OFF-FARM INCOME AND INVESTMENTS IN AGRICULTURAL INPUTS: EVIDENCE FROM NIGERIA

By

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ABSTRACT

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Various studies have documented the effects of off-farm income on investments in specific agricultural inputs. However, few studies had empirically tested the impacts of specific forms of off-farm income on a combination of agricultural input investments and no study to date exists for Nigeria. Such an analysis can reveal the relative impacts of alternative forms of off-farm income on the investment choices of farmers and, perhaps, the best policy choices to achieve improvements in technologies and inputs that are most limiting in achieving agricultural sector growth. In this study, I use the World Bank's LSMS panel data and a range of econometric models to test the relationship between the three most common types of off-farm income (remittances, off-farm wages and enterprise profit) received by Nigerian households and investments in agricultural input such as seed, fertilizer, land and machinery. Using the Seemingly Unrelated Bivariate Probit regression Model, I empirically find jointness in the decisions to use an agricultural input and work off-farm. Using a multivariate probit regression model, I find off-farm income sources to have significant effects on the use of most agricultural inputs. Furthermore, I find a strong degree of interdependence between alternative agricultural input use decisions. The results suggest that policies that strongly promote off-farm income show promise in improving the use of a portfolio of farm inputs, and should enhance agricultural production amongst Nigeria's farm households.

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CHAPTER ONE: BACKGROUND AND MOTIVATION

1.1. General Background

Since the Green Revolution[1], the importance of improved use of seeds, fertilizer, mechanization, irrigation and other modern inputs in increasing agricultural productivity has been emphasized by many studies (Pingali, 2012; Evenson et al., 2003). The Green Revolution aided the transformation of several low agricultural production areas into areas of sound agricultural production in many Asian countries. In contrast, the adoption of modern farm inputs has been slow in many Sub-Saharan African (SSA) countries, affecting the overall growth in agricultural productivity and the income levels of many households. In-turn, slow growth in agricultural productivity and income has stymied the overall economic development and growth of countries in the region (Kelly et al., 2003). Therefore, the use of modern agricultural inputs is generally believed to be a key factor in transforming the agricultural productivity of many SSA countries.

Nigeria is the most populous SSA country. A majority of the population (70%) depends on subsistence agriculture. Despite the high percentage of population engaged in agricultural production, agricultural productivity remains low in the country. To ameliorate this development challenge, Nigeria has been implementing several strategies to upgrade agricultural productivity; which include the Comprehensive Africa Agriculture Development Program (CAADP)-based Nigerian Agriculture Investment Plan (NAIP)[2] (Kimenyi et al., 2013). NAIP mainly focused on agricultural development reforms, with the focal point of enhancing input related problems such

[1]The Green Revolution refers to a set of technology and research initiatives that occurred between 1930's and late 1960's which resulted in increased agricultural production worldwide, particularly in developing countries (Hazell, 2009).

[2]Nigerian Agricultural Investment Plan (NAIP) is the extension of the CAADP program which comprises the four pillars for agricultural development (1) strengthening agricultural technology dissemination and adoption, (2) improve rural infrastructure and trade related capacities, (3) Increasing food supply and reducing hunger and (4) Extending the areas under sustainable land management and reliable water control system (Federal Ministry of Agriculture and Rural Development, 2010).

as access to land, fertilizer, credit and others. Despite these government initiatives and investment, farm input use remains low when compared to global levels (Sheahan and Barrett, 2014). Financial stability, among others, is a principal reason for this low agricultural input use in Nigeria as well as in many SSA countries (Reardon, 1994; Smale et al., 2016; Adjognon et al., 2017).

The earnings from agricultural production is the prime source of income to subsistent farmers. Despite being the main source of income, the income from agricultural production is not sufficient to cover household's expenses, let alone to be used for agricultural inputs (Reardon, 1994). A combination of several factors limits agricultural production potential. The first factor is risk-averse behavior of agrarian households. Many households trust and want to deploy those agricultural inputs that they are well accustomed rather than using any new agricultural inputs. The second factor is the lack of extension agents who play a key role in encouraging agrarian households to use new agricultural inputs. The third factor consists of various environmental conditions such as rainfall, soil fertility, and topography. These conditions may preclude agrarian households from using modern agricultural inputs. Finally, even if households are willing to deploy modern agricultural inputs, the existing input market structure and services such as unavailability of agricultural inputs, excessive transportation costs, and the lack of spare parts in the case of machinery may preclude households from using agricultural inputs. These factors lead to low agricultural production and ultimately low farm income.

Access to credit has been identified as one the most crucial factor in expanding agricultural production. Agrarian households with access to credit can improve and increase agricultural production. This ultimately leads to increased income generation from farm production. Nigerians, for long, had practiced traditional and informal forms of a micro-crediting system (Acha, 2012), where households borrow money from friends, relatives and some cooperatives to purchase

agricultural inputs and to cover other expenses. The use of the informal credit system is due to the problems faced in the formal crediting system, including the need for high collateral and high interest rates which screens out most Nigerian smallholders. This slows down agricultural productivity as it precludes most households from attaining the necessary credit to purchase agricultural inputs. Although the government of Nigeria had devised policies to improve formal micro-crediting system, agrarian households still face challenges in gaining access to credit (Nwanyanwu, 2011). This raises the important question; "if income is not sufficient and households do not have access to credit, how do they finance agricultural inputs?"

Evidence from the literature suggests that households which earn low farm income and face credit constraints tend to use off-farm income to support agricultural input purchases (Reardon, 1994; Barrett et al., 2001; Lanjouw et al., 2001; Pfeiffer et al., 2009; Smale et al., 2016; Sheahan et al., 2017; Adjognon et al., 2017). Such literature explains the role of off-farm income in farm input investments. Specifically, it shows how households choose a portfolio of off-farm activities to increase their income, which is then used to purchase different farm inputs. For example, Smale et al., (2016), showed that income generated mainly from off-farm work has a significant effect on the use of nitrogen fertilizers on farms in Kenya. Similarly, in a cross-country study covering Nigeria, Niger, Ethiopia, Tanzania, Malawi, and Uganda, Sheahan et al., (2017) used mostly descriptive statistics to show the significant effect of off-farm income on various agricultural inputs. Sheahan et al., (2017) further showed that irrigation and mechanization remain low while credit use in the purchase of farm inputs remains nearly non-existent. A recent study by Adjognon et al., (2017) showed the significant effect of rural non-farm income on the purchase of agricultural input in countries such as Nigeria, Malawi, Tanzania and Uganda.

Several factors drive the decision to engage in income generating off-farm activities. These include constraints on production due to the physical environment, limited rural infrastructure, limited markets, inappropriate government policies and several constraining household characteristics such as the abundance of labor (Reardon et al., 1994). In summary, the literature suggests that one of the key constraints to investments in modern farm inputs is that households have inadequate farm income to make such investments. Hence, they tend to rely on income from off-farm activities to support their input investments (Barrett et al., 2001).

1.2. Motivation and Objective of the Study

The relationship between various types of off-farm income and investment in various agricultural inputs has not been well researched. There are three dimensions of this relationship. The first is whether or not the decision to work off-farm and to use modern agricultural inputs are related. For example, Smale et al.'s (2016) findings indicate the jointness in off-farm work and fertilizer purchase decisions by Kenyan agrarian households. Evidence from the literature indicates that farm income for most agrarians is low and that they need to engage in income generating off-farm activities to afford agricultural input investments. Therefore, this study explores whether there exists a jointness in agricultural input use decisions and off-farm work decisions. For example, household members might decide to work off-farm in order to purchase fertilizer or rent farm machinery.

The second dimension of this relationship is the possible interdependence between purchase decisions for alternative inputs (seed, fertilizer, machinery and land). For example, the purchase of seeds might depend on the purchase of fertilizer or vice versa. The third dimension of this relationship relates to the question of "which specific source of off-farm income is relevant to which specific form of modern agricultural inputs". Adjognon et al., (2017) focused only on a

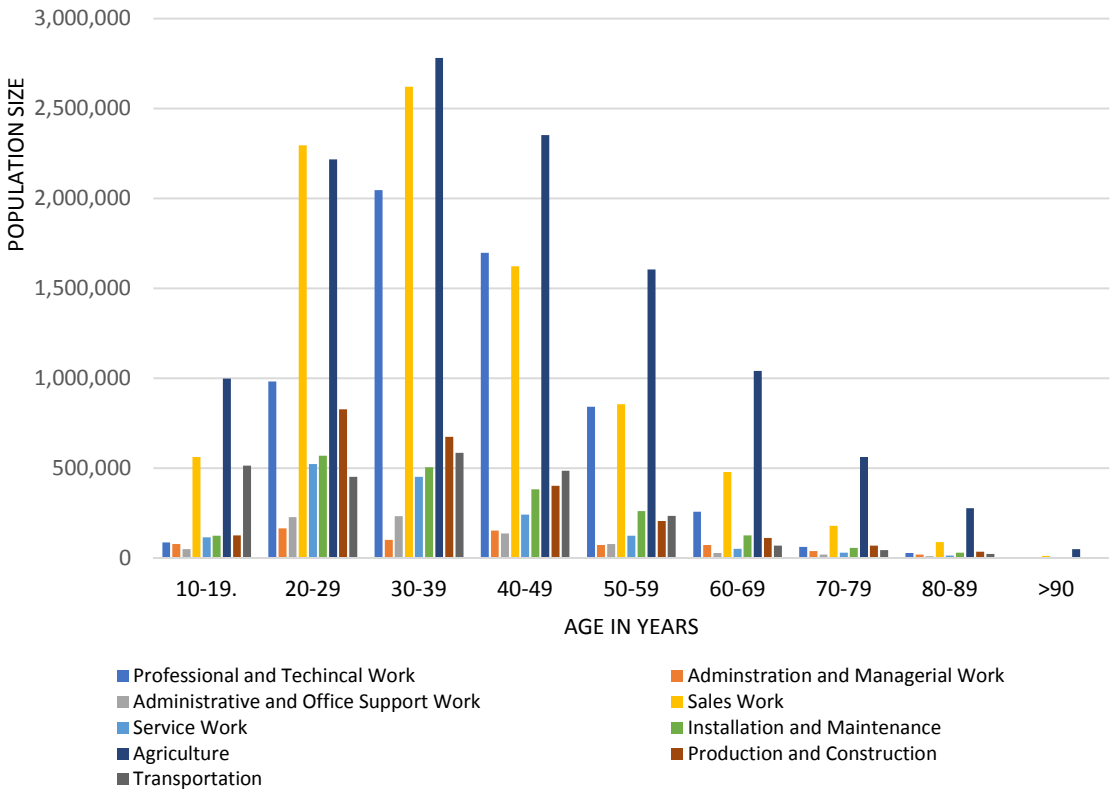
single agricultural input while Sheahan et al., (2017) and Reardon (1994) did not involve direct examination of the causal link between off-farm income and several agricultural inputs. No published studies have yet examined the relationship between various forms of off-farm income and a combination of farm input investments in Nigeria. Next, I provide more detail on the four agricultural inputs of interest in Nigeria (seed, fertilizer, machinery and land).

1.3. Farm Input Investments in Nigeria

This section provides a general overview of farm input investments in Nigeria. In Nigeria and elsewhere in SSA, meeting the increasing demand for food is one of the most significant challenges in agricultural production due to the rapid increases in population over time. Nigeria is the most populous country in SSA and its population increases by around 2.6% annually (World Bank, 2017). As shown in Figure 1, agriculture remains the prime occupation for all the age-ranges except for the age-range of 20-29. This is highly indicative of the fact that the majority of the population is highly dependent on the income generated from agricultural production (Ifatimehin et al. 2010). Sales related businesses rank second as a practiced occupation in almost all age-ranges of the population. Most agrarian household members work in off-farm activities such as sales businesses to supplement the low income generated from agricultural production. Professional occupations rank third among most age-ranges. It is important to note that the education level of a given agrarian household member would greatly impact on agricultural input use. For example, an agrarian household member with a higher level of education could have greater tendency to use (or inform family members to use) inputs such as fertilizer and machinery on a plot, compared with household members with low levels of education.

Given the growing population and the fact that the majority of the population participate in agriculture as an occupation, production enhancing farm inputs is critical to meet the growing demand for food. Next, I discuss seed, fertilizer, machinery and agricultural land use in Nigeria.

Figure 1: Distribution of Population by Age and Occupation



Source: Ifatimehin et al., 2010

1.3.1. Seed Use

This section explores the effect of off-farm income on seed investments in Nigeria. Seed is purchased in Nigeria either through the formal or informal seed market system. The formal seed system is mostly operated by government and the seed varieties supplied are certified and well known to the farm community. The informal seed system is locally integrated and seed is produced

and disseminated from farmer's own harvests. The majority of seed purchases in Nigeria are conducted through the informal seed system.

Factors that encourage farmers to participate in this informal seed system include: timely availability of seeds, risk-averse behavior, and the ability to purchase seeds in the form of barter or loan from family, relatives, neighbors and others. On the other hand, despite the government's efforts to enhance the formal seed input use system in Nigeria by renewing the existing policy set by National Agricultural Seeds Council (NASC) in 2010, Nigeria's seed system still faces challenges. The challenges include ineffective and unstable implementation of government policies, poor socio-economic conditions of farmers, wide spread misconceptions, near crisis in the pricing of seed, inadequately trained personnel at field level, poor private participation and the lack of credit and other factors. Off-farm income can enhance the purchase of seed from the formal seed system and quality certified seed varieties can enhance agricultural productivity.

1.3.2. Fertilizer Use

Like many countries in SSA, Nigeria's low fertilizer usage is a result of inefficient policies; poor quality, timing and availability of fertilizers; the supplemental requirement of other inputs such as improved seeds; inefficient market; low farmer income; high transportation cost; and high prices (Wilfred, 1996). Although, these factors are constraining in the short-run, over time, with effective policies, fertilizer use can be enhanced. In fact, with growing food insecurity and population, fertilizer use is highly advocated to boost agricultural production (Morris et al., 2007). Similarly, deterioration in soil nutrient constraining factor in agricultural production. Hence, given the poor soil nutrient situation in Nigeria, fertilizer application is highly recommended to increase production through multiple production cycles within the farming season (Otitoju et al., 2016).

As described by Otitoju et al., (2016), Nigeria's low fertilizer usage can also be attributed to the inconsistency of government fertilizer policies over the years. Policies designed to address the challenges related to fertilizer use such as poor quality, high prices, low access and timely availability have not been effective. The frequent change in policies over time is one of the main reasons for this ineffectiveness. Furthermore, the use of subsidies in a free-markets situation had constrains the private sector from participating in such markets, leaving the public sector as a sole actor in fertilizer markets (Liver pool Tasie et al., 2010). The purchase of fertilizer is also constrained by the insufficient amount of income generated from farm production. A recent cross-country study by Adjognon et al., (2017) used the same LSMS data as this study to show that fertilizer use increases in response to an increase in rural non-farm. However, their study included only two-time periods, this study incorporates data on a more recently available third time period.

1.3.3. Farm Land Rental

As previously discussed, Nigeria's low level of agricultural productivity can be attributed to a number of factors. These include: (1) low use of modern agricultural inputs; (2) rural population growth and the resultant shrinkage in farm size and increase in land scarcity and; (3) the continual degradation in soil quality (Otitoju et al., 2016). In addition, the growing incidence of agricultural land grabbing[3] by foreign investors further depletes the available arable land (Attah et al., 2013). Several studies from the development economics literature delineated the efficiency of small-scale farming, and the inverse farm size-productivity relationship (Sheahan et al., 2017; Barrett et al., 1996). This inverse relationship has been the basis for different agricultural production action plans to promote small-scale agriculture, especially in countries like Nigeria

[3] Land grabbing is the acquisition of large-scale land by private and governmental companies. Large-scale of land can be between 1000-500,000ha of land, although those farms owned by foreign investors are accelerating the development of industrial farming and producing for world markets, small scale producers are marginalized. This can affect the majority of subsistent agricultural producers in Nigeria (Onoja et al., 2015).

where land is scarce. Small-scale agricultural production is defined as those occurring on less than 5ha of arable land. However, medium scale farming covers 5-100ha. Large-scale production involves farming on 100ha of land and beyond. Although below 5ha is the convention used to identify small-scale farms in many SSA countries, most of them are actually below 2ha. Furthermore, inefficient land markets, archaic land tenure systems, inconsistent land policies and the use of land as a prestige form of wealth constrains productive use of those small-scale farms. Land markets can alleviate this challenge by creating the opportunity for land rentals.

The renting of land by more productive households from less productive households is crucial in agricultural development (land transfer can prevail through informal land markets where land rich households can rent out land and land deficient households can rent in). The land rental market plays a significant role in facilitating efficient and equitable land use (Chamberlin and Jacob, 2016). Furthermore, a study by Jin and Jayne (2013) showed that land rentals enable households to experience an increase in their income levels through increased agricultural productivity. Although efficient and equitable distribution of land can be attained through land markets, the income generated from farm production by most small-scale farmers is not always sufficient to cover household expenses, let alone afford to rent-in land. Hence, could off-farm income in this case be a source of finance for land rentals? This study will investigate this possibility.

To explore the questions above, this study analyzes the incremental effect of off-farm income on farm land rental in Nigeria. As farm production usually does not generate sufficient income, off-farm income can be a supplement to agricultural production, and, therefore can assist households in land rentals. A study by Ibrahim et al., (2017) showed that factors such as remittances and off-farm wages both have positive and significant effects on land demand and

transactions. The existence of environmental, economic and political challenges, as well as poor governance and ineffective land market policies can hamper the devotion of those off-farm income to land rental investments. On the other hand, land rental investments can further accelerate the use of machinery and therefore reduce labor intensive agricultural production.

1.3.4. Farm Mechanization

In many SSA countries, the use of improved agricultural technologies by households has proven to be effective in improving agricultural productivity, improving food security, and addressing persistent poverty (Pingali, 2012). Most strategic plans to enhance agricultural productivity mainly focus on technologies such as improved seed and inorganic fertilizer. Therefore, policies that promote the adoption of such technologies, along with different research and development initiatives, were expected to transform agricultural production in many SSA countries and the African continent in general. The eminent role of mechanization (powered machinery) in agricultural production has not been the focus to agricultural development.

One can attribute this lack of focus on mechanization to the failure to engage in intensive research prior to the introduction of mechanization. In the 1980's, the promotion of mechanization in most SSA countries was based on the region's land abundance and less attention was paid to the availability of labor and cost effectiveness of such machinery, in comparison to hand tools and animal traction. Another reason is that while input subsidy programs were created to enhance the utilization of improved seed and fertilizer, farm mechanization received relatively less focus. Such programs there was less focus on mechanization. Hence, the degree of agricultural mechanization has been low in many SSA countries, including Nigeria.

Almost 90% of farming activities in Nigeria is done manually. About 7% use some equipment drawn by draft animals and only 3% use engine driven technologies (Asoegwu et al.,

2007). Nigeria's low usage of machinery in agricultural production is due to the lack of intensive agricultural production, poor access to credit, financial insecurity, lack of government support (subsidies and extension services), lack of availability of spare parts and small farm sizes (< 2ha). One of the important factors that constrains machinery investment is the financial insecurity of households. The high initial investment cost, running cost (spare parts) and depreciation cost of some agricultural machinery refrains households from investing in machinery. The existence of machinery rental markets can alleviate this challenge as machinery rental can be relatively cheaper than purchases. Further, with the prevalence of machinery rental opportunities, off-farm income can play a prominent role on machinery use.

In Nigeria, the required degree and type of mechanization varies across the different regions of the country. For instance, in Northern Nigeria, where arable land is abundant, the demand for mechanization is associated with increased off-farm income. However, in the Southern part of Nigeria, staple crop producing households exhibit a high degree of willingness to pay for mechanization and reallocate labor to off-farm income generating activities (Takeshima et al., 2013). Like many countries in SSA, in Nigeria, the idea of commercial production drives most mechanization. Hence, highly mechanized technologies tend to be designed for large farms (Takeshima et al., 2013). Taking into consideration the high percentage of subsistence farmers in the country, research institutes, government agencies and NGOs have been working on technologies that suit the farms of subsistent producers. In light of the above, in this thesis, I analyze the effect of three types of off-farm income on the uses of farm machinery in Nigeria.

1.4. Organization of the Study

The rest of this thesis is organized as follows. Chapter two presents a literature review and the objectives of this study. It highlights the scope of off-farm income examined in the study, the importance of off-farm income in farm input investments, and the rationale for considering off-farm income in addition to microfinance. Chapter three presents the conceptual framework and the associated empirical framework for the analysis. Chapter four presents the nature of the data and summary statistics. Chapter five presents the empirical findings and discuss the implications. Chapter six contains conclusions, policy recommendations and the limitations of the study.

CHAPTER TWO: LITERATURE REVIEW AND STUDY OBJECTIVES

2.1. Literature Review

2.1.1. The Scope of Off-farm Income

Off-farm income, as the term indicates, is defined in this thesis as any source of income outside of farm production income. Depending on the community that the household is situated in and the availability of off-farm activities, sources of off-farm income can vary. Off-farm opportunities are dependent on several factors, including distance to markets, access to main roads, government and private investments around the area, the presence of financial institutions and the availability of Non-Governmental Organizations (NGOs) (Reardon et al., 1994).

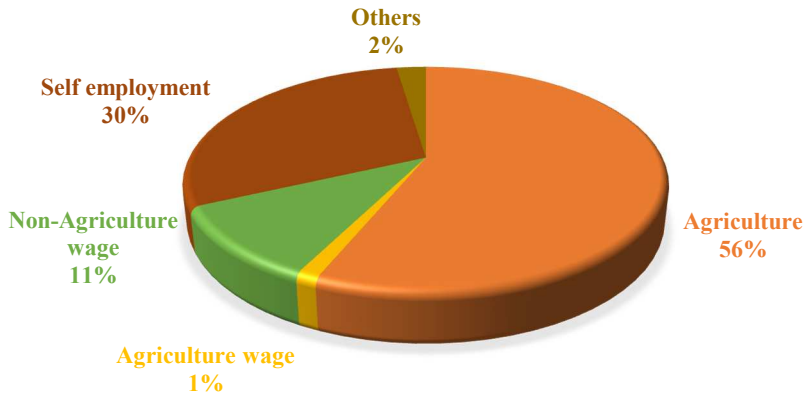
Household's participation in any off-farm income generating activities result mainly from insufficient and unstable income generated from farm production activities (Reardon, 1998). Due to its relative non-variability, off-farm income is then used as a supplement to farm-based production activities. In Nigeria, agricultural production makes the largest contribution to total household income. Specifically, agriculture production contributes around 56% of all household income. As described in Figure 2 below, the lowest contributor to household income is agricultural wages (i.e. household members working on other farms), which is around 1% (Nagler and Naude, 2017). This study focuses on three leading types of off-farm income generating activities in Nigeria's agriculture (small enterprises, off -farm work and remittances from migrants).

2.1.1.1. Incomes from Off-farm Enterprises

Due to financial constraints, most Nigerian rural households participate in self-operated, easy to enter, small sales and trade businesses rather than costly, highly professional or skill demanding businesses. Consequently, the most significant share of those trade and sales activities are dominated by agribusiness activities, including input supply, livestock market and farm equipment rentals. In addition, most off-farm enterprises are run by household members to reduce

the cost of hired labor. In most SSA countries, more than 80% of off-farm enterprises do not recruit any laborer outside their family members (Nagler and Naude, 2017).

Figure 2: Off-farm Activity Contribution to Total Household Income in Nigeria



Source: Nagler and Naude, 2017

The motivation to participate in small enterprises is driven by low agricultural production, environmental shocks, lack of insurance and credit support, inability to finance farm inputs and other household expenses (Barrett et al. 2001). Hence, households diversify their activities to become financially secure. Despite the small sizes and the seasonality of these enterprises, income generated from them supports the households considerably. Households that engage in off-farm enterprises are better-off than those that do not (Nagler and Naude, 2017). By using total household consumption as a well-being indicator, Shehu et al. (2014) showed that households participating in enterprise activities experienced better consumptions than those that do not.

2.1.1.2. Income from Off-farm Labor Wages

Off-farm labor wage is the wages obtained by participating in activities other than on one's farm and other farms. Households members who are capable of working, participate in income

generating activity to support their families. This happens during the farming season and during off farm season. Off-farm work can be within the settlement area of the farmer, or household members can migrate to other cities, states or countries (Taylor, 1999). The decision of household members to work off-farm depends on several factors including: the number of family members in the household who are capable of working on farm and off-farm, availability of employment opportunities.

Off-farm employment can have positive impacts on the purchase of farm inputs, and on-farm capital investments. Those households that were constrained by credits and insurance support can utilize wages from off-farm employment to enhance agricultural productivity. Reardon et al., (1998) showed that despite the unequal distribution of income, rural non-farm employment has had a substantial impact on increasing input purchases and farm capital investment, leading to farm modernization. On the other hand, the effect of wages from off-farm employment is conditional on the type of input use. For example, for rural Kenya, Smale et al., (2016) showed that off-farm work and fertilizer application are inversely related suggesting a trade-off between labor allocation and farm input investment. The same study showed that off-farm work is directly related to seed purchases. Other studies showed that the allocation of the labor to off-farm activities decreases farm production through loss of productive labor on the farm. In this study, I will test the impact of off-farm wages on farm input investments in Nigeria.

2.1.1.3. Remittances

Remittances represent one of the emerging credit-constraint relieving tools used by many rural households. The flow of remittance to many developing countries has increased and shown to have a significant impact on ameliorating the livelihood constraints of many rural households (Castello et al., 2013). Although, the use of remittances in investments and development activities

is still being debated in many countries, it has proven to be highly significant in improving the welfare of many rural households.

In SSA, Nigeria is one of the highest ranked foreign remittance receiving countries. Annual foreign remittances reached around $22 Billion in 2017 (World Bank, 2018). Almost 94% of the remittances are transferred via informal channels while only 6% are done through formal channels (such as banks and financial institutions). Foreign remittance to Nigeria have had a significant impact in alleviating poverty and income inequality (Odozi et al., 2010). Nwaru et al., (2011) showed that not only does the welfare of a family receiving a remittance improve, lives of the non-recipients do as well. This is because more money in the local community could spur employment of resource, and therefore increase income and general consumption level.

Based on the above, above I except the stated off-farm income sources to have a significant and positive impact on the livelihood of many rural households. Next, I describe the importance of the three sources of off-farm income in agricultural input use decision.

2.1.2. Importance of Off-farm Income in Farm Input Investment Decisions

Several studies describe the importance of off-farm income in farm input investments. For example, Reardon et al., (1998) described how off-farm income significantly impacts the overall well-being of rural household. Their study suggest that off-farm income can increase farm productivity by increasing the ability to finance input purchases. In addition, it can also curtail the overall income variance in situations of farm and non-farm income variability. Off-farm income can also smoothen consumption in times of shortfalls in farm production. Most rural households search for opportunities around their communities to earn additional income to support their families. However, in places where the opportunities are deficient, rural households may leverage the migration of relatives as their best option to generate income and support their family through

inward remittances. The differentials in income and opportunities between urban and rural residents allow the former to support their lower income relatives that live in the rural areas (Castello and Boike, 2013).

Gracious and Abdoul (2015) study of rural Uganda showed that with the existence of credit constraints, off-farm income (such as remittances) can encourage the adoption of improved agricultural inputs. This study, as well as Smale et al., (2016) and Adjognon et al., (2017), strongly supports the hypothesis that various forms of off-farm income have significant impacts on alternative farm input investments. The recent study by Adjognon et al., (2017) specifically indicates that increased off-farm income has significant impact on fertilizer use, compared with credit use. Consequently, in this study, I empirically test this hypothesis in the case of Nigeria. Specifically, this study uses the nationally representative Nigerian LSMS data to investigate how the various sources of off-farm income received by households' impact specific input investments.

The income generated from farm production is not sufficient to motivate farmers to participate in farm input investments (Rosenzweig et al., 1993). Most of the countries in SSA depend on subsistence agricultural production. Hence, production is directed towards self-consumption and very little is sold in markets if a surplus is attained (Boughton et al., 2007). If insufficient production leads to poor financial liquidity, households will ultimately be constrained from participating in input investments. In Nigeria, off-farm income has significant contributed to general household income (Adelekan et al., 2017). Such income is used as a supplement to farming income, to purchase farm inputs.

2.1.3. The Importance of Considering Off-farm Income, vis-à-vis, Microfinance Receipts

In most SSA countries, the benefit of financing obtained from Microfinance institutions[4] to rural households is not very clear. Stewart et al., (2010) suggests that the clients of microfinance institutions are made even more destitute and that the small amounts of lending from microfinance institutions refrains households from investing, such lending is used for consumption purposes. The inability to pay back the amount borrowed further puts households in a cycle of borrowing more, which deteriorates their saving capabilities. Furthermore, micro-savings is shown to be in greater use than the micro-credit[5]. Also, micro-credits are provided to credit constrained households based on the assumption that all are entrepreneurs, but very few households are capable of using the amount borrowed in investments. On the other hand, the lack of successful performance and continuity of several microfinance institutions is exacerbated by poor governance, lack of funds and lack of effective policies (Barry et al., 2014).

In Nigeria, many microfinance institutions have collapsed due to inadequate finance, higher risk, high transaction cost, high loan losses, low capacity and technical skills in microfinancing (Nwanyanwu, 2011). Also, fluctuating policies have led many microfinance clients to lose confidence in such institutions (Okpara, 2010). Rural households, therefore, tend to work off-farm to generate more certain incomes rather than taking loans from such institutions.

[4] Microfinance institutions is an organization that offers financial services to low income population including loans, insurances, deposit and other services.

[5] Microcredit is an extremely small loan given to impoverished borrowers who lack collateral, steady employment and verifiable credit history. While Micro-savings is a process in which microfinance institutions offers small deposit accounts to lower income households as an incentive to store funds to future use.

2.1.4. Literature Gap

Farm input investments include increased use of agricultural inputs, adoption of new agricultural technologies or improvement of existing input use efficiency (Sheahan et al., 2014). The study referenced above has addressed the roles of some off-farm income types in the decision to use or adopt various farm inputs. The authors mainly described cross-country input investment activities in SSA countries and recommended further analysis of the interdependence between off-farm income and agricultural input use. Based on their suggestion, Smale et al., 2016 analyzed the interdependence of nitrogen fertilizer and off-farm income. This study will further extend the literature by analyzing the effects of specific types of off-farm income on a portfolio of agricultural inputs.

Therefore, this study seeks to test the following specific hypotheses:

Hypothesis 1: The decision to work off-farm and to use modern agricultural inputs are jointly made.

Hypothesis 2: Remittances received by households have a significant and positive effect on agricultural input investment.

Hypothesis 3: Off-farm wages have a significant and positive effect on agricultural input investment.

Hypothesis 4: Profits from enterprises have a significant and positive effect on agricultural input investment.

Hypothesis 5: Strong interdependence exists between various agricultural input investment decisions.

To test these hypotheses, I use a nationally representative Nigerian Living Standard Measure Survey (LSMS) data from the Nigerian Bureau of Statistics to analyze the impact of off-farm income on farm input investments.

2.2. Research Questions

The primary objective of this study is to analyze the impact of off-farm income on farm input investments, by providing information on how alternative income sources affect farm input investments. Specifically, the study aims to answer the following questions:

(1) Is there a jointness in the decision to purchase or rent an agricultural input and to work in off-farm activities?

(2) What are the impacts of profits from off-farm enterprises, off-farm wages, and remittances on farm input investments?

(3) Is there an interdependence between various agricultural input investment decisions?

2.3. Study Contributions

This study contributes to the existing literature in several ways. First, by using Nigerian LSMS panel data from three time periods, I demonstrate the role and importance of off-farm income sources as supplements to farm income in farm input investment decision. Previous studies on this topic evaluated this hypothesis using descriptive statistics on cross-country data in SSA. This study extends the existing literature and test the hypothesis using empirical models. While, most studies focused on the impact of a single input, this study examines four crucial farm inputs: seed, fertilizer, land and machinery. The purchase of a seed variety might trigger the use of a new fertilizer on a farm, or the use of mechanization might lead to more land rentals. Consequently, I analyze the interdependence between all four input investments.

CHAPTER THREE: CONCEPTUAL FRAMEWORK AND METHEDOLOGY

3.1. Conceptual Framework

The existence of necessary market conditions, but not all, is referred to as an incomplete market (Michael, 2002 and Magill, 1991). In such economies, markets may fail for many reasons, including: (1) incomplete markets for credit and insurance, (2) incomplete markets for factors of production, (3) high transportation cost and (4) risk and uncertainty. In this study, market failures are assumed to be associated with incomplete markets for credit affecting the input markets (see Pitt, 2000). To address the problems of incomplete markets for credit in Nigeria, the effect of off-farm income on agricultural input investments is analyzed within an agricultural household model that combines production and consumption decisions.

Several studies in the literature had addressed agricultural input investments using the agricultural household models (Franklin and Zeller, 2006; Strauss et al. 1986). This paper utilizes the utility maximization framework induced by imperfect credit markets for investment in four crucial agricultural inputs (seed, fertilizer, machinery and land). The agricultural household model influenced by market imperfections has been widely used in several studies. This study extends the basic agricultural model by incorporating the effect of off farm income on agricultural input investments.

Gine and Yang (2009) identified financial constraints as the main causes of low rates of agricultural input investments. As most Nigerian households depend on subsistence agriculture (with small land holdings) income generated from farm production is barely enough to meet the household's needs. Therefore, household members participate in off farm activities to generate income that supplement farm production (Adelekan et al., 2017). The utility maximization

framework used in this study integrates the farm production function into the standard household utility function.

The individual household's utility is assumed to depend on household leisure time [T_H] and goods purchased for direct and indirect consumption [Q]. That is:

$$Max\ U\ =\ U\ (T_H, Q;\ H_H, X_P), \qquad [1]$$

where H_H and X_P are, respectively household characteristics [H_H] and plot-related characteristics [X_P]. The choice variables include both T_H and Q. While, the utility function also depends on factors pertaining to (1) household characteristics [H_H] such as household age, education level, gender and (2) plot related characteristics [X_P] such as, rainfall, distance to market, distance to road and nearness of households to a highly populated settlement.

The optimal utility attained by households is constrained by the total time available to the household members, net cash income and the farm production function. Hence, the total time endowment [T] includes (1) time to work on the farm [T_F], (2) time to work off-farm [T_{OF}] and (3) household leisure time [T_H]. That is:

$$T = T_F + T_{OF} + T_H \qquad [2]$$

Farm household income encompasses farm harvest sales income, off-farm income (remittance, off farm wage and enterprise profit) and total assets owned by the household. The model assumes that households are price takers. Therefore, they have no influence on input and output prices. The budget constraint for households can be expressed as:

$$P_{OP}\, Q_{OP} - P_I\, Q_I + S_{OF}\, T_{OF} + A_H = PQ \qquad [3]$$

The first term on the left-hand side of equation (3) describes the net farm income [$P_{OP}\, Q_{OP} - P_I\, Q_I$], where, [$P_{OP}$] is the price of farm output produced, [Q_{OP}] in the quantity of farm output produced and sold, [P_I] is the price of farm inputs purchased and [Q_I] is the quantity of farm inputs

purchased. Similarly, the second term in the left-hand side [$S_{OF}T_{OF}$] describes off farm income, components of which includes off-farm income from (remittance, off farm wage and enterprise profit). The last term in the left-hand side describes the total assets owned by households. Asset acquisition assists households to diversify production either through self-financing or using assets as collateral to obtain credit (Reardon, 1998). Hence, the level of assets owned is treated as another source of income to households.

Households, depending on the number of plots owned, climatic conditions and environmental factors, produce a variety of outputs [Q_F], using the inputs [Q_I] and the farm endowed time [T_F]. The farm production of Nigerian households can be represented by the following concave production function:

$$Q_F = f(T_F, Q_I; H_H, X_P) \quad [4]$$

The production function is substituted into the budget constraint from equation 3 as follows:

$$P_{OF} f(T_F, Q_I; H_H, X_P) - P_I Q_I + S_{OF} T_{OF} + A_H = PQ \quad [5]$$

Hence, from the above production function, households need to make simultaneous decisions on (1) the total amount of time to spend on agricultural production, (2) the total quantity of inputs to purchase or invest in and (3) the consumption goods to be purchased to maximize utility. To maximize utility, the above function can be expressed in the Lagrange form as follows:

$$\mathfrak{I} = U(T_H, Y_I; H_H, X_P) + \lambda_1 ((P_{OF} f(T_F, Q_I; H_H, X_P) - (P_I Q_I + S_{OF} T_{OF} + A_H - PQ)) + \lambda_2 (T - T_F - T_{OF} - T_H) \quad [6]$$

The first order conditions for utility maximization are:

$$\partial \mathfrak{I} / \partial Q_I = \lambda_1 (P_{OF} f_{QI} - P_I) = 0 \quad [7]$$

$$\partial \mathfrak{I} / \partial T_F = \lambda_1 (P_{OF} f T_F) - \lambda_2 = 0 \quad [8]$$

$$\partial \mathfrak{I} / \partial T_{OF} = \lambda_1 (S_{OF}) - \lambda_2 = 0 \quad [9]$$

$$T - T_F - T_{OF} - T_H = 0 \quad [10]$$

$$P_{OP} Q_{OP} - P_I Q_I + S_{OF} T_{OF} + A_H - PQ = 0 \quad [11]$$

Household members invest in inputs and spend these time on agricultural production only if the marginal benefit is equal to the marginal cost of investments. Hence the optimal demand function for the household's labor and input purchased can be obtained by using equation (7) and (8):

$$T_F^* = f(S_{OF}, P_I, P, H_H, X_P), \text{ where } \partial T_F^* / \partial S_{OF} < 0 \quad [12]$$

$$Q_I^* = f(S_{OF}, P_I, P, H_H, X_P), \text{ where } \partial Q_I^* / \partial P_I < 0 \quad [13]$$

As described in equation (13), the optimal demand for farm inputs [Q_I^*] depends on off farm income [S_{OF}], price of farm inputs [P_I], sales price of output [P] and households and environmental factors that affects the decision of demand [H_H, X_P].

3.2. Empirical Framework

As stated in the conceptual framework, agricultural input demand depends on off-farm income, input price, output price, and household & environmental characteristics. The effect of these factors can further be analyzed using an empirical model that specifies the statistical relationship between the dependent variable (agricultural input demand) and independent variables (the stated factors). Specifically, the empirical model analyzes the effect of off-farm income on the purchase and rental of agricultural inputs, and the degree of jointness in decision making about agricultural inputs, and the degree of jointness in the decisions related to off-farm income and input use. Reinvestment of off-farm income and the decision to purchase or rent an agricultural input is an endogenous decision to the household. Because the error term may capture several

unobserved factors, it may be correlated with the covariates, leading to a biased estimation. To address this problem, the efficacy of several instrumental variables was tested (access to electricity, access to internet service, non-farm income share to total income and extension services). However, none of these instrumental variables were significant enough to be included in the final set of models. The instrumental variables would have had allowed the exploration of the presence of endogeneity with respect to the presumed independent variables. Therefore, this study does not fully address the problem of endogeneity.

As a means of comparison, the effects of off-farm income and other hypothesized exogenous factors are examined by using the Pooled Ordinary Least Square (POLS) regression technique (see Appendix-A). Univariate models address the effects of off-farm income and other independent variables on agricultural input use. However, they do not address join decisions regarding agricultural input use. Agricultural input use decisions are expected to be inter-linked. TH existence of contemporaneous correlation between the error terms of the input demand equations will therefore, lead to biased estimates. To address such bias Seemingly Unrelated Bivariate Probit regression (SUBP) and the multivariate probit (MVP) regression model are used in this analysis.

The SUBP regression model is used to test the possibility of a joint relationship between the binary decisions to work off-farm and to purchase or rent an agricultural input. For example, a household member might decide to work off-farm work in order to purchase or rent an agricultural input. Unobserved characteristics which are not explained in the model might also lead to the joint decision making. The SUBP regression model also addresses the potential simultaneity bias by allowing free correlation between the residuals of the two equations. The binary choices between the decision to work off-farm and purchase or rent an agricultural input (m) by a household (h) at a time (t) is described as:

$$W_{ht} = [1 \text{ if } X_{ht}\beta + V_{ht} > 0, = 0 \text{ otherwise} \quad [14]$$

$$Y_{hmt} = [1 \text{ if } X_{hmt}\beta_1 + W_{ht}\beta_2 + U_{hmt} > 0, = 0 \text{ otherwise} \quad [15]$$

$$\text{Cov}[V_{ht}, U_{hmt}] = \rho$$

where W_{ht} in equation (14) captures the binary decision of a household member to work off-farm, X_{ht} captures all the covariates that affect this decision, and V_{ht} captures the error term. Similarly, equation (15), Y_{hmt} captures the binary choice decision of agricultural input use, X_{hmt} describes the various covariates used in this analysis, W_{ht} captures the binary decision to work off-farm and U_{hmt} captures the error term. The diagnostic statistics for this analysis includes the Wald-test, which describes the correlation among the error terms, and the t-test describes the systematic relationship.

Similarly, the MVP model estimates the effect of an off-farm income and other control variables on four agricultural inputs by allowing the error terms in each equation to freely correlate. The dependent variable represents the input use where by positive result (=1 indicates the decision to use agricultural input) and negative (=0 indicates the decision not to use the input). The multivariate probit model is based on multivariate normal distribution and is best used when there exists a strong interdependence between the use of alternative agricultural inputs. This model has been used in several studies involving agricultural input use (Smale and Heisey, 1993; Chirwa, 2005 and Teklewold et al. 2013). The Correlated Random Effects (CRE) approach is incorporated to address the effect of unobserved heterogeneity. The exclusion of unobserved factors household factors (interest in reinvesting, personality, inherent management capabilities etc.) may lead to biased estimation. Hence, the covariates are left to be correlated with the unobserved heterogeneity through the use of CRE to minimize the effect of unobserved heterogeneity.

The multivariate probit regression model using CRE is described in the following equations:

$$Y_{hmkt} = \alpha + G_{ht}\beta_1 + X_{hmkt}\beta_2 + Z_t\beta_3 + C_h + U_{hmkt} \quad [16]$$

where, Y_{hmkt} is a binary outcome variable capturing the decision of a household (h), to purchase or rent an agricultural input (m), for a plot (k) at a specific time (t), the term α indicates the constant term, G_{ht} describes the amount of off-farm income (remittance, off-farm wages and enterprise profits) a given household (h) received at a time (t), X_{hmkt} captures all household related covariates i.e. (gender, age education level, household size, credit, asset holding), and all plot and environment related covariates i.e. (plot size, input price, stored inputs from previous season, rainfall, distance to nearest market and nearness to a highly populated area) covariates that affect the decision to utilize agricultural input, Z_t, describes the year dummies, C_h describes unobserved heterogeneity and U_{hmkt} is the error term. When CRE is incorporated, the model becomes:

$$Y_{hmkt} = \alpha + G_{ht}\beta_1 + X_{hmkt}\beta_2 + Z_t\beta_3 + \psi + \bar{x}_{hmkt}\beta_4 + a_h + U_{hmkt} \quad [17]$$

where, c_h is decomposed in to the mean values of the covariates stated above, $\bar{x}_{hmkt,}$ and the household specific effects $a_{h,}$ ($C_h = \psi + \bar{x}_{hmkt} + a_h$). This is done by assuming strict exogeneity where the expected value of the error term conditional on the covariates and the unobserved effect must be equal to zero.

$$Y_{hmkt} = \alpha + G_{ht}\beta_1 + X_{hmkt}\beta_2 + Z_t\beta_3 + \bar{x}_{hmkt}\beta_4 + \varepsilon_{hmkt} \quad [18]$$

where, $\varepsilon_{hmkt=}\ a_h + u_{hmkt}$, captures both the error term and household specific unobserved heterogeneity. The term β captures the coefficient for all the covariates, with β_1 being the coefficient for the variables of interest. Therefore, the model in equation (16) estimates the effects of the treatment variables and other covariates on the purchase and rental of agricultural input in question. The following chapter discuss the data and summary statistics for this study.

CHAPTER FOUR: DATA DESCRIPTION AND SUMMARY STATISTICS

4.1. Data

This study relies on the Nigerian LSMS-ISA data from the World Bank, which includes general household, agriculture and community information across six geo-political zones over three time periods; 2010/11, 2012/13 and 2015/16. In each time period, information was collected twice, during the post planting and post-harvest periods. As described in Table (B2) of Appendix B, the data is an unbalanced panel data of 18,509 observations, with an attrition rate of 6.9%,

The panel data is comprised of four dependent variables (seed use, fertilizer use, plot rental and machinery rental). All the dependent variables are in a binary form, where the variable is assigned a value of one if an input is used and zero otherwise. Each of these dependent variables are analyzed at the plot level.

With respect to the independent variables, three levels of off-farm income are relevant in this analysis (remittance, off-farm wages and enterprise profits). The remittances variable is defined as both in-cash and in-kind amount remitted. The Off-farm wages variable defined as the total wages obtained by working in any off-farm activities other than in agriculture. The enterprise profits variable is defined as the level of profits obtained by operating an enterprise. Data is available on household, plot and environment related characteristics, which are briefly described in Table 7. The rest of this chapter discusses specific treatment of the data related to (1) Agricultural input purchases by Zone, (2) the average annual rainfall, (3) agricultural input purchase by level of off-farm income, (4) amount of farm and off-farm income by household size, (5) agriculture input purchase by gender of household head and participation of other household members, and, (6) the effect of inter-household income distribution.

4.2. Agricultural Input Purchases by Zone

Table (1) shows the percentage of plots which used (purchased or rented) new agricultural input in each of the six geo-political zones of Nigeria. Although all regions of Nigeria depend primarily on agricultural production for their livelihoods, the dynamics has changed in recent years. The South-West of Nigeria highly focused on service and commerce. The South-East is mostly focused on trade. The South-South is mostly focused on oil extraction (much of its arable land has been lost to oil spillage). The North-East and North-West are mostly focused in agriculture (performance has been hampered by insurgencies by the Boko-Haram. Lastly the North-central, also known as the "middle belt" appears to be the main beneficiary of the developments in agriculture sector. Despite the differences in the dynamics of the economic sectors and regional variation in the percentage of agricultural input use, farmers from almost all the regions participate in agricultural input purchase and rental.

Table 1: Summary Statistics for Agricultural Input Use by Geo-Political Zone

Zone	The Percentage of Plots which used New Agricultural Input by Zone			
	Seed Purchase	Fertilizer Purchase	Machinery Rental	Land Rental
North-Central	9.20	14.67	32.70	16.54
North-East	16.16	21.44	42.74	15.06
North-West	17.85	26.23	9.09	6.67
South-East	21.10	13.91	3.19	14.29
South-South	25.59	17.96	0	31.28
South-West	10.10	5.79	12.28	16.15

Source: Author's estimation from the Nigerian LSMS-ISA data.
Note: Seed purchase captures any type of seed purchased in kg/ha, fertilizer captures (Urea, NPK and manure) purchased in kg/ha, machinery rental captures any three of (tractors, harvesters, planters, grinders, wheel barrow, peeling machine, driers and others) rented during planting and harvest season and land rental captures the additional square meter (m^2) rented by Nigerian households.

Based on our data, the South-South zone leads the country in the purchase of seeds and land rentals. However, fertilizer purchases are more common in North-East and North-West zones.

Finally, North-East and North-Central zones have relatively more households who are willing to rent machinery compared to other zones. Overall, households residing in the North-east purchased and rented the most agricultural inputs while the households in the South-south zone purchased and rented the least. In short, there is significant geographic variation across the geo-political zones in the adoption of agricultural inputs.

4.3. Average Annual Rainfall by Zone

Table (2) provides summary statistics on the average annual rainfall in the six geo-political zones of Nigeria. Rainfall[6] in Nigeria considerably varies across the six zones. Rainfall is relatively high in the south, moderate around the sahelian region in the north and a bit low around the central regions. As described in Table 2, the South-South zone experiences the highest, whereas the North-West experiences the lowest rainfall. Sufficient precipitation in an area might greatly impact on agricultural input purchase and rental decision of households. Among other factors, one of the reasons for the high seed purchase and farm land rental in Table 1 could be the fact that rainfall in South-South zone is relatively higher.

Table 2: Summary Statistics for Average Annual Rainfall by Geo-Political Zone

Zone	Mean	Standard Deviation	Min	Max
North-Central	1341	171	1045	1844
North-East	907	247	356	1516
North-West	853	250	443	1534
South-East	1958	206	1229	2408
South-South	2369	447	1318	3901
South-West	1330	163	1128	1900

Source: Author's estimation from the Nigerian LSMS-ISA data.
Note: The amount of rainfall is measured in millimeters (mm).

[6] The rainy season lasts four months in the Northern region June-September. It lasts from April to October (six-months) in the central region and from March to October (Seven-months) southern region.

4.4. Agricultural Input Purchase by Type of Off-farm Income

Table (3) shows the purchase of agricultural inputs by off-farm income type. The purchases of agricultural inputs from off-farm wages and enterprise profits are comparatively higher for most regions than the purchases from the use of remittances. More specifically, the total number of households that participated in the purchase of seeds from remittances is relatively higher than for other inputs. However, the total number of households participating in fertilizer purchase was higher through the use of off-farm wages and enterprise profits. The South-South region featured the highest percentage of households using remittance in the purchase of seed and fertilizer as well as land rentals. Interestingly, none of the households devoted any of the off-farm income towards machinery rentals.

In both the North-West and South-South regions, most of the households used off-farm wages to finance seed and fertilizer purchases. Similarly, in these two regions, the percentage of households that purchased seed and fertilizer through the use of enterprise profits is relatively high. The fact that a high number of households used off-farm wages highlights the reliability of the off-farm income. On the other hand, the purchase and rental of almost all agricultural inputs is low in the South-West region. In the North-East region, none of the households used remittances towards the purchase of any of the agricultural inputs.

The greater use of one type of off-farm income higher than are other may be due to several hidden factors: (1) the amount and timing of the off-farm income can affect the decision to use such income in agricultural input purchase or rentals. The following section discusses the level of off-farm income by household size and its effect on agricultural input investments.

Table 3: Summary Statistics on Agricultural Input Purchase Through Various Types of Off-farm Income

Zone	Remittance %				Off-farm Wages %				Enterprise Profits %			
	seed	Fertilizer	Machinery	Land	Seed	Fertilizer	Machinery	Land	Seed	Fertilizer	Machinery	Land
North-Central	9.52	3.80	50.00	13.33	9.20	14.67	32.70	16.54	9.15	14.54	33.73	17.60
North-East	0	0	0	0	16.16	21.44	42.74	15.06	15.86	21.41	36.32	14.57
North-West	1.19	3.80	50.00	0	17.85	26.23	9.09	6.67	20.07	27.72	12.74	7.93
South-East	64.29	72.15	0	73.33	21.10	13.91	3.19	14.29	20.12	13.70	3.30	12.59
South-South	15.48	12.66	0	6.67	25.59	17.96	0	31.28	22.98	15.77	0	31.59
South-West	9.52	7.59	0	6.67	10.10	5.79	12.28	16.15	11.81	6.85	13.92	15.73
Total Households	**84**	**79**	**4**	**15**	**6,010**	**8,612**	**627**	**1,560**	**3,682**	**5,371**	**424**	**858**

Source: Author's estimation from the Nigerian LSMS-ISA data.

Note: Remittance captures both in-cash and in-kind amount of remittances received by a household member, Off-farm wages describes any work outside one's farm and other farms (Mining, manufacturing, professional activities, construction, transportation, public administration and others) and enterprise profit captures the profits obtained by operating small sales and service businesses. All the off-farm incomes used in this study is measured using Nigerian currency Naira.

4.5. Farm and Off-farm Income by Household Size

Table (4) describes the average farm and off-farm incomes earned by household and average household size by geo-political zone. In almost all zones, the average off-farm income is relatively higher than the average farm income. For example, in the North-Central region with average household size of seven the average farm income is 21,274 Naira. However, the average off-farm income adds up to 116,451 Naira. The latter is almost six times the former. Of the three types of income that constitute off-farm income, enterprise profits represented about 70% while wage income represents about 22% in the North-Central region. Generally, this pattern is followed in every region with the exception of the North-East where average farm income was very low, remittance income was non-existent and enterprise profits was astronomically negative. Looking across states the South-West appears to be economically buoyant for households. The average farm income is about 90,000 Naira, remittances are about. Off-farm wages represent about 67,000 Naira, enterprise profit represented 164,000 Naira.

The low-level farm income, across the board appears to be one of the factors that push households to work off-farm. Although, farm income can be consistent and off-farm income can indeed be unstable the huge gap between both would suggest that households, if serious about farming will take advantage of periods were enterprise profit, off-farm income and remittances are high.

Table 4: Summary Statistics for Farm and Off-farm Income by Household Size

Zone	Average Household Size	Average Farm Income	Average Off-farm Income			Average per capita Income
			Remittance	Off-farm Wage	Enterprise Profit	
North-Central	7	21274	11404	25041	80006	19675
North-East	8	7656	0	10889	-3405939	-423424
North-West	7	10667	71	12885	140377	23428
South-East	5	4787	5539	19890	102394	26522
South-South	6	10782	566	23288	131854	27748
South-West	5	88921	978	66524	163786	64041

Source: Author's estimation from the Nigerian LSMS-ISA data.
Note: All the stated income levels are in Nigerian currency, Naira.

4.6. Agricultural Input Purchase by Gender of Household Head and Participation of Other Household Members

The diversity of income opportunities for a household, the distribution of income amongst household members and the control of income flow can influence the decision to reinvest in agricultural inputs. The household's demography, relationships, requirements and priorities can determine the distribution of income. The gender of the household head, for example, can affect the decision to invest in agricultural inputs. As described in table (5), the percentage of male headed households (89.25%) who participated in agricultural input purchase is more than female headed households (10.75%). Consistent with table (4), remittance remain the lowest source of off-farm income for both male or female led households. On the other hand, off-farm wages and enterprise profits are the most used off-farm income sources.

It is immediately obvious from the table that remittances are more occasional than other sources of off-farm income. Based on Table 5, in the North-central and North-east regions, no remittances are recorded for the time period of our study. The explanation for such low remittances in these regions is the low connectivity to the outside world. What these regions lack in remittance income, they compensate for in off-farm wages and enterprise profits.

These various off-farm incomes flow toward the household. However, managing, controlling and channeling such income flows towards agricultural input investment could be a challenge. This is especially so for income generated by members of the household other than the household head. In this study, it is found that many household members devote their off-farm incomes towards agricultural inputs. Across all zones, the percentage of family members who purchase or rent agricultural inputs is higher than the percentage for household heads. This indicates that apart from household heads other family members contribution to the total family income can have strong impact on agricultural input investments.

Table 5: Agricultural Input Purchase by Gender of Household Head and Participation of Other Household Members

Zone	Percentage of household members receiving remittance (%)			Sub Total HH #	Percentage of households member receiving off-farm Wages (%)			Sub Total HH #	Percentage of household members receiving enterprise Profit (%)			Sub Total HH #	Total HH #
	Male	Female	Other		Male	Female	Other		Male	Female	Other		
North-Central	0	0	0	0	43.93	2.68	53.39	560	36.07	1.80	62.12	499	1059
North-East	0	0	0	0	56.55	0.58	42.87	863	24.61	0.43	74.96	1,410	2273
North-West	0	0	100.00	4	47.20	0.19	52.61	1,072	15.82	0.06	84.12	1,681	2757
South-East	5.26	1.32	93.42	76	32.10	9.30	58.59	1,193	8.94	2.21	88.85	1,085	2354
South-South	7.14	0	92.86	14	36.52	7.87	55.62	890	15.72	2.60	81.68	999	1903
South-West	0	0	100.00	9	36.07	1.80	62.12	499	21.74	1.81	76.45	552	1060
Total				**103**				**5077**				**6226**	**11406**

Source: Author's estimation from the Nigerian LSMS-ISA data.
Note: The table describes purchase of agricultural inputs by male headed, female headed and other family members. Nigerian female farmers accounts for about 75% of Nigerian farming population, with the responsibility of producing and processing almost 80% of staple foods (Olakojo 2017). Yet as described in the table the agricultural input purchase and rental capacity remains lower than their male counterparts.

4.7. Inter-household Off-farm Income Distribution Across Households

The distribution of income in rural areas of most West African countries is largely unequal (Reardon et al., 1994). The initial high capital requirement and the lack of adequate credit constrain poor households from participating in off-farm activities. Woldehanna and Arie (2000) found that in rural Ethiopia, the wealthy rural households dominate most of the lucrative and risky non-farm activities. This increases the income gap between the poor and the wealthy rural households and restricts poor agricultural households from investing in agricultural inputs. Even if poor households participate in easy to enter and less capital demanding off-farm activities, the income generated may not be sufficient enough for further reinvestments in agricultural inputs. The table below describes inter-household off-farm income distribution in six geo-political zones of Nigeria.

Table 6: Off-farm Income Distribution Across Households

Zone	Off-farm Income Distribution in Percentage								Total
	0	<10	<50	<100	<200	<500	<1000	>1000	
North-central	87.43	0.68	1.48	0.90	1.25	2.25	2.04	3.97	18,499
North-East	83.69	0.85	2.08	1.68	1.67	2.69	2.48	4.86	18,500
North-West	85.59	1.57	1.38	1.09	1.50	3.13	2.18	3.55	18,501
South-East	84.69	0.99	3.30	2.03	1.50	2.94	1.89	2.66	18,509
South-South	93.78	0.46	1.95	0.87	1.18	1.75	0	0	17,420
South-West	96.95	0.23	0.61	0.45	0.73	1.04	0	0	17,726

Source: Author's estimation from the Nigerian LSMS-ISA data.
Note: The second row describes off-farm income distribution in multiple of thousands. The dashes in the South-south and South-west indicates zero percentages. If households had run a business and had incurred losses its included with in the zero off-farm income category.

Table (6) shows the percentages of people receiving various forms of off-farm income. For example, in South-West Nigeria, 96.95% did not receive any off-farm income. Table (6) therefore shows that the magnitude of off-farm income received by households varies.

4.8. Description of Dependent and Independent Variables

The four sections in Table (7) present the summary statistics for all dependent and independent variables used in this analysis. The first section captures the four dependent variables. All the dependent variables are expressed in binary form, if households have either purchased seed and fertilizer or rented land and machinery and zero. The second section presents the three treatment variables. Remittance captures the amount remitted to a household (both in cash and in kind). Enterprise profits is the profits generated by operating an enterprise. Off-farm wages is the income generated by working in any off-farm activities other than agricultural activities. All three treatment variables are measured in Naira. Among the three sources of off-farm income, remittance represent the lowest source of off-farm income, compared to enterprise profits and off-farm wages.

The third section in Table (7) presents summary statistics of household's characteristics that could affect the decision to invest in agricultural inputs. Most of the variables presented in this section has been used in several previous studies (Smale et al., 2016; Adjognon et al., 2017; Otitoju et al., 2016). Many of these variables captures the household head's characteristics. These is because for most households the household head is the decisive family member in decisions regarding agricultural input uses. Control variables included gender, age and education of household head, asset holdings (which describe the financial stability of a household) and credit (a binary variable describing the availability of credit institutions). Household size is the number of household members, which on one hand explains the sufficiency of labor that can participate in both farm and off-farm activities and, on the other hand, shows the total number of household members that needs to be fed. The average household size by zone is described in Table (4), while the dependency ratio by zone is described in Table (B4) of Appendix B.

The last section of Table (7) presents summary statistics in plot related characteristics that affect agricultural input use decision. Like plot rental, seed and fertilizer purchase prices were not readily available in the Nigerian LSMS-ISA data.

Hence, price indices for those variables was calculated using Fisher's price index which is described in Appendix-C. The stock of Fertilizer and seeds from previous seasons could greatly affect the purchase of these inputs in the current period. The table indicates that seed storage is high in the North-central zone (18%) and low incidence in the South-west zone (7%). Similarly, the incidence of fertilizer storage is high in the North-west zone (17%) and low in the South-west zone (7%). On the other hand, the distance of a household to a populated settlement or a market area seems to greatly impact the agricultural input purchase and rental decisions hence those variables are included in this analysis. As a result of this distance, transportation cost for those agricultural inputs, especially in the case of fertilizer, could also affect the purchase decision.

The data indicates that almost 96% of households own < 2ha of land and only 4% own >2ha of land. A total of 670 households own >2ha of land in which 44% of this ownership is located in the North-East zone, with the lowest of 1% in the South-east zone. The variable rainfall captures the annual mm of rainfall as it was described in Table (2). The following chapter discusses the regression results using the variables stated in Table (7).

Table 7: Summary Statistics and Description of Dependent and Independent Variables

	Description	N	Mean	SD
Dependent Variables				
Purchased seed	=1 if purchased seed, zero otherwise.	18,509	0.3407531	0.4739753
Purchased fertilizer	=1 if purchased fertilizer, zero otherwise.	18,509	0.4813874	0.499667
Machinery rented	=1 if household rents a machinery, zero otherwise.	18,509	0.0338754	0.1809133
Plot rented	=1 if a household rents a plot, zero otherwise.	18,509	0.0843373	0.2779006
Treatment Variables				
Remittance	Amount of remittance received (Naira).	18,509	3333.983	210984.1
Enterprise profit	Amount of profit generated from enterprises (Naira).	18,509	94203.61	3306701
Off-farm wage	Off-farm wags from off-farm work (Naira).	18,509	11575.98	154666.9
Household Characteristics				
Household head age	Household head age (years).	17,676	52.65858	14.75825
Male	=1 if gender is male.	18509	0.8924765	0.309802
Primary Education	Primary education level of a household head.	18,509	0.2804582	0.4492352
Secondary Education	Secondary education level of a household head.	18,509	0.1592198	0.3658909
Training	Vocational and religion related trainings a household head gained.	18,509	0.0853639	0.27943
Higher Education	Higher education level of a household head.	18,509	0.0712086	0.2571799
Household size	Number of family members with in a household.	18,509	6.406883	3.522741
Credit	=1 if a household has access to credit zero otherwise.	18,460	0.296533	0.4567412
Household wealth	The level of wealth which is measured by the number of assets owned.	18,380	137498.9	1115030

Table 7 (cont'd)

	Description	N	Mean	SD
Plot and Environmental Characteristics				
Stored fertilizer	Quantity of fertilizer from previous season or attained for free.	18,509	55.73654	292.9534
Stored seed	Quantity of seed from previous season or attained for free.	18,509	176.8588	1956.892
Fertilizer price	Price Index of fertilizer (Naira).	18,509	965.7158	1718.746
Seed price	Price Index of seeds (Naira).	18,509	92.62575	181.8085
Fertilizer Transportation cost	Fertilizer transportation cost per quantity purchased (Naira/kg)	18,509	60.03616	3213.224
Plot rental price	Plot rental price (Naira).	18,509	434.9499	6318.304
Plot size	Plot size in square-meters (sq. m)	18,509	4523.405	10596.55
Distance to market	Distance to nearest market (km).	18,508	72.88731	39.46642
Populated area	Distance to a highly populated settlement (+20,000)	18,508	25.6522	18.93632
Rainfall	Annual rainfall (mm)	18,508	1423.727	618.2268
North-central	=1 if household located in North-central zone, zero otherwise	18,215	0.1947296	0.3960033
North-east	=1 if household located in North-east zone, zero otherwise	18,215	0.2271754	0.4190184
North-west	=1 if household located in North-west zone, zero otherwise	18,215	0.1767225	0.3814441
South-east	=1 if household located in South-east zone, zero otherwise	18,215	0.1800165	0.3842117
South-south	=1 if household located in South-south zone, zero otherwise	18,215	0.1432885	0.3503764
South-west	=1 if household located in South-west zone, zero otherwise	18,215	0.0780675	0.2682852

Source: Author's estimation from the Nigerian LSMS-ISA data.
SD: stands for standard deviation.

CHAPTER FIVE: RESULTS AND DISCUSSIONS

This chapter is divided into three sections. The first section reports the results for test of jointness in the decision to earn off-farm income and the decision to purchase agricultural input and rent machinery and land. These results were obtained by using SUBP model. These results are presented in Tables 8-11. The second section reports the results of the effect of off-farm income on agricultural input use. These results were obtained through the MVP model. These results are presented in Table 12. The third section presents the results of the tests related to whether or not agricultural input use decisions are made jointly. These results were also obtained through the MVP model with correlated random effects. These results are also presented in Table 12. As unobserved factors that affect the decision of agricultural input may vary greatly for all equations the standard errors of the regression are clustered at local government area level (LGAs)[7].

5.1. Testing for Jointness between the Decision of Off-farm Work and Agricultural Input Use: Seemingly Unrelated Bivariate Probit Model

Recall that the seemingly unrelated bivariate probit regression model (see Tables 8-11) were implemented to explore the possibility of jointness in household decision making between working off the farm and purchasing or renting of agricultural inputs. One required model specification for each test is a probit function, with a binary dependent variable representing the decision to purchase an agricultural input, and several independent variables expected to affect that decision. Added to the list of such independent variables is the off-farm source of income. The counterpart is the one where the dependent variable is the decision to engage in the specific off-farm activity and the independent variables are the factors that affect that decision. The first specification in Table 8 tests the jointness of the decisions to allocate effort to own enterprise and

[7] There are 774 LGAs in Nigeria but this study covers only 376 LGAs. Each LGA is administered by local government council and is further divided in to wards with a minimum of ten and a maximum of fifteen in each area.

the decision to purchase seed. The result suggests that households do not allocate effort to such enterprises in order to purchase seed. That is, the Wald-test shows the independence of the two decisions. The estimated negative effect of enterprise profits on the purchase of seeds cannot be explained, as the essence of the model is to test jointness. The second specification, in Table 8, tests the jointness of the decision to allocate effort to off-farm work and the decision to purchase seed. The Wald-test asserts the jointness of the decision to work off-farm and to purchase seed. Interestingly, in the jointness tests, off-farm wage does not have a significant effect on seed purchase.

The third specification, in Table 9, tests the jointness of the decisions to allocate effort to own enterprise and the decision to purchase fertilizer. Contrary to the results obtained for seed purchase, households do allocate effort to own enterprise in order to purchase fertilizer. That is, the Wald-test result shows the jointness of these two decisions. In these models to test for joint decision making, enterprise profits show a positive and significant effect in the purchase of fertilizer. The fourth specification tests the jointness of the decision to allocate effort to off-farm work and the decision to purchase fertilizer. The Wald-test result suggests that households do not allocate effort to off-farm work in order to purchase fertilize. Off-farm wages do not have a significant effect in the purchase of fertilizer.

The fifth specification, in Table 10, tests for jointness in the decision to allocate effort to own enterprises and to rent a farm land. The result suggests that households do not allocate labor to their own non-farm enterprise in order to rent a plot. Interestingly, enterprise profits indicate a positive and significant effect on plot rental. The sixth specification suggests that households do allocate effort to off-farm work in order to rent a plot. The jointness in these decision is asserted by the Wald-test. Off-farm wages do not have a significant effect on plot rental.

The seventh specification, in Table 11, tests the jointness in the decision to allocate effort to own enterprises and the decision to rent a machinery. The result suggests that households do allocate effort to own enterprises in order to rent machinery. Enterprise profits shows a positive and significant effect on machinery rental. The eighth specification however, suggests the independence in decision to allocate effort to off-farm work and the decision to rent a machinery. Off-farm wages do not have a significant effect on machinery rental.

The effects of the decision to pursue the various sources of off-farm income on agricultural inputs use, purchase or rental will be further analyzed using the multivariate probit regression with correlated random effects. However, in conclusion, the regression result in (Table 8 - 11) shows jointness in the decisions to allocate effort to off-farm work, to purchase seed and to rent land. Similarly, the results indicate jointness in the decisions to allocate effort to own enterprises, to purchase fertilizer and to rent machinery. Please note that due to the data limitations on remittances, no joint decision-making tests were performed on such remittances.

Table 8: Seemingly Unrelated Bivariate Probit Model (Seed-purchase)

	Specification-1		Specification-2	
Independent variables	Seed-Purchase	Enterprises	Seed-Purchase	Off-farm Work
Gender of Household Head (=1 if household head is male)	-0.0517	**0.212****	-0.0605	0.119
	(0.0775)	**(0.0877)**	(0.0782)	(0.0927)
Household members age (>15 and <64)	-0.0162	**0.0214***	-0.0164	**0.0241****
	(0.0107)	**(0.0115)**	(0.0107)	**(0.0113)**
Household head age	0.000393	**-0.00537*****	0.000602	**0.00531*****
	(0.00142)	**(0.00156)**	(0.00143)	**(0.00176)**
Credit (=1 if households have access)	**0.0888****	**0.129*****	**0.0912****	**0.178*****
	(0.0395)	**(0.0425)**	**(0.0395)**	**(0.0510)**
Household wealth (ln)	0.0116	**0.110*****	0.0133	**0.0614*****
	(0.0114)	**(0.0150)**	(0.0114)	**(0.0147)**
Secondary education level of HH (1/0)	**-0.105****	0.0579	**-0.0999****	**0.263*****
	(0.0466)	(0.0570)	**(0.0467)**	**(0.0651)**
Vocational training of HH (1/0)	0.00743	**0.392*****	-0.00409	-0.125
	(0.0722)	**(0.0701)**	(0.0722)	(0.0866)
Higher education level of HH (1/0)	-0.0798	**-0.333*****	-0.0710	**1.245*****
	(0.0717)	**(0.0870)**	(0.0719)	**(0.107)**
Plot size	-0.00000224	**0.00000197***	-0.00000242	-0.000000781
	(0.00000223)	**(0.00000115)**	(0.00000224)	(0.00000140)
Distance to populated area	**-0.00808*****	-0.00129	**-0.00829*****	**-0.00843*****
	(0.00172)	(0.00165)	**(0.00172)**	**(0.00196)**
Year 2011/12	-0.0120	**0.555*****	-0.0243	-0.00995
	(0.0852)	**(0.0912)**	(0.0857)	(0.0959)
Year 2015/16	-0.0276	**0.561*****	-0.0399	**-1.180*****
	(0.0849)	**(0.0958)**	(0.0857)	**(0.102)**
Farm productivity (ln)	**0.0264*****	**-0.0187****	**0.0272*****	**0.0290*****
	(0.00867)	**(0.00829)**	**(0.00869)**	**(0.0109)**
Seed price (ln)	**0.0531*****		**0.0503*****	
	(0.0131)		**(0.0132)**	
Rainfall	**-0.000144*****		**-0.000168*****	
	(0.0000534)		**(0.0000541)**	
Enterprise	**-1.02e-10*****			
	(1.45e-11)			
Off-farm Work			-0.000000192	
			(0.000000163)	
Constant	**-0.723*****	**-1.652*****		**-0.786*****
	(0.190)	**(0.200)**		**(0.215)**
Observation	17,420		17,420	
Pseudo-likelihood	-19505		-18108	
Wald test of ρ=0:	χ^2=2.31 Pr >χ^2 =0.128		χ^2=14.328 Pr >χ^2 =0. 0.0002	

*Note: The values in parentheses describe robust standard errors clustered at LGA level, with a p-value of *** p<0.01, ** p<0.05, * p<0.1*

Table 9: Seemingly Unrelated Bivariate Probit Model (Fertilizer-purchase)

	Specification-3		Specification-4	
Independent variables	Fertilizer-Purchase	Enterprises	Fertilizer-Purchase	Off-farm Work
Gender of Household Head (=1 if household head is male)	0.0279	**0.212****	0.0226	0.119
	(0.0912)	**(0.0878)**	(0.0914)	(0.0928)
Household members age (>15 and <64)	**0.0497*****	**0.0213***	0.0496***	**0.0240****
	(0.0105)	**(0.0115)**	(0.0105)	**(0.0113)**
Household head age	**-0.00341****	**-0.00536*****	-0.00331**	**0.00530*****
	(0.00164)	**(0.00156)**	(0.00165)	**(0.00176)**
Credit (=1 if households have access)	**0.0943****	**0.129*****	**0.0949****	**0.177*****
	(0.0404)	**(0.0425)**	**(0.0403)**	**(0.0511)**
Household wealth (ln)	**0.0663*****	**0.110*****	0.0666***	**0.0611*****
	(0.0154)	**(0.0150)**	(0.0153)	**(0.0147)**
Secondary education level of HH (1/0)	0.0313	0.0581	**0.0324**	**0.262*****
	(0.0595)	(0.0570)	**(0.0594)**	**(0.0650)**
Vocational training of HH (1/0)	**0.303*****	**0.393*****	0.295***	-0.127
	(0.0835)	**(0.0701)**	(0.0829)	(0.0865)
Higher education level of HH (1/0)	0.0172	**-0.333*****	0.0150	**1.244*****
	(0.0782)	**(0.0870)**	(0.0767)	**(0.107)**
Plot size	0.000000164	**0.00000196***	4.11e-08	-0.000000762
	(0.00000148)	**(0.00000114)**	(0.00000149)	(0.00000139)
Distance to populated area	-0.00205	-0.00129	**-0.00218**	**-0.00844*****
	(0.00179)	(0.00165)	**(0.00179)**	**(0.00196)**
Year 2011/12	**-0.234****	**0.556*****	-0.241**	-0.00995
	(0.0948)	**(0.0913)**	(0.0950)	(0.0959)
Year 2015/16	**-0.309*****	**0.562*****	-0.316***	**-1.180*****
	(0.0999)	**(0.0959)**	(0.100)	**(0.102)**
Farm productivity (ln)	0.0195	**-0.0187****	**0.0201***	**0.0290*****
	(0.0121)	**(0.00829)**	**(0.0121)**	**(0.0109)**
Fertilizer price (ln)	**0.167*****		**0.168*****	
	(0.0223)		**(0.0222)**	
Rainfall	**-0.000571*****		**-0.000589*****	
	(0.0000844)		**(0.0000846)**	
Enterprise	**7.38e-11*****			
	(1.43e-11)			
Off-farm Work			2.87e-08	
			(7.97e-08)	
Constant	**-1.107*****	**-1.654*****		**-0.782*****
	(0.253)	**(0.200)**		**(0.215)**
Observation	17,420		17,420	
Pseudo-likelihood	-21321		-19946	
Wald test of ρ=0:	χ^2=3.82 Pr >χ^2 =0.0505		χ^2=2.58 Pr >χ^2 =0.1083	

*Note: The values in parentheses describe robust standard errors clustered at LGA level, with a p-value of *** p<0.01, ** p<0.05, * p<0.1.*

Table 10: Seemingly Unrelated Bivariate Probit Model (Plot-rental)

	Specification-5		Specification-6	
Independent variables	Plot-rental	Enterprises	Plot-rental	Off-farm Work
Gender of Household Head (=1 if household head is male)	**0.345*** **(0.184)**	**0.212**** **(0.0877)**	0.333* (0.183)	0.119 (0.0926)
Household members age (>15 and <64)	0.000118 (0.0151)	**0.0214*** **(0.0115)**	0.0000360 (0.0154)	**0.0239**** **(0.0113)**
Household head age	**-0.0105***** **(0.00238)**	**-0.00538***** **(0.00156)**	**-0.0103***** **(0.00238)**	**0.00532***** **(0.00176)**
Credit (=1 if households have access)	-0.0274 (0.0699)	**0.129***** **(0.0425)**	-0.0276 (0.0696)	**0.178***** **(0.0511)**
Household wealth (ln)	**-0.0336**** **(0.0158)**	**0.110***** **(0.0150)**	**-0.0321**** **(0.0159)**	**0.0610***** **(0.0147)**
Secondary education level of HH (1/0)	-0.135 (0.0907)	0.0579 (0.0570)	-0.124 (0.0907)	**0.263***** **(0.0650)**
Vocational training of HH (1/0)	**-0.247*** **(0.127)**	**0.393***** **(0.0701)**	**-0.259**** **(0.128)**	-0.126 (0.0866)
Higher education level of HH (1/0)	(0.127) (0.0782)	**-0.334***** **(0.0869)**	0.198 (0.127)	**1.243***** **(0.107)**
Plot size	**0.00000423**** **(0.00000168)**	**0.00000197*** **(0.00000114)**	**0.00000407**** **(0.00000165)**	-0.000000749 (0.00000139)
Distance to populated area	-0.00204 (0.00271)	-0.00129 (0.00165)	-0.00218 (0.00266)	**-0.00842***** **(0.00196)**
Year 2011/12	**0.885***** **(0.188)**	**0.556***** **(0.0912)**	**0.864***** **(0.187)**	-0.0101 (0.0958)
Year 2015/16	-0.107 (0.205)	**0.562***** **(0.0959)**	-0.121 (0.205)	**-1.180***** **(0.102)**
Farm productivity (ln)	0.0237 (0.0144)	**-0.0187**** **(0.00829)**	**0.0240*** **(0.0144)**	**0.0291***** **(0.0109)**
Plot rental price (ln)	**0.619***** **(0.0389)**		**0.617***** **(0.0397)**	
Rainfall	**0.000296***** **(0.0000820)**		**0.000267***** **(0.0000807)**	
Enterprise	**7.38e-11***** **(1.43e-11)**			
Off-farm Work			-3.94e-08 (0.000000136)	
Constant	**-1.660****** **(0.300)**	**-1.653***** **(0.200)**	**-1.625***** **(0.296)**	**-0.782***** **(0.215)**
Observation	17,420		17,420	
Pseudo-likelihood	-14073		-12688	
Wald test of ρ=0:	χ^2=0.54 Pr >χ^2 = 0.4633		χ^2= 3.68 Pr >χ^2 = 0.0551	

*Note: The values in parentheses describe robust standard errors clustered at LGA level, with a p-value of *** p<0.01, ** p<0.05, * p<0.1.*

Table 11: Seemingly Unrelated Bivariate Probit Model (Machinery-rental)

	Specification-7		Specification-8	
Independent variables	Machinery-rental	Enterprises	Machinery-rental	Off-farm Work
Gender of Household Head (=1 if household head is male)	0.294 (0.205)	**0.212**** **(0.0877)**	0.276 (0.205)	0.119 (0.0926)
Household members age (>15 and <64)	0.0434** (0.0207)	**0.0214*** **(0.0115)**	0.0424** (0.0209)	**0.0239**** **(0.0113)**
Household head age	**-0.00157** **(0.00355)**	**-0.00538***** **(0.00156)**	**-0.00146** **(0.00351)**	**0.00532***** **(0.00176)**
Credit (=1 if households have access)	0.0541 (0.0766)	**0.129***** **(0.0425)**	(0.0772) (0.0696)	**0.178***** **(0.0511)**
Household wealth (ln)	**0.124***** **(0.0347)**	**0.110***** **(0.0150)**	**0.127***** **(0.0352)**	**0.0610***** **(0.0147)**
Secondary education level of HH (1/0)	0.134* (0.0718)	0.0579 (0.0570)	0.136* (0.0718)	**0.263***** **(0.0650)**
Vocational training of HH (1/0)	**-0.460***** **(0.161)**	**0.393***** **(0.0701)**	**-0.472***** **(0.161)**	-0.126 (0.0866)
Higher education level of HH (1/0)	0.456*** (0.123)	**-0.334***** **(0.0869)**	0.466*** (0.123)	**1.243***** **(0.107)**
Plot size	**0.00000276** **(0.00000185)**	**0.00000197*** **(0.00000114)**	**0.00000259** **(0.00000189)**	-0.000000749 (0.00000139)
Distance to populated area	-0.00115 (0.00348)	-0.00129 (0.00165)	-0.00158 (0.00351)	**-0.00842***** **(0.00196)**
Year 2011/12	**-0.0289** **(0.198)**	**0.556***** **(0.0912)**	**-0.0465** **(0.198)**	-0.0101 (0.0958)
Year 2015/16	0.214 (0.212)	**0.562***** **(0.0959)**	0.184 (0.214)	**-1.180***** **(0.102)**
Farm productivity (ln)	0.00897 (0.0137)	**-0.0187**** **(0.00829)**	**0.0103** **(0.0139)**	**0.0291***** **(0.0109)**
Plot rental price (ln)	**-0.0000248** **(0.0198)**		**0.000538** **(0.0195)**	
Rainfall	**-0.000638***** **(0.0000875)**		**-0.000658***** **(0.0000873)**	
Enterprise	**2.69e-10***** **(5.68e-11)**			
Off-farm Work			-3.94e-08 (0.000000136)	
Constant	**-2.672***** **(0.409)**	**-1.653***** **(0.200)**	**-2.634***** **(0.417)**	**-0.782***** **(0.215)**
Observation	17,420		17,420	
Pseudo-likelihood	-14073		-12239	
Wald test of ρ=0:	χ^2=4.67 Pr >χ^2 = 0.0306		χ^2= 1.82 Pr >χ^2 = 0.18	

*Note: The values in parentheses describe robust standard errors clustered at LGA level, with a p-value of *** p<0.01, ** p<0.05, * p<0.1.*

5.2. Estimated Demand Function for Agricultural Inputs

Recall that a primary objective of this analysis is to determine whether the earning of off-farm income affects the decision to invest in agricultural inputs. Specifically, we test whether or not earnings from remittances, off-farm wages and enterprises have significant impacts on the purchases of fertilizer and seed and the rental of machinery and land. We use the MVP, with correlated random effects to test this hypothesis. In the regression, the binary variable representing whether or not the farmer utilized the input was regressed against variables reflecting household characteristics, plot characteristics as well as the treatment variables. The results are reported in Table (12).

5.2.1. Off-farm Income and Seed Purchases

Table (12) reports the regression results for the seed demand equation for Nigerian households. The result indicates that profit from enterprises such as manufacturing of food products, manufacturing of wearing apparel, retail and wholesale trade, food and beverage service and others has a positive and significant effect on seed demand. The demand for seed depends on three factors; (1) the need for seed replacement, (2) requirement of new variety and (3) emergency response (for example, stored seed infested by pests and rodents). Hence, if the need arises to purchase seed due to any of these three factors, the household pursue alternate income sources. If enterprise income is chosen as the means of funding, the level of investment will depend on (1) the level of profits from enterprises (which should be above the consumption requirement of the household), (2) the immediate requirement of seed purchase (running out of stored seed), the timing of profits and the planting season. If the amount of profits is sufficient and the availability matches the planting season, profits from enterprises would be topped to purchase seed. The findings on seed suggests that such profits are used to fund farm seed demand. An alternative result

is found with respect to off-farm wages and seed purchase. The results suggest that off-farm wages do not have a significant impact on seed purchase. Recall that in order of magnitude, enterprise profit is typically three times the income from off-farm wages. It may well be the case that the off-farm wage incomes typically are too low to affect the decision on seed purchase.

Remittances were found to have a significant and positive effect on seed purchase. This is an important finding, considering that remittances are increasingly being looked at as a potential source of funding for agricultural investments. In summary, with respect to seeds, enterprise profit and remittances seem to be relevant sources of funding.

Some mention of the signs of household and plot characteristics is appropriate. The results suggest that there exists an inverse relationship between vocational training and seed demand a direct relationship between access to credit and seed purchase. These suggest that remittances and profit from enterprises are alternative forms of finance for seed.

The coefficient of the natural logarithm of seed price interestingly has a positive and significant effect on seed purchase. Since seed is a necessary but non-replaceable item, even if prices increase, households are forced to still make purchases. Otherwise, they will not be able to the needs of their family. Similarly, annual rainfall level has negative and significant effect on seed purchases. This finding is contrary to a priori expectations. All other region has shown to exhibit statistically higher demand than the North East. This is understandable, considering that the North east has been battered by Boko-Haram since the beginning of our study period. Hence in light of the results, both remittances and profit from enterprises supports *hypothesis (2)* and *hypothesis (4)*

while in the case of off-farm wages, *hypothesis (3)* is rejected as the variable has an insignificant effect on seed demand.

5.2.2. *Off-farm Income and Fertilizer Purchases*

Table (12) reports the regression results for the fertilizer demand equation for Nigerian households. Out of the three treatment variables used, only profit from enterprises has a positive and significant effect on fertilizer demand at a 5% significance level**.** This is similar to the result obtained from the seed demand model, where profit from enterprises had positive and significant effect on seed demand.

Remittance, on the other hand, does not have a significant effect on fertilizer demand. As remittances are infrequent and vary greatly in amount, it is difficult for households to rely on this source of income to support their fertilizer investments. Most of the time, remittances are meant for specific expenses, which may include school fees, medical expenses and food related expense in times of agricultural production shocks. Hence, although remittance could supplement agricultural production costs, the infrequency, variance and timing can preclude households from devoting such income towards fertilizer investments.

Off-farm wages do not have a significant effect on fertilizer purchases. From Table 4, it was off-farm income in comparison to income from off-farm enterprises. It is difficult to determine whether the insignificant of remittances is the result of its low volume or the fact that off-farm income is used to supplement household expenses. Considering the fact that in much of Nigeria, rural communities were hit with famine, there are few options available to farmers for off-farm wages. It appears that most farmers can only obtain such wages from nearby farms that pays off-farm wages.

The educational level of the household head, listed under the household characteristics section of Table 12, shows that while both, vocational training, and higher education level have positive and significant effects on fertilizer purchases, primary education level, does not. The finding that advanced education, not basic education, is what matters suggests that fertilizer use, and therefore, productivity responses to education are consistent with expectations of a neoclassical production function. At low doses of education, there is no seed demand response. However, at higher doses, it is expected that farmers are able to comprehend the intricacies of fertilizer management and they therefore use it. The positive relationship between education and fertilizer use has important policy implications.

The natural logarithm of household asset holding shows a positive and significant effect on fertilizer purchases. Asset holding reflects the wealth of a household. The standard view of small holder farmers is that they have difficulty transitioning to commercial level farming due to their low income, land constraints, lack of access to markets and other limiting factors. The finding of a positive relationship between wealth and fertilizer use suggests that one of the benefits of improved wealth could be the modernization of the agricultural production system, at least through fertilizer adoption. Although the availability of off-farm income, credit and better household asset level can assist households in fertilizer purchases, the existing price level and distance to market can hamper fertilizer purchases. Surprisingly, fertilizer price and transportation cost have positive and significant effects on fertilizer purchases which contradicts the law of demand. With respect to fertilizer prices, if these are typically stable, positive demand response could indicate that price increases result in the anticipation of higher prices. With respect to transportation costs, poor rural infrastructure, longer distance to markets and agro-dealers and the lack of alternative transportation options translate into high transportation cost. Farmers may in fact be hoarding fertilizer when

transportation costs increase, especially when their distance also reflects higher costs of other services.

The dummy variable for time were both negative and significant at 1% significance level. This suggests that the purchase of fertilizer was lower in 2012/13 and 2015/16, in comparison to the 2010/11. On the other hand, in comparison to households residing in the North-central zone, households residing in the North-west zone purchased more fertilizer, while the purchase of fertilizer was lower in the South-west zone. This relationship may also butter the notion that distant farmers from market may hoard fertilizer.

In conclusion, the regression result rejects both *hypothesis (2)* and *hypothesis (3)* in chapter two. Both off-farm wages and remittances have no relationship with fertilizer use. However, the results support *hypothesis (4).* That is*, enterprise profits* are positively related to fertilizer use.

5.2.3. Off-farm Income and Land Rental

According to the Nigerian LSMA-ISA data base, 96% Nigerian households own small-scale farms which are less than two hectares in size and only 4% of households own medium-scale and large farms. As shown above, those households which own small scale farms also work more on off-farm activities than those that own larger farms. Their off-farm income reliance is mainly due to low agricultural production and therefore insufficient income. Further, approximately 10% of households receiving off-farm-wages participated in land rental investments. The percentages for profitable enterprise owners and remittance receiving households are 7.8% and 2.5%. The above statistics show that households that received off-farm wages participated more in land rental investments.

As shown in the third column of Table (12), wages from off-farm work has a significant and positive effect on land rentals. Land requires higher investments than the other three

agricultural inputs (seed, fertilizer and Machinery). Therefore, I expect that a more reliable source of income is required to finance land rental investments, compared with other inputs. Hence, when comparing the three types of off-farm income, wages from off-farm work are the most reliable source of income (duration of work and payment amount is known). However, households might also receive remittances targeted to land rental investments. But in comparison to remittances receivers, household that attained off-farm wages participated more on land rentals. The reinvestment of remittances and off-farm wages can also greatly depend on the management and control of intra-household income, as well as the inter-household off-farm income distribution. Households with relative low off-farm income may be hindered from participating in land rentals, whereas the relatively wealthier farmers and those with higher off-farm income may rent more land.

The household's asset holdings, measured by the log of household wealth in Naira, has a significant and negative effect on land rentals. This result is contrary to Chamberlin and Jacob (2016) findings, which show that Malawian households with larger asset holdings were able to rent in more land compared to households with small asset holding. One explanation for this result is that households with more assets also probably own more land, and therefore are less likely to want to rent in land. It is noteworthy that household head's age has a significant and negative effect on land rental investment. One explanation is that the older people are, the more assets they tend to own and the less land they are require to rent to meet their production goals. This inverse relationship between age and land rental warrant deeper investigation. A negative relationship is more justifiable for people beyond their prime age, but not for people before their prime.

Table 12: Multivariate Probit Regression with Correlated Random Effects (CRE)

Panel-1 Independent Variables	(1) Seed	(2) Fertilizer	(3) Plot	(4) Machinery
Treatment Variables				
Remittance	**0.000000105****	-5.09e-08	**0.00000264****	0.00000245
	(4.13e-08)	(3.57e-08)	**(0.00000112)**	(0.00000209)
Profit from enterprises (ln)	**0.00533***	**0.0110****	0.00174	**0.0136*****
	(0.00305)	**(0.00434)**	(0.00618)	**(0.00498)**
Off-farm wages attained (ln)	-0.00223	-0.00702	**0.0236****	**0.0222****
	(0.00511)	(0.00627)	**(0.00920)**	**(0.00913)**
Household Characteristics				
Gender of household Head (=1 Male)	0.0219	-0.00113	0.212	0.224
	(0.0845)	(0.0936)	(0.183)	(0.209)
Household head age	-0.00148	-0.00484	**-0.0148***	-0.00703
	(0.00469)	(0.00563)	**(0.00781)**	(0.00670)
Secondary education level of household head (1/0)	-0.0371	0.0551	-0.138	0.0800
	(0.0447)	(0.0688)	(0.0901)	(0.0745)
Vocational training (1/0)	**-0.125****	**0.196***	-0.187	**-0.354****
	(0.0624)	**(0.113)**	(0.116)	**(0.176)**
Higher education level of household (1/0)	0.0441	**0.178***	0.185	**0.429*****
	(0.0751)	**(0.103)**	(0.140)	**(0.102)**
Number of family members with in household	0.00665	0.00823	0.00749	**-0.0470****
	(0.0125)	(0.0143)	(0.155)	**(0.0183)**
Credit (=1 if household obtained credits zero otherwise)	**0.109*****	0.0796	-0.0165	0.00219
	(0.0388)	(0.0499)	(0.0686)	(0.0720)
Household wealth (ln)	0.0138	**0.0873*****	**-0.00857***	**0.121*****
	(0.0125)	**(0.0166)**	**(0.0191)**	**(0.0365)**
Plot Characteristics				
Seed price (ln)	**0.0628*****			
	(0.0132)			

Table 12 (cont'd)

Panel-1 Independent Variables	(1) Seed	(2) Fertilizer	(3) Plot	(4) Machinery
Stored Seed from previous season	0.000000108			
	(0.000000111)			
Fertilizer price (ln)		**0.111*** **		
		(0.0201)		
Fertilizer Transport cost (ln)		**2.058*** **		
		(0.146)		
Stored fertilizer from previous season		0.000000180		
		(0.000000227)		
Plot rental price (ln)			**0.644*** **	-0.00238
			(0.0454)	(0.0238)
Rainfall	**-0.00101***	-0.000148	-0.00212	0.000741
	(0.000610)	(0.00120)	(0.00175)	(0.00188)
Distance to nearest market	-0.00466	0.000781	0.0141	
	(0.00499)	(0.00561)	(0.0108)	
Distance to populated area			**-0.00441*** **	-0.00124
			(0.000)	(0.00415)
Plot size	0.000000821	**0.00000224** **	0.00000164	0.00000116
	(0.00000172)	**(0.00000112)**	(0.00000221)	(0.00000166)
Year 2012	0.0399	**-0.354*** **	**0.771*** **	-0.0733
	(0.0955)	**(0.117)**	**(0.187)**	(0.205)
Year 2015	-0.0418	**-0.501*** **	-0.129	0.260
	(0.105)	**(0.116)**	(0.206)	(0.211)
North-east	0.0584	**0.254***	0.0116	-0.101
	(0.110)	**(0.154)**	(0.180)	(0.330)
North-west	**0.762*** **	**1.084*** **	**-0.340***	**-0.699** **
	(0.110)	**(0.176)**	**(0.198)**	**(0.320)**
South-east	**1.107*** **	-0.0727	-0.0358	-0.558
	(0.111)	(0.183)	(0.203)	(0.469)

Table 12 (cont'd)

Panel-1 Independent Variables	(1) Seed	(2) Fertilizer	(3) Plot	(4) Machinery
South-west	**0.381*** **	**-1.046*** **	**0.527*** **	0.0242
	(0.120)	**(0.180)**	**(0.182)**	(0.279)
South-south	**0.586*** **	-0.377	**0.557** **	**-4.273*** **
	(0.128)	(0.388)	**(0.267)**	**(0.278)**
Constant	**-1.037*** **	**-2.267*** **	**-1.978*** **	**-2.581*** **
	(0.250)	**(0.352)**	**(0.352)**	**(0.654)**
Pseudo-likelihood	**-17196**			
Likelihood ratio test of ρ=0:	**χ^2 = 41.939**	**Pr >χ^2 =0.000**		
Panel-2 Dependent Variables Correlation				
Purchased Seed		**0.0997*** **	**0.0688* **	**0.0796** **
		(0.0243)	**(0.0389)**	**(0.0347)**
Purchased Fertilizer			**0.113** **	-0.00679
			(0.0472)	(0.0392)
Plot Rented				**0.103*** **
				(0.0397)
Observation	**17415**	**17415**	**17415**	**17415**

*Note: Panel-1 describes all the independent variables used and panel-2 describes the correlation among the error terms of each equation that shows the interdependence in agriculture input use decision. With the anticipation of varying unobserved factors across the country, standard errors are clustered at local government areas (LGAs). The values in parentheses therefore describes robust standard errors, *** p<0.01, ** p<0.05, * p<0.1 level. Pseudo-likelihood approximates the joint probability distribution of the variables stated and likelihood ratio tests the null hypothesis which states that there is no correlation among the error terms of the equations.*

The distance to the nearest population center variable shows a significant and negative effect on the probability of renting land. This means that households living in more rural areas are less likely to rent land for agricultural purposes. A possible reason is that more rural areas have less defined land markets and the search costs for available land could be prohibitive. Another possible reason is the relative difficulty in gaining access to various farm inputs in remote places. The likelihood of households renting land was higher in 2012, compared to 2010. Similarly, households residing in the South-south and South-west zones where more likely to rent land, compared with households in the North-central zone. In conclusion, the statistically significant effect of off-farm wages on land rental supports *hypothesis (3). Hypotheses (2) and (4) are rejected*.

5.2.4. Off-farm Income and Machinery Rental

This section analyzes the effects of the three off-farm income types on machinery rental. As shown in Table 12, both enterprise profits and off-farm wages have significant and positive effects on machinery rental. This is consistent with Takeshima (2013) findings on the determinants of mechanization in agriculture in Northern Nigeria. Remittances were found not to be statistically significant, suggesting their irrelevance in machinery rental decisions. One possible explanation is the infrequency and non-certainty of income from remittances.

The vocational training variable has a significant and negative effect on machinery rental. This is inconsistent with a priori expectation. However, the higher education level variable has a positive and significant effect on machinery rental. This indicates that, at low levels of education, there exists no machinery rental response. However, at higher levels of education, farmers are able to comprehend the intricacies of deploying machinery on farm land and they therefore use it.

The variable, household size, has a negative and significant effect on machinery rental. This indicates that larger families have better chance of using family labor on farm than renting machinery for agricultural production. It could also mean that the demands of a larger family for livelihoods stands in the way of being able to afford to rent machinery.

The variable, household wealth, has a positive and significant effect on machinery rental. Household wealth can either be directly converted in to cash or can be used as a form of collateral to obtain credits which can ultimately be used to rent machinery, if needed. Households residing in the North-West and South-South zones rented less machinery in comparison to the North-Central zone. This is understandable, considering the shortage of arable land in some South-south and North-west zones. It also is consistent with the summary statistics described in Table 1, where the incidence of machinery rental in the North-central region is 32.70%, compared with 9.09% in the North-west and zero percent in the South-South. In conclusion, the results from our machinery decision equation support *hypotheses (3)* and *(4),* as both enterprise profits and off-farm income had positive and significant effect on machinery rental. *Hypothesis (2*) is rejected.

5.2.5. Summary of Off-farm Work and Agricultural Input Use

The multivariate probit regression results indicate that the three off-farm income variables of interest (remittances, off-farm wage and enterprise profits) had varying impacts on the purchase and rental of the agricultural inputs. The variable, profit from enterprises, is estimated to have a positive and significant effect on the use of all agricultural inputs, except land rentals. Although remittances (due to their lumpiness) were expected to have a positive and significant effect on fixed input investments (machinery and land), it only had a significant and positive effect on plot rental. Remittances also had a positive and significant effect in seed purchases. As noted earlier,

off-farm wages were relatively the most reliable source of off-farm income. Hence households devoted such income towards fixed input investments (Machinery and Land).

5.3. Interdependence of Agricultural Input Use Decision

The basic assumption in modeling input decision choices is that the error terms in each equation is uncorrelated with others and follows a multivariate normal distribution. The violation of this assumption made it necessary to estimate the joint decision of a Nigerian household to use agricultural inputs and to earn off-farm income. The multivariate probit regression is similar to seemingly unrelated regression except the decision in the former is binary one.

In modeling decision-making regarding agricultural input use, two key issues become relevant: simultaneity and interdependence. The decision of Nigerian households to maximize utility by investing their off-farm income in any of the agricultural inputs may be inter-linked with respect to the inputs. This implies that the error terms in each equation are not independent and that the equations are either seemingly unrelated or simultaneous. The model described in equation (18) allow simultaneity and interdependence in decision to use agricultural inputs (seed, fertilizer, plot and machinery) with the additional off-farm income generated (remittance, off-farm wage and profit from enterprises). The last section in Table (12), panel-2, describes the correlation of the embedded unobserved characteristics in the error term across all four equations that may lead to joint agricultural input use. The simultaneity between agricultural input use can therefore be justified using multivariate probit regression with CRE by testing the correlation between the error terms of the equations. As shown in panel-2, I find the bivariate correlation between the agricultural inputs to be statistically different from zero. These suggest that a univariate model ignore the interdependence in input use decisions and therefore would bias the estimation. Hence,

multivariate probit regression best fits the data in analyzing the effect of off-farm income on interdependent agricultural inputs use decision.

The bivariate correlation results in panel-2 show that the decision to invest off-farm income in seed also affects the decision to use fertilizer and vice-versa. This supports the finding of Ogada eta al. (2014) of inter-linkage in the decision to use organic fertilizer and improved maize seed by Kenyan households. Furthermore, Smale and Heisey (1993) emphasized that the decisions regarding fertilizer and seed uses are a joint decision, rather than independent ones. The bivariate correlation coefficients between the error terms of the equation are significant for almost all the agricultural inputs, except for machinery rental and fertilizer purchase. The likelihood ratio test of rho = 0 (null hypothesis of zero correlation between the error terms indicates a non-zero correlation. So, I reject the null hypothesis that input use decisions are uncorrelated.

In conclusion, there exists strong bivariate correlation between all agricultural inputs, except fertilizer-machinery uses. This suggests that agricultural input use decisions are not independent, but rather are greatly inter-linked. Hence, to enhance agricultural production, effective policies that promote the use of a package of agricultural inputs should be taken as a prerequisite. These result support *hypothesis* (5).

CHAPTER SIX: CONCLUSIONS, POLICY IMPLICATION AND LIMITATIONS

6.1. Conclusion and Policy Implication

Several studies have emphasized that agricultural productivity is low in many SSA countries. One of the main reasons for this low is limited agricultural input use. In most SSA countries, this low input usage is attributed to several factors, including market inefficiency, lack of efficient policy, poor transportation infrastructure, non-timely availability of inputs, lack of extension services, land constraints, lack of credit and subsidy, as well as farmers financial illiquidity. financial liquidity is perhaps the leading constraining factor. Although several Microcredit and Microfinance institutions were set to relax the problem of financial illiquidity, their poor performances have limited many agricultural producers from enhancing agricultural productivity. Therefore, transforming agriculture would require eliminating such financial constraints, not only to improve agricultural productivity but also to improve the economic performance of the host countries.

There are many ways to improve agricultural input use. Several studies have shown off-farm income to be one of the most impactful. The decision to participate in off-farm activities and to reinvestment off-farm income in to agriculture can depend on several factors; (1) the physical environment and infrastructure (e.g. access to market and distance to road may affect the decision of reinvest off-farm income on risky agricultural production); (2) the economic and institutional environment, including market and government policies (e.g. availability of credit, input market, type of technologies extension services); (3) the type of available off-farm activity and initial capital requirements of those activities; and (4) control and management of off-farm income flows.

This study explores the utilization of modern inputs and factors that can promote such utilization. Off-farm wages are the most readily available source of off-farm income to rural

households. Enterprise profits, all be it less available have huge potential to generate income. e. The third and the least understood source of off-farm income examined in this study is foreign remittances, which accrue from family members who moved to other countries. This study analyzes the effects these three forms of off-farm income on investment in four major agricultural inputs (seed, fertilizer, machinery and land). Overall off-farm income has a significant effect on almost all agricultural inputs. For example, enterprise profit is estimated to have positive and significant effects on seed, fertilizer and machinery, but not on land. Off-farm wages were estimated to have positive and significant effect on machinery and land, but not on seed and fertilizer purchase. Remittances were estimated to have positive and significant effects on seed and land rental, but not on fertilizer and machinery.

The study also found evidence of joint decision-making between agricultural input use and off-farm work. For example, the decisions to purchase seed, rent plot and work off-farm are made jointly. Similarly, the decision to purchase fertilizer, rent machinery and own enterprises are made jointly. This result suggest that households can deploy a portfolio of agricultural inputs on their farms if they have a conducive environment. Policy makers may want to consider attempt to utilize the off-farm income as a mechanism for improving agricultural input utilization and therefore, increase agricultural productivity, must involve government interventions.

This study revealed, that with the exception of fertilizer purchase vocational trainings beyond formal education have a negative impact on agricultural input use. Age of household head was also found to have a negative significant effect on agricultural input use. These findings suggest that efforts may be needed to encourage older people to use modern inputs. Access to credit was found to have positive and significant effect on seed purchases. This emphasizes the importance of credit to enhance farm productivity. Since this study's result suggest that off-farm

income has a portfolio-like effect on important agricultural inputs credit institutions should strongly consider the possibility of promoting agricultural investments by lending to farmers based off-farm activities. Often this off-farm activities may be able to provide required collateral and evidence of credit worthiness that financial institutions require.

The interdependence of agricultural inputs can affect the investment decisions in two directions. First, if off-farm income generated is not sufficient the decision to not use an agricultural input can affect the decision to use another input. For example, with an increase in the price of either fertilizer or seed, households may not use both input on plot. Second, with the availability of sufficient off-farm income, the use of one input might trigger the use of the other. This indicates that with more conducive environment for off-farm activities increases the probability that the income generated from such activities can be channeled towards a portfolio. This study's finding regarding the interdependence of decisions on almost all agricultural inputs suggest policies that create a conducive environment for off-farm activities should be considered as a mechanism for enhancing agricultural productivity. As off-farm income is shown to have a significant effect on agricultural input investments, a more in-depth study focusing on the timing, amount and the control of off-farm income by household may be warranted.

6.2. Limitations of the Study

The lack of appropriate instruments for endogenous variables limits this study's ability to fully addressing the problems of endogeneity. It is also important to note that the comparison of seed and fertilizer prices at the plot level and across three-time periods was a challenge. This is because of plot variabilities in the types of fertilizers and seeds used. For example, on a specific plot cassava may be produced in 2010, beans in 2012 and maize 2015. This makes it difficult to clearly observe the input price changes across years. Also, the lack of appropriate conversion factors for traditional/local seed measurement units was another difficulty in estimating crop quantity with accuracy. In addition, the lack of sufficient information on earned off-farm income by time with in each given survey period constrained deeper analysis of the effects of specific of off-farm income types on specific agricultural input.

APPENDICES

APPENDIX A: POOLED ORDINARY LEAST SQUARE REGRESSION RESULT

Table A1: Pooled Ordinary Least Square Regression Result

Independent Variables	Seed-purchase	Fertilizer-purchase	Plot-rental	Machinery
Remittance	**4.78e-08*** **	-5.01e-09	1.82e-09	**4.33e-08*** **
	(1.31e-08)	(1.19e-08)	(7.04e-09)	**(6.27e-09)**
Profit from enterprises (ln)	**0.00120** **	**0.00248*** **	-0.000309	**0.00107*** **
	(0.000510)	**(0.000464)**	(0.000273)	**(0.000244)**
Off-farm wages attained from off-farm work (ln)	-0.000667	**-0.00111***	**0.00257*** **	**0.00155*** **
	(0.000716)	**(0.000655)**	**(0.000383)**	**(0.000342)**
Gender of Household Head (=1 Male)	0.00494	0.0123	0.00545	0.00487
	(0.0158)	(0.0144)	(0.00848)	(0.00759)
Household head age	**-0.000470** **	-0.000294	**-0.000909*** **	0.0000114
	(0.000213)	(0.000195)	**(0.000114)**	(0.000102)
Secondary education level of household (1/0)	-0.00945	**0.0191** **	**-0.0148*** **	0.00323
	(0.00832)	**(0.00758)**	**(0.00447)**	(0.00399)
Vocational training (1/0)	**-0.0366*** **	**0.0779*** **	**-0.00966***	**-0.0211*** **
	(0.0107)	**(0.00975)**	**(0.00572)**	**(0.00510)**
Higher education level of household (1/0)	0.00861	**0.0469*** **	0.00286	**0.0514*** **
	(0.0120)	**(0.0109)**	(0.00645)	**(0.00575)**
Number of family members with in household	0.000736	**0.00855*** **		**0.000785***
	(0.000888)	**(0.000809)**		**(0.000425)**
Credit (=1 if household obtained credits zero otherwise)	**0.0247*** **	**0.0247*** **	**-0.00640***	0.00194
	(0.00637)	**(0.00580)**	**(0.00341)**	(0.00305)
Household wealth (ln)	**0.00331***	**0.0130*** **	**0.00373*** **	**0.00624*** **
	(0.00189)	**(0.00172)**	**(0.000992)**	**(0.000907)**
Seed price (ln)	**0.0137*** **			
	(0.00183)			
Stored Seed from previous season	-1.60e-08			
	(1.62e-08)			
Fertilizer price (ln)		**0.0155*** **		
		(0.00166)		

Table A1 (cont'd)

Independent Variables	Seed-purchase	Fertilizer-purchase	Plot-rental	Machinery
Fertilizer Transport cost (ln)		**0.202*** **		
		(0.00216)		
Stored fertilizer from previous season		**0.000000104*** **		
		(2.26e-08)		
Plot rental price (ln)	-0.000000154		**0.112*** **	0.0000157
	(0.000000273)		**(0.000932)**	(0.000831)
Rainfall	**-0.0000817*** **	**-0.0000351*** **	0.000000877	**-0.0000238*** **
	(0.0000110)	**(0.0000101)**	(0.00000592)	**(0.00000529)**
Distance to nearest market	**-0.000424*** **	**-0.00111*** **	**0.000299*** **	
	(0.0000806)	**(0.0000733)**	**(0.0000431)**	
Distance to a highly populated area				**-0.000253*** **
				(0.0000820)
Plot size		**0.000000578** **	**0.000000280***	**0.000000244***
		(0.000000248)	**(0.000000146)**	**(0.000000131)**
Year 2012	0.00507	**-0.0762*** **	**0.0696*** **	**-0.0175** **
	(0.0159)	**(0.0154)**	**(0.00851)**	**(0.00761)**
Year 2015	0.00311	**-0.0864*** **	-0.00201	0.00576
	(0.0172)	**(0.0150)**	(0.00862)	(0.00773)
North-east	0.00814	**0.0434*** **	-0.00340	-0.000563
	(0.0103)	**(0.00935)**	(0.00547)	(0.00486)
North-west	**0.188*** **	**0.263*** **	**-0.0191*** **	**-0.0457*** **
	(0.0116)	**(0.0106)**	**(0.00613)**	**(0.00527)**
South-east	**0.283*** **	0.00420	0.00369	**-0.0395*** **
	(0.0125)	(0.0115)	(0.00668)	**(0.00600)**
South-south	**0.129*** **	**-0.0809*** **	**0.0590*** **	**-0.0422*** **
	(0.0152)	**(0.0141)**	**(0.00809)**	**(0.00737)**
South-west	**0.0732*** **	**-0.115*** **	**0.0545*** **	-0.00898
	(0.0127)	**(0.0116)**	**(0.00671)**	(0.00613)
Constant	**0.151*** **	**0.0716** **	**0.0726*** **	0.0116
	(0.0314)	**(0.0285)**	**(0.0165)**	(0.0143)
Observation	**17420**	**17420**	**17420**	**17420**

APPENDIX B: GENERAL INFORMATION

Table B1: Plot Rental by Farm Size and Off-farm Income Level

		Number of off-farm receiving households by farm size			Number of households who rented plot using off-farm income		
	# of Plots	Remittance	Off-farm wages	Enterprise profit	Remittance	Off-farm wages	Enterprise profit
Small-scale	17,839	160	6,382	6485	15	641	508
Medium-scale	551	0	176	189	0	22	15
Large-scale	119	0	41	43	0	5	3
Total	**18,509**	**160**	**6,579**	**6,717**	**15**	**668**	**526**

Source: Author estimation from the Nigerian LSMS-ISA data.
Note: small-scale farms indicate farms which are less than 2ha (<20,000m^2), medium-scale farms indicate farms which are between 2ha and 5ha (>20,000m^2 - 50,000m^2) while large-scale farms indicate farms which are greater than 5ha (>50,000m^2).

Table B2: Attrition Rate by Study Time-period

Time period	# of Plots	Attrition in Number	Attrition in percent
Wave-1 (2010-2011)	6380	0	0
Wave-2 (2012-2013)	6182	198	3.1%
Wave-3 (2015-2016)	5947	235	3.8%
Total	**18,509**	**433**	**6.9%**

Source: Author estimation from the Nigerian LSMS-ISA data.
Note: The attrition rate in total is around 7% across the three-time period.

Table B3: Dependency Ratio by Zone

Zone	2010-2011	2012-2013	2015-2016
North-Central	16.31	18.10	20.27
North-East	22.53	19.75	20.85
North-West	24.63	25.62	32.89
South-East	10.03	11.26	13.78
South-South	11.14	15.86	20.40
South-West	0	0	0

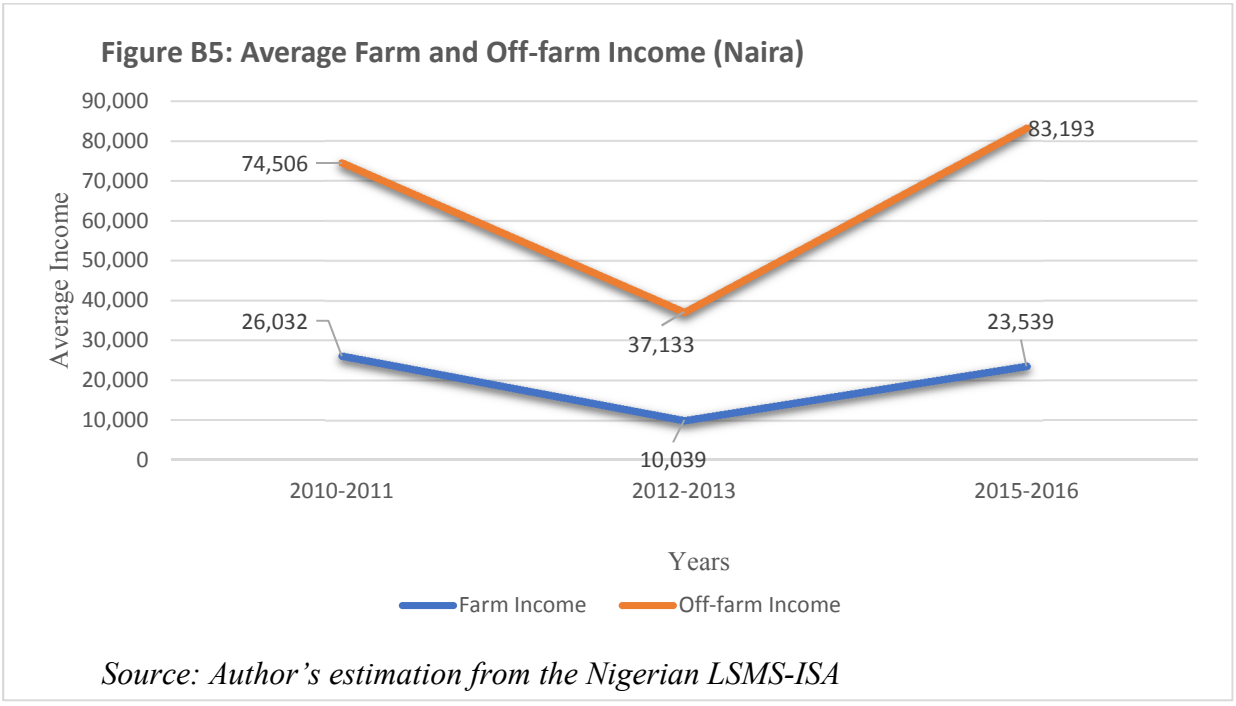
Source: Author estimation from the Nigerian LSMS-ISA data.

Table B4: Agricultural Input Purchase and Rental for Small Scale Farms

Zone	Small-scale farms <20,000m^2			
	Seed Purchase (%)	Fertilizer Purchase (%)	Machinery Rental (%)	Land Rental (%)
North-Central	9.13	14.38	30.93	16.78
North-East	15.75	20.80	43.13	14.92
North-West	17.43	26.04	9.62	6.03
South-East	21.47	14.32	3.44	14.79
South-South	26.01	18.51	0	31.90
South-West	10.21	5.96	12.89	15.58

Source: Author's estimation from the Nigerian LSMS-ISA data.
Note: All agricultural input purchase and rental were performed on small scale farms which are less than 2ha (20,000m^2).

Figure B5: Average Farm and Off-farm Income



Source: Author's estimation from the Nigerian LSMS-ISA

Note: This result contradicts figure-2 where the majority of the agrarian household's income (56%) generated from farm is higher than the off-farm income.

APPENDIX C: METHODS USED IN CALCULATING PRICE INDICES

C1: Methods Used in Calculating Price Indices

(1) Laspeyre's Price Index

$$I_L = \frac{\Sigma P_t Q_o}{\Sigma P_o Q_o} \text{ x } 100$$

where (I_L) describes the price index for Laspeyres shows the summation of price of the current period (P_t) times the quantity at the base year (Q_o); and the denominator shows the summation of (P_o) price times quantity at the base year (Q_o) and the whole equation is multiplied by 100.

(2) Paasche's Price Index

$$I_P = \frac{\Sigma P_t Q_t}{\Sigma P_o Q_t} \text{ x } 100$$

where (I_P) describes the price index for Paasche's; the numerator shows the summation of price of the current period (P_t) times the quantity at the current period (Q_t); and the denominator shows the summation of (P_o) price at the base year times quantity of the current period (Q_t) and the whole equation is multiplied by 100.

(3) Fisher's Price Index

$$I_F = \sqrt{\frac{\Sigma P_t Q_o}{\Sigma P_o Q_o} \text{ X } \frac{\Sigma P_t Q_t}{\Sigma P_o Q_t}}$$

where (**I_F**) describes the fisher's price index and the variables under the square root describes the product of Laspeyre's and Paasche's price index described above. Laspeyer's equation overstates the price indices and Paasche's price index understates the price indices hence I used Fisher's equation. This equation takes the geometric mean of both Laspeyre's and Paasche's price index solving the problem of over or under statement.

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