is important because it expresses a warning for policy-makers intent on encouraging cash-crop production to be wary of the fact that there may be a pre-existing threshold below which engaging in the production of cash crops, which are often riskier, could leave them worse off in terms of food security.

Table 7: Average treatment effects on the treated (ATT) of Crop Choice on *Number of Days with No Food*

Matching algorithms	Without fixed effects (1)	With fixed effects (2)	With IV (3)
NNM[a]	-0.032 (0.096)	-0.021 (0.088)	-0.021 (0.048)
KBM[b]	-0.095 (0.191)	-0.073 (0.120)	-0.073 (0.120)
RBM[c]	-0.014 (0.202)	-0.024 (0.042)	-0.024 (0.042)

Note: Absolute values of bootstrapped standard errors in parenthesis. *Significant at 10% level **Significant at 5% level ***Significant at 1% level. a NNM = single nearest neighbour matching with replacement, common support. b KBM = kernel-based matching with band width 0.06, common support. c RBM = radius-based matching with radius 0.03, common support.

The final way that food security has been represented in this research is by the use of the number of days the farm household had gone without food in the recall period of the last 5 days prior to the interview. The results in Table 7 show that there is no significant effect of choosing to grow cash-crops on the number of days without food. Even with the lack of statistical significance, it is instructive to note that all the coefficients from the different model specifications turn out negative suggesting that there may be an inverse relationship between growing cash crops and at the minimum, having something for the family to eat.

3.7 Robustness checks

In this sub-section we examine the robustness of the results to within-household correlation effects, if there are any issues regarding the validity of the instrument or the attrition rates.

Table 8 reports results of the same models of food security outcomes and the choice in favour of cash-crop production where the standard errors have been clustered by household. Also, two different radius matching models of higher and lower radii have been included to check the sensitivity of the previously reported results. If the households behave as a unitary model, food consumption and days without food variables are likely to be correlated between household members.

Table 8 compared to Tables 4-7 produce similar results except for some differences in standard errors. However, cash-crop production now has a statistically significant effect on the number of days of without food using a different radius or calliper of (0.5) and cash-crop production is also significant using other matching technique.

One argument against the validity of our instrument could be that the international food price vector interacted with the distance from borders could affect some of the food security measures directly. For example, it could be the case that the households which are closer to the borders could have better access to food varieties due to the cross mixing of cultures. This hypothesis is tested directly with a linear probability fixed effects model of the effect of distance-price interaction on the different food security measures. There was no evidence of a statistically significant effect in this sample.

Attrition rate, which is often a concern in longitudinal household surveys such as the one used for this analysis, was confirmed to be too low to cause concern (2.4%), and the main reason given for drop-outs is the household moving away from the area which is quite random. However, to check for the robustness of the results to attrition bias, a sample of the regressions were re-run, using a balanced panel of households that completed both waves, to compare whether the estimates produced are similar. The results showed the sign and size of the effect of cash-crop production on food security to be generally unchanged.

Table 8: Some average treatment effects (ATT) and results of sensitivity analysis

Matching algorithm	Outcome	ATT
Nearest neighbour matching (clustered standard errors)	Log(Household Dietary Diversity Score)	0.018*** (0.002)
	Log(Food Consumption per capita)	0.621*** (0.155)
	Log(Squared Difference from mean of Food Consumption per capita)	0.131*** (0.026)
	Number of days without food	-0.032 (0.08)
Radius-based matching (radius 0.1)	Log(Household Dietary Diversity Score)	0.019*** (0.003)
	Log(Food Consumption per capita)	0.014** (0.0056)
	Log(Squared Difference from mean of Food Consumption per capita)	0.147*** (0.043)
	Number of days without food	-0.055 (0.10)
Radius-based matching (radius 0.5)	Log(Household Dietary Diversity Score)	0.034*** (0.0085)
	Log(Food Consumption per capita)	0.014*** (0.0028)
	Log(Squared Difference from mean of Food Consumption per capita)	0.144*** (0.010)
	Number of days without food	-0.108* (0.072)

Note: t-values in parenthesis. **Significant at 5% level. ***Significant at 1% level

Source: Author's calculation based on the Nigerian LSMS data for 2011 and 2013

3.8 Conclusion

This paper set out to determine if the choice of a farmer to grow cash crops or food crops would have a significant effect on the food security outcomes of that household. The results show that this relationship is not quite straightforward due to the competing income and local food needs effects. The question is an important one because it lends itself to the ongoing cash crop vs food crop debate as to which is preferable as a source of policy focus if the objective of food security is to be achieved.

The results showed that in general growing cash crops has a positive effect in improving food security. However, this effect is demeaned when access to export markets and fluctuations in international food prices is taken into account. These results from the PSM counterfactual technique are likely to be of value in the prediction of the food security effects of changing crop promotion policies.

The results show that for households who are already below the average level of food consumption, growing cash-crops would cause a more sever gap to develop between them and the typical household in terms of food consumption. There were however no effect of growing cash crops on the number of days a family went without food. Food quality represented by the household dietary diversity score was also shown to be improved among farm households that produced cash crops.

Overall, there appears to be some scope for improving the food security outcomes of small-holders by crop promotion policies in conjunction with appropriate export promotion. This is because what is crucial to this question is not just the type of crop grown but the opportunities for marketing and other general value-chain improvements.

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Chapter 4

Determinants of Food Imports in Africa: A Dynamic Panel Approach

Summary

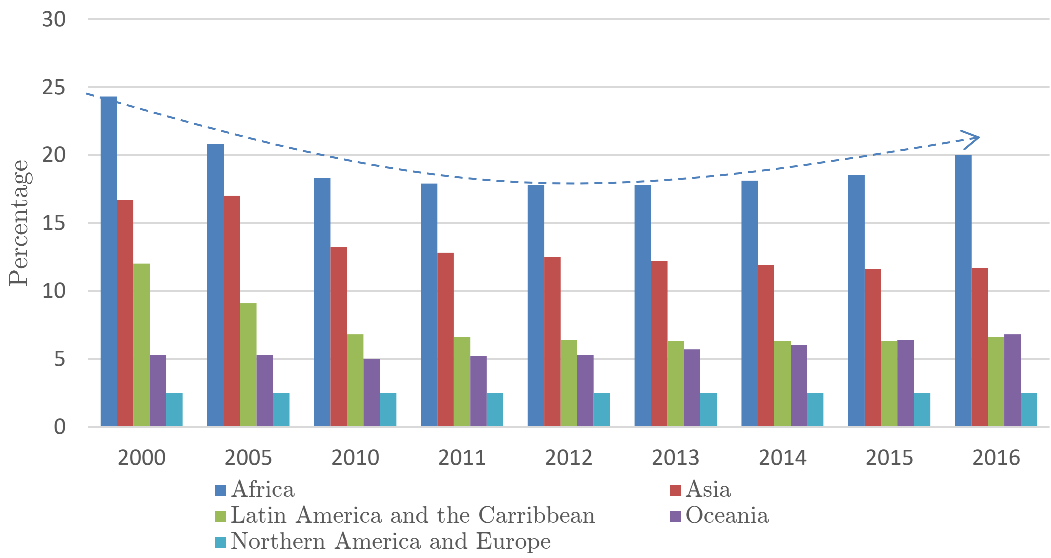
This paper examines the determinants of food availability at the national level from the perspective of food imports in African countries. The system-GMM method is adopted for this purpose to account for the endogeneity of variables in a dynamic model. The results show that past import levels, food aid, armed conflicts, food price fluctuations, as well as overall income per capita levels were some of the influential factors for food-security sufficient food imports. The expectation was that there would be a one-to-one relationship between food imports and domestic food production after accounting for the other cofactors responsible for determining food imports. In reality, the results showed that a 1% decrease in domestic food production corresponds to only about a 0.72% increase in food imports in the OLS specification and a 0.40% increase in the system-GMM specification. The consequence of this is that the difference between these numbers and the expected 1% food import increase if otherwise unexplained, would result in the reduction in food consumption levels in the country (or increased food insecurity).

Keywords: Food Security, Food Availability, Food Imports, System-GMM, Africa

4.1 Introduction

Ensuring food security for all, especially in Africa has been a major challenge the world has tried to solve in the last few decades. This motivated *Goal 1* of the United Nations' Millennium Development Goals (MDGs) as well as the the newer 2030 Agenda for Sustainable Development (otherwise known as the Sustainable Development Goals, SDGs) and the United Nations' Decade of Action on Nutrition 2016-2025, which are all calls on every nation and stakeholder to act collectively to end hunger and prevent malnutrition in all forms by 2030. The State of Food Insecurity (SOFI)[10] report of 2017 by the Food and Agricultural Organisation (FAO, 2017b) states that in 2016 the number of chronically malnourished people had actually increased for the first time in decades from 777 million in 2015 to 815 million, which is about a 5% increase in one year. As shown in Figure 1, even though this number is lower than the year 2000 levels of about 900 million, the increase is still a troubling setback. For Africa in particular, the situation is worse. FAO (2017b) indicates that on average between 2014 and 2016, the percentage of the African population in food insecurity was 25.9% as against 9.1% in the rest of the world, and the number of people in immediate food need now stands estimated at 243.2 million, which has increased from 218.7 million in 2015 (about an 11.2% increase).

Figure 1: The World Prevalence of Undernourishment by Regional Percentages

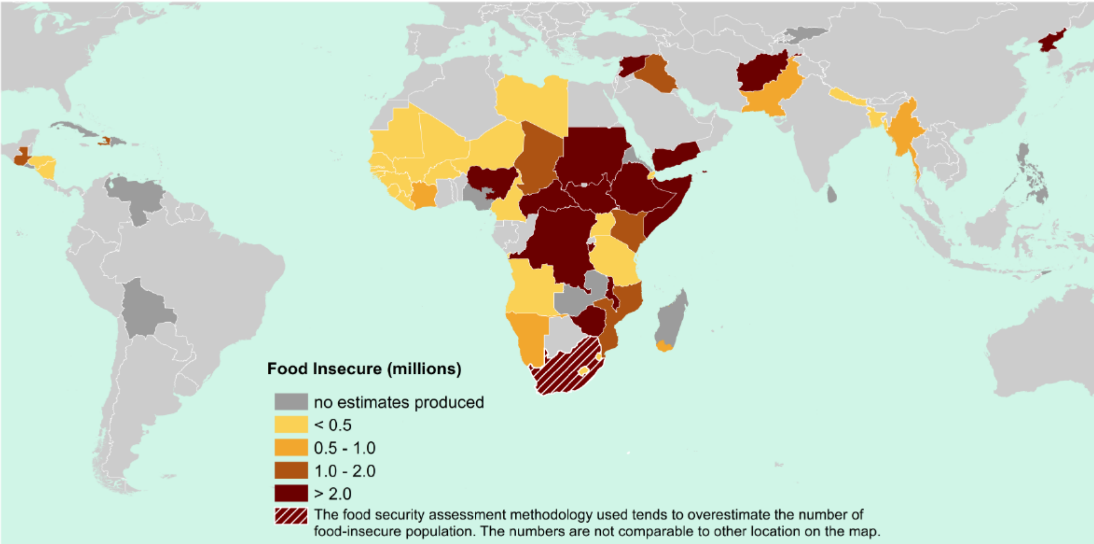


Source: FAO (2017)

[10] The State of Food Insecurity (SOFI) report is a collaborative effort representing a snapshot of the current state of food security and nutrition in the world. It is written by the Food and Agricultural Organisation (FAO), International Food for Agricultural Development (IFAD), the World Food Programme (WFP), the United Nations Children Education Fund (UNICEF), and the World Health Organisation (WHO) and published by the FAO.

As troubling as these numbers seem, the hunger situation in Africa is projected to get worse. Even though food-aid had originally been designed to be a temporary measure to make-up for specific food crises, several regions in many African countries have increasingly become more dependent on food aid than was the situation 50 years ago. In fact over the last 40 years, many African countries that had been net food exporters have become net importers (Rakotoarisoa et al., 2011; Von Grebmer et al., 2008); they not only have become more dependent on foreign aid, but are dealing with a steadily rising food bill in foreign currency which has presented new fiscal challenges to growth.

Figure 2: Level of food insecurity using FSIN data (by millions of people)



Source: Food Security Information Network, FSIN (2017)

This paper explores some of the issues regarding why many African countries are unable to maintain adequate levels of domestic food consumption over time leading to malnutrition and loss of food security. It focuses on the food import market in particular and analyses the factors that influence the volumes of national food imports when there are negative shocks to domestic production.

There is also a historical context to this study. In the 1970s, as the population of developing countries continued to increase, the argument was made that more grain would be needed to feed the people as well as livestock and if these demands could not be met, there would be justifiable fear of violent conflict over diminishing food supplies. This theory was encapsulated by Malthus (1798) after which the issues addressed at the UN conference in Rome of 1974 were largely based. This Malthusian pessimism that a growing world population would outstrip the earth's productive capacity, leading to famines and starvation has come to pass yet for the most part in the developed countries, largely because agricultural production has increased sufficiently to offset healthcare improvements which increase lifespans. However in these countries, it should be noted that there has also been a cultural influence towards having fewer children. In sub-Saharan Africa however, this has not been the case. Population growth rates have remained high and agricultural productivity improvements have not been extensive enough and this is another likely reason for the hunger (and high conflict) situation in some parts of Africa apart from the trade deficits. This angle is analysed by the inclusion of population growth in the dynamic model estimation for any effects on food imports.

Recognising this foundation, this paper seeks to focus on the determinants of international food trade in Africa and how this affects national food security. There are two main ways a country provides food for its people: through domestic production and through food imports. The prevailing wisdom is that countries should focus on the production of crops in which they have production advantages (Matsuyama, 1992). If these are food crops, they could consume their requirements domestically, export the excess and import the other foods they need but do not produce. And similarly, if these are cash crops, they could export them and then import the foods they need. In the case where this model works smoothly, there would be no food shortages; every country would have enough food (either by production or by import) as this would be the overall optimal strategy. By theory, this model should work consistently as long as aggregate food supply covers the aggregate food demand and even though it does for many developed countries, the evidence of large food shortages, malnutrition and frequent appeals for food aid indicate that it does not for some parts of Africa. The question is why not?

There are several perspectives one could take in attempting to answer this question. The first is that the national food supply system could be faulty or there are inefficiencies along the value-chain of local food production. This could happen for a variety of reasons all of which would be a representation of the usual economic problems of the allocation of scarce input resources into the most productive areas, which when not adequately solved, would lead to market failure. Solving this problem would include answering questions like: "what is the right crop to produce?" "what is the best method of production?" and "how can productivity be improved"? It would be appropriate to answer questions of these types at the level at which the decisions are made; which is mostly micro or by the household, as has been discussed in earlier chapters. Research in these areas would aim to inform policy on improving agricultural productivity and crop choice.

On the other hand, it is also possible that the market frictions are caused by some demand side problems like the inability of the consumers to afford what the available food at the going market rate. Thus by this view, countries not producing all the food they need or being able to import the difference is simply a welfare problem which can be solved by possessing more money. But if this were simply the case, then the wealthier African countries should not be experiencing any food shortages. This paper reports that even after controlling for national income, there are still discrepancies between food shortfalls and imports. It is also possible that inefficiencies occur due to problems with resource dispersal in such a way that wealth is concentrated at the top of the income distribution with a destruction of the purchasing power of the middle and lower classes (Davis, 2006). This would however still not fully explain the puzzle because in most African countries, up to 70% of the farming activity is carried out by small-holders or farmers with a land size of less than 5 hectares, who would normally be classified as middle or lower class (Collier and Dercon, 2009). If this were the case, then at least they should be able to provide food for themselves at a subsistence level, even if they do not have the resources to import. One major factor that cannot be ignored though is the fact that in agricultural enterprise, there is always some uncertainty about if or when a negative shock will occur, like a drought or a flood. This has indeed been shown to be a major reason for emergency food aid needs (Haile, 2005; Devereux, 2006; Barret, 2010).

If the above is to be taken for granted, it might be useful to study why African countries are unable to meet their food import requirements when such negative shocks to domestic production or the inability to grow locally occur. This is the perspective this paper approaches the problem from. The inability of trade to make up for any gaps in food consumption requirements could lead to a further worsening of the current food security situation and is thus an important topic to study. The market failure could be caused by any number of reasons and this paper seeks to empirically determine what the most important of these are.

If we assume that a country at some initial period has sufficient quantities of food to provide adequate nutrition for its citizens, in order to maintain its consumption levels *ceteris paribus*, the apriori expectation is that a 1% decrease in domestic food production would correspond to a 1% increase in food imports to meet this shortfall, controlling for any differences in their relative magnitudes (Kirkpatrick & Diakosavvas, 1985). Kirkpatrick & Diakosavvas (1985) suggest that if this relationship does not hold, it would be meaningful to examine why. The relevance of other factors that influence food imports apart from the shortfalls in domestic production could be studied.

This paper takes a macro-approach to understanding the food security problem in Africa by analysing what the determinants for food imports are and what factors constrain the ability of countries to purchase the food required from the international market to smooth out consumption when there are negative shocks to domestic production.

The results show that international food prices, the incidence of crisis/conflict, quantities of pre-existing food aid and other socioeconomic factors are important determinants of the food import behaviour of African countries. It is important to note here that the governments of most sub-Saharan African countries play an equally active role with the private sector in the food import and export market because of strong foreign exchange and capital controls policies. For example, there is a 100% import duty as well as a 10% development levy for all rice imports in Nigeria (Daramola, 2005), and as such a technical ban. Policies of this kind are also likely to lead to an increase in food smuggling, the effect of which is discussed in the results. In some countries, for a private firm to import food, they would need to get clearance from the government in order to obtain the required foreign exchange to make the trade. This point should be noted because if the market were purely in private hands, then it may be argued that there is less of a role for national policy in determining food imports.

The rest of this chapter is organised thus: after this introduction, there is a brief background in the next section which explains the backdrop and motivation upon which this research is presented, followed by a brief review of the main arguments in the literature that this paper intends to make a contribution; thereafter the methodology is discussed, the variables to be used in the analysis are explained, and then the data section, results and analyses are presented.

4.2 Background

4.2.1 The dimensions of food security

Food security has been defined by the Food and Agricultural Organisation (FAO) to exist when all people at all times have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). This definition is full of meaning and would thus need to be unpacked to fully be understood.

The main sentiments from the stated definition[11] can be divided into three parts or dimensions: the availability of food, access to food and the usage of food. Some literature also considers there to be a fourth: the stability of the previous

[11] For a more detailed discussion on Food Security, its definition and measurement, see FAO (2002)

three dimensions over time (Maxwell, 1996; Barett, 2010). These components are discussed below with a view to situating this paper.

The availability of food dimension addresses the supply-side aspects of food security. It is mostly determined by the level of food production, food stock levels and net food trade. It could be taken to be the most important dimension because all the others are built on this foundation in the sense that if food is not first available, then neither can there be access, proper usage or stability.

Access to food in this sense refers not only to the physical access to food as it relates to food distribution, but particularly to the economic access to food. Having adequate supplies of food at the national or international level is insufficient to ensure food security on its own. Even though that is a first necessary step, people within the country would need to have access to be able to take full benefit of any available food. This dimension takes aspects like incomes, expenditures, markets and prices into consideration in determining food security outcomes. Thus in order to improve access to food, poverty alleviating measures should be the major policy focus.

Food utilization is commonly understood to be the way the human body makes use of the various nutrients in food. As a dimension of food security, it focuses on ensuring that households and individuals are consuming not only the right quantities of food, but also the right qualities. Thus, if food is available, and the individual has access to this food, it is of further importance the way the food is prepared and utilised. It captures the nutritional aspects of food security by making sure that there is sufficient education on the best practices on food preparation, the diversity of foods for different nutrient sources and a balanced diet and the appropriate distribution of food intra-household (with child nutrition being particularly important).

Finally, all of these dimensions are brought together by the concept of sustainability. Because even when there is enough food available, with sufficient access and utilization, food security may not be achieved if there is an acute or chronic danger of experiencing shortages in any of the dimensions. Sudden changes in the political situation, adverse weather conditions, or even shocks to economic conditions may have serious impacts on the vulnerability of a population to food insecurity.

According to Barett (2010) all of these dimensions of food security can be studied under three levels of aggregation: at the household level (micro), the communal level (meso) and the national level (macro). These different levels of study allows for different aspects of the food security problem to be studied in different ways. It is often easier to study the different dimensions at a particular level of aggregation due to the ease of data and its practical application. For example, the usage of food dimension which involves nutritional education of the end-users of food would be best studied at the micro-level due to the fact that this would be the level where research in this area would have the most effect.

This paper focuses on the macro-level analysis of the food availability dimension to food security. The premise is that if a country would prefer to maintain current levels of food consumption, when there is a shock to domestic production some action would need to be taken to smooth out consumption levels. One emergency measure that could be taken is for the country to release emergency food reserves, but most African countries do not have sufficient reserves to smooth consumption (Wright & Cafiero, 2011). The other possibility is for the country to increase imports to obtain the food it needs to make up the gap. Thus if a country is unable to achieve either of these, there is likely to be a food crisis and a reduction in food security and nutrition levels (assuming all other factors like food aid or population remain constant).

4.2.2 Food Security and the Food Supply Chain

Figure 3 is a representation of the food supply chain from production to the table of the final consumer. Each stage corresponds to the fulfilment of one or more of the dimensions to food security.

Figure 3: The Food Supply Chain

Source: Author's schematic

First the food would have to be produced. This corresponds to the food availability dimension because as stated earlier as more food is produced domestically, more food would be available for the population which should lead to better food security. This is one of the most important stages because it lays a foundation upon which the rest of the supply chain is built. Research that focuses on improving this aspect would normally involve asking questions relating to how agricultural productivity can be improved. This would also include research on solving problems relating to crop pests and diseases and how losses due to these factors can be minimised.

The next stage is harvest. This also corresponds to the food availability dimension because it ensures that there is not so much food waste at the point of harvest. Research on this stage with the view to improving food security would focus on the use of modern technology and constantly updated best practice techniques to increase harvest efficiency and to minimise food waste. This would also involve research on the most appropriate timing and speed of harvest.

Following from this, there is the processing and storage stage in the supply chain. Once again, this has a lot to do with increasing the national availability of food. It is a very important stage because most food waste by post-harvest losses occurs here. According to the FAO (2011), 13.5% of the grains produced across sub-Saharan Africa is lost post-harvest, equivalent to over $4 billion per year or enough to meet the food energy needs of 48 million people per year. These losses are both quantitative due to wastage, insufficient storage and processing and qualitative due to a reduction in food quality by insect damage and other causes as a result of non-suitable facilities and techniques.

The next stage of the food supply chain: trade and distribution is where this paper focuses on in terms of national food security. This stage corresponds to the food availability and access to food dimensions because if there are shortages in domestic production, international trade should be able to supplement the gaps to ensure that food remains available and consumption is smoothed over. Equally important is the fact that food would need to be distributed efficiently for the population to be able to have physical access to the food even when it is available. This is a vital stage because it plays the intermediate linking role as the connection between the producer side and the consumer side of the supply chain. Thus, the aim of this paper is to examine what the impediments to food imports are with a view to suggesting policy that further ensures food security via strong, stable food trade networks.

The other two stages of the food supply chain: retail and consumption correspond to the access to food and usage of food dimensions of food security respectively. Research on these areas would normally focus on the economic and educational empowerment of the populace to ensure they have not only the spending power to purchase the food when it is available but also the education to make informed choices on how to spend their resources to purchase the right kinds of foods and to prepare them in such a way as to ensure the maximum nutritional benefit to their households.

4.2.3 The duration of food security

Food security can also be studied as it regards to time or duration. This section explains the three main considerations of food security by duration and where this paper fits within this framework. The three main types of food security by duration are: chronic, seasonal, and transitory food insecurity.

Chronic food insecurity is a long-term persistent condition where people are unable to meet their nutritional/caloric energy needs over a sustained period of time (Jones et al., 2013). This condition is typically caused by extended periods of poverty (often even intergenerational), a lack of productive assets and inadequate access to financial/credit resources. At the national level, it is the product of systemic failures in institutions over time. As this is caused by long term development challenges, chronic food insecurity can be addressed by dealing with entrenched poverty and by the provision of lines of credit and access to productive resources with the education on how to use them most efficiently. As is often the case, the lack of adequate nutrition forms a vicious cycle because it means that the people would have less energy to work, this would in turn lead to lowered productivity, reduced earning power, and back in turn to a reduced capacity to provide food for themselves (Bliss & Stern, 1978a; Bliss & Stern, 1978b, Dasgupta, 1997). An element of this type of food insecurity is captured in this paper by the use of different time-lagged import data as explanatory variables on current imports. This accounts for the likelihood in the analysis that there is some level of persistence in food security outcomes over time and the past responses to negative shocks could influence future responses.

According to Jones et al. (2013), the concept of seasonal food insecurity is kind of a mid-way point between chronic and transitory insecurity cases. It is similar to chronic insecurity because it is the result of a known or specifiable sequence of events, but the difference lies in the fact that it is not persistent. Rather it is cyclical and of limited duration. This situation could be caused by seasonal fluctuations in labour, disease, changing cropping patterns or climate which happen around the same time every growing season. This form of insecurity does not feature in this paper because the effects are more or less annually recurrent (or time-invariant) and time invariant parameters are eliminated by the fixed effects estimation of the panel structure in the dynamic model.

The final classification of food insecurity by duration is the transitory or temporary insecurity. This is a short-term shock in the ability of a population to produce or access sufficient food to maintain good nutrition. It is often sudden and unexpected and could be caused by a variety of factors including year-to-year variations in domestic food production, food prices and household incomes and national income or GDP at the national level. Primarily, emergency food imports and national food reserves are the first line response measures a government could use in attempting to reduce the impact of this form of insecurity and only when these are not possible, would they be forced to rely on food aid in order to avoid a major humanitarian crisis like mass starvation. This is the duration of food insecurity of primary concern in this paper. The shocks to normal levels of domestic food production and food imports are analysed to determine what parameters are important to this and by how much.

4.3 Literature Review

There have not been many empirical studies on the precise import behaviour of countries when faced with domestic food shortages and this paper is an attempt to bridge this gap. In addition, it aims to perhaps provide some explanation as to why there is some apparent recurrent vulnerability of several Sub-Saharan Africa countries to shocks in domestic food supply.

The following sections outline some of the past research on the factors which influence food trade. The points are divided into the economic and the non-economic determinants. The economic factors are those strictly quantifiable variables relating to the economic situation of countries which explain the level of their food imports while the non-economic factors are either those less quantifiable, more tacit, or social reasons why countries have the food imports they do.

4.3.1 Economic determinants of food imports

Among the economic predictors of food imports in the literature to be discussed in this section include lack of food self-sufficiency, improper food pricing policy, national income levels and the economics of the re-export of food.

The most important of these in the literature is the inability of a country to attain food self-sufficiency, either because of a temporary shortfall in domestic food production or for structural reasons (Porkka et al., 2017). These structural reasons could include the adoption of faulty agricultural policies or the inadequate enforcement of good ones, impractical food pricing policies or the non-adoption of modern technology resulting in low productivity. This low productivity would then lead to an increased dependence on food imports and this has been the case in several African countries (Clapp, 2007; Safoulanitou & Ndinga, 2010; Porkka et al., 2017).

Other factors include the level of GDP, which determines the general level of wealth of the countries and the research shows that in general, the higher the general national income level, the higher the food import bill would be. General food price levels are also important in determining food trade (FAO, 1995; Safoulanitou & Ndinga, 2010; Astou, 2015). Finally, there has been interest on the impact of re-export trade on the food trade data. This refers to a situation where goods are imported into a country in large quantities as a gateway to being moved out to other neighbouring countries in turn. This could lead to the strange situation where the trade numbers of the middle-man country indicates quantities of imports which outstrip the population's consumption capacity only to be moved out again through formal or informal channels (INICA, 2005; Safoulanitou & Ndinga, 2010). This leads to a discussion on smuggling, which is also an important consideration in studies regarding food imports because though it is often unmeasured, this can be quite influential in subsidizing any deficits in domestic food production. The level of smuggling in Nigeria is quite high (though there is no reliable data for this) due to the strict FOREX control regime and high food tariffs and is expected to explain some of the discrepancy between shortfall in domestic production and food imports (Astou, 2015).

4.3.2 Non-economic determinants of food imports

This section discusses those predictors of food imports in the literature which are more demographic or behavioural. They include smuggling, food reserves, the "Dutch disease" phenomenon, urban bias, changing tastes and preferences, population and armed conflicts. Several of these affect food imports indirectly, by influencing other areas of the food supply chain, especially domestic food production.

An important determinant of food imports is wars and armed conflicts. When there are violent conflicts, local living conditions are affected with the often accompanying loss of human capital and the destruction of economic and social infrastructure. This is also often followed by the displacement of large numbers of people in the affected areas including local farmers who would have been hitherto responsible for producing food thereby affecting the food supply chain by reduced domestic production. Misselhorn (2005) compiles a meta-study of the factors which influence food security and establish the fact that apart from these direct effects, one of the channels by which food security is affected by conflict is through the destruction of important social networks or social capital. Some of the components of this include problems with relation to trust, reciprocity and exchange, norms, culture, social bonding or cohesion and a variety of other similar concepts (Adger, 2003).

Another factor in the literature which has influenced food imports, albeit indirectly is the concept of "the Dutch disease". This phrase was coined by The Economist in 1977 to describe the decline in the manufacturing sector of the Netherlands after the discovery of large reserves of natural gas. An economic model describing this phenomenon was developed by Corden and Neary (1982) where they construct an economic model with two tradable sectors: the booming sector and the lagging sector. The booming sector usually being the extractive industry of some natural resource (perhaps oil, natural gas, diamonds, gold etc.) with the lagging sector being either manufacturing or in this case, agriculture. The prediction of the model is that the boom in the natural resource sector would draw productive resources and capital away from the lagging agricultural sector towards the booming sector and thus decrease the overall productivity of the agricultural sector and domestic food production. This would in turn lead to greater food import dependence to feed the labour force, which is increasingly employed in the booming sector. This phenomenon has been extensively studied in relation to food imports, for example by Collier (1988), Fielding & Gibson (2013), Timmer (2014) etc.

Some of the other factors which influence food trade include changing population, changing tastes and smuggling. The population of a country has always been seen as an important determinant of food supply right from the days of Thomas Malthus who theorized that since populations grew in geometric progression and food production increased by arithmetic progressions, there are bound to be food shortages due to demand outstripping supply (Malthus, 1798). Since then, research has consistently confirmed population levels to be a significant determinant of food trade (Ehrlich, 1993; FAO, 2017a) Similarly, because changing tastes is also a determinant of changing demand, when people begin to favour the taste or flavours of foreign food items, either due to rising incomes or increased globalization, it is bound to create more scope for food imports (FAO, 1995; Kearney, 2010; Breslin, 2013).

4.4 Methodology and Data

4.4.1 Methodology

The system generalised method of moments (sys-GMM) methodology will be employed in estimating the parameters required in this paper. The formalization of the GMM is usually attributed to Hansen (1982), where he showed that every previously suggested instrumental variables estimator, in linear or non-linear models, with cross-section, time-series, or panel data, could be cast as a GMM estimator. A consistent GMM estimator was formalized by Arellano & Bond (1991) and Blundell & Bond (1998) gave a better system estimator using the same general idea. The GMM is based on moment functions that depend on observable random variables and unknown parameters, that have zero expectation in the population when evaluated at the true parameters. This can be formalised in the following way. Starting from the linear model to be estimated:

$$M_{it} = \boldsymbol{X_{it}\theta} + u_{it} \tag{1}$$

Where M_i represents the level of imports, $\boldsymbol{X_i}$ is the matrix of explanatory variables, $\boldsymbol{\theta}$ is a vector of the unknown parameters, u_i is the error term, the i's would represent the different countries and the t's are the time periods in the panel. Putting this in expectation form to obtain moments would mean:

$$\mathbb{E}(\boldsymbol{T_{it}}' u_{it}) = 0 \tag{2}$$

$$But\ since\ u_{it} = M_{it} - \boldsymbol{X_{it}\theta}, \tag{3}$$

$$\mathbb{E}[\boldsymbol{T_{it}}'(P_{it} - \boldsymbol{X_{it}\theta})] = 0 \tag{4}$$

where $\boldsymbol{T_{it}}$ would represent the moment function[12], and in this case, it would denote the vector of import lags which are act as the instruments.

Thus, provided that the sample is random, the analogy principle[13] would allow population moments to be replaced by sample moments, thereby allowing the estimation of $\boldsymbol{\theta}$ (the vector of parameter estimates we seek) based on the data. If the model is exactly identified, that is the number of instruments is same as the number of unknown parameters, then there will be that exact number of moment conditions, which would all hold precisely. Depending on how the moments are written, this could give either the OLS estimator, or the IV estimator. However, if the model were overidentified with more instruments than parameters, then in general there will be no unique solution because not all the sample moments will hold exactly, with there being too many equations. To solve this problem, an attempt can be made to make the sample moments as close to zero as possible, by minimizing the quadratic form with respect to $\boldsymbol{\theta}$. This was the innovation of

[12] Note that if $\boldsymbol{T_{it}}$=$\boldsymbol{X_{it}}$, then the OLS is obtained as there is no instrumentation.
[13] See Manski (1988).

Hansen (1982), and he noted that this would produce a consistent estimator of $\boldsymbol{\theta}$. Thus, the GMM estimator will be:

$$\hat{\theta}^{GMM} = \left((\boldsymbol{X'T}) \,.\, C \,.\, (\boldsymbol{T'X})\right)^{-1} (\boldsymbol{X'T}) \,.\, C \,.\, \boldsymbol{T'}y \tag{5}$$

Where C is a weight matrix, and because it is always square by construction, the estimator reduces to:

$$\hat{\theta}^{GMM} = (\boldsymbol{T'X})^{-1} \boldsymbol{T'}y \tag{6}$$

Thus, if $\boldsymbol{T_{it}}$=$\boldsymbol{X_{it}}$, this would be the OLS estimator, as the weight C, plays no role:

$$\hat{\theta}^{GMM} = (\boldsymbol{X'X})^{-1} \boldsymbol{X'}y \tag{7}$$

However, in the over-identified case, the choice of C would be important for point estimates, but not for the sake of the consistency of the GMM estimator, because it is always consistent, as long as C is positive definite.

Thus say, for example, a weight of $C = (\boldsymbol{T'T})^{-1}$ is used, the GMM estimator becomes:

$$\hat{\theta}^{GMM} = \left((\boldsymbol{X'T}) \,.\, (\boldsymbol{T'T})^{-1} \,.\, (\boldsymbol{T'X})\right)^{-1} (\boldsymbol{X'T}) \,.\, (\boldsymbol{T'T})^{-1} \,.\, \boldsymbol{T'}y \tag{8}$$

But this is simply the two-stage least squares (2SLS) estimator.

For the purposes of this research, a recalculated weight matrix is used after the first stage, which is what differentiates this technique from the normal 2SLS. This calculation is performed by software using maximum likelihood methods. The purpose of the recalculation is to find the best weight of C, which is normally regarded as the inverse of the covariance of the moments:

$$C = [Var(\boldsymbol{T_{it}}' u_{it})]^{-1} \tag{9}$$

The use of sys-GMM here is appropriate because of the flexibility it provides in the use of instruments in terms of how many lags to introduce, since if the model is exactly identified, then it would coincide with the IV, but if overidentifying instruments are to be considered, then it would be asymptotically efficient if the weight matrix is optimal.

Some further issues which this methodology resolves includes simultaneity (or backward causality), omitted variables, country-specific effects, measurement errors and finally, it accounts for the fact that the process of estimating the effects of food production and prices on imports is dynamic rather than static. What this means is that the model directly incorporates the variableness of time into the model rather than just taking a snapshot of the trade information at a single point in time. This small distinction is important in accounting for and analysing the persistence of the significant determinants of imports over time, including the lagged dependent values.

It also accounts for the possible endogeneity of the lagged variables of imports, which are now used as instruments within the GMM specification and because idiosyncratic disturbances are uncorrelated across individual countries, fixed effects are assumed away in favour of using time to directly identify parameters.

What makes the sys-GMM method different from the alternative difference GMM is that it allows the inclusion of time-invariant (or relatively time-invariant) regressors such as political and trade systems, which would otherwise disappear in first-difference GMM. However, asymptotically, this is not likely to affect the coefficient estimates for the other regressors because of the instruments used (they are assumed to be orthogonal to fixed effects). The methodology is implemented using 'xtdpdsys' on STATA 15.

The next section details the specific reduced form empirical model that would be estimated here.

4.4.2 Empirical Specification

The reduced form equation below is estimated:

$$M_{i,t} = \beta_0 + \beta_1 \varphi_{i,t} + \beta_2 \rho_{i,t} + \beta_3 \boldsymbol{X_{i,t}} + \partial_i + \varepsilon_{i,t} \qquad (10)$$

Where: $M_{i,t}$ is the level of imports, $\varphi_{i,t}$ is the level of domestic food production, $\rho_{i,t}$ represents an index of the general price level to import food, $\boldsymbol{X_{i,t}}$ is a vector of controls (which includes the Gross Domestic Product, population, the amount of food aid received, foreign direct investment, trade as a percentage of GDP, and the violent conflict index), ∂_i represents country fixed-effects and $\varepsilon_{i,t}$ is the stochastic error term. The betas are the parameters of interest, which are estimated using $\hat{\theta}^{GMM}$.

4.4.3 Data

Most of the data used for this research comes from the FAOSTAT (2018) database of the Food and Agricultural Organisation (FAO); others were obtained from the World Bank's (2018) World Development Indicators (WDI) database and from the Armed Conflict Location and Event Data Project (ACLED).

Dependent variable

Level of imports – This variable was obtained from FAOSTAT (2018) and is defined by the International Merchandise Trade Statistics (IMTS) as the physical quantity of domestic origin or manufactured products shipped out of the country. It also includes re-exports, which are controlled for in the analysis. According to the FAO methodology, the quantity of crop imports included in the database is expressed in terms of weight (tonnes). The logged and first differenced transformations of this variable were used for different analysis.

Key Independent variables

Domestic food production – Production in this sense refers to harvested production which includes the after-harvest losses and wastage, quantities consumed directly by the farm household as well as marketed quantities, and it is measured in tonnes. If all other things remain the same, the expectation is that the year on year change of this variable should have a directly proportional negative relationship with the change in the countries' food imports. This means a coefficient of -1 is expected. If this result is not achieved, explanations would have to be sought about the unexplained gap.

Index of price for food imports – This is a calculated variable by the FAO and it is obtained from a detailed trade matrix from each country. The unit values (in US dollars) of imported foods are differenced using a Laspeyres-type[14] formula to create the index (FAO, 2018). It represents a general sense of the price level for food importation for the individual countries. Since the index is already differenced, the level annual figures are used rather than being double differenced. The apriori expectation for this variable is that it should vary negatively with the level of imports because the higher the price level, the less willing people should be

[14] A Laspeyres index (proposed by German economist Etienne Laspeyres) is used for measuring the current prices of quantities of selected items in relation to those same items in a base period (for example, as used for the Consumer Price Index). Computationally, it involves taking a ratio of the current prices to prices in the base period of the specified quantities of goods and multiplying by 100. This differs from a Paasche index, for example, because the index is weighed by the current relative importance of the products in comparison to the base year.

to engage with the food import market as the incentives for increasing domestic production and exports are higher.

Controls

Amount of food aid received – This variable was obtained by FAOSTAT (2018) from the FAO's Creditor Reporting System (CRS) database. The objective of this database is to keep track of where food aid goes and what purposes it serves. If there was a sudden increase of food aid received, it probably means that there was some shortfall in domestic food consumption, severe enough to trigger an international humanitarian response. In this sense, the year-on-year changes in food aid could be more informative than the levels. Conversely, if there are consistently high levels of aid received in comparison to similar countries, this could be an indication of a more systematic food supply problem. If this condition persists over time, this could also be an indication of the baseline economic health of the country.

Depth of the food deficit (kilocalories per person per day) – The depth of the food deficit is calculated and reported by the FAO for all developing countries on a regular basis and it indicates how many calories would be required to raise all undernourished individuals from that status into food security, all things being equal. It is computed in the following way: the difference between the average dietary energy requirement and the average dietary energy consumption of the undernourished or food-deprived is first obtained; this is known as the average intensity of food deprivation of the undernourished. When this is multiplied by the number of estimated undernourished people it produces an estimate of the total food deficit in the country. This can then be normalised by the total population as a weight. As at 2016, Zambia had the highest value of 405.16 and Tunisia has the lowest with a value of 3.00.

This variable is important because it provides a short-term estimate as to the energy requirements of the undernourished portions of the population and how much food would be needed to meet it. It is hypothesized that if the food imports are not increased to match the deficit in domestic food production, the depth of the food deficit and insecurity would increase as would the change in quantities of food aid received.

Violent conflicts – The purpose of this variable is to control for the fact that when there is violence or war, it often affects the national or regional economy and in turn the ability and willingness of the country to import food. It could have a negative relationship with imports when there is simply a lack of foreign exchange either because of a breakdown in business activity and exports to earn foreign exchange, or a need to spend more of the available foreign exchange on weapons and other forms of military spending. This data was obtained from the Armed Conflict Location and Event Data Project (ACLED) database.

Other controls used include gross domestic product (GDP), population, foreign exchange reserves and foreign direct investment which were obtained from WDI (2018). Exchange rates are not explicitly controlled for because they are already considered in the construction of the food import price level index of the different countries and would thus be endogenous.

Table 1: Descriptive statistics of the between country values

Variable	Symb	Mean	Std. Dev.	Min	Max
Import (in thousands of tonnes)	Imp	580	1270	9.345	7454
Domestic Production (in thousands of tonnes)	Prod	2016	3666	0.010	15700
Import Price Index (2004-2006=100)	Price	112.54	38.80	61.62	232.79
Merchandise Trade (as % of GDP)	Merc	55.43	29.79	24.05	166.73
Trade (as % of GDP)	Trade	68.61	32.70	32.50	193.46
Government Foreign Debt (as % of GDP)	Debt	68.24	53.12	13.64	182.24
Depth of food deficit	Defcit	186.83	112.72	3	405.16
Food Aid (as % of food imports)	Aid	27.26	26.77	0	136.11
Conflict Index	Conf	14.24	7.47	0.36	62.42
Population (in millions of people)	Pop	11.28	16.89	0.0007	99.94

Note: Values here are in levels and averages over the 20 year time period.

Source: Author's calculation

Table 1 shows the descriptive statistics of some variables in the data. The average trade as a percentage of GDP of about 68 percent among the African countries in the set shows that imports and exports in general play an essential role in the economies of these countries. The percentage is quite high when compared with the 26 percent average of OECD countries. Even more important than the total proportion of trade, is the amount of this trade that is from merchandise, especially raw materials or intermediate goods for higher level production. The high percentage of the GDP that is accounted for by merchandise trade could also be a subtle indication of resource dependence (Gylfason, 2001).

There has been an average of 580 million tonnes of food imported in Africa (over the time panel) with the large range of about 7444 million metric tons (between the highest and lowest estimates) explained by the differing sizes of the countries. It is difficult to obtain similar data of this type in comparison for developed countries due to how decentralised their import and export markets are. Their governments often do not play a major direct role in this sector, except for regulation. But in Africa, the reverse is often the case especially for food products with the central government having to approve foreign exchange for a lot of the foreign trade transactions. Here the trade economies are still heavily regulated, and the federal governments decide on not only what crops to allow in but also how much (not merely by setting tariffs but by direct policy). In many cases, the food is even imported directly by the government for strategic reasons. The central banks play a major role in this due to their computations on how much foreign exchange is available and by how much the level of imports would affect the national economy.

Food aid accounting for almost 30% of all food imports in Africa on average, is quite a large proportion. The implication of this is that there is at least preliminary evidence of a growing food aid dependency, which if it were to stop suddenly, would create a huge humanitarian crisis of food insecurity in many households in Africa.

4.5 Results and Analysis

In this section, we present the main results obtained from the econometric model and these results are discussed with a view to exploring their possible policy implications. Three different estimation techniques are reported: pooled OLS, fixed-effects and system GMM. The pooled OLS provides a first preliminary idea of how the data are correlated without controlling for country fixed effects. These coefficients are expected to incorrectly estimate the true effects on the dependent variable (food imports). The fixed effects estimator controls for country effects but biases the coefficients when the dependent variable is present with a finite time period. As discussed in the methodology section, the system GMM estimator provides consistent and unbiased estimates accounting for the system dynamics. The likely endogenous variables including domestic food production and the price index are instrumented by using the first to third lags of the dependent variable as is the usual procedure in the system GMM method. The reason that a maximum of three lags are used here is because when there are too many instruments, there is likely to be the problem of over-fit of instruments. Blundell and Bond (1998) showed how with a persistent dependent variable (such as food imports), system GMM should be adopted as the estimation method. The persistence of this variable confirmed in the results was also tested in different specifications as robustness checks.

Table 2: Regression results of the impact of shocks in domestic production to food imports (Dependent Variable: Food Imports (log)).

	Pooled OLS (1)	Fixed Effects (2)	System GMM (3)	System GMM (4)	System GMM (5)
Food imports$_{t-2}$, log	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Domestic Production (in tonnes), log	-0.721*** (0.206)	-0.451* (0.186)	-0.682*** (0.120)	-0.550** (0.120)	-0.405** (0.129)
Import price index, log	-0.684*** (0.044)	-0.553*** (0.099)	-0.877*** (0.134)	-0.818*** (0.099)	-0.718*** (0.099)
Food aid (as % of food imports)	0.201*** (0.089)	0.260*** (0.116)		0.247** (0.095)	0.257** (0.098)
Conflict index, log	0.030** (0.013)	0.023** (0.010)		-0.171** (0.066)	-0.190* (0.076)
Trade (as % of GDP)	-0.013** (0.005)	-0.001 (0.005)			-0.050 (0.056)
Government foreign debt (as % of GDP, log)	0.058 (0.059)	-0.022 (0.055)			0.037 (0.030)
GDP per capita (nominal, log)	-0.011 (0.058)	-0.315*** (0.090)			0.125* (0.063)
Time Dummy	Yes	Yes	Yes	Yes	Yes
Country effects		Yes	Yes	Yes	Yes
Hansen Test (p-value)			0.12	0.23	0.39
ABond AR(1)			0.00	0.00	0.00
ABond AR(2)			0.51	0.55	0.72
No. of observations	522	260	1588	1588	1588
No of countries	50	50	50	50	50
R^2	0.88	0.28			

Notes: Absolute values of robust standard errors clustered at the country level are reported in parentheses. ABond AR(1) and AR(2) represents Arellano-Bond tests for serial correlations. *** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level. *Source:* Author's calculations.

In Table 2, the columns correspond to the results of the estimation techniques described. According to Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998), two main specification tests – the Hansen and AR2, should be used in verifying the validity of a system GMM regression. The Hansen test verifies the overall validity of the instruments with a null hypothesis that the instruments as group are exogenous. This test provides p-values that are greater than 0.1, thus confirming that the lags are exogenous. Also, the AR tests are to check for serial correlation with the first-differenced disturbances. Although the p-values of the AR-1 test are 0 and we can reject the no autocorrelation hypothesis of order 1, the key test of interest (the AR-2) is greater than 0.1 and thus we cannot reject the no autocorrelation hypothesis of order 2. These results mean that the Arrellano-Bond model assumptions have been satisfied.

According to the apriori expectations, food imports are highly persistent due to the high effect of the lagged variable on current outcomes. Even though these effects are small, they are significant. Also as expected, the coefficients on domestic production are negative and highly significant across the different model specifications. In the OLS specification, this effect is only as high as 0.72 percent, meaning that when all other factors are held constant, every 1 percent decrease in domestic food production corresponds to a 0.72 percent increase in food imports. By the theory expressed earlier, the expectation was for this variable to have a one-to-one relationship with imports if current food consumption levels were to be maintained (Kirkpatrick & Diakosavvas, 1985) but the data indicates that this was not the case.

The other specifications produced some different results. For the fixed effects regression, the effect of domestic food production on food imports is still negative and significant, but drops to 0.45 percent. Similarly in the sys-GMM baseline regression (column 3) the absolute effect value is about 0.68 percent which is more than the other specifications with a selection of control variables. The fact that the absolute value of this coefficient reduces as more cofactors are added emphasizes the roles that they play in the determination of the domestic food production effect of interest.

It is important to note that all measures apart from the pooled OLS include fixed country and time effects and are thus robust to country-specific characteristics such as majority religion or religious composition, ethnic composition, language, colonial ties, topological and geographical variables, which in a loose sense can be considered to be time-invariant. Worldwide trends and many other unobservable characteristics have also been controlled for and this could explain the reduced effects of domestic food production in these other specifications.

Another point to note here is the reduced level of significance along with the reduced effect in columns 4 and 5, the sys-GMM specification without selected covariates and that of the full model. This is another indication that the added covariates have some explanatory power as to why the expected 1-1 relationship between food production and food imports does not happen in reality. As discussed earlier, when this relationship does not hold, it implies that domestic shortfalls in food production are not completely offset by food trade or other means of food supply such as food aid. This evidence implies that the shortfall between domestic production and trade supplementation is likely to result in corresponding shortfalls in food consumption, nutrition and thus at least in the short-term, to food insecurity.

As an attempt to explain the lack of matching imports when domestic production reduces, the significance of the other covariates could provide clues. The general price level of food imports to the different countries in the sample is a consistently negative and significant determinant of food imports. In the full model, a one percent increase in import prices would lead to a 0.72 percent decrease in food imports all other variables held constant. This is quite a large percentage indicating how influential food prices are to the international food trade market.

In addition to the narrative above, it is important to note that many countries in sub-Saharan Africa depend on the export of agricultural products for the sustenance of their economies. This leads to a somewhat complex relationship between agricultural prices and food imports. The final food import price effect on imports which is represented in the regression is exacerbated by other price factors. When food import prices are high, countries[15] would tend to import less and thus have reduced national food stocks; however, this often corresponds with increases in food export prices as well, which the countries would like to take advantage of by exporting more, further depleting the national food stocks[16]. When general food price levels are high, there would also be the added income and better trade balance effect since the countries could export more.

The question remains though as to what decisions are made with income when there is a negative shock to domestic food production by exogenous forces. The results show that government foreign debt is not a significant determinant of food imports and the GDP per capita is only marginally significant. The direction of effect of the latter changes from negative in the fixed effects model to positive in the full sys-GMM model. One likely reason for this is the ambiguity the role of the current economic situation of the countries plays in determining current food imports. If a country has a higher GDP per capita, this could be an indication that it possesses a better capacity to produce its food needs domestically, however this

[15] In this analysis, countries are assumed to be the trading entities, even though in reality it is the individuals in the countries who make food purchases from the international market, with the federal governments often importing large amounts themselves.

[16] The reverse is also true. When import prices are low, even though there may be more capacity to import, the usually corresponding reduced export prices could depress exports, further increasing national food stocks. However, the income effect works in the opposite direction.

could also mean that there would be an increased capacity to import food if and when there was the need to do so.

4.6 **Robustness Checks**

As previously described, the use of fixed effects and system-GMM methodologies with the lags of the import levels included accounts for different endogeneity issues as well as the inclusion of time dummy controls for global trends. Thus, the basic results are robust to different specifications and have appropriate standard errors for hypothesis testing.

In addition to the above, further tests were made to investigate the issue of omitted variables. This involved re-estimating the model in first differences to remove any remaining country specific effects. According to Wooldridge (2005), the fixed effects estimator by construction assumes that the error terms are serially uncorrelated. This makes it more efficient than the simple first difference estimator in our research context. However, the first difference estimator would be more appropriate if only the first differences in the errors are uncorrelated. The following reduced form regressions were estimated:

$$\Delta M_{i,t} = \beta_0 + \beta_1 \Delta\varphi_{i,t} + \beta_2 \Delta\rho_{i,t} + \varepsilon_{i,t} \qquad (A)$$

$$\Delta M_{i,t} = \beta_0 + \beta_1 \Delta\varphi_{i,t} + \beta_2 \Delta\rho_{i,t} + \partial_i + \varepsilon_{i,t} \qquad (B)$$

where $\Delta M_{i,t}$ is the first difference level of imports in logs, $\Delta\varphi_{i,t}$ is the first difference level of domestic food production in logs, $\Delta\rho_{i,t}$ represents an index of the general price level of food imports in logs, ∂_i represents country fixed-effects and $\varepsilon_{i,t}$ is the stochastic error term.

Specification A uses the first differences to control for country fixed effects and specification B includes the country fixed effects in differences as a separate variable. In addition, different time bands of three and five years were also tried as units of analysis rather than annual data. The results are also robust to these specifications, however annual data is preferred to prevent the loss of efficiency.

Table 3: Robustness results of the impact of shocks in domestic production to food imports (Dependent Variable: First Differenced Food Imports (log)).

	First Differenced (1A)	**First Differenced (1B)**	**With 3 year averages (2)**	**With 5 year averages (3)**
Domestic Production (in tonnes), log	-0.721*** (0.206)	-0.721*** (0.206)	-0.451* (0.186)	-0.682*** (0.120)
Import price index, log	0.684*** (0.044)	0.684*** (0.044)	0.553*** (0.099)	0.877*** (0.134)
Country effects		Yes	Yes	Yes
Hansen Test (p-value)			0.12	0.12
ABond AR(1)			0.00	0.00
ABond AR(2)			0.51	0.51
No. of observations	522	522	170	104
No of countries	50	50	50	49

Notes: Absolute values of robust standard errors clustered at the country level are reported in parentheses. ABond AR(1) and AR(2) represents Arellano-Bond tests for serial correlations. *** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level. *Source:* Author's calculations.

In addition, long-run differences are also tested for using much longer lags than 3 (up to 10) to find if there is corroborating evidence of these effects. In all the regressions, the coefficients on the domestic production of food were still correctly signed and significant.

4.7 Conclusion

In recent times there have been global concerted efforts to eliminate food insecurity (or to reduce it to the barest minimum). This is evidenced by the second goal of the sustainable development goals (SDGs) which states the following as targets:

"2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons"

UNDP (2017)

Thus, it is important for research to examine these issues using recent data and updated techniques. At the heart, this paper examines the roots of national food insecurity by analysing what happens when there is a shortfall in domestic production of food as it relates to trade and the international food market. This has been done by answering the question: what is the relationship between domestic food production and food imports? The study has also examined the implications of this relationship.

This paper answers these questions by using the most recent data from the FAO's statistic database and from the World Development Indicators. Using this dataset, we have discovered that there is a strong correlation between lagged import levels and current levels. This strong persistence in the values on an annual basis means that there may not be very sharp fluctuations in food imports year-on-year. However, having controlled for this and other cofactors, there is evidence in support of a strong negative relationship between domestic food production and food imports, even though this relationship does not conform to the one-to-one theoretical hypothesis as suggested by Kirkpatrick & Diakosavvas (1985). Part of the discrepancy may be explained by the reduced coefficients when some control variables including agricultural prices, food aid, internal conflict, trade, government debt, GDP per capita, country fixed effects, time fixed effects, and country-specific trends are included. Nonetheless, the significance of the results still remains.

This paper makes the following contention from this outcome: if it is the case that after controlling for many important variables determining imports there is still not a one-to-one relationship (or close enough) between food imports and domestic food production, then there is likely to be a corresponding reduction in domestic food consumption levels (or an increase in food insecurity) due to the said decrease in food production. Other possible explanations for this result such as the amount of food aid received, smuggling of food through unofficial borders and currency controls by central banks have also been discussed as possibilities.

The implication of this paper for agricultural policy making includes that further evidence is necessary regarding how short-term national food insecurity develops at macro levels. Since there is a high propagation of previous trade results, when a country is already importing less food than its national needs, there is likely to be less importation possible in the future, leading to a rapidly expanding cycle of the food availability-requirement gap and thus, food deprivation. Also, as regards sub-Saharan African counties there is stylistically no evidence for a robust temporary response by these countries in the international food market when there are domestic food shortages by way of food imports. This holds irrespective of international food prices, GDP per capita or the foreign exchange capability of the countries. This is arguably considered to be evidence to support the building of resilient domestic food supply and storage systems to counter shocks to production rather than a dependence on food imports, which could be a slow and inadequate response. Finally, the results show that food aid is an important and large component of the food imports of many African countries and by extension, their domestic food consumption, which if they were to be stopped suddenly could create a humanitarian crisis of malnutrition. Further research would be needed in this context on what exactly the impact of food aid has been on the domestic production capacity of countries and on if the countries might benefit from being weaned from the aid.

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Appendix

1. List of African Countries

Country	Freq.	Percent	Cum.
Algeria	10	1.97	1.97
Angola	10	1.97	3.94
Benin	10	1.97	5.92
Botswana	10	1.97	7.89
Burkina Faso	10	1.97	9.86
Burundi	10	1.97	11.83
Cameroon	10	1.97	13.81
Central African Republic	10	1.97	15.78
Chad	10	1.97	17.75
Comoros	10	1.97	19.72
Congo	10	1.97	21.70
CÃ´te d'Ivoire	10	1.97	23.67
Democratic Republic of the Congo	10	1.97	25.64
Djibouti	10	1.97	27.61
Egypt	10	1.97	29.59
Equatorial Guinea	10	1.97	31.56
Eritrea	10	1.97	33.53
Ethiopia	10	1.97	35.50
Gabon	10	1.97	37.48
Gambia	10	1.97	39.45
Ghana	10	1.97	41.42
Guinea	10	1.97	43.39
Guinea-Bissau	10	1.97	45.36
Kenya	10	1.97	47.34
Lesotho	10	1.97	49.31
Liberia	10	1.97	51.28
Libya	10	1.97	53.25
Madagascar	10	1.97	55.23
Malawi	10	1.97	57.20
Mali	10	1.97	59.17
Mauritania	9	1.78	60.95
Mauritius	10	1.97	62.92
Morocco	10	1.97	64.89
Mozambique	10	1.97	66.86
Namibia	10	1.97	68.84
Niger	10	1.97	70.81
Nigeria	10	1.97	72.78
Rwanda	10	1.97	74.75
Sao Tome and Principe	10	1.97	76.73
Senegal	10	1.97	78.70
Seychelles	10	1.97	80.67
Sierra Leone	10	1.97	82.64
Somalia	10	1.97	84.62
South Africa	10	1.97	86.59
South Sudan	9	1.78	88.36
Sudan	9	1.78	90.14
Swaziland	10	1.97	92.11
Uganda	10	1.97	94.08
United Republic of Tanzania	10	1.97	96.06
Zambia	10	1.97	98.03
Zimbabwe	10	1.97	100.00
Total	507	100.00	

Chapter 5

Conclusion

The previous three chapters have examined different aspects of farmer and national crop choice and food security. The second chapter discusses what goes into the thought process of smallholder farmers when they decide on what type of crops to grow. And then it goes on to analyse the impacts of this choice on the productivity and welfare outcomes of the households. The idea of this research stemmed from the erroneous often-made assumption that farmers planted whatever crop they did for simply random reasons and that this choice was quite unimportant in the grand scheme of things. Our research supports the view instead that farmer efficiency through crop choice was the most important factor to the welfare outcomes of farming households. Moreover, from the results it is evident that the crops that farmers choose to grow are hardly randomly selected. Even though there may be latent or unobservable reasons why they make their choice, there are also definitely some observable factors which could determine the likelihood of a farmer to grow a certain type of crop rather than another, all other things being held constant. Some of these factors which play a role in this selection process include the level of education of the head of the farm household, his/her age, size of the household, number of dependents, the quantities of free farm inputs provided for farming activities as well as culture or tradition (proxied by the use of saved seeds from previous planting seasons in the next growing period).

An important question that comes from this knowledge is to find out if there are any consequences to this choice. Is there such a thing as a “bad” or “good” crop to grow? And if so, what would determine this? The chapter categorizes the most common crops grown by farmers in Nigeria into different groups based on three properties: cash-crops vs non-cash crops, roots and tubers vs non roots and tubers and by the level of crop commercialisation. Using these groups, the chapter examines the overall farmer productivity and farm household welfare outcomes for the farmers who grew crops in those different categories against those who did not using stochastic frontier analysis and treatment effects methods respectively. The results showed that grouping crops in this way, it was possible to extract differences in the possible efficiencies in production of the different crops on average. Importantly, the results as to the effects of crop choice also differ by crop groups on agricultural productivity and farm household welfare outcomes. Although farmers who grew cash-crops did not experience significantly higher total factor productivity than those who did not, those that grew either a root or tuber crop did. This is likely due to their properties relating to the cost of and ease of access to inputs. On the other hand, farmers who grew cash crops and roots and tubers indicated significantly better welfare outcomes in all specifications than those who did not.

These results are important because they present a new way of viewing the relationship between the farmer and his/her crop, especially for policy makers who are imbued with the responsibility of deciding the production of which crops deserve to get a part of scarce subsidies, grants, or other development funds to achieve a pre-set objective. Furthermore, the results from this chapter show that the level of commercialization of the crop groups (i.e. how much of the crop is marketed as against domestic consumption) also have differing significant effects on productivity and poverty outcomes. Although the level of commercialization itself did not have a significant effect on productivity, it did on the poverty outcome. But on interaction, the farmers who both grew cash crops and had a high level of commercialization enjoyed far greater benefits with productivity and welfare improvements, whereas the cash-crop farmers with a low level of commercialization experienced worse outcomes than the non-cash crop farmers with the same amount of commercialization. The implication of these results is that if a government is interested in increasing agricultural efficiency and productivity as a policy objective and cash-crops have been decided as the way to go, commercialization should be encouraged and proper channels should be sought for the farmers who engage in growing these products to effectively market their produce. Without these safe-guards in place, the chapter shows that they may end up in a worse situation than if they were growing food crops, which at least the household could fall back to for food when their farm products cannot be marketed. The results agree with papers like Amaza et al. (2005) who find an average farm productivity of about 0.68 percent. It also supports the conclusions that growing cash crops and high-value crops produces better welfare outcomes (Brown & Kennedy, 2005; Sarris, Savastano & Christiaensen, 2006; Maertens & Swinnen, 2009; Murekezi & Loveridge, 2009), and agricultural commercialization is beneficial for poverty (von Braun, 1995; Carletto, Corral, & Guelfi, 2017). However, it also adds the knowledge that growing cash crops produces heterogeneous effects on smallholder farmer productivity.

The next chapter continues this line of thought by asking the question: what impact does the choice of crop have on the food security outcomes of the households? This question is of current importance due to the urgency of the achievement of the sustainable development goals, the second of which specifically entails the elimination of hunger in all its forms from everywhere in the world.

This chapter adds to the research on the pathways towards sustainable food security. Food security in this paper is measured in four ways: by a household dietary diversity score, the total amount of food consumption per household member, the squared difference in food consumption from the mean household, and by the number of days in a week the household has gone without food. The objective was to obtain comparable groups of farm households who grew cash crops and contrast their food security outcomes with those who did not.

Using propensity score matching techniques, suitable comparison groups were obtained and analysed. The empirical estimates suggested that there were no clear consistent significant effects of smallholders who grew cash crops than those who did not as it relates to food security, but rather there were differing effects based on the measure of food security used and the matching technique. The total amount of food consumption measure was only significantly different for cash crop growers using the nearest neighbour matching but was insignificantly affected otherwise. Similarly, there were no significant differences between the groups of farmers who grew different types of crops using the number of days without food measure. However, the results show that growing cash crops could improve the dietary diversity score of the farm households that grow them significantly by up to 1.9%.

More interestingly, there is also evidence that if a farm household's food consumption is already below average, growing cash crops could cause a worsening of the food security gap between that household and the average. The implication of this result is that careful attention needs to be taken before the advocation for the production of cash-crops or some high value crop as a channel to sustainable food security. This is because if the household is currently in a bad situation, there is a risk of worsening food security by widening the nutritional gap. A possible explanation for why this is the case is that households that are at or below the food security boundary when faced with the sometimes peculiar challenges in the production and marketing of their output may not have the resilience or financial reserves to see it through and could then end up with either a failed crop resulting in losses or with products that they can neither sell nor consume for food, leading to a worse food security outcome.

Following from this, chapter three takes a more macro-economic view of the concept of food security, analysing the factors that determine national food imports when there are shortages to domestic food production. The foundation of the premise is that countries will normally import food when they cannot produce sufficient quantities domestically. However, if for one reason or the other, they are constrained or are unable to import food in sufficient quantities to meet this gap, there would be a drop in the domestic consumption of food and thus in national food security, all other things being equal. In a way, this chapter scrutinizes the roots of friction in the availability and access to food components of national food security.

The expectation was that there would be a one-to-one relationship (or close enough) between food imports and domestic food production after accounting for other cofactors responsible for determining food imports. In reality, the data showed a relationship of only about 0.72% in the OLS specification and 0.40% in the system-GMM specification. The consequence should be that the difference between these numbers and 1% would be the reduction in food consumption levels in the country (or increased food insecurity). This would only be the case though, if we have accounted for all the possible reasons why the proportional relationship does not hold. The paper shows the importance of the persistent correlation effects between lagged food import levels and the current levels, indicating that there is usually a lag between shortfalls in domestic production and the arrival of imports. Food aid was also found to be an important component of the food import equation with there being over 500 metric tonnes of food aid received in Africa every year. In conclusion, the paper makes a policy suggestion that the research further supports the importance of short-term food supply buffer stocks or national food reserves (which are currently mostly lacking in adequate capacity) to help smooth consumption when there are short to medium term shocks to domestic production. This would be an appropriate stop-gap measure to avoid significant nutritional crises before more food import orders can be made.

Taking all the chapters of the thesis as a whole, some policy implications may be drawn regarding what steps could be taken by international development organisations, governments, non-governmental organisations and individuals in order to achieve the 1st and 2nd SDG goals of eliminating poverty and hunger in totality by the year 2030. The main idea is that crop choice as a concept needs to be taken more seriously in general. It should not be taken for granted that farmers plant whatever crops they choose without any careful economic or sociological study. Crop and farmer productivities need to be objectively measured and used as a basis for crop production along with the other prevailing socio-economic characteristics of individual farming households. This thesis has shown that if these factors are ignored, an otherwise “better” crop choice could turn out much worse for the productivity and food security outcomes of the household.

The papers in this thesis are mainly limited by time, scope and the availability of data. As more data becomes available, opportunities for further research in these areas would open up. For example, more can be said in chapter 3 regarding the mechanisms and pathways through which greater food security may be attained using the vehicle of proper crop selection. Also, from chapter 3, further research may be conducted on the importance of smuggling on the levels of national food imports and thus, national food security.

Overall, this thesis attempts to contribute to the under-researched area of the economic determination of farmer crop choice as well as a useful addition to the literature on food security using new datasets and modern econometric techniques. Although the papers confirm many of the existing common knowledge, some new insights have been uncovered as well and new opportunities for further research in these areas are also opened up.

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