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Macroeconomic Factor Influence on Agricultural Program Sustainability in Kaduna State, Nigeria

By

Patrick L. Hatzenbuehler and George Mavrotas

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ABSTRACT

In this paper, we measure the degree to which a change in key macroeconomic variables, such as the global oil price, influences the ability of state Ministries of Agriculture in Nigeria to sustain agricultural program funding. More precisely, we estimate and compare the degree to which Nigerian federal and Kaduna state (hereafter Kaduna) government revenues co-move with the global oil price, assess the degree to which the Kaduna government has historically relied on federal allocations to fund its activities, and evaluate the share of the Kaduna Ministry of Agriculture and Forestry (KDMAF) budget that is provided by donors in order to measure how much the KDMAF budgetary condition can change due to adjustments in the global oil price or reductions in donor funds.

Historical fiscal data and empirical results show that the federal government structure and heavy reliance of the Nigerian federal government on oil sector fees and rents for its revenues mean that changes in the global oil price substantially influence budgetary conditions in all levels of government. The institutional structure of the federal government, however, also provides an opportunity for the Federal Ministry of Agriculture and Rural Development (FMARD) to provide a buffer to state Ministries of Agriculture during periods of poor state government funding conditions, such as when donor funds are reduced or removed. This is because FMARD has some autonomy regarding the allocation of its own budget and can reserve part of it to temporarily support programs of state Ministries of Agriculture that advance the FMARD policy agenda. Therefore, improving budgetary coordination between the federal and state government Agricultural Ministries would plausibly help sustain agricultural program funding levels over time.

Keywords: public expenditures; oil price; agricultural programs; Nigeria; Kaduna.

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1. INTRODUCTION

In its promotion of agriculture as a potential driver for economic growth and poverty reduction in sub-Saharan Africa (SSA), the World Bank highlighted the crucial need to increase smallholder farmer productivity to increase marketable surpluses (World Bank 2007). Productivity and input use statistics for SSA farmers relative to those in all other parts of the world make it clear that low productivity and input use has been a stubborn "steady state" for some time. In identifying the challenge of breaking out of this undesirable status quo, the World Bank highlighted the importance of support by donors to expand the capacity of SSA government institutions, especially those that at the state and local level that are closely connected to farmers, to improve the investment climate for development of modern agricultural supply chains (World Bank 2007).

In the case of Nigeria, the focus country for this study, Diao et al. (2012) estimated that substantial increases in public investment in agriculture, such as funding research for improved agricultural technologies, are needed to achieve agricultural growth and poverty reduction goals. However, funding levels for agricultural programs in Nigeria vary across states and over time (Olomola et al. 2014). Additionally, among Nigerian states, there are differences in the structure and capacity of agricultural program implementing institutions, and the relative share of funding that comes from different actors, including donors, in those institutions (Olofinbiyi and Mogues 2016).

The challenge of increasing government institutional capacity is inherently linked to the current fiscal structure and conditions in each country, since these conditions determine the availability of funds for agricultural and other publicly funded programs. In many developing countries, however, public revenue generating institutions currently have poor institutional capacity (G20 2016). The issue of expanding the tax bases and diversifying the tax portfolio of developing countries has been a recent focus of the group of twenty (G20) major economies. In 2016, the G20 requested advice from the International Monetary Fund (IMF), the Organization for Economic Cooperation and Development (OECD), the United Nations (UN), and the World Bank to determine ways in which developed country member governments can assist with expanding tax revenue generation capacity in developing countries (G20 2016).

In the Nigerian case, federal government revenue has been primarily generated from oil industry fees and rents since the 1970s (Collier 1988; IMF 2016). The heavy reliance on the oil sector for government funds has caused great instability in federal budget revenues over time (Ebeke and Ehrhart 2011a), and has created challenges for fiscal policy management during periods of steep oil price fluctuations like between 2014 and 2015 (Konuki and Villafuerte 2016). This federal fiscal budget instability creates uncertainty regarding funding allocation levels and timing for implementation of publicly funded government programs, including those for agriculture.

The history of the Agricultural Development Programs (ADP), the primary agricultural extension agencies in Nigeria, is instructive for why fiscal capacity and economic structure is a key determinant of current and future expenditure allocations. The ADPs were initially established in the 1970s as a pilot program by the World Bank in a few states in Nigeria. The success of these pilots led to the establishment of an ADP in each state, operated under the administration of individual state Ministries of Agriculture (IEG 2012). Over time, however, ADPs in some states and in some periods, have been severely underfunded, hampering their ability to initiate or continue already ongoing agricultural programs (NAERLS and FDAE 2013). It is plausible that

the states with ADPs that are best funded have fiscal conditions and economic structures that are conducive for facilitation of public funding allocations to agricultural policy activities.

In this study, we measure the degree to which a change in key macroeconomic variables, such as the global oil price, influences the ability for state Ministries of Agriculture to sustain agricultural program funding. To highlight the issue of dependence of state governments on the federal allocation, and the state Ministry of Agriculture on donor funds, a two-period simulation model was developed to represent the economy of Kaduna, a Nigerian state with a relatively large geographic scope and population. The simulation model results show that changes in the global oil price and levels of donor funds can have pronounced effects on state government and Ministry of Agriculture budgets. This implies that improved coordination between the FMARD and state Ministries of Agriculture and institutional mechanisms that can provide funding relief for state Ministries of Agriculture during poor fiscal conditions periods would help sustain agricultural programs over time.

2. LITERATURE REVIEW

The literatures on commodity price cycles and fiscal response in resource-dependent economies, the typical characteristics of agricultural policies, and the specific fiscal structure and agricultural policy implementation mechanisms in Nigeria are relevant for the discussion of Nigerian agricultural funding levels and changes over time.

Commodity Price Cycles and Fiscal Response in Resource-dependent Economies

Many resource-rich countries, defined as those for which natural resources, such as metals and energy, comprise a large share of economic output, government revenue, and foreign exchange (IMF 2012), in SSA, including Nigeria, experienced generally slow average economic growth from the end of the "Commodity Boom" of 1973-1980 until the early 2000's (Bova et al. 2016). The reasons for this are multiple and complicated. First, natural resource dependence can spur "Dutch Disease", under which the shift in focus to the oil sector causes appreciation in the domestic currency relative to other currencies, rendering the production of non-oil products for the export market less competitive. Furthermore, in the Nigerian case, dependence on government revenue from oil fees and rents increases its exposure to global oil price volatility and limits its ability to use fiscal measures to stimulate the economy during economic downturns (Otaha 2012). More importantly, the discovery of oil in Nigeria has limited diversification of the economy through development of other sectors, including agriculture.

Second, resources can create a "rentier effect," which encourages governance arrangements that are unfavorable to growth. This is because the "rents" from natural resources reduce the need for the government to tax the population and, consequently, remove a significant degree of accountability from its spending (Ross 2001). The resultant decline in trust in government institutions can reduce the effectiveness of regulatory and legal institutions that are necessary to create a conducive environment for long-term domestic and international investments in economically vibrant sectors (Ross 2001). Institutional quality is, thus, linked to resource dependence and the resulting rents (Mavrotas et al. 2011). Fierce competition for resource rents

among the citizenry in the absence of adequate checks and balances also hinders growth, and can lead to domestic unrest and civil war (Collier and Hoeffler 2009).[1]

In the most recent commodity boom period of 2003-08, global energy and metals prices maintained a steady upward trend, and developing country exporters of these commodities, including Nigeria, experienced relatively high economic growth rates because of these favorable commodity price movements (Baffes and Haniotis 2010; Frankel 2011). The commodity boom led to a fiscal windfall in which resource-based fees and rents obtained by the government increased in line with commodity prices (Ehrhart and Guérineau 2011). The subsequent improvement in fiscal conditions led many developing countries, especially oil exporters, to implement expansionary fiscal policies (Konuki and Villafuerte 2016).

These linkages between commodity price trends, fiscal conditions, and fiscal policy implementation observed during recent commodity booms are consistent with general patterns of procyclical fiscal policies observed over the past few decades, in which government expenditures move upward (downward) during expansions (recessions) (Talvi and Végh 2005). The general tendency for developing country governments to adopt procyclical fiscal policy was found to broadly apply for countries in SSA during the period 2000-14. Moreover, it was more common for oil exporting countries to implement procyclical fiscal policies over this period than was the case for mineral exporters or non-oil and non-mineral exporting countries (Konuki and Villafuerte 2016). These recent procyclical trends in SSA fiscal policy are consistent with earlier findings by Fielding (1997), which showed that variation in government expenditure was highly correlated with government revenue variance. This observed co-movement of government revenues and expenditures is a concern because it influences the ability to initiate and maintain public investments and programs. For instance, the unavailability of tax revenue due to an economic downturn can prevent implementation of long-term infrastructure or agricultural research projects, and, thus, reduce overall economic potential output and dampen future growth potential (IMF 2015).

The existence of intermittent commodity booms and busts over time, the co-movement of commodity prices with government revenues, and the dependency of government expenditures on government revenues results in generally unstable fiscal conditions in SSA countries with resource-dependent government budgets (Bleaney et al. 1995; Ebeke and Ehrhart 2011a). The degree to which tax revenues are unstable varies across countries, however, and is dependent on both economic structure and the mechanisms in the tax portfolio used to obtain government revenues. Ebeke and Ehrhart (2011a) found that governments that are relatively more reliant on natural resource export taxes and fees for government revenue have relatively unstable government revenue streams compared to governments that rely on domestic taxes, such as taxes on income, and indirect taxes such as value-added taxes (VAT). Additionally, adoption of VATs, which has become increasingly common in SSA countries in recent decades (Ebeke and Ehrhart 2011a), has a stabilizing effect on fiscal revenues (Bleaney et al. 1995; Ebeke and Ehrhart 2011b). This is because indirect taxes, such as the VAT, are linked to final consumption, which is relatively stable compared to exports, imports, or corporate profits that are determined by fluctuations in the domestic and global macroeconomic performance (Ebeke and Ehrhart 2011b).

[1] See also Auty (1997), Sachs and Warner (2001), Mehlum et al. (2006), Collier and Goderis (2007), and Mavrotas et al. 2011), among others, for detailed discussions of issues related to the natural resource curse and its effects on economic growth and fiscal conditions in resource-dependent countries.

The above described stylized facts of generally higher government revenue instability and procyclical fiscal policies for resource-dependent countries in SSA apply for Nigeria. In recent years, the Nigerian government has implemented a mix of procyclical and countercyclical fiscal policy regimes, but the decline in global oil prices between 2014 and 2015 has coincided with a large fiscal contraction, and thus, a resumption of a procyclical fiscal stance (Kanuki and Villafuerte 2016).

In 2012, the International Monetary Fund released a report that provided guidance for resource-rich developing country governments, and in doing so, emphasized the importance of conversion of natural resources into other financial and non-financial assets that can lead to sustainable economic growth (IMF 2012). Conversion of natural resources to other assets is a challenge because the financial flows needed to purchase non-resource assets have tended to co-move with the oil price in oil exporting countries (Khandelwal et al. 2016). Additionally, large fluctuations in macroeconomic performance of oil exporting countries due to oil price volatility creates substantial uncertainty regarding future macroeconomic performance, which can impede both domestic and foreign capital flows used for investment in productivity enhancing industries (Hadis 2016).

The fiscal response literature, within which the study by Heller (1975) was pioneering, has been reignited in recent years considering the persistent challenges faced by governments that are dependent on resources for government revenue.[2] For example, Agénor (2016) developed a macroeconomic model of optimal fiscal response to a commodity price shock for a low-income resource-dependent country with low levels of infrastructure investment.[3] This model emphasizes the trade-off made by a government to either save intermittent resource windfalls for future use or to immediately make crucially needed infrastructure investments, and accounts for the revealed preferences of developing country governments that have sought to minimize both household consumption variability and macroeconomic volatility (Agénor 2016).

This fiscal response literature is germane to the present case of agricultural program implementation in Nigeria, since a commodity price shock effect on federal government revenues influences the availability of public funds to allocate to state governments. In the next section, the typical characteristics of agricultural policies are discussed to discern how public spending on agriculture may vary from other uses of government revenues. The implications of the Nigerian state-level economic structure and tax composition on agricultural policy implementation and sustainability there are discussed afterward.

Agricultural Policy Characteristics and Fiscal Policy Linkages

The findings of Fielding (1997) that SSA government expenditure is determined by government revenues implies that revenue instability impacts intertemporal flows of government expenditures to fund both public investment and social programs. Since the instability in government revenues is particularly high in resource-dependent countries (Ebeke and Ehrhart 2011a), it follows that expenditure instability is also high in these countries. Fluctuations in government expenditures have implications for all sectors within which the

[2] Following the seminal paper by Heller (1975), the fiscal response literature has seen various applications since then, with extensive use in many aid effectiveness studies examining the linkages between aid inflows and fiscal conditions in aid recipient countries. In this context, early fiscal response studies include Gang and Khan (1990), Khan and Hoshino (1992), and Otim (1996) as well as more recent studies by Mavrotas (2002, 2005), Gupta et al. (2004), Mavrotas and Ouattara (2006a, b), Ouattara (2006a, b), and Mavrotas and Ouattara (2007). Mavrotas (2010, 2015) provide further discussion.

[3] Primus (2016) developed a similar model for the specific case of Trinidad and Tobago.

government is active, but the historical nature of agricultural policies mean that large fluctuations in government budgets are plausibly non-ideal for implementation of agricultural policies that often require consistent expenditures during specific periods every crop year.

A mix of agricultural and trade policies have been implemented in developed countries to address the "farm problem" of low and unstable earnings from farming (Schultz 1945; Gardner 1992). In the United States, trade policy has been used since the country was founded to protect domestic producers from import competition (Sumner 2007). Modern trade agreements have lessened protections for many crops, but support for farmers continues in the form of redistributive transfers from taxpayers and consumers to farmers to support farm income through direct transfers and/or price supports (Gardner 1992; Sumner 2007).

Agricultural policies in developing countries have historically been designed with many of the same elements as in developed countries, but differences in the impetus to implement agricultural or trade policies arise due to dissimilarities in the fiscal structure. Developing countries have relied relatively heavily on agricultural trade taxes to obtain government revenue, because they are relatively easier to administer than other types of taxes (Rodrik 1995). More recently, however, some developing countries have taxed agricultural trade less. This is in part due to an "agricultural transformation" taking place in which agriculture accounts for a smaller share, and other industries a larger share, of GDP over time (Brooks 2010; Anderson et al. 2013; Diao and McMillan 2017). The decline in tax share from agricultural trade has also coincided with a rise of more diversified tax sources such as indirect taxes, e.g., VAT, in many developing countries (Ebeke and Ehrhart 2011a), which is expected as economies diversify.

In recent years, agricultural policy in some developing has started to resemble agricultural policy in developed countries, such that many countries have implemented direct interventions in agricultural markets to stabilize output prices, as well as to provide input subsidies (Brooks 2010). These agricultural market interventions are like historical developed country agricultural policies in that they are designed to raise and reduce the volatility of farmer income through transfers from taxpayers or consumers.

Not all agricultural policy expenditures are direct transfers to farmers. Expenditures on agricultural research and development, for example, are viewed as a public good that lead to farm productivity gains in the long-run (Benin et al. 2016). However, agricultural research expenditures are presently relatively small in terms of budget shares for SSA country governments as compared to input subsidies (Benin et al. 2016). This is plausibly due to the long lag in crediting a policymaker with the success of a research and development investment output that are commonly not ready to disseminate to farms for many years past program inception (Mogues 2015).

Implementation of agricultural policies in their current form has invited controversy in both developed and developing countries. In the developed country case, criticisms of agricultural policy include: they are commonly not the most efficient manner to address the issue of farmer income levels; and, that the problem that they were initially designed to address arguably no longer exists due to structural changes in the agricultural economy (Gardner 1992; Sumner 2007). The issue of persistence of agricultural policy is, thus, often explained in the context of political economy, such that implementation of the policy leads to enough benefits to farmers and policymakers that they lobby for its continued implementation (Anderson et al. 2013). The economic model developed by Coate and Morris (1999) provides insights into how such a status quo

becomes the preferred policy strategy by showing that implementation of a policy can cause agents to act to benefit from the enacted policy, and the costs associated with the effort to take this action raises their willingness to pay for the policy.

Criticisms of developing country agricultural policy persistence are more nuanced and, in cases in which market failures are rampant and markets for credit or inputs do not exist, are also more difficult to defend (Brooks 2010). The main argument against developing country agricultural policy persistence is that they often do not address the main factors causing existing market failures, and may inhibit market development (Brooks 2010). However, country context is viewed as important in consideration of the merits of agricultural policies, and publicly funded subsidy programs may be designed in a manner that encourages the development of input markets, especially in cases of missing markets (World Bank 2007).

Fiscal Structure and Agricultural Program Implementation in Nigeria

The previous two sections provide background to the goals of this study. The section on tax revenue volatility and fiscal policy showed that developing countries, especially resource-rich countries, have recently had procyclical fiscal policy stances and more revenue volatility. Additionally, for SSA countries, for which expenditure variation has been found to be determined by revenue variation (Fielding 1997), design of a fiscal policy aimed to both minimize variation in consumption and volatility in macroeconomic performance – as in the model by Agénor (2016) – is a challenge, since these countries have many pressing needs for uses of public funds. The linkages between agriculture, government revenues, and government expenditures were also discussed.

Nigeria's division of government between federal, state, and local levels provides an opportunity to analyze how cross-state differences in economic structure and tax composition influences state-level fiscal expenditure allocation decisions. Nigeria's 36 states and the Federal Capital Territory (Abuja) have unique economic structures and independent state and local government entities (Olomola et al. 2014). The Nigerian fiscal system is vertically integrated such that the federal, state, and local governments are all linked by various channels through which government resources flow. The system is somewhat complex in that each level of government has its own sources of revenue, and then, for some taxes, revenues are distributed to higher-level institution, i.e., the federal government, which then redistributes the funds from a central account based on legislatively established criteria (Salami 2011). Thus, all states rely on a federal government allocation to fund state-level programs, but the degree to which individual states rely on this allocation varies based on their socioeconomic characteristics and internal tax structure (Salami 2011).

Regarding agricultural policy implementation in Nigeria, the main institutions that implement agricultural programs are the FMARD, state Ministries of Agriculture, and the ADPs. FMARD recently unveiled a new policy agenda, the Agricultural Promotion Policy (APP), which aims to build a private sector driven agribusiness economy that can sustainably meet Nigeria's domestic food security goals, generate exports, increase farm income, and spur job growth (FMARD 2016). State governments have their own policy initiatives as well, and international institutional donors often coordinate with the state ADPs, since they are the main extension institutions that interact directly with farmers. Since both federal and state institutions both implement agricultural programs, vertical coordination between FMARD and state Ministries of Agriculture plausibly could allow for more efficient achievement of shared policy objectives and outcomes. However, these institutions presently operate with very little synchronization.

The model used here is designed to investigate how the likelihood of sustainability of agricultural programs over time is influenced by the dependence of a state on the federal allocation, which relies heavily on changes in the global oil price. This assessment of fiscal response at state-level builds on models such as that of Gramlich (1969), which showed that different decision-making rules for state government relative to federal institutions can lead to variation in fiscal allocations between levels of government.

Through development of the economic model, it is conjectured that some states are better positioned to accommodate fiscal shocks caused by changes in key macroeconomic variables than are others due to differences in socioeconomic conditions and economic structure. To analyze how fiscal allocations are linked to each other among the various levels of government, how these allocations can change in response to adjustments in key macroeconomic variables, and how allocation changes can impact household decisions, a two-period economic model was developed to represent current conditions in Kaduna. Federal fiscal, state fiscal, and household level data were consulted to calibrate the model, and the economic and fiscal structural conditions that came to light upon examination of these data have important implications for the magnitude of variable changes in the simulation model.

3. TYPOLOGIES OF IRRIGATOR FARM HOUSEHOLDS IN NIGERIA

There are four levels in the economic model, which capture the linkages between the federal government, state government, state Ministry of Agriculture, for which donors are a key source of funding, and a set of household types (small, big, and non-farmers). The state government relies on funding allocation from the federal government as part of its revenue, the state Ministry of Agriculture is allocated funds from the state government and donors, and farm households interact with the state Ministry of Agriculture through service or input provision by the Ministry of Agriculture to small farm households. Additionally, all households interact with the state government through payment of income and VAT taxes.

Since the goal of the model is to examine the ability for the state government to fund agricultural programs over time, the model is dynamic. There are two periods, which represent the period before and after a "fiscal shock". The potential fiscal shocks, which are outlined in more detail below, include changes in the global oil price, losses of donor funds, and reductions in small farm household interest rates. It is assumed that the economic structure and household type, i.e., farmer or non-farmer, remain constant over the two periods, as in the Development Policy Evaluation Model (DEVPEM) model of Brooks et al. (2010). Thus, the model does not investigate the issue of agricultural transformation and associated movement of labor out of agriculture into other sectors, or vice versa. Capital assets used in agricultural production, labor endowments, and agricultural technology are assumed to be fixed.

The model elements are described from the top down, beginning with the federal government and ending with households.

Government

The complex inter-level flows in funds between Nigerian government institutions, such as state to federal government and back to the state government described above, and in more detail by Salami (2011), are simplified for the purposes of the model. It is assumed here that the federal government is only linked to the state government through its federal allocation. Since most funds flow from the federal to state government

rather than vice versa, the simplification is argued to capture the primary fund flows between levels of government.

Federal government

Taxes and rents paid by entities in the oil sector remain the principle source of Nigerian government revenue (IMF 2016). In the economic model, the federal government budget is a function of revenues from petroleum and non-petroleum sources. The revenue obtained from the petroleum industry is only a fraction of the total value of oil (defined as the world price of oil multiplied by the quantity of oil produced) that is produced during a given period. Thus, a conversion factor is multiplied by the monetary value of produced oil volumes to account for the less than full pass-through of the total oil production value that is accrued to the government in each period.

The federal government budget constraint for any period $t = 1,2$ has the form:

$$\Gamma_t = \phi_t + \omega^{\xi}((o_t * e_t) * \Omega_t), \quad (1)$$

where, Γ_t is total federal government revenue, ϕ_t is government revenue from non-petroleum sources, o_t is the annual average world oil price in U.S. Dollars (USD) per barrel, e_t is the Nigerian Naira to USD exchange rate, and Ω_t is the quantity of oil produced in Nigeria in barrels per year. The parameters are the share of government revenue from the petroleum industry (ω) and the conversion factor used to obtain the share of the total value of oil that is translated into federal government revenue (ξ). In currency terms, the federal government budget is in Nigerian Naira.

State government

Maintaining the assumption that there are only top-down fiscal flows, the state government budget is determined in part by the allocation from the federal government budget, and by internally generated revenue. For purposes of simplification, and thus, ignoring revenue sources such as fees for state government provided services, e.g., motor vehicle registration, two types of taxes are assumed to be obtained by the state government: income taxes and value-added taxes (VAT). These are two of the main revenues collected by state governments, although both income tax and VAT revenues are first aggregated by the federal government and then redistributed in different amounts across states based on criteria established in national legislation (Salami 2011).

Total state government revenues (N_t) in each period $t = 1,2$ are composed of revenue from income taxes (Υ_t), which is comprised of total taxable household income (y_t) multiplied by the income tax rate (τ), revenue from VAT taxes on durable good expenditures (Λ_t), which is obtained from VAT tax (v) on total household durable goods expenditures ($k_t * p_d$), where k_t is total durable good consumption and p_d is the price of the durable good, and allocated funds from the federal government (Φ_t). The state government budget has the form:

$$N_t = \Upsilon_t + \Lambda_t + \Phi_t, \quad (2)$$

with $\Upsilon_t = \tau y_t$; $\Lambda_t = v(k_t * p_d)$; and $\Phi_t = \delta\Gamma_t$.

State government expenditures (G_t) are a summation of appropriations to the Ministry of Agriculture ($g_{a,t}$) and allocations to all other ministries and administration ($g_{x,t}$). State government saving after the first period

is income minus expenditures, $\Pi_g = N_1 - G_1$, and there is no government saving in period 2. The carry-over in funds between periods amounts are influenced by the state government interest rate (r_g).[4]

State Ministry of Agriculture

The Ministry of Agriculture has a total operating budget (M_t) that is a function of the appropriations from the state government as defined above and donor funds (Δ_t). Total Ministry of Agriculture expenditures (Σ_t) are equal to the summation of expenditures on inputs to provide to farmers (I_t) and administration (A_t). The value of saving by the Ministry of Agriculture, which is equal to income minus expenditures, $\Pi_m = M_1 - \Sigma_1$, is determined in part by the Ministry's interest rate (r_m).

Households

There are three types of households: non-farmer, big farmer, and small farmer. The demarcation between big farmers and small farmers is made due to differences in their consumption preferences, production technologies, and input endowments found in the household level data. However, there is presently not a clear benchmark in the literature on how to define big or small farms. Kirsten and van Zyl (1998) argue that differentiating farm into sizes based on land area is misleading in terms of farm efficiency and profitability. Additionally, Fan et al. (2013) show evidence that average farm sizes in terms of area differ across developing countries and over time within countries. Thus, for the purposes of this study, we differentiate between big and small farm households based on their level of farm produce commercialization due to presumed differences in input purchase behavior and production technologies among farms with different degrees of market participation. Specifically, if a household has crop sales (both unprocessed and processed) that are greater than two times the median level of crop sales, then they are considered a big farm, and those with less than two times the median level of crop sales are small farms.

Both farm household types are assumed to be different from the non-farm households due to variation in income sources and consumption preferences. There are two household consumption goods, one agricultural and one durable. The farm households produce the agricultural good. For purposes of simplification, it is assumed that the farm households do not consume any of their production, but rather purchase them from the market.

It is assumed that the farm household consumption and production choices are made simultaneously such that their consumption choice depends on their production choice, i.e., they are non-separable, such as in the household models of Singh et al. (1986). Non-separable choices argued by de Janvry and Sadoulet (2006) as consistent with the developing country farmer decision making context in which there are missing or incomplete factor markets, meaning that factor prices are not determined within a perfectly competitive market (Dillon and Barrett 2017). In a recent empirical assessment of agricultural factor markets in SSA, Dillon and Barrett (2017) found that SSA factor markets more commonly fail rather than are completely missing. In the current case of Nigeria, Takeshima et al. (2014) found that very few farmers who purchased tractors used financing, which suggests that at least some factor markets, e.g., finance in the case of tractors, are incomplete in Nigeria. Thus, non-separable choices between production and consumption are argued to fit the present case.

[4] All interest rates included in the model are related to the rate of time preference as defined in Deaton and Muellbauer (1980).

For the purposes of the model, households are linked to the state government in two main ways: 1) all households pay the income tax on taxable income and a VAT tax on durable good purchases, and these revenues accrue to the state government budget; and, 2) the Ministry of Agriculture provides inputs to small households, which influence their income (and, thus, also their level of income tax paid).

Small farmer

The small farmer maximizes utility subject to a budget constraint that is in part determined by on-farm production. A constant elasticity of substitution (CES) utility function, as described in Deaton and Muellbauer (1980; p. 57), is used to represent preferences, since it allows for a general representation of preferences across differentiated products. In each period, the small farmer chooses consumption of the agricultural good ($c_{s,t}^{a}$), consumption of the durable good ($c_{s,t}^{d}$), and the amount of farm inputs to use in production of the agricultural good ($i_{s,t}$).

Thus, a one-period objective function has the form:

$$\max_{c_s^a, c_s^d, i_s} u\,(c_s^a, c_s^d) = [\mu_s (c_s^a)^{-\lambda_s} + (1-\mu_s)(c_s^d)^{-\lambda_s}]^{-1/\lambda_s}, \tag{3}$$

where, μ_s is the consumption share of the agricultural good, and $\lambda_s = \frac{(1-\sigma_s)}{\sigma_s}$, such that σ_s is the elasticity of substitution between the agricultural and durable goods. The small farmer chooses optimal consumption and input combinations in both periods. The small farmer's rate of time preference (β_s) is related to the interest rate for borrowing faced by the small farmer (r_s) such that, $\beta_s = 1/(1+r_s)$, which is consistent with the intertemporal consumption and savings logic outlined in Deaton and Muellbauer (1980; p. 311). The two-period utility function, with t=1,2, has the form:

$$\max_{c_{s,t}^a, c_{s,t}^d, i_{s,t}} u\,(c_{s,1}^a, c_{s,2}^a, c_{s,1}^d, c_{s,2}^d) = [\mu_s (c_{s,1}^a)^{-\lambda_s} + (1-\mu_s)(c_{s,1}^d)^{-\lambda_s}]^{-\frac{1}{\lambda_s}} + \beta_s \left\{ \left[\mu_s (c_{s,2}^a)^{-\lambda_s} + (1-\mu_s)(c_{s,2}^d)^{-\lambda_s} \right]^{-\frac{1}{\lambda_s}} \right\}. \tag{4}$$

The small farmer has a budget constraint, which maintains same general form in each period such that total expenditures ($E_{s,t}$) equal total income ($Y_{s,t}$) across periods, such that:

$$p_d(1+v)c_{s,t}^d + p_i i_{s,t} + p_a c_{s,t}^a = [p_a q_{s,t}^a + Z_s](1-\tau), \tag{5}$$

with the included parameters defined as,

p_d: price of the durable good;
v : VAT tax on consumption of the durable good;
p_i: price of farm input;
p_a: price of agricultural good;
Z_s: exogenous income; and,
τ: income tax rate.

Since the small farmer makes simultaneous consumption and production decisions, primarily regarding farm input purchases, the small farmer agricultural production function ($q_{s,t}^a$) is encompassed into the budget

constraint (equation (5)) for each period. Additionally, the small farmer receives inputs from the Ministry of Agriculture ($i_{g,t}$) to supplement its own input purchases ($i_{s,t}$) in production. The small farmer production function, thus, has a Cobb-Douglas form like that in Hayami (1970), such that:

$$q_{s,t}^{a} = f(a_s, l_s, i_{s,t}, i_{g,t}) = a_s {l_s}^{\alpha_s} (i_{s,t} + i_{g,t})^{\theta_s}, \quad (6)$$

with the included parameters defined as,

a_s: small farmer technology endowment;
l_s: labor endowment;
α_s: labor share; and,
θ_s: farm input share.

The associated intertemporal budget constraint, which includes total small farmer household expenditures and income, is:

$$E_{s,1} + \frac{E_{s,2}}{(1+r_s)} - Y_{s,1} - \frac{Y_{s,2}}{(1+r_s)} = 0. \quad (7)$$

Small farmer household saving after the first period is $\Pi_s = Y_{s,1} - E_{s,1}$. There is no saving after period 2.

Big farmer

The big farmer utility maximization problem has virtually the same form to that of the small farmer, but with replacement of the subscript *s* for *b* for the big farmer problem. There is one substantive exception that pertains to the big and small farmer interactions with the Ministry of Agriculture. It is assumed that the big farm households do not receive inputs from the Ministry of Agriculture, and so the government input purchase variable is not part of the big farmer production function.

Non-farm households

The non-farm household utility maximization problem maintains the same general structure to those of the farm households, but there is no agricultural production function in its budget constraint. Income for the non-farm household is solely from exogenous sources.

Total income and expenditures

The summation of total expenditures on durable goods across small farmer, big farmer, and non-farm households comprises total household durable expenditures. Summation of total income across all household types comprises total taxable income.

Model Solving

The model is solved using an objective function that maximizes the joint utility for all households, so that each household utility function is given an equal one-third weight in the full system objective function. This combined objective function is maximized such that all household budget, government entity budget, and intertemporal savings constraints are satisfied. Non-negativity constraints on all household choice variables

are also imposed. Appendix A includes a list of all variables and parameters included in the model, and Appendix B shows an outline of the full model.

4. DATA MODEL AND SIMULATION VALUES

There are three primary types of data used to calibrate the simulation model: federal fiscal data, state fiscal data, and household consumption and production data.

Federal Fiscal Data

The primary sources for information on the Nigerian federal budget were the International Monetary Fund Article IV Consultation Staff Reports for 2000 to 2016 (IMF-Nigeria). Some of the statistics on government revenues included in the tables for these reports on consolidated government operations, which includes federal, state, and local government revenues, are presented in Table 4.1. The degree to which the share of petroleum revenues in total revenues has varied over time, as well as some trends in a few non-petroleum revenue sources is apparent upon examination of these data. It is observed that non-petroleum revenue, especially revenue from the VAT, have steadily risen over time, while the petroleum revenue has fluctuated. Regarding the petroleum-based revenue, there is a substantial increase in revenue between 2003 and 2004, which coincides with the global energy and metals commodity boom described by Baffes and Haniotis (2010) during which time prices for energy and metals commodity prices began a sustained upward rise that lasted until the global economic recession in 2008-09. One of the more variable sources of revenue has been VAT revenue, which is somewhat unexpected based on the findings of Ebeke and Ehrhart (2011b) of broadly lower fiscal revenue variability among countries with the VAT than those without. This is plausibly explained by the largely unimpeded rise from a very low level in 2000, and suggests that it may take some years for the stabilizing effects of VAT revenues on the federal budget to emerge.

Table 4. 1 Select information on government revenues in Nigeria, 2000-2016, billions of Naira

				Select elements of non-petroleum revenue	
Year	Total Revenue	Petroleum Revenue	Non-petroleum Revenue	Value-added tax (VAT)	Import and excise duties
2000	1,927	1,585	342	58	116
2001	2,227	1,712	515	92	171
2002	2,038	1,483	554	109	181
2003	2,752	2,106	646	136	195
2004	4,127	3,355	773	157	217
2005	5,621	4,759	863	184	233
2006	6,376	5,445	931	227	178
2007	5,886	4,555	1,331	300	246
2008	8,063	6,535	1,529	405	281
2009	5,003	3,192	1,811	468	298
2010	6,883	4,809	2,074	563	309

2011	11,285	8,834	2,451	649	422
2012	10,416	7,583	2,833	710	475
2013	8,949	5,774	3,176	769	433
2014	9,484	5,890	3,595	794	566
2015	7,445	3,560	3,885	773	514
2016 (est.)	6,244	1,557	4,687	1,178	636
Mean	6,160.4	4,278.5	1,792.3	447.0	321.8
Standard deviation	2,924.9	2,234.4	1,358.2	327.9	156.1
Coefficient of variation	0.47	0.52	0.76	0.73	0.49

Sources: International Monetary Fund Article IV Consultation Reports for Nigeria 2000 to 2016 (IMF-Nigeria, 2000 to 2016).

The fluctuations in the total government revenue and the revenue from petroleum suggest that there is a high correlation between these variables and the global oil price. Results from exploration of this issue are shown in Table 4.2, which includes the world oil price from the World Bank (2017) alongside total government revenue and the estimated correlation between these variables since 2000. The very high and positive correlation estimate of 0.93 suggests that, to a substantial degree, government revenue in Nigeria moves in line with the global oil price. Since total revenue is the consolidated value of federal, state, and local government revenues, it is expected that the degree to which the state and local government revenue aligns with the federal government varies with the economic structure of the state.

Table 4. 2 Correlation between Nigerian government total revenue and world oil price, 2000-2016

Year	Total Revenue, billions Naira	World oil price, USD/barrel, annual avg.	Correlation coefficient
2000	1,927	28.23	
2001	2,227	24.35	
2002	2,038	24.93	
2003	2,752	28.90	
2004	4,127	37.73	
2005	5,621	53.39	
2006	6,376	64.29	
2007	5,886	71.12	**0.93**
2008	8,063	96.99	
2009	5,003	61.76	
2010	6,883	79.04	
2011	11,285	104.01	
2012	10,416	105.01	
2013	8,949	104.08	
2014	9,484	96.24	
2015	7,445	50.75	

2016 (est.)	6,244	42.81

Sources: IMF (2016) and World Bank (2017).

Kaduna Fiscal Data

The Kaduna government is comprised of several ministries that implement state government service provision activities. In the case of the agricultural sector, projects are implemented using funds from both the general state budget and those provided by donors. Data on total state government revenues were obtained from the Kaduna Ministry of Budget and Planning (KDMBP 2017) and the United Kingdom's Department for International Development (DFID) State Partnership for Accountability, Responsiveness and Capability (SPARC) program fact sheets on Kaduna fiscal conditions for 2004-10 (SPARC 2011). For total revenues and expenditures, the data obtained from the KDMBP and those in SPARC (2011) corresponded well. However, there were discrepancies between the state budgetary allocations to agriculture in SPARC (2011) and those obtained from KDMBP. Thus, budgetary data were also obtained from the Ministry of Agriculture and Forestry (KDMAF 2017), but these were only available for 2016. Since those obtained for 2016 were closer in range to those reported in SPARC (2011), the SPARC (2011) expenditures on agriculture were reported for 2004-10 to supplement those obtained from the KDMAF for 2016. The KDMAF data are unique from those in KDMBP (2017) and SPARC (2011) since they provide a demarcation between state government and donor funded projects. Data for 2011 were unavailable from any sources.

Kaduna Government Revenues and Expenditures on Agriculture

The federal government allocation, total Kaduna government revenues, share of the federal allocation in the total budget, correlation between Kaduna government revenues and the global oil price, total Kaduna government expenditures, allocations by the Kaduna government to the KDMAF, and the share of the KDMAF allocation in total expenditures are shown in Table 4.3. While the federal allocation share of total Kaduna government revenues has fluctuated over time, it has generally remained above 60 percent of the total state government budget. This implies that, on average, roughly 30 to 40 percent of annual Kaduna government revenues are internally generated. The semi-independence of the Kaduna government means that its revenues do not move as closely in line with the global oil price as do the federal government revenues. Indeed, the estimated correlation coefficient between the global oil price and Kaduna government revenues is 0.53, which is lower than to the analogous estimate of 0.93 for the federal government. Kaduna government expenditures have generally shown an upward trend since 2000, but with intermittent fluctuations since 2010. There has not been a steady upward trend in the allocation to the KDMAF, but rather the allocations fluctuated highly from year to year during the period 2004-10. This may be in part due to changes in donor funding provisions during this period, but it is not possible to make this determination, since a demarcation between state government and donor funded activities was not made in the SPARC (2011) report.

Table 4. 3 Kaduna government fiscal conditions, correlation of Kaduna government revenues with global oil price, and allocations to the KDMAF, 2000 – 2016

Year	Federal allocation to Kaduna, billions Naira	Total revenue, billions Naira	Federal allocation as share of total revenue	World oil price, (USD/ barrel, annual avg.	Correlation of total revenue with world oil price	Total state government expendi-tures, billions Naira	KDMAF allocation, billions Naira	KDMAF share of total state expendi-tures, percent
2000	9.00	10.05	0.63	28.23		10.05	…	…
2001	11.50	18.36	0.63	24.35		13.64	…	…
2002	12.78	18.06	0.71	24.93		14.12	…	…
2003	14.13	23.46	0.60	28.90		23.65	…	…
2004	20.37	28.73	0.71	37.73		24.69	2.42	9.8
2005	24.51	32.83	0.75	53.39		28.50	0.74	2.6
2006	33.34	42.89	0.78	64.29		33.12	1.85	5.5
2007	42.97	54.72	0.79	71.12		37.02	2.51	6.7
2008	42.41	55.77	0.76	96.99	**0.52**	40.92	2.33	5.6
2009	37.03	55.19	0.67	61.76		45.51	1.34	2.9
2010	42.94	75.41	0.57	79.04		38.02	5.81	15.3
2011	…	…	…	104.01		…	…	…
2012	60.57	85.60	0.71	105.01		94.29	…	…
2013	62.13	86.37	0.72	104.08		75.64	…	…
2014	57.69	84.32	0.68	96.24		82.89	…	…
2015	42.18	65.33	0.65	50.75		92.19	…	…
2016	38.93	82.63	0.48	42.81		104.78	2.63	2.5

Sources: Kaduna Ministry of Budget & Planning (KDMBP 2017), Kaduna Ministry of Agriculture & Forestry (KDMAF 2017), SPARC (2011), and the World Bank (2017). KDMAF – Kaduna Ministry of Agriculture and Forestry.

Budget of the KDMAF

The KDMAF is comprised of three main entities: general administration; its ADP; and, the Forest Management Project (FMP). The combined budget for the KDMAF, the share of the budget provided from the state government, the share provided by donors, and the demarcation of expenditures for 2016 are shown in Table 4.4. The KDMAF obtained more than half of its operating budget from donors, and most expenditures were on projects. Allocations for personnel and overhead accounted for the remaining 16.3 percent of expenditures. It is apparent in Table 4.4 that any adjustments to donor funds from 2016 would likely have dramatic effects on the KDMAF budget, especially on project implementation.

Table 4. 4 KDMAF budget for 2016, billions of Naira

Combined budget for KDMAF	Kaduna state government allocation	Donor funds	Share donor funded, percent	Expenditures		
				Projects	Personnel	Overhead
5.58	2.63	2.95	53	4.67	0.54	0.37

Source: KDMAF (2017). KDMAF – Kaduna state Ministry of Agriculture and Forestry.

Household Data

To obtain information on socioeconomic conditions, such as levels of expenditures on consumption, income levels and sources, and farm productivity at the household level, data were obtained from the 2015-16 wave of the National Bureau of Statistics (NBS) and World Bank implemented Living Standards Measurement Study Integrated Surveys on Agriculture (LSMS-ISA) dataset for Nigeria (NBS-World Bank 2016). Summary statistics calculated from these NBS-World Bank (2016) data for various household and economy-wide variables are included in Tables 4.5 to 4.10.

Household Characteristics

Recall that there are three household types of focus: non-farms, small farms, and big farms. Additionally, the distinction between big farms and small farms was made regarding crop sales such that big farms were those with double the median amount of crop sales. The median level of annual crop sales was 18,000 Naira. Based on this demarcation level, there were 48 small and 26 big farm households. The addition of the 36 non-farm households leads to a 110-household sample.

To determine if there are differences in preferences for food and durable goods across household types, expenditure levels and expenditures shares for each category of good and household type were calculated. These values were converted to annual values such that the value shown in Table 4.5 presents the average annual expenditure in each category. The data show that there are differences in expenditures between non-farm and farm households regarding total expenditure levels. Non-farm households have higher expenditures in each category, as well as higher total expenditures. However, the food share of the budget (which is the ratio of expenditures on food at home to total expenditures) is similar across household types.

Table 4. 5 Annual expenditures on food and other goods by household type, thousands of Naira

	Expenditure categories					
Household type	Durable goods	Education	Food at home	Food away from home	Total	Food at home share
Non-farm	205.73	22.20	341.77	118.89	688.59	0.50
Big farm	123.98	4.05	195.15	76.99	400.17	0.49
Small farm	121.61	8.94	182.28	57.05	369.88	0.49

Source: Authors' calculations from NBS-World Bank (2016) data

The composition of income across household types provides additional insight into the ways in which the households obtain income for expenditures. The income sources and levels obtained from each are shown in Table 4.6. Non-farm households are the only type of households to report any remittance income, but the

clear majority of non-farm income comes from employment. Both big and small farm households obtain a sizeable amount of income from off-farm enterprises, e.g., informal trading. However, big farm households have much higher income from crop sales than small farm households, while small farm households earn more from employment. The observed disparity in the expenditure and income levels is likely due to the differences in survey methods for the expenditure and income questions in the LSMS-ISA surveys. In general, the expenditure questions were answered by a more complete set of households than were income-related questions. Thus, there is likely more aggregation error in the income than expenditure data.

Table 4. 6 Annual income by source, by household type, thousands of Naira

	Income sources				
Household type	**Employ-ment**	**Farm crop sales**	**Off-farm enterprises**	**Remit-tances**	**Total**
Non-farm	358.99	…	…	9.44	368.44
Big farm	3.46	117.01	197.08	…	317.55
Small farm	97.88	9.22	147.74	…	254.84

Source: Authors' calculations from NBS-World Bank (2016) data

While big farm households had more income from crop sales than small farm households, the differences in characteristics across household types regarding farm assets and agricultural productivity show that small farms are more efficient than big farms. The farm production data presented in Table 4.7 show that big farms produced more, but since they also used more than double the land area relative to small farms, the implied yield is substantially higher for small farms. Small farms also were found to grow a slightly higher number of crop types grown on their farms than big farm households.

Table 4. 7 Average farm production by farm type

Farm type	**Annual quantity produced, kg**	**Area farmed, ha**	**Yield, kg/ha**	**Number of crops grown, average**
Big farm	4,511	3.52	1,282	2.7
Small farm	2,796	1.63	1,715	3.1

Source: Authors' calculations from NBS-World Bank (2016) data

To help explain some of the agricultural productivity differences between small and big farm households, expenditures on agricultural inputs were consulted and are presented in Table 4.8. Big farm households spent more than double the amount of small farm households on fertilizer and labor. Only small farmers obtained any subsidized fertilizer, but the average expenditures on subsidized fertilizer were substantially lower than non-subsidized fertilizer expenditures.

Table 4. 8 Annual farm input and labor expenditures by farm type, thousands of Naira

Farm type	Non-subsidized fertilizer	Subsidized fertilizer	Seed	Pesticide and herbicide	Labor	Animals	Machinery	Total
Big farm	42.37	0.00	1.18	8.99	53.36	4.04	1.19	111.13
Small farm	20.62	0.26	0.96	5.98	24.53	2.23	0.29	54.87

Source: Authors' calculations from NBS-World Bank (2016) data

The large disparity in labor expenditures between big and small farms makes it seem that the higher observed implied yield among small farm households could be due to a greater availability of non-hired labor for small farm households. The data displayed in Table 4.9 show that there is not a major difference between household sizes among big and small farms. While small farm households expend less than half as much on hired labor per year than do big farm households, they have nearly the same non-hired labor endowments, and, as seen in Table 4.7, less than half the land to manage with such labor. Thus, labor availability per hectare and labor productivity may be slightly higher for small farms than for big farms.

Table 4. 9 Labor endowments and labor share of total farm input expenditures by farm type

Farm type	Household size	Expenditures on hired labor per year, thousands of Naira	Labor share of total inputs expenditures
Big farm	10.2	53.36	0.48
Small farm	9.1	24.53	0.45

Source: Authors' calculations from NBS-World Bank (2016) data

Examination of these household data provides some insights into the composition of the Kaduna economy. If the LSMS-ISA dataset is at least reasonably representative, it means that most of the population in Kaduna reside on small farms, and there are more farm households than non-farm households. However, small farm households were found to obtain the largest share of their income from off-farm enterprises and employment. Since off-farm enterprises were also an important income source for big farm households, farm crop sales comprise a relatively small share of the total Kaduna income generation activities. Regarding expenditures, about half of all household budgets are devoted to food at home. Non-farm households expend more on average than both big and small farm households, especially on durable goods and food away from home. Since durable goods and food away from home are often subject to the VAT, combining the household data with statewide population data provides estimates of how much VAT revenue may have been gathered during the 2015-16 survey year.

Economy-wide Variables

To obtain economy-wide estimates on total durable goods expenditures, it was assumed that the LSMS-ISA sample for Kaduna was reasonably representative for the state. Thus, the shares of small farm households, big farm households, and non-farm households were multiplied by the total population for Kaduna for 2012, which was the most recent year available in the population data in NBS (2012). The total population by household type was then divided by the average household size, as shown in Table 4.9, to obtain the inferred

number of households by type. These are: 308,554 non-farm households, 171,139 big farm households, and 354,140 small farm households. The VAT level is 5 percent on the value of all taxable goods and services as set in the Value-Added Tax Act of 1993 (FIRS 1993).

The data in Table 4.10 show some of the economy-wide economic variable estimates for Kaduna, with a primary focus on VAT revenues and borrowing interest rates. The total expenditures on durable goods were obtained by multiplying the annual average expenditure on durable goods and food away from home for each household type by the implied number of households by type. This was then multiplied by the VAT rate of 5 percent to obtain the estimate of 10.398 billion Naira in implied VAT revenue. This level is somewhat close to that observed in the actual VAT revenue data reported in KDMBP (2017), which means that the aggregation strategy provides reasonable estimates, at least for the case of the VAT revenue. Regarding interest borrowing rates, interest rates are higher in rural than urban areas for larger loans but lower for smaller ones. While these values were obtained from only a few observations in the LSMS-ISA data, the values imply that it is generally more expensive to borrow in rural than urban areas.

Table 4. 10 Total expenditures on durable goods, vat tax rates, and loan interest rates

Total expenditure on durable goods, millions of Naira	**VAT rate, percent**	**Implied VAT tax revenue, millions of Naira**	**Actual VAT tax revenue for 2015, millions of Naira**
207,965	5	10,398	9,597
	Borrowing interest rates, percent, on a loan of…		
	10,000 Naira	**50,000 Naira**	**100,000 Naira**
Urban	20	10	20
Rural	15	17.5	25

Source: authors' calculations from NBS-World Bank (2016) data and FIRS (1993)

Model Simulation Values

The federal fiscal, state fiscal, and household data and their resultant summary statistics were used to calibrate the economic model such that it represents general economic conditions in Kaduna for 2015. The initial values for the parameters and exogenous variables are found in Appendix C.

The federal and state fiscal data parameters were informed based on datasets and reports from a variety of sources. Daily oil production estimates were obtained from the U.S. Energy Information Administration (EIA 2015). These were then converted to annual equivalent values. The annual average exchange rate for 2015 was obtained from the IMF International Financial Statistics database (IMF-IFS). The income tax rate was obtained from a report provided by the Kaduna Board of Internal Revenue (KDBIR 2011). While the income tax rate is scaled progressively based on income levels such that higher income earners are taxed at higher rates, the base rate of 7 percent was used under the assumption that most households pay at least that rate, while some pay more and others pay less. In a few cases, the initial parameter and variable values were residuals based on assumptions in the model framework, e.g., zero initial savings.

5. SIMULATION SCENARIOS AND RESULTS

Four simulation scenarios were used to assess changes in fiscal and household variable levels after a change in key economy-wide factors. These scenarios are as follows:

- Decrease in the global oil price from the 2015 level;
- Increase in the global oil price from the 2015 level;
- Decrease in donor funds from the 2015 level; and,
- Reduction in the borrowing rate for small farmers.

The importance of oil revenue in the federal fiscal budget and the high reliance on the federal allocation by the Kaduna government observed in the fiscal data make it apparent that changes in the global oil price can filter down to affect Ministry of Agriculture budgets, and to households. Simulation of the first two scenarios are designed to measure how large these effects may be on various fiscal and household variables. The third simulation scenario relates more to the composition of the KDMAF budget, and how changes in the levels of donor funding can influence its resource allocation over time. The final simulation is designed to assess potential effects of reduction of loan borrowing rates for small farm households, which is one of the principal aims of recently outlined Anchor Borrowers' Programme, which is administered by the Central Bank of Nigeria (CBN 2016).

The results from the first simulation of decreases in the global oil price from the 2015 level are shown in Table 5.1. The results show that adjustments in both the federal government and state government budgets can be quite substantial due to decreases in the global oil price. To accommodate the relatively sharp reductions in period 2 income due to the fall in federal allocation levels, the Kaduna government would need to save a substantial amount between period 1 to period 2. Since savings is the difference between period 1 revenues and expenditures, and revenues fall due to the decline in the federal allocation, both period 1 and period 2 Kaduna government expenditures are forced to decline. These reductions in expenditure have particularly poignant implications for its allocations to the KDMAF. After a 30 percent reduction in the global oil price, the allocation of the state government to the KDMAF is estimated to be zero in period 1 to sustain some expenditures in period 2. These reductions in the state government allocations to the KDMAF mean that there is an even higher reliance on donor funds by the KDMAF than before the oil price decrease. Additionally, the KDMAF needs to redistribute the smaller level of funds across the two periods to smooth expenditures to some degree. However, once the decrease in the global oil price reaches 30 percent, the reductions in period 1 spending on farm inputs are reduced to a higher degree than those in period 2. The reduction in spending on inputs reduces small farmer income, requiring small farmers to increase savings. This is accommodated through reductions in consumption, since incomes decline, to smooth consumption across periods.

Table 5. 1 Change in variable values due to decreases in the global oil price

	Base, billions of Naira	Change from base due to oil price decrease from 2015 level by…				
		10%	20%	30%	40%	50%
Federal government period 2 income	7,438.29	-355.33	-710.66	-1,065.99	-1,412.32	-1,776.65
State government savings after period 1	-0.39	+1.42	+2.83	+3.63	+4.30	+4.98
State government period 1 income	85.27	-0.01	-0.02	-0.03	-0.06	-0.07
State government period 2 income	85.84	-1.96	-3.91	-5.86	-7.81	-9.76
State government period 1 allocation to KDMAF	2.64	-1.21	-2.44	-2.64	-2.64	-2.64
State government period 2 allocation to KDMAF	2.30	0.00	0.00	-0.48	-1.06	-1.64
KDMAF savings after period 1	0.14	-0.51	-1.03	-0.71	-0.22	+0.27
KDMAF period 1 inputs expenditures	3.09	-0.35	-0.70	-1.15	-1.63	-2.11
KDMAF period 2 inputs expenditures	3.08	-0.30	-0.60	-0.65	-0.65	-0.65
Small farmer savings after period 1	4.95	+0.02	+0.06	+0.06	+0.21	+0.20
Small farmer period 1 income	153.66	-0.15	-0.31	-0.51	-0.93	-1.20
Small farmer period 2 income	156.66	-0.05	-0.10	-0.11	-0.11	-0.11

Source: Model simulation results by authors.

The changes in variable values that result from an increase in the global oil price from the 2015 levels are displayed in Table 5.2. The changes in the levels of the fiscal variables are nearly symmetric to those in scenario 1 such that there are substantial increases in both the federal and state government revenues and expenditures. The increases in period 2 revenues allow the Kaduna government to substantially reduce savings and increase period 1 expenditure. Some of the period 1 expenditure increases are provided to the KDMAF, with the remaining going to increases in allocations to expenditures by other ministries on administration. Due to the larger allocations from the state government, the KDMAF can increase savings and expenditures on agricultural inputs in both periods. Small farm household income increases in both periods. Additionally, small farm households increase expenditures and reduce savings due to the increases in KDMAF provided inputs.

Table 5. 2 Change in variable values due to increases in the global oil price

	Base, billions of Naira	Change from base due to oil price increase from 2015 level by…				
		10%	20%	30%	40%	50%
Federal government period 2 income	7,438.29	+355.33	+710.66	+1,065.99	+1,421.32	+1,776.65
State government savings after period 1	-0.39	-1.47	-2.93	-4.36	-5.80	-7.24
State government period 1 income	85.27	+0.01	+0.01	+0.03	+0.04	+0.04
State government period 2 income	85.84	+1.96	+3.91	+5.87	+7.82	+9.78
State government period 1 allocation to KDMAF	2.64	+0.95	+2.00	+3.12	+4.24	+5.35
State government period 2 allocation to KDMAF	2.30	0.00	0.00	0.00	0.00	0.00
KDMAF savings after period 1	0.14	+0.40	+0.85	+1.32	+1.79	+2.27
KDMAF period 1 inputs expenditures	3.09	+0.27	+0.57	+0.89	+1.21	+1.53
KDMAF period 2 inputs expenditures	3.08	+0.23	+0.49	+0.77	+1.04	+1.31

Small farmer savings after period 1	4.95	-0.04	-0.07	-0.17	-0.26	-0.29
Small farmer period 1 income	153.66	+0.12	+0.24	+0.41	+0.58	+0.69
Small farmer period 2 income	156.66	+0.04	+0.08	+0.12	+0.16	+0.20

Source: Model simulation results by authors.

The effects of the reduction in donor funds are next analyzed, and the simulation results provided in Table 5.3. Due to the model design, the largest effects of reductions/losses in donor funds are on the KDMAF budget. Since the state government budget is partially determined by income and VAT taxes, there are some small observed changes in the state government budget, but the federal government budget is not affected. To accommodate the somewhat substantial reductions in the KDMAF budget due to loss of donor funds, the state government increases its allocations to the KDMAF. These increases in state government allocations are not large enough, however, to allow the KDMAF to maintain input expenditure levels across periods. In each period, the KDMAF must increase savings through reductions in expenditures. In the case of a full loss in donor funds, the value of savings carried over by the KDMAF is equivalent to half of all input expenditures. The reductions in input expenditures mean that small farm household income is reduced, which requires them to increase savings to smooth consumption across periods. The changes in small farm household income due to the loss of donor funds are smaller than those observed due to the adjustments in the global oil price, because the estimated reductions in the state government allocations from the federal government due to the oil price change have a larger impact on the overall KDMAF revenue than do losses in donor funds.

Table 5. 3 Change in variable values due to decreases in donor funds

	Base, billions of Naira	Change from base due to donor fund declines from 2015 level by…				
		10%	20%	30%	40%	50%
Federal government period 2 income	7,438.29	0.00	0.00	0.00	0.00	0.00
State government savings after period 1	-0.39	+0.10	+0.09	0.00	-0.08	-0.16
State government period 1 income	85.27	0.00	-0.01	-0.01	-0.01	-0.02
State government period 2 income	85.84	0.00	0.00	0.00	0.00	0.00
State government period 1 allocation to KDMAF	2.64	-0.10	-0.08	0.00	+0.14	+0.29
State government period 2 allocation to KDMAF	2.30	+0.12	+0.17	+0.17	+0.17	+0.17
KDMAF savings after period 1	0.14	+0.20	+0.47	+0.81	+1.16	+1.52
KDMAF period 1 inputs expenditures	3.09	-0.15	-0.28	-0.40	-0.51	-0.61
KDMAF period 2 inputs expenditures	3.08	-0.13	-0.24	-0.34	-0.44	-0.53
Small farmer savings after period 1	4.95	0.00	+0.02	+0.04	+0.05	+0.06
Small farmer period 1 income	153.66	-0.05	-0.12	-0.18	-0.22	-0.27
Small farmer period 2 income	156.66	-0.02	-0.04	-0.06	-0.07	-0.09

Source: Model simulation results by authors.

Since the model is designed such that the effects of variable changes influence small farmer households to the greatest degree, there is an opportunity to analyze the potential effects of reductions in the loan borrowing rates for small farm households. The simulation results due to reductions in the small farm household loan

borrowing rates are presented in Table 5.4. The results show that small farm households increase savings due to the reduction in the interest rate, primarily through a reduction in period 1 consumption. This implies that small farmers are more willing to delay consumption under lower period 2 loan borrowing rates, and that consumption in period 2 becomes even more important for small household utility than it was prior to the interest rate reduction. The increases in period 2 consumption are seen through increases in consumption of agricultural goods at all levels of interest rate reduction. However, increases in consumption of farm inputs or durable goods are dependent on the size of the interest rate reduction. Under the largest interest rate reduction, period 2 purchases of durable goods increase, while under smaller interest rate reductions period 2 purchases of farm inputs increase. The overall effects of changes in interest rates on the household level variables are smaller in magnitude than those observed with changes in the global oil price, but are somewhat larger than those resulting from a loss in donor funds. This means that adjustments in variables such as the interest rate, which influences general time preference rather than solely input availability, can have more pronounced effects on economic outcomes than initiatives that specifically target one segment of the small household choice problem.

Table 5. 4 Change in variable values due to reductions in the loan interest rate for small farmers

		Change from base due to small farmer interest rate reduction by…				
	Base	3%	6%	9%	12%	15%
Total period 1 durables expenditures	211.85	0.00	-0.80	-0.79	-0.79	+0.02
Total period 2 durables expenditures	211.35	+0.12	-0.45	-0.34	-0.21	+0.66
State government period 1 allocation to KDMAF	2.64	0.00	+0.01	+0.01	+0.01	-0.01
State government period 2 allocation to KDMAF	2.30	0.00	0.00	0.00	0.00	0.00
KDMAF savings after period 1	0.14	0.00	0.00	0.00	0.00	-0.01
KDMAF period 1 inputs expenditures	3.09	0.00	+0.02	+0.02	+0.02	0.00
KDMAF period 2 inputs expenditures	3.08	0.00	+0.02	+0.02	+0.02	0.00
Small farmer savings after period 1	4.95	+0.25	+0.73	+0.98	+1.25	+1.37
Small farmer period 1 income	153.66	-0.10	+0.18	+0.09	-0.02	-0.54
Small farmer period 2 income	156.66	0.00	+0.26	+0.25	+0.25	+0.02
Small farmer period 1 agricultural good consumption	68.72	0.00	-0.36	-0.36	-0.36	-0.02
Small farmer period 2 agricultural good consumption	68.30	+0.03	+0.07	+0.10	+0.14	+0.17
Small farmer period 1 durable good consumption	35.74	0.00	-0.40	-0.40	-0.39	-0.04
Small farmer period 2 durable good consumption	35.30	+0.06	-0.23	-0.17	-0.11	+0.29
Small farmer period 1 input purchases	1.08	-0.07	+0.14	+0.07	-0.02	-0.39
Small farmer period 2 input purchases	4.29	+0.01	+0.35	+0.35	+0.34	+0.02

Source: Model simulation results by authors.

6. CONCLUDING REMARKS

The data exploration and simulation results in this study provide detailed insights into the current economic and fiscal conditions in Kaduna, and the degree to which fiscal and household level variables adjust when there are changes in key macroeconomic variables such as the global oil price. The Kaduna government has historically relied somewhat highly on the federal government allocation to fund its operations. Additionally, donor funds comprised roughly half of the 2016 KDMAF budget. This means that downward adjustments in the global oil price, which causes sharp decreases in federal revenues, or drops in donor funding from current levels can cause sharp declines in the availability of funds for agricultural programs, with implications for the well-being of smallholder farmers. The economic model is designed such that the state government can adjust its allocation to the KDMAF to dampen the impact of a loss in donor funds on expenditures on agricultural inputs provided to small farm households. However, in the absence of a similar federal level buffer, a decrease in the oil price affects the entire state government budget by such a large amount that sizable reductions in funding for the Ministry of Agriculture (and other ministries) are observed without an adjustment in the ministry allocation shares from the status quo.

While not captured directly in the empirical analysis, these results imply that there is an opportunity for the FMARD to use a portion of its funds to provide temporary funding to sustain state government or donor funded projects during periods when a negative funding situation occurs or is anticipated. Such an initiative would require FMARD staff to establish regular communication channels and working relationships with state Ministries of Agriculture staff and donors to keep track of ongoing initiatives and funding levels, and to record changes to each over time. A program could be instituted such that state Ministries of Agriculture could then apply for FMARD funding grants that provide such temporary provisions when budgetary conditions worsen. The award of such grants could be based on criteria such as the degree to which the program goals and observed outcomes are consistent with the FMARD policy initiatives, and whether program initiation required large upfront costs that have already been incurred. This would prevent FMARD from incurring potentially large initiation costs for successful programs. Increased coordination and communication between the state Ministries of Agriculture, donors, and the FMARD would plausibly increase the likelihood that agricultural programs are sustained over time, and improve overall public funding efficiency.

Further studies could analyze the funding levels and allocations of the FMARD over time, and measure how large those are relative to most state Ministries of Agriculture budgets. This could allow for a determination of the likelihood that the previously described buffer funding grant program could reasonably be encompassed within the FMARD budget. The estimated grant program cost could then be compared to the estimated potential needs when all Nigerian state Ministries of Agriculture budgets are considered to assess whether such a program could have a sizable impact in all states under current funding levels, or whether the federal government would need to allocate more funds toward the FMARD to sufficiently fund such a program.

Since a state's economic structure impacts average household income and expenditures, which then have feedback effects on state fiscal conditions through taxation channels, there plausibly are differences in the sizes of feedback effects on fiscal conditions across states with different socioeconomic characteristics. Thus, it is encouraged that future studies that estimate economy-wide outcomes such as public and private savings and investment flows across sectors capture the differences in economic and fiscal composition across Nigerian states.

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APPENDICES

Appendix A: List of variables and parameters in the model

Variable

Households

(types: small farmer (*s*), big farmer (*b*), non-farmer (*n*))

c_j^a: consumption of agricultural good by *j*=s,b,n

c_j^d: consumption of the durable good by *j*=s,b,n

i_l: farm input purchases by *l*=s,b

i_g: farm input purchases by government

q_l^a: quantity of agricultural good produced by *l*=s,b

E_j: total household expenditure by *j*=s,b,n

Y_j: total income for *j*=s,b,n

Π_j: household savings by *j*=s,b,n

Government

y: total taxable household income

k: total value of household durable good consumption

Γ: total federal government revenues

o: world oil price

Φ: federal government allocation to state government

N: state government revenues

Υ: income tax revenue

Λ: VAT tax revenue

g_a: state government appropriation to Ministry of Agriculture

g_x: state government appropriation to non-agriculture ministries and administration

G: total state government expenditures

Π_g: state government savings

M: total Ministry of Agriculture revenue

Δ: donor funds to Ministry of Agriculture

Σ: total Ministry of Agriculture expenditures

I: Ministry of Agriculture expenditure on farm inputs

A: Ministry of Agriculture expenditure on administration

Π_m: state Ministry of Agriculture savings

Parameters

Households

(types: small farmer (*s*), big farmer (*b*), non-farmer (*n*))

μ_j: consumption share parameter by *j*=s,b,n

λ_j: consumption substitution parameter *j*=s,b,n

σ_j: elasticity of substitution for *j*=s,b,n

β_j: rate of time preference for *j*=s,b,n

r_j: interest rate for *j*=s,b,n

p_a: price of the agricultural good

p_d: price of the durable good

p_i: price of the farm input

a_l: production technology for farmer *l=s,b*

l_l: labor endowment for farmer *l=s,b*

α_l: labor share of agricultural production for farmer *l=s,b*

θ_l: farm input share for farmer *l=s,b*

Z_j: exogenous income for *j*=s,b,n

Government

v : VAT tax on durable good

τ: income tax rate

r_g: interest rate for state government

r_m: interest rate for state Ministry of Agriculture

e: dollar to Naira exchange rate

Ω : quantity of oil produced

ω : share of federal government revenue from petroleum

ξ : conversion factor of oil production nominal value to government revenue

ϕ: federal government revenue from non-petroleum

δ: state share of total federal government revenues

Appendix B: Outline of the full economic model

Small farmer problem

$$\max_{c^a_{s,t}, c^d_{s,t}, i_{s,t}} u\left(c^a_{s,1}, c^a_{s,2}, c^d_{s,1}, c^d_{s,2}\right) = \left[\mu_s\left(c^a_{s,1}\right)^{-\lambda_s} + (1-\mu_s)\left(c^d_{s,1}\right)^{-\lambda_s}\right]^{-\frac{1}{\lambda_s}} + \beta_s\left\{\left[\mu_s\left(c^a_{s,1}\right)^{-\lambda_s} + (1-\mu_s)\left(c^d_{s,1}\right)^{-\lambda_s}\right]^{-\frac{1}{\lambda_s}}\right\}$$

s.t.

$$E_{s,1} + \frac{E_{s,2}}{(1+r_s)} - Y_{s,1} - \frac{Y_{s,2}}{(1+r_s)} = 0,$$
$$\lambda_s = \frac{(1-\sigma_s)}{\sigma_s},$$
$$E_{s,1} = p_d(1+v)c^d_{s,1} + p_i i_{s,1} + p_a c^a_{s,1},$$
$$E_{s,2} = p_d(1+v)c^d_{s,2} + p_i i_{s,2} + p_a c^a_{s,2},$$
$$Y_{s,1} = [p_a q^a_{s,1} + \mathrm{Z}_{s,1}](1-\tau),$$
$$Y_{s,2} = [p_a q^a_{s,2} + \mathrm{Z}_{s,2}](1-\tau),$$
$$\Pi_s = Y_{s,1} - E_{s,1},$$
$$q^a_{s,1} = a_s {l_s}^{\alpha_s}\left(i_{s,1} + i_{g,1}\right)^{\theta_s}, \text{ and}$$
$$q^a_{s,2} = a_s {l_s}^{\alpha_s}\left(i_{s,2} + i_{g,2}\right)^{\theta_s}.$$

Non-farmer problem

$$\max_{c^a_{n,t}, c^d_{n,t}} u\left(c^a_{n,1}, c^a_{n,2}, c^d_{n,1}, c^d_{n,2}\right) = \left[\mu_n\left(c^a_{n,1}\right)^{-\lambda_n} + (1-\mu_n)\left(c^d_{n,1}\right)^{-\lambda_n}\right]^{-\frac{1}{\lambda_n}} + \beta_n\left\{\left[\mu_n\left(c^a_{n,2}\right)^{-\lambda_n} + (1-\mu_n)\left(c^d_{n,2}\right)^{-\lambda_n}\right]^{-\frac{1}{\lambda_n}}\right\}$$

s.t.

$$E_{n,1} + \frac{E_{n,2}}{(1+r_n)} - Y_{n,1} - \frac{Y_{n,2}}{(1+r_n)} = 0,$$
$$\lambda_n = \frac{(1-\sigma_n)}{\sigma_n},$$
$$E_{n,1} = p_d(1+v)c^d_{n,1} + p_a c^a_{n,1},$$
$$E_{n,2} = p_d(1+v)c^d_{n,2} + p_a c^a_{n,2},$$
$$Y_{n,1} = \mathrm{Z}_{n,1}(1-\tau),$$
$$Y_{n,2} = \mathrm{Z}_{n,2}(1-\tau), \text{ and}$$
$$\Pi_n = Y_{n,1} - E_{n,1}.$$

Federal government

$$\Gamma_1 = \phi + \omega^{\xi}((\mathrm{o}_1 * \mathrm{e}) * \Omega)$$
$$\Gamma_2 = \phi + \omega^{\xi}((\mathrm{o}_2 * \mathrm{e}) * \Omega)$$

Big farmer problem

$$\max_{c^a_{b,t}, c^d_{b,t}, i_{b,t}} u\left(c^a_{b,1}, c^a_{b,2}, c^d_{b,1}, c^d_{b,2}\right) = \left[\mu_b\left(c^a_{b,1}\right)^{-\lambda_b} + (1-\mu_b)\left(c^d_{b,1}\right)^{-\lambda_b}\right]^{-\frac{1}{\lambda_b}} + \beta_b\left\{\left[\mu_b\left(c^a_{b,1}\right)^{-\lambda_b} + (1-\mu_b)\left(c^d_{b,1}\right)^{-\lambda_b}\right]^{-\frac{1}{\lambda_b}}\right\}$$

s.t.

$$E_{b,1} + \frac{E_{b,2}}{(1+r_b)} - Y_{b,1} - \frac{Y_{b,2}}{(1+r_b)} = 0,$$
$$\lambda_b = \frac{(1-\sigma_b)}{\sigma_b},$$
$$E_{b,1} = p_d(1+v)c^d_{b,1} + p_i i_{b,1} + p_a c^a_{b,1},$$
$$E_{b,2} = p_d(1+v)c^d_{b,2} + p_i i_{b,2} + p_a c^a_{b,2},$$
$$Y_{b,1} = [p_a q^a_{b,1} + \mathrm{Z}_{b,1}](1-\tau),$$
$$Y_{b,2} = [p_a q^a_{b,2} + \mathrm{Z}_{b,2}](1-\tau),$$
$$\Pi_b = Y_{b,1} - E_{b,1},$$
$$q^a_{b,1} = a_b {l_b}^{\alpha_b}\left(i_{b,1}\right)^{\theta_s}, \text{ and}$$
$$q^a_{b,2} = a_b {l_b}^{\alpha_s}\left(i_{b,2}\right)^{\theta_s}.$$

State government

$$\mathrm{N}_1 = \Upsilon_1 + v\mathrm{K}_1 + \delta\Gamma_1$$
$$\mathrm{N}_2 = \Upsilon_2 + v\mathrm{K}_2 + \delta\Gamma_2 \; \mathrm{G}_1 = \mathrm{g}_{a,1} + \mathrm{g}_{x,1}$$
$$\mathrm{G}_2 = \mathrm{g}_{a,2} + \mathrm{g}_{x,2},$$

s.t.

$$\mathrm{N}_1 + \frac{\mathrm{N}_2}{(1+r_g)} - \mathrm{G}_1 - \frac{G_2}{(1+r_g)} = 0,$$
$$\Pi_g = \mathrm{N}_1 - \mathrm{G}_1,$$
$$\Upsilon_1 = Y_{s,1}\tau + Y_{b,1}\tau + Y_{n,1}\tau,$$
$$\Upsilon_2 = Y_{s,2}\tau + Y_{b,2}\tau + Y_{n,2}\tau,$$
$$\mathrm{K}_1 = c^d_{s,1} + c^d_{b,1} + c^d_{n,1},$$
$$\mathrm{K}_2 = c^d_{s,2} + c^d_{b,2} + c^d_{n,2},$$

State Ministry of Agriculture

$$\mathrm{M}_1 = \mathrm{g}_{a,1} + \Delta_1,$$
$$\mathrm{M}_2 = \mathrm{g}_{a,2} + \Delta_2,$$
$$\Sigma_1 = \mathrm{I}_1 + \mathrm{A}_1,$$
$$\Sigma_2 = \mathrm{I}_2 + \mathrm{A}_2,$$

s.t.

$$\mathrm{M}_1 + \frac{\mathrm{M}_2}{(1+r_m)} - \Sigma_1 - \frac{\Sigma_2}{1+r_m} = 0,$$
$$\Pi_m = \mathrm{M}_1 - \Sigma_1,$$
$$\mathrm{I}_1 = p_i i_{g,1}, \text{ and}$$
$$\mathrm{I}_2 = p_i i_{g,2}.$$

Note: Non-negativity is imposed on all household choice variables.

Appendix C: Parameter and exogenous variable initial values

Parameter values based on gathered data

Parameters	Parameter values	Calculation method
Households *(types: small farmer (s), big farmer (b), non-farmer (n))*		
μ_j: consumption share parameter by *j*=s,b,n	μ_s: 0.49 μ_b: 0.49 μ_n: 0.50	Share of total expenditure devoted to food at home
β_j: rate of time preference for *j*=s,b,n r_j: interest rate for *j*=s,b,n	r_s: 0.192 r_b : 0.192 r_n: 0.167	Average interest rates: rural for farm households and urban for non-farm
a_l: production technology for farmer *l*=*s,b*	a_s: 1.34 a_b: 1	Ratio of implied yield (in kg/ha) from production (kg) and avg. farm size (ha.)
l_j: labor endowment for farmer *l*=*s,b*	l_s: 10 l_b: 13.1	Expenditure on labor per household multiplied by number of households
α_l: labor share of agricultural production for farmer *l*=*s,b*	α_s: 0.48 α_b: 0.57	Ratio of labor expenditures to total expenditures
θ_l: farm input share for farmer *l*=*s,b*	θ_s: 0.46 θ_b: 0.39	Ratio of fertilizer to total input expenditures
Z_j: exogenous income for *j*=s,b,n	Z_s: 160 Z_b: 85 Z_n: 230	Total expenditure minus crop sales (for farm households) plus implied income tax
Government		
v : VAT tax rate on durable good	v: 0.05	Source: FIRS
τ_j: income tax rate for *j*=s,b,n	τ_s: 0.07 τ_b: 0.07 τ_n: 0.07	Source: Kaduna state Board of Internal Revenue
r_g: interest rate for state government	r_g: 0.167	Assumed equivalence with average urban rate
r_m: interest rate for state Ministry of Agriculture	r_m: 0.167	Assumed equivalence with average urban rate
Ω : quantity of oil produced	Ω : 832,701 bbl per year	Annual equivalent of EIA daily estimate
e: dollar to Naira exchange rate	e: 197 N/$	IMF IFS exchange rate for 2015
ω : share of federal government revenue from petroleum	ω : 0.48	Ratio of petroleum-based revenue to total
ξ : conversion factor of oil production nominal value to government revenue	ξ : 1.16	Used values above to solve for parameter
ϕ: federal government revenue from non-petroleum	ϕ: 3,885 bil. Naira	IMF Article IV data for 2015
ρ: share of state government funds allocated to non-agriculture ministries and administration	ρ: 0.975	Use ratio for 2016, and assume same for 2015
δ: state share of total federal government revenues	δ : 0.0055	Ratio of federal allocation to total federal revenue

Other parameter values to input based on assumptions and gathered data

Parameters	Para-meter values	Calculation method
Households *(types: small farmer (s), big farmer (b), non-farmer (n))*		
λ_j: consumption substitution parameter *j*=s,b,n	λ_j: -0.333	$\sigma_j = 1$ implies a Cobb-Douglas form, $\sigma_j = 0$ implies perfect complements, and $\sigma_j = \infty$ implies perfect substitutes. Assume imperfect substitutability based on expenditure share data.
σ_j: elasticity of substitution for *j*=s,b,n	σ_j: 1.5	
p_a: price of agricultural good	p_a: 1	Agricultural good is numeraire
p_d: price of durable good	p_d: 2	Used expenditure share of non-food to food expenditure relative to total expenditure to infer price
p_i: price of farm input	p_i: 4.6	Used expenditure share of farm input expenditure relative to total expenditure to infer price

Initial values of exogenous household variables based on gathered data

Variables	Initial variable values, in billions of Naira	Calculation method and assumptions
Households *(types: small farmer (s), big farmer (b), non-farmer (n))*		
c_j^a: consumption of agricultural good by *j*=s,b,n	c_s^a: 67 c_b^a: 34 c_n^a: 106	Total expenditure on food multiplied by number of households by type and rounded
c_j^d: consumption of the durable good by *j*=s,b,n	c_s^d: 33 c_b^d: 17 c_n^d: 53	Total expenditures on non-food and non-farm inputs multiplied by number of households by type, divided by the price and rounded
i_l: farm input purchases by *l*=s,b	i_s: 4 i_b: 5	Total expenditures on inputs by farm households multiplied by number of households by type and divided by the price
i_g: farm input purchases by government	i_g: 0.65	Assume at least half of project funds devoted to inputs

Initial values of exogenous government variables based on gathered data

Variables	Initial variable values, in billions of Naira, unless noted otherwise	Calculation method and assumptions
Government		
o: world oil price (in USD/bbl.)	o: 50.75 $/bbl.	Annual average World Bank price for 2016
g_a: state government appropriation to Ministry of Agriculture	g_a: 2.3	Assume ratio from 2016 applies for 2015 and multiplied ratio by 2015 total expenditures
g_x: state government appropriation to non-agriculture ministries and administration	g_x: 83	Residual value from total revenue based on other initial values to make initial state government savings equal to zero
Π_g: state government savings	Π_g: 0	Assume initially zero savings
Δ: donor funds to Ministry of Agriculture	Δ: 3	Assume 2016 value applies for 2015
I: Ministry of Agriculture expenditure on farm inputs	I: 3	Assume most of donor funds go to input purchases
A: Ministry of Agriculture expenditure on administration	A: 2.3	Residual value to make initial savings equal to zero
Π_m: State Ministry of Agriculture savings	Π_m: 0	Assume initially zero savings