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Agricultural Growth and Investment Options for Poverty Reduction in Nigeria

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ABSTRACT

This study uses an economy-wide, dynamic computable general equilibrium (DCGE) model to analyze the ability of growth in various agricultural subsectors to accelerate overall economic growth and reduce poverty in Nigeria over the next years (2009-17). In addition, econometric methods are used to assess growth requirements in agricultural public spending and the relationship between public services and farmers' use of modern technology. The DCGE model results show that if certain agricultural subsectors can reach the growth targets set by the Nigerian government, the country will see 9.5 percent annual growth in agriculture and 8.0 percent growth of GDP over the next years. The national poverty rate will fall to 30.8 percent by 2017, more than halving the 1996 poverty rate of 65.6 percent and thereby accomplishing the first Millennium Development Goal (MDG1). This report emphasizes that in designing an agricultural strategy and prioritizing growth, it is important to consider the following four factors at the subsectoral level: (i) the size of a given subsector in the economy; (ii) the growth-multiplier effects occurring through linkages of the subsector with the rest of the economy; (iii) the subsector-led poverty-reduction-growth elasticity; and (iv) the market opportunities and price effects for individual agricultural products.

In analyzing the public investments that would be required to support a 9.5 percent annual growth in agriculture, this study first estimates the growth elasticity of public investments using historical spending and agricultural total factor productivity (TFP) growth data. The results show that a 1 percent increase in agricultural spending is associated with a 0.24 percent annual increase in agricultural TFP. With such low elasticity, agricultural investments must grow at 23.8 percent annually to support a 9.5 percent increase in agriculture. However, if the spending efficiency can be improved by 70 percent, the required agricultural investment growth becomes 13.6 percent per year. The study also finds that investments outside agriculture benefit growth in the agricultural sector. Thus, assessments of required growth in agricultural spending should include the indirect effects of nonagricultural investments and emphasize the importance of improving the efficiency of agricultural investments. To further show that efficiency in agricultural spending is critically important to agricultural growth, this study utilizes household-level data to empirically show that access to agricultural services has a significantly positive effect on the use of modern agricultural inputs.

Keywords: **poverty reduction, agricultural growth, public investment, agricultural services, Nigeria**

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ABBREVIATIONS AND ACRONYMS

BOF	Budget Office of the Federation
CAADP	Comprehensive Africa Agriculture Development Program
CBN	Central Bank of Nigeria
DCGE	Dynamic Computable General Equilibrium
FMA	Federal Ministry of Agriculture
FMARD	Federal Ministry of Agriculture and Rural Development
GFS	Government Finance Statistics
IMF	International Monetary Fund
MDG	Millennium Development Goal
NBS	National Bureau of Statistics
NEEDS	National Economic Empowerment and Development Strategy
NEPAD	New Partnership for Africa's Development
NFSP	National Food Security Program
NPC	National Population Commission
OAGF	Office of the Accountant General of the Federation
SAM	Social Accounting Matrix
TFP	Total Factor Productivity

1. INTRODUCTION

Poverty remains a challenge in Nigeria's development efforts. Although the national poverty rate was 54 percent , or 69 million people, in 2004, which was reduced from its highest level in the early 1990s, it is still two times higher than the poverty rate in 1980. On the other hand, relatively impressive economic growth rates were recorded during the 2000-07 period. Compared to the periods of 1990-94 and 1995-99, when the economy grew at 2.6 and 3.0 percent per year, respectively, the annual growth rate of GDP rose to 7.3 percent during 2000-07. This suggests that while economic growth is necessary for the country's development, it does not automatically impact poverty reduction. Notably, the agricultural sector has been a key driver of recent growth in Nigeria. Between 1990 and 2006, the agricultural and oil sectors accounted for 47 and 39 percent of national growth, respectively. Despite the high dependence of government revenues and national export earnings on the oil sector, the agricultural sector has comprised the most important source of growth in recent years. Furthermore, as agriculture is the single largest employer among sectors (70 percent of labor force) (NBS 2006) and labor is the main and sometimes only asset for the poor (Agenor et al. 2003), the agricultural sector outperforms all other sectors in reducing poverty.

In recognition of the importance of the agricultural sector in Nigeria, the government has initiated and endorsed many national and international projects, programs and policies aimed at rapidly growing the sector, and thereby reducing poverty. These include the National Economic Empowerment and Development Strategies (NEEDS and NEEDS II), the implementation of the Comprehensive Africa Agriculture Development Program (CAADP) and the National Food Security Program (NFSP), as well as product-specific programs, such as the presidential initiatives on cassava, rice and other crops. Motivating pay offs to these programs have been seen; for example, agriculture's growth rose from 3.5 percent per annum in 1990-99 to 5.9 percent per annum in 2000-07, and poverty decreased from 65.6 percent in 1996 to 54.4 percent in 2004. Despite these accomplishments, however, further efforts will be necessary if we hope to lift more people out of poverty and meet the first Millennium Development Goal (MDG1) of halving the proportion of people who live under the poverty line, with incomes of less than US$1 dollar per day.

Against this background, the present study analyzes the agricultural growth and investment options that could support the formation of a more comprehensive rural development component under NEEDS II, in alignment with the principles and objectives collectively defined by African countries as part of the broader NEPAD agenda. In particular, the study seeks to position Nigeria's agricultural sector and rural economy within NEEDS II. For these purposes and to assist policy makers and other stakeholders in making informed long-term decisions, we herein develop an economy-wide, dynamic computable general equilibrium (DCGE) model for Nigeria, and use it to analyze the linkages and trade-offs between economic growth and poverty reduction at both the macro- and microeconomic levels. After introducing the DCGE model in the next section, we have considered two scenarios using the DCGE model. In the first scenario in Section 3, we consider a growth path following the country's current growth trends and we define it as a baseline scenario. In the second scenario in Section 4 we simulate a growth path along which growth at the agricultural subsector levels is accelerated to meet with the targets set by the government. Additional growth is assumed from increases in productivity instead of more land expansion. In this scenario we also evaluate whether subsector level targets can allow the country's total agriculture to grow at 10 percent annually, a growth target defined in NEEDS II. We call this scenario a 'CAADP scenario' though the targeted 10 percent of agricultural growth is much higher than the 6 percent of CAADP goal. In Section 5, we attempt to quantify the public resources that should be funneled to the agricultural sector in order to achieve the government's stated development goals, while in Section 6 we turn to analyze the linkages between public services and farmers' use of modern technology. Section 7 concludes the paper with major findings and policy implications.

2. MODELING AGRICULTURAL GROWTH AND POVERTY REDUCTION[1]

Previous CGE Models for Nigeria

Previously, CGE modeling has been used to study the Nigerian economy and analyze the ability of agriculture and its different subsectors to achieve various poverty and growth goals. These papers include those by Iwayemi (1995), the UNDP (1995b), Ajakaiye and Olomola (2003) of the Nigerian Institute of Social and Economic Research (NISER), and the analysis done for NEEDS II using the National Planning Commission-Center for Econometric and Allied Research (NPC-CEAR) model (NPC 2007). All of these models were done at the national level (i.e., they were not disaggregated to the levels of the various regional economies) and were relatively aggregated in their sectoral structures. Iwayemi (1995), for example, designed a quasi-CGE model to check the consistency of targets laid out in the first perspective plan developed during the 1990s (it is not clear whether this model was actually used to analyze policy issues). The UNDP (1995b) model was a follow up to that of Iwayemi (1995), and used a Social Accounting Matrix (SAM) that comprised 52 sectors, including some agricultural subsectors. However, we were unable to find any policy analysis performed using this model.

In contrast, the NISER (Ajakaiye and Olomola 2003) and NPC-CEAR (NPC 2007) models have been successfully used to analyze various economic targets in relation to overall growth targets. The NISER model projected the expected growth rates of the economy between 2001 and 2015 based on assumptions of future levels of key economic variables, namely the exchange rate, interest rate, minimum wage, government capital expenditure, exports, and investments. The analysis for NEEDS II using the NPC-CEAR model focused on estimating the sectoral growth rates required to achieve 10 percent growth in the economy for 2008-11.

While the latter two studies linked national growth to that in economic variables and different sectors, they did not consider the agricultural sector in detail and did not fully assess the relative roles that the different agriculture subsectors can play in accelerating agricultural and economy-wide growth. With regard to poverty impacts, the NISER model was limited to concluding that the daily per capita income would increase from US$1 in 2001 to US$4.4 in 2015 if the assumed levels of the economic variables were met; however, it is not clear how this result was obtained from the model. As for NEEDS II, the existing modeling analysis did not clearly distinguish what poverty impact would be expected from the 'required' 10 percent economic growth. Another limitation for both reports was that the analysis could not be applied to disaggregated households, and the papers therefore failed to discuss the impact of growth on different types of rural and urban households.

The Dynamic General Equilibrium (DCGE) Model and a Microsimulation Module for Nigeria

A standard static CGE model was developed in the early 2000s at the International Food Policy Research Institute (IFPRI), as documented by Lofgren (2001). The recursive dynamic version of the CGE model incorporates a series of dynamic factors into the standard static CGE model. An early version of the DCGE model was first developed by Thurlow (2004), and its recent application to two country case studies (in Zambia and Uganda) was done by Diao et al. (2007). We herein develop a DCGE model for Nigeria in this study. The DCGE model captures the trade-offs and synergies that come from accelerating growth in various agricultural subsectors, as well as the economic inter-linkages between agriculture and the rest of the economy. Although our study focuses on the agricultural sector, the DCGE model for Nigeria also contains information on nonagricultural sectors. The model examines 62 subsectors in total, more than half of which are in agriculture. The examined agricultural crops fall into four broad groups: (i) cereal crops, including rice, wheat, maize, sorghum, and millet; (ii) root crops, such as cassava, yam, cocoyam, Irish potatoes, and sweet potatoes; (iii) other food crops, including plantain, beans, groundnuts,

[1] Sections 2, 3, and 4 were written by Xinshen Diao, Manson Nwafor and Vida Alpuerto.

soybeans, other oil crops, vegetables for domestic use, and fruits for domestic use; and (iv) higher-value export-oriented crops, such as cocoa, coffee, cotton, oil palm, vegetables for export, fruits for export, sugar, tobacco, cashew nuts, other nuts, rubber, and other export crops. The DCGE model also identifies four primary livestock sectors, namely: cattle, goats and sheep, poultry, and other livestock. To complete the agricultural sector, the model also includes forestry and fisheries. Most of the agricultural commodities listed above are not only used for domestic consumption or export, they are also used as intermediate inputs into various processing activities in the manufacturing sector. The ten agricultural processing activities (including eight food-processing activities) identified in the model comprise the processing of: beef; goat and sheep meat; poultry meat; eggs; milk; other meats; beverages; other foods; textiles; and wood. The agricultural sectors themselves also use inputs produced from nonagricultural sectors, such as fertilizer and transport and trade services for crops.

The DCGE model for Nigeria also captures regional heterogeneity. Rural agricultural production is disaggregated across six zones in Nigeria, with representative farmers engaging in different crop- and livestock-production strategies across zones. Therefore, the model is calibrated to the initial agricultural structure at the zonal level. The representative farmers within each zone respond to changes in production technology, commodity demand, and commodity prices by making decisions on how to allocate land and family labor across the different crops and livestock subsectors, and whether or not to purchase other inputs (e.g., hired labor, capital, and intermediate inputs) in order to maximize their net incomes from agriculture. The allocation of labor is also determined by the opportunity to participate in nonagricultural activities, which primarily occur in urban areas or rural towns. Such opportunities are modeled from the demand side, in that the representative producers in the nonagricultural sectors, when making their production decisions, decide on the amount of labor to be hired in, taking market wage rates as given. Thus, by capturing production structure at the subnational level, the DCGE model effectively integrates the information on different agents and activities into an economy-wide model that can be used to assess growth effects at the national level. The DCGE model for Nigeria is therefore an ideal tool for capturing the growth linkages, income effects, and price effects resulting from growth acceleration in different agricultural sectors. Additional detail on the DCGE model is available in Appendix A.

Finally, the DCGE model endogenously estimates the impact of alternative growth paths on the incomes of various household groups. These household groups are defined based on the six zones and rural or urban location, for a total of 12 representative household groups. Each household group is aggregated from the Nigeria Living Standards Survey (NLSS) 2003/04 such that all households sampled in NLSS 2003/04 can be linked directly to their corresponding representative household in the DCGE model. The microsimulation module[2], which contains all households sampled in NLSS 2003/04, is linked to the DCGE model. In this macro-to-micro linkage, changes in representative households' consumption patterns and prices in the DCGE model are passed down to their corresponding households in the microsimulation module (containing all sampled households from NLSS 2003/04, where the total consumption expenditure for each sample household is recalculated from the new level of consumption on a by-commodity basis. The new level of per capita expenditure obtained for each survey household is then compared to the official poverty line, and standard poverty measures are re-calculated. Thus, the poverty measures are consistent with official poverty estimates, while the changes in poverty draw on the analyzed across-group consumption patterns, income distributions, and poverty rates.

The Data

The data used to calibrate the base year of the DCGE model used in this study are drawn from a variety of sources. The core dataset underlying the DCGE model is a SAM constructed in 2006 using data from the national accounts, trade data from the Nigeria Bureau of Statistics (NBS), and balance-of-payment information from the Central Bank of Nigeria (CBN). National- and state-level data on agricultural production, agricultural yield, and market prices come from the Federal Ministry of Agriculture and Rural

[2] See Appendix A for a detailed description of the microsimulation module.

Development (FMARD). In cases where production data are unavailable for certain crops (e.g., horticulture), information is taken from the Food and Agriculture Organization (FAO) of the United Nations. These agricultural production data are disaggregated across the zones by mapping each of the states to the six zones. The DCGE model is therefore consistent with official agricultural production levels and yields at the zonal level. Nonagricultural production, employment, and other value-added component of national-level sectoral GDP data are compiled from national account tables (NBS 2007a). On the demand side, the information on industrial technologies (e.g., intermediate and factor demand) comes from an earlier SAM for Nigeria (UNDP 1995b), while the income and expenditure patterns for the various household groups are taken from NLSS 2003/04. The DCGE model is therefore based on the most recent available data for Nigeria and represents the country's economy in 2006.

3. POVERTY REDUCTION UNDER NIGERIA'S CURRENT GROWTH PATH

Design of a Baseline Simulation to Capture Growth Trends

The dynamic CGE model developed for this study is first used to simulate a base-run that captures Nigeria's current growth and poverty reduction trends, taking into account the recent changes in the country's external environment (e.g., the global financial crisis and the sharp decline in world crude oil prices). These external changes are expected to negatively affect the Nigerian economy's performance in the near future, as crude oil accounts for 37 percent of national total GDP. History shows that the Nigerian economy is very vulnerable to oil price shocks, which impact the effective exchange rate, government expenditures, money supplies, trade, and inflation (Akpan 2009). Given that both the global financial crisis and the declines in world crude oil prices are expected to last for some time, the base-run simulation considers a modest, targeted economic growth rate that is lower than the 7.6 percent annual growth recorded during the period of 2002-07 (CBN 2009). Measured in real terms, although the crude oil sector's GDP grew at only 4.4 percent annually during this period, due to rising world oil prices, the sector's contribution to overall economic growth was mainly channeled through increased oil revenues. Given that this factor is unlikely to play a key positive role in stimulating growth in the present and near future, and some of its effects may even become negative (e.g., declines in oil revenue may force the government to increase the allocation of growth-stimulating funds), the base-run simulation targets a modest annual GDP growth rate of 6.5 percent over the next years (2008-17) (Table 1). While this growth rate is lower than the recent performance of the Nigerian economy, it is still relatively high considering the current external conditions worldwide. Moreover, this growth rate is higher than the historical average growth rate if a longer period is considered. For example, the average annual GDP growth rate during the period 1995-2007 was 5.5 percent (CBN 2009).

The base-run also considers relatively modest growth in the agricultural sector. In addition to the reasons noted above to explain our growth projection of the general economy, another factor reminds us to be cautious when projecting agricultural growth: Although the national account tables show high-level growth (6.7 percent) in agricultural GDP between 2002 and 2007, such a rapid growth in agricultural GDP is not consistent with individual crop production data obtained from FMA or the market situation (e.g., the price situation) for the major food crops in the domestic markets. In terms of the production reported by FMA for certain smallholder-produced crops, the average annual growth rate was 5.5 percent in 2000-06. Such growth was primarily driven by area expansion, whereas yield increase-driven growth was very modest. For example, the FMA data show that the annual yield-growth rates for cassava, sorghum, millet, and maize, were 0.9, 0.3, 0.4, and 0.8 percent, respectively, for this period. These four major food crops together account for more than 50 percent of agricultural area in Nigeria at present. Given this historical perspective, we use a set of more realistic growth rates for each individual crop and livestock product, and apply an annual agricultural growth rate of 5.7 percent (similar to that of 2000-07) in the baseline scenario.[3]

[3] The NBS is aware of potential problems in agricultural crop GDP calculations during this period, particularly in 2002, as shown below:

Year	Crop production GDP (1990 constant prices in billions of Naira)	Annual growth rate (%)
1997	87.4	
1998	90.8	3.9
1999	95.5	5.2
2000	98.4	3.0
2001	102.1	3.8
2002	***168.8***	***65.3***
2003	181.2	7.3
2004	192.4	6.2
2005	206.2	7.2
2006	221.6	7.5

Source: NBS (2007).

Table 1. GDP growth rates in the baseline and CAADP scenarios

	Share of GDP	Annual growth rate, 2008-17 (%)	
	In 2006	Baseline	CAADP scenario
Total GDP	19,909 (billion Naira)	6.5	8.0
Agriculture	29.7	5.7	9.5
Cereals	7.7	5.4	9.5
Rice	2.6	5.1	10.2
Wheat	0.0	5.0	25.9
Maize	2.2	7.3	12.0
Sorghum	1.6	4.0	5.7
Millet	1.3	4.2	5.7
Root crops	9.4	6.0	8.9
Cassava	4.4	5.6	8.7
Yams	3.9	6.4	9.3
Cocoyams	0.2	4.7	6.0
Potatoes	0.3	8.8	12.4
Sweet potatoes	0.6	4.7	7.0
Other food crops	7.6	5.7	8.1
Plantains	0.6	3.8	4.9
Beans	1.0	5.3	7.6
Groundnuts	1.1	5.5	7.7
Soybeans	1.1	5.7	8.5
Other oilseeds	0.1	4.5	6.3
Vegetables	1.8	6.1	8.6
Fruits	1.6	6.4	8.7
High-value crops	1.5	5.6	17.6
Cocoa	0.1	3.9	4.9
Coffee	0.2	6.1	8.8
Cotton	0.1	5.2	11.2
Oil palm	0.5	3.8	5.7
Sugar	0.3	7.3	33.1
Tobacco	0.1	6.8	10.0
Nuts	0.0	5.7	7.9
Cashew nuts	0.004	5.7	7.7
Rubber	0.2	6.1	6.1
Other export crops	0.017	8.5	12.8
Livestock	1.9	5.4	6.9
Cattle	0.6	5.5	6.4
Goats & sheep	0.9	5.1	6.5
Poultry	0.4	5.9	8.8
Other livestock	0.0	6.1	7.0

Table 1. Continued

	Share of GDP	Annual growth rate, 2008-17 (%)	
	In 2006	Baseline	CAADP scenario
Other agriculture	1.6	5.8	10.9
Forestry	0.5	4.2	5.7
Fisheries	1.0	6.5	12.9
Mining	34.6	3.7	3.7
Cruel oil	34.5	3.7	3.7
Other mining	0.1	3.7	3.7
Manufacturing	6.9	6.7	7.4
Beef	0.6	6.2	7.6
Goat & sheep meat	2.2	6.0	7.2
Poultry meat	0.2	8.2	13.3
Eggs	0.03	7.3	10.7
Milk	0.01	7.5	9.9
Other meats	0.02	5.7	5.9
Beverages	0.3	7.3	7.7
Other foods	0.4	8.1	8.6
Textiles	0.5	7.8	8.3
Wood processing	0.3	7.9	8.8
Electronic manufacturing	0.9	6.4	5.4
Other manufacturing	1.1	6.5	6.0
Oil refining	0.3	6.2	6.2
Other industries	4.3	8.5	8.8
Construction	1.2	9.2	9.5
Utility	3.1	8.2	8.6
Services	24.5	9.6	10.7
Road transportation	2.2	14.9	16.3
Other transportation	0.1	15.1	16.1
Trade	8.3	9.8	11.4
Hotels and restaurants	1.2	8.2	9.1
Communication	0.8	13.2	14.1
Finance and other business services	1.8	13.8	14.4
Real estate	2.6	7.5	7.5
Education	1.3	5.8	6.5
Health	0.6	6.0	6.8
Public services	4.6	4.8	5.6
Other private services	1.0	7.2	7.4

Sources: Nigerian SAM and DCGE model results.

Factors Determining Growth in the Model

To model a realistic baseline, it is also important to be aware of the growth sources across sectors and for different input factors. In the model, economic growth results from increases in labor supply, land expansion, capital accumulation, and productivity changes. We assume that the growth in total labor supply is consistent with the projected annual population growth of 3.0 percent.[4] Three types of labor are distinguished in the model: (i) rural family labor employed in agricultural production only; (ii) unskilled labor that can move freely across sectors (i.e., between agricultural and nonagricultural production); and (iii) skilled labor employed only in the nonagricultural sector. Taking into account a more rapid growth in labor supply to the nonagricultural sector, we assume that the annual growth rate for rural family labor is 2.0 percent, while the growth rates in unskilled and skilled labor (the two economy-wide labor categories) are 3.3 and 3.4 percent, respectively.

The total zonal-level land expansion for 2009-17 is exogenously determined based on the recent trends observed by FMARD (2007). The assumed initial expansion rate of 5.2 percent per year is consistent with FMARD data recorded in 2001-06. After 2011, land expansion is assumed to fall to 4.2 percent, which is still relatively high. The average annual growth rate of land expansion across the modeled period is 4.4 percent (Table 2). Due to a lack of information regarding land expansion potential at the zonal level, we have to assume a uniform growth rate across the six zones. Given that agricultural production activities are modeled at the zonal level, it will be straightforward to adopt different land expansion rates once such information is available.

Capital accumulation is an endogenous outcome of savings and investments, which are modeled recursively in our model. Investments are financed through private and government savings. Private savings are determined by a fixed proportion of total income (an endogenous variable) received by each of the 12 representative households, while government savings is the difference between government income (an endogenous variable) and total non-investment spending (an exogenous variable). Both private and public savings rates are calibrated to the 2006 SAM. Investments are also affected by foreign capital flows. Since Nigeria has experienced a trade surplus in recent years, the net foreign capital inflows are negative in the model (indicating capital outflow). In the recursive dynamic model, this outflow is an exogenous variable whose growth is assumed to decline due to the expected slow growth in oil exports. This assumption brings the expectation that more oil revenues will be used to finance domestic investments, instead of purchasing foreign bonds or investing in foreign capital markets (as seen in the current situation). In the baseline, capital accumulates at 4.6 percent annually in real terms after a 5.0 percent depreciation (Table 2).

While the total factor supply grows either exogenously (labor and land) or endogenously (capital), its sectoral-level demand is endogenous. Factor demand is determined by competition in the factor markets, and by the profitability of each individual sector. The third part of Table 2 shows the growth rate in aggregate labor and capital demand for agriculture and nonagriculture. As can be seen in the table, the demand for total agricultural labor grows at 2.2 percent annually, while that for the nonagricultural sector grows at 3.7 percent annually. The growth rate of total agricultural capital demand is higher than that for total nonagricultural capital demand (6.7 percent vs. 4.5 percent, respectively); however, since agricultural capital accounts for a very small portion of total capital input, even given rapid growth the share of capital in agricultural GDP remains very small (< 5.0 percent of agricultural GDP; by comparison, capital accounts for more than 60 percent of nonagricultural GDP, as shown in the first part of Table 2).

[4] Different population growth rates have been estimated for Nigeria. According to NBS (2007) and the National Population Commission (2002), the annual growth rate was 2.83 percent during 1991-2005, while Nigeria population census shows an annual growth rate of 3.07 percent during 1991-2006.

Table 2. Growth decomposition in the model simulations

	GDP		AgGDP		NagGDP	
	Baseline	CAADP	Baseline	CAADP	Baseline	CAADP
Annual output growth rate (%)	6.5	8.0	5.7	9.5	6.8	7.4
Share in the economy (%)	In GDP		In AgGDP		In NagGDP	
Land	11.0		37.0			
Labor	45.7		59.4		39.9	
Capital	43.3		3.6		60.1	
Contribution to growth (%)	To GDP growth		To AgGDP growth		To NagGDP growth	
	Baseline	CAADP	Baseline	CAADP	Baseline	CAADP
Land	9.5	9.8	33.3	24.7		
Labor	20.2	16.2	21.2	12.4	21.7	20.1
Capital	31.6	25.9	5.0	3.3	41.2	38.6
Total Factor Productivity (TFP)	38.7	48.1	40.6	59.6	37.1	41.2
Annual input and TFP growth rate (%)	Baseline	CAADP				
Land	4.8	5.7				
Labor	3.0	3.0				
Agricultural (ag) labor	2.2	2.1				
Nonagricultural (nag) labor	3.7	3.7				
Capital	4.6	4.7				
Ag capital	6.7	7.1				
Nag capital	4.5	4.6				
TFP	2.5	3.8				
Ag TFP	2.3	5.6				
Nag TFP	2.5	3.0				

Source: Nigerian DCGE model results.

It is impossible to have sustainable growth without a change in productivity. The model assumes that total factor productivity (TFP) grows exogenously at the sectoral level across all six zones. The TFP growth rate is drawn from historical data and is based on the yield-growth rate for crop sectors, and on sectoral value-added growth in the case of non-crop sectors.

While productivity growth is a driving force of growth at the sectoral level, growth is also affected by demand. If the supply of a specific commodity cannot find enough demand in either the domestic or foreign markets, the price for this commodity in the domestic market falls, subsequently reducing the factor demanded by the production of this commodity and lowering its growth rate.

We calculate the contribution of the factors and productivities to overall economic growth, as shown in Table 2. The contribution of a given factor to growth depends on its growth rate and share in adding value. For the economy as whole, land accounts for 11.0 percent of GDP, while labor and capital account for 45.7 and 43.3 percent, respectively. In terms of GDP growth in the baseline scenario, 61.3 percent of growth is due to factor accumulation, while 38.7 percent comes from TFP growth (Table 2, second part). We also examine the contributions to growth in agricultural and nonagricultural GDP. In the baseline scenario, almost 60 percent of agricultural growth is due to land expansion, increased labor supply, and capital accumulation, whereas productivity increases explain the remaining 40 percent of growth. Within the crop sectors, productivity gains come both from yield improvements and more efficient allocations of land to the production of higher-return commodities.

Growth at the Subsectoral Level

While the base-run models overall annual growth in GDP and the agricultural sector at 6.5 and 5.7 percent, respectively, during 2008-17, the growth rates differ across sectors. Specifically, input allocation across sectors differs over time due to differences in sectoral productivity growth and price changes. For example, although agricultural GDP grows at 5.7 percent annually, the growth in total cereal value-added is 5.4 percent, while those in rice, maize, and Irish potato production are 5.1, 7.3, and 8.8 percent, respectively (Table 1).

Table 1 presents the base-run GDP growth rates for the subsectors included in the model, as well as for some subsector groups. All of these growth rates are the endogenous results of the model. The first column of the table gives the size of each sector as a share of the total GDP, representing the initial structure of the Nigerian economy in 2006.

Poverty Reduction Outcome in the Baseline Simulation

The poverty-reduction impact of the modeled economic growth is analyzed using a microsimulation module that includes all households sampled in NLSS 2003/04. By taking into account micro-level consumption patterns across households, we determine demand changes at the individual-food-commodity level for each sampled household, by linking such demand with the representative household demand for the same commodity in the DCGE model. As discussed in Section 2, the representative households are aggregated from the sample households (based on the six zones and by rural/urban location). Although such top-down linkages between the DCGE model and the microsimulation module do not allow us to capture the distributional effects of growth within each zone's rural or urban household group, we do capture certain differential welfare effects across zones and between rural and urban households.

Before we start the exercise, we assess the impact of growth on poverty reduction using historical national-level poverty data available for 1980, 1985, 1992, 1996, and 2004. Because the poverty rate of 65.6 percent in 1996 was much higher than that in 1992 (42.7 percent), it is difficult to perform a trend analysis over a longer period. For this reason, we focus on the poverty rates in the recent period between 1996 (in which the poverty rate was 65.6 percent) and 2004 (54.4 percent), and compare them with actual per capita GDP growth over the same period. While the annual growth rate of GDP per capita was 2.5 percent (calculated from the CBN's annual GDP growth rate of 5.5 percent and the annual population growth rate of 3.0 percent during this period), the total decline in the poverty rate was only 11.2 percentage points over these seven years (or 2.3 percent per year). By comparing the total decline in the national poverty rate (i.e. 2004's poverty rate is 17 percent, not percentage points, lower than that in 1996) with the total growth in per capita GDP (22 percent) across the same seven years, we derive a poverty-reduction-growth elasticity of –0.78.[5] This indicates that for a 1 percent growth in per capita GDP in Nigeria between 1996 and 2004, the poverty rate fell by 0.78 percent from the 1996 level. Although the elasticity is affected by the initial poverty rate (which was high in 1996) and the pattern of income distribution around the poverty income line, such elasticity is comparable with that obtained for other African countries (See Diao et al. 2007).

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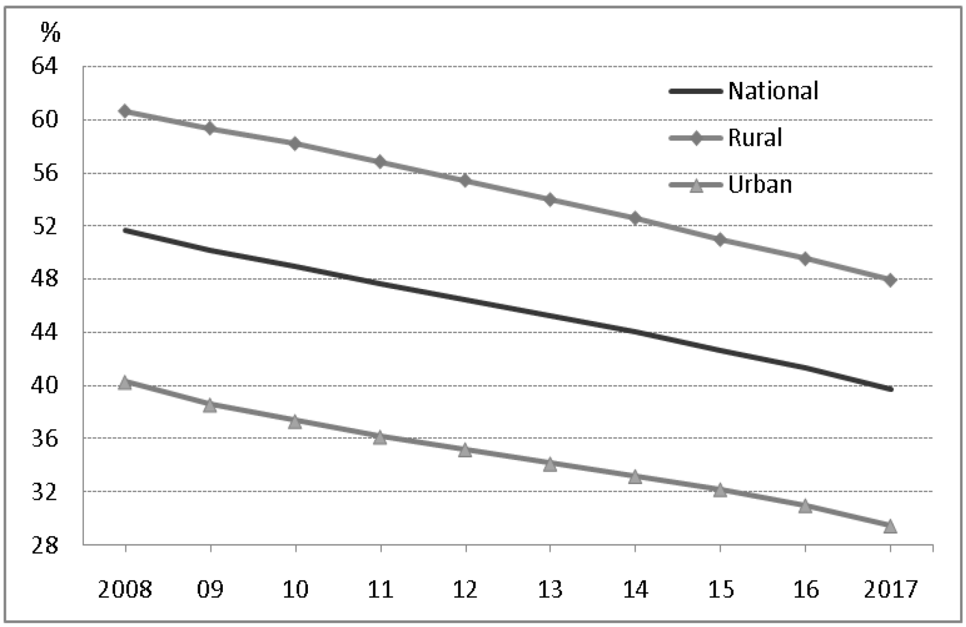
[5] The poverty–growth elasticity used in this study measures the responsiveness of the poverty rate to changes in the per capita GDP growth rate. The formula for this elasticity is:

$$\frac{\Delta P_0 / P_0}{\Delta GDP_{pc} / GDP_{pc}} = \frac{\Delta P_0}{\Delta GDP_{pc}} \cdot \frac{GDP_{pc}}{P_0},$$

where ΔP_0 and ΔGDP_{pc} are the average annual changes (from the base year) in the poverty headcount rate and the level of per capita GDP, respectively, and P_0 and GDP_{pc} are the base-year poverty headcount rate and per capita GDP, respectively. The poverty–growth elasticity measures the percentage change in the poverty headcount rate caused by a 1 percent increase in per capita GDP. This is *not* equivalent to a percentage point change in the poverty headcount rate.

We also use the same formula to calculate the poverty-growth elasticity from the results of the baseline simulation, and obtain a similar elasticity of -0.851. That is to say, for a 1 percent of growth in per capita GDP over the next ten years along the base-run path, the national poverty rate will fall by 0.851 percent. Given such elasticity, our poverty analysis shows that annual growths of 6.5 percent in total GDP and 5.7 percent in agricultural GDP over the next years (2008-17), together with a 3.0 percent annual population growth in the same period, will decrease the national poverty rate from 51.6 percent in 2008[6] to 39.4 percent by 2017 (Figure 1). However, although this poverty rate is already lower than that seen in 1992 (42.7 percent), given the 3.0 percent population growth per year, the number of poor people will actually increase over time. The base-run result shows that there will be 287,000 more poor people in Nigeria in 2017 versus 2008.

Figure 1. Poverty rates (%) in the baseline scenario



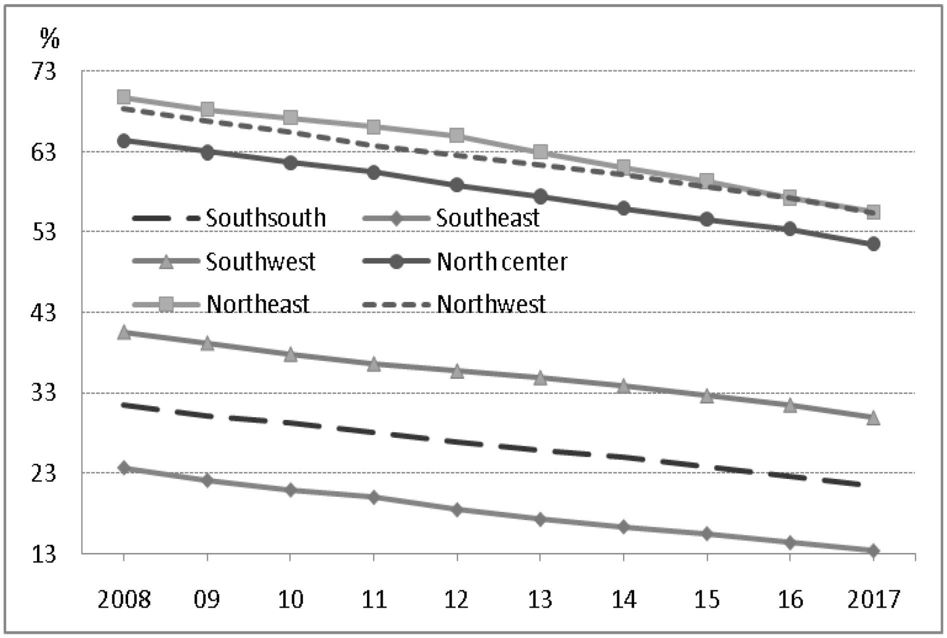
Source: Nigerian DCGE model results.

The base-run also generates national-level rural and urban poverty rates (Figure 1), as well as zonal-level rates for the six regions (Figure 2). The NLSS 2003/04 data show that in 2004, poverty was worse in rural areas (63.3 percent) than in urban areas (43.2 percent). These poverty rates are the starting points in the model and are used to simulate the poverty rates in 2008 and beyond. As shown in Figure 1, given a 6.5 percent annual growth in total GDP and 5.7 percent growth in agricultural GDP, the poverty rates fall to 47.9 and 29.4 percent in rural and urban areas, respectively, by 2017. Because the absolute percentage-point decline for the rural group is slightly higher than that for the urban group (12 vs. 11 percentage points, respectively, between 2008 and 2017), the poverty gap between the rural and urban regions becomes smaller (20.1 percentage points in 2008 vs. 18.5 percentage points in 2017).

As discussed in Section 1, the spatial pattern of poverty distribution in Nigeria shows a south-to-north disparity; in 2004, the three southern regions had poverty rates between 26.7 to 43.0 percent, while the northern regions had poverty rates between 67.0 to 72.2 percent. This type of regional gap in poverty will continue through the next years. The base-run model results show that the poverty rates in the three southern regions will fall between 13.4-30.0 percent by 2017, but will remain high between 51.5 to 55.6 percent in the three northern regions (Figure 2).

[6] The poverty rate in 2008 is also a model result obtained using the same formula defined in footnote 5.

Figure 2. Regional poverty rates (%) in the baseline scenario



Source: Nigerian DCGE model results.

4. ACCELERATING AGRICULTURAL GROWTH AND POVERTY REDUCTION

Going Beyond the CAADP Agricultural Growth Target

In the previous section, we describe the results of the base-run scenario and estimate the poverty-reduction impact of a growth path that takes into account both Nigeria's past growth experiences and our present external conditions. In this section, we examine the potential contribution of different agricultural subsectors toward helping Nigeria achieve a much higher overall rate of agricultural growth.

The CAADP initiative has set a 6 percent annual agricultural growth rate as a target for African countries. Considering that recent agricultural growth in Nigeria has been close to this CAADP target, the government has set a higher growth target of 10 percent. To meet the 10 percent target for overall agricultural growth, a set of sector-specific growth targets have been defined for the production of major crops and livestock (FMARD 2008). Most of these subsectoral-level targets specify the sector's output; growth in productivity (or yield) is only mentioned for cassava. Table 3 summarizes the current levels and production targets at the subsectoral level, both obtained from a draft of FMARD (2008).

Given that there is a large yield gap between the current and maximum levels for most crops (Table 4), the potential for agricultural growth in Nigeria is high. However, considering that FMARD (2008) addresses only a relatively short period, the targeted growth seems to be unrealistic for most food crops. According to a report published by ReSAKSS WA (2009), potential yield predictions are often based on growth under the idealized conditions of controlled field trials. Thus, it is unlikely that farmers will be able to achieve such yields at the national level over the short period under consideration. It will also be difficult to realize nationwide adoption of the improved seeds and modern technologies that are needed to reach such high yield potentials. It does not seem that these constraints have been taken into account when the production targets were designed. For example, in FMARD (2008), cassava yield and production are both targeted to double nationwide over a period of four years (2008-11), for annual growth rates of 19.5 percent. When we design a scenario that we call the "CAADP growth scenario," which is based on the targets set in FMARD (2008), we apply such targets to a period from 2009 to 2017, giving farmers a longer timeframe to meet similar targets. For example, in the case of cassava, the annual growth rate becomes about 8.9 percent in our model. The second part of Table 3 gives the modeled growth rates for crop and livestock production, which we set using the government's targets.

FMARD (2008) includes production targets for ten crops, five livestock products, and the fishery sector. To model the accelerated growth in these crops and livestock production subsectors under the CAADP scenario, we assume additional land expansion for some crops (rice, wheat, cocoa, sugar and oil palm), while for the other crops, as well as livestock and fisheries, additional growth is assumed to come only from productivity improvement (e.g., yield increases in the case of crops). While production targets are not available for many of the crops included in the model, a number of these are large subsectors in the agricultural economy (e.g., maize, sorghum, yams, pulses and oilseeds); therefore, the simulation also assumes additional productivity growth for these crops.

Table 3. Production targets at the subsectoral level

	Target defined in NFSP				DCGE model results		
	Current level	**Level by 2011**	**Total increase**	**Annual growth**	**Level by**	**Total increase**	**Annual growth**
	Million mt	Million mt	%	(08-11, %)	2017	(06-17, %)	(09-17, %)
Crops							
Cassava	49.0	100.0	104.1	19.5	96.0	115.0	8.9
Rice	2.8	5.6	100.0	18.9	22.8	142.0	10.3
Millet	4.0	6.5	62.5	12.9	14.1	64.1	5.7
Wheat	0.1	0.5	614.3	63.5	0.5	548.7	23.1
Sugar	0.2	2.2	1034.0	83.5	33.9	1072.5	31.5
Tomatoes	1.1	2.2	100.0	18.9	11.7	99.6	8.0
Cotton	0.4	1.0	185.7	30.0	2.1	172.7	11.8
Cocoa	0.4	0.7	84.2	16.5	0.7	141.4	10.3
Palm oil	0.8	1.3	50.0	10.7	12.6	74.5	6.4
Palm kernels	0.4	0.6	50.0	10.7			
Rubber	0.2	0.3	50.0	10.7	0.6	82.9	6.9
Livestock & fisheries							
Poultry	166.0	249.0	50.0	10.7	182.2	110.1	8.6
Goats	52.0	67.6	30.0	6.8	391.6	81.9	6.9
Sheep	33.0	42.9	30.0	6.8			
Cattle	16.0	20.0	25.0	5.7	257.8	78.5	6.6
Pigs	6.6	8.3	25.0	5.7	28.7	113.3	8.8
Fisheries	0.5	1.5	200.0	31.6	750.8	189.4	12.5
Agricultural GDP				10.0 -15.0			9.5

Sources: FMARD (2008) and Nigerian DCGE model results.

Table 4. Current and potential yields for selected crops

	Current yield (mt/ha)	Potential yield (mt/ha)
Rice	1.9	7.0
Cassava	12.3	28.4
Maize	1.6	4.0
Sorghum	1.1	3.2
Millet	1.1	2.4
Yams	12.3	18.0
Irish Potatoes	7.6	10.5
Soybeans	1.2	2.0
Beniseeds	0.6	1.0
Melons	0.4	0.5
Cocoa	0.2	2.0
Cowpeas	0.5	2.3
Okra	3.1	5.5

Sources: The current yields come from FMARD (2007) and NBS (2005a); the potential yields come from ReSAKSS WA (2009).

Taking maize as an example, data from FMARD (2007) indicates that the current national yield level is around 1.4 metric tons per hectare (mt/ha). Under the base-run scenario, we assume that the average maize yield for the next years will grow at 0.3 percent annually, which is consistent with the yield growth seen in the country during the prior seven years (1999-2006). Given such growth, the maize yield level will unlikely to change over the next years, and growth in maize production will be primarily driven by area expansion. Under the CAADP scenario, we model a slightly more ambitious maize yield improvement, with an annual growth rate of 2.9 percent per year (Table 5). This implies that the national average maize yield will reach 1.8 mt/ha by 2017. This is still below the potential yield of 4.0 mt/ha that has been achieved in certain experimental projects and farm trials using improved technologies and practices (Valencia and Breth 1999). As discussed above, however, the majority of maximum yields are achieved under 'ideal' conditions in agricultural research stations or on-farm trials. These potential yields can only be achieved through access to modern inputs, including the use of improved high-yield seed varieties and new technologies, as well as improved farming practices that differ from the traditional methods that most farmers presently use (ReSAKSS WA 2009). Because maximum yields require better technology, farming knowledge, and market conditions, we deem it unrealistic to assume that such high yields will be realized at the national level in the next years. However, even though we project conservative crop yields in the CAADP scenario, the annual growth rates required to achieve the target yields are already higher than the historical trends (Table 5). Clearly, it will be a daunting task to achieve the government's target yields.

Table 5. Crop yield, area and production and CAADP targets and growth rates (national level)

	Crop yield				Harvested area				Production quantity		
	Initial level mt/ha	Baseline growth %	Target mt/ha	CAADP growth %	Initial level 1000 ha	Share %	Baseline %	CAADP %	Initial level 1000 mt	Baseline %	CAADP %
Cereals											
Rice	1.5	1.1	2.4	5.1	6,214	8.6	4.5	5.0	9,436	5.6	10.3
Wheat	1.1	0.1	1.3	1.8	70	0.1	5.5	20.9	80	5.6	23.1
Maize	1.4	0.3	1.8	2.9	8,984	12.4	6.8	8.2	12,540	7.1	11.3
Sorghum	1.4	0.6	1.7	2.8	8,963	12.4	3.7	2.9	12,208	4.3	5.8
Millet	1.5	0.3	1.9	2.6	5,651	7.8	4.0	3.0	8,584	4.2	5.7
Root crops											
Cassava	13.0	1.1	18.2	3.8	3,428	4.7	4.9	4.9	44,630	6.1	8.9
Yams	8.3	1.2	11.2	3.4	4,206	5.8	5.5	5.8	34,726	6.7	9.4
Cocoyams	0.6	2.5	0.8	3.4	5,027	7.0	4.2	4.7	3,047	6.8	8.2
Potatoes	8.9	5.7	18.8	8.7	226	0.3	2.6	2.7	2,003	8.5	11.6
Sweet	3.4	0.7	4.3	2.7	1,128	1.6	4.4	4.3	3,832	5.2	7.2
Other food crops											
Plantains	6.9	2.0	9.7	3.7	440	0.6	2.5	1.6	3,055	4.5	5.4
Beans	0.5	1.5	0.7	3.4	10,259	14.2	4.0	4.0	5,328	5.6	7.5
Groundnuts	1.2	1.3	1.6	3.6	3,665	5.1	4.3	4.0	4,258	5.7	7.7
Soybeans	0.7	1.2	0.9	3.4	2,739	3.8	4.5	4.9	1,834	5.7	8.5
Other oilseeds	1.8	0.9	2.2	2.1	77	0.1	4.3	4.7	141	5.3	6.9
Vegetables	7.6	1.2	10.0	3.0	770	1.1	4.6	4.9	5,873	5.9	8.0
Fruits	5.2	1.6	6.8	3.2	1,482	2.1	4.5	5.0	7,634	6.2	8.3
High-value crops											
Cocoa	0.3	5.3	0.5	6.5	1,050	1.5	3.0	3.6	277	8.4	10.3
Coffee	0.5	1.7	0.6	3.2	566	0.8	4.6	5.4	267	6.3	8.8
Cotton	0.8	0.4	0.9	1.5	1,016	1.4	5.8	10.0	778	6.2	11.7
Oil palm	1.4	2.5	2.0	4.1	5,167	7.2	1.8	2.2	7,194	4.4	6.4
Sugar	19.2	1.4	30.0	5.1	151	0.2	6.0	25.1	2,893	7.5	31.5
Tobacco	8.7	1.9	11.8	3.4	4	0.0	5.1	6.4	33	7.0	10.1
Nuts	0.8	1.3	1.0	2.7	142	0.2	5.0	5.5	107	6.4	8.4
Cashew nuts	4.2	2.0	5.5	3.1	6	0.0	5.2	5.5	25	7.4	8.8
Rubber	0.6	-0.1	0.6	0.4	500	0.7	6.9	6.6	305	6.8	6.9
Other crops	0.5	1.8	0.7	3.3	252	0.3	6.9	9.3	134	8.8	12.9

Sources: The current yields come from FMARD (2007) and NBS (2005a). The targeted yields, area, and production data are based on a literature review of various Nigerian government documents in which different crop targets are. The growth rates are the results from the model.

In order to assess the contribution of each agricultural product/subsector to the realization of the 10 percent goal for national growth in overall agriculture and the poverty reduction goal of MDG1, we use a series of scenarios in which the growth rates in specific crops or groups of crops/livestock products are simulated individually, while the growth rates in the remaining crops/subsectors maintain their base-run levels. Table 6 summarizes these scenarios, most of which are based on targets that have recently been set by the government for specific commodities and subsectors. For commodities that do not have available target information (e.g., plantains), we use what we believe to be a reasonable growth rate, which is mainly based on the potential market demand driven by household income growth, and is set such that the prices for these commodities will not rise unrealistically.

In each scenario listed in Table 6, additional growth in productivity (or yield) is assumed to occur only in the targeted crop(s) or subsector, while productivity growth for the non-targeted crops or subsectors is assumed to be the same as that in the base-run. For example, in the maize-led growth scenario, additional productivity growth in maize is exogenously assumed such that the level of maize yield will reach the targeted level by 2017. On the other hand, there is no additional productivity growth for any other crop or non-crop subsector, and the productivity growths for all non-maize crops are the same as those in the base-run.

While productivity growth in an agricultural subsector can be assumed exogenously, this does not imply that there is no growth impact on any other subsector for which additional productivity growth is exogenously assumed. Growth in other sectors may occur through the linkage effects captured in the general equilibrium model. These effects include the competition (and hence reallocation) of factors/inputs across subsectors, changes in relative prices, and differential changes in domestic market demand or international trade across sectors that are experiencing increased incomes. Because of the complex general equilibrium linkages, growth in subsectors other than the targeted subsector can be affected positively or negatively. For example, if an increased maize supply can easily find demand in the market (domestically or internationally) and maize prices do not fall significantly, then maize production will compete with other crops for additional resources (land or labor) and intermediate inputs (fertilizer and so on); therefore, the growth rates of some other crops (e.g., sorghum or millet) could be negatively affected. On the other hand, if there are demand constraints in the market (e.g., due to a weak income elasticity of demand, or a lack of export- or import-substitution opportunities), domestic maize prices will fall. In the latter case, even if the maize yield rises, the maize output may increase by less than the yield growth, and resources (land, labor and other inputs) will be released from maize production to potentially increase the production of other crops. These complex linkage effects imply that although yield or production targets can be set individually for a specific crop or subsector on the supply side, target realization will be jointly determined by both the supply and the market demand. Therefore, policies affecting demand (including market development and access) are equally important for meeting CAADP goals in agricultural growth.

We first focus on the overall simulation results for the comprehensive CAADP scenario regarding the economy as a whole. According to the model, if the growth rates set for the individual crops and agricultural subsectors can be achieved in the next years, the Nigerian agricultural GDP will grow at 9.5 percent annually in this period, more than 4 percentage points higher than the base-run growth (Table 1). Through economy-wide effects, additional growth will also occur in nonagricultural subsectors that have close linkages with the agricultural sector. As shown in Table 2, accelerated agricultural growth is mainly driven by productivity under this scenario. Total factor productivity (TFP) in the agricultural sector grows at 5.6 percent annually, instead of the 2.3 percent seen in the baseline. The contribution of TFP to agricultural GDP growth therefore rises to 59.6 percent (from 40.6 percent in the baseline). While rapid productivity growth attracts more capital into the agricultural sector (capital demand in the agricultural sector grows at 7.1 percent annually in this scenario, compared to 6.7 percent in the baseline), labor employment in the agricultural sector is similar (the agricultural labor growth rate slightly falls from 2.2 percent annually in the baseline to 2.1 percent in this scenario). Productivity-led agricultural growth also benefits growth in the nonagricultural sector, as TFP annual growth in the nonagricultural sector rises from 2.5 percent in the baseline to 3.0 percent under the CAADP scenario. The pace of capital accumulation also rises, allowing total capital (and hence capital employed in the nonagricultural sector) to grow more rapidly than we see in the baseline.

Table 6. Model growth scenarios

Growth is led by:	Model name												
	Rice	Wheat	Maize	Millet & sorghum	Grains	Cassava	Roots	Pulses	High-value	Livestock	Fisheries	Forestry	CAADP
	1	2	3	4	5	6	7	8	9	10	11	12	13
Rice	×				×								×
Wheat		×			×								×
Maize			×		×								×
Sorghum				x	×								×
Millet				x	×								×
Cassava						×	×						×
Yams							×						×
Cocoyams							×						×
Potatoes							×						×
Sweet potatoes							×						×
Plantains													×
Beans								×					×
Groundnuts								×					×
Soybeans								×					×
Other oilseeds								×					×
Vegetables, domestic													×
Vegetables, export									×				×
Fruits, domestic													×
Fruits, export									×				×
Cocoa									×				×
Coffee									×				×
Cotton									×				×
Oil palm									×				×
Sugar									×				×
Tobacco									×				×
Nuts									×				×
Cashew nuts									×				×
Rubber									×				×
Other export crops									×				×
Cattle										×			×
Goats & sheep										×			×
Poultry										×			×
Other livestock										×			×
Fisheries											×		×
Forestry												×	×

Sector-level growth is further examined in Table 1, which gives a detailed list of the agricultural subsectors and agriculture-related food processing sectors (beef, goat and sheet meat, poultry meat, eggs, milk, other meats, beverages, other foods), and non-food agriculture-related sectors (textile and wood processing). The economy-wide impact of CAADP growth (both directly and indirectly) increases the annual growth rate of total GDP from 6.5 percent in the base-run to 8.0 percent in the CAADP scenario. More than 75 percent of this GDP growth is the direct outcome of accelerated agricultural growth, while the other 25 percent comes from increases in nonagricultural-sector growth via linkage effects.

Subsectoral-Level Contributions to Accelerated Agricultural Growth

Table 7 reports the contribution of each agricultural subsector toward reaching the 10 percent agricultural GDP growth goal (far right column). For this analysis, we first divide the agricultural subsectors into six groups: cereals, root crops, other food crops, high-value crops, livestock, and other agriculture. Each subsector's contribution to overall agricultural growth is determined by: (i) its size in the economy, as measured by its share of agricultural GDP; (ii) its baseline growth trend; and (iii) its possible additional growth in the future. All of these factors are reported in the table. The first column gives the share of each subsector in total agricultural GDP; these shares are calculated from the new Nigerian SAM developed for this study and represent the situation in 2006. The second column shows the annual growth rates in the base-run, and represents the same baseline information found in Table 1. The third column shows the rates of additional annual growth under the CAADP scenario (i.e., the difference between the baseline and CAADP growth rates in Table 1). In other words, the sum of the values in the second and third columns gives us the average annual growth rate for each sector under the CAADP scenario. The far-right column gives each subsector's contribution to additional growth in overall agricultural GDP under the CAADP scenario; this contribution is roughly equal to the product of the first and third columns normalized by the additional growth in overall agricultural GDP.

The results presented in Table 7 show that accelerated growth in cereal crop production, particularly in rice, contributes most to overall agricultural growth under the CAADP scenario. Cereal crop production as a whole contributes 30.9 percent of accelerated agricultural growth under the CAADP scenario, while rice alone contributes 14.5 percent. This is expected given that cereal crops are the second most important agricultural subsector in the Nigerian economy (after root crops, which accounted for 25.9 percent of initial agricultural GDP in 2006), and have the highest growth targets in FMARD (2008). In terms of the targeted growth rates, in order to reach the targeted level of rice production by 2017, annual growth must increase by almost 10 percent between 2009 and 2017. Among the five cereal crops included in the model, wheat has the highest required growth rate under the CAADP scenario, due to the wheat self-sufficiency target set in FMARD (2008). To meet such an ambitious target, wheat is modeled to grow at 26 percent each year over the next years. However, because this sector holds a relatively small share in total agriculture, its growth contribution is the smallest among the cereals (0.8 percent in total) even given this extremely rapid growth.

Although the root crops represent the largest subsector in agriculture, currently composing 31.6 percent of agricultural GDP, root crops have the second most important contribution to agricultural growth (after cereals). Among the five root crops included in the model, only cassava is subject to a national target in FMARD (2008). We assume modest additional growth in the other four roots and tubers contained within the subsector. However, because their growth is relatively low compared to that in most of the cereal crops, the root crops as a whole only experience 2.9 percent additional annual growth in this scenario, and the subsector contributes 29.1 percent of agricultural growth. Given its large size in the agricultural economy, however, cassava is still the second most important contributor to growth, accounting for 14.1 percent of accelerated agricultural growth. Yams ranks third, with a contribution of 12.2 percent.

Given the diversity in the diets and agricultural food production strategies in Nigeria, many other food crops are important for both food security and poverty reduction. We group them into the "other food crops" group. This group accounts for 25.7 percent of agricultural GDP, making it the third largest subsector after roots and cereals. Consistent with this ranking, the other-food-crops group is the third most important contributor, with 18.4 percent of accelerated growth in agriculture being explained by growth in this subsector.

Table 7. Subsectoral-level contributions to agricultural CAADP growth

	Share in AgGDP (%)	Base growth rate (%)	Additional growth in CAADP (%)	Contribution to AgGDP growth (%)
Cereals	25.9	5.4	4.1	30.9
Rice	8.9	5.1	5.2	14.5
Wheat	0.1	5.0	20.9	0.8
Maize	7.3	7.3	4.7	10.8
Sorghum	5.4	4.0	1.7	2.8
Millet	4.2	4.2	1.5	2.0
Root crops	31.6	6.0	2.9	29.1
Cassava	14.7	5.6	3.1	14.1
Yams	13.2	6.4	2.9	12.2
Cocoyams	0.7	4.7	1.3	0.3
Potatoes	1.0	8.8	3.6	1.1
Sweet	1.9	4.7	2.2	1.4
Other food crops	25.7	5.7	2.4	18.4
Plantains	2.1	3.8	1.2	0.8
Beans	3.4	5.3	2.3	2.5
Groundnuts	3.6	5.5	2.2	2.5
Soybeans	3.8	5.7	2.9	3.4
Other oilseeds	0.4	4.5	1.8	0.2
Vegetables	6.2	6.1	2.5	4.9
Fruits	5.5	6.4	2.4	4.1
High-value crops	4.9	5.6	12.0	10.9
Cocoa	0.3	3.9	0.9	0.1
Coffee	0.5	6.1	2.7	0.5
Cotton	0.3	5.2	6.0	0.5
Oil palm	1.5	3.8	1.9	0.9
Sugar	1.02	7.3	25.8	8.3
Tobacco	0.49	6.8	3.2	0.5
Nuts	0.1	5.7	2.2	0.1
Cashew nuts	0.01	5.7	1.9	0.0
Rubber	0.5	6.1	0.0	0.0
Other export	0.1	8.5	4.4	0.1
Livestock	6.5	5.4	1.4	2.8
Cattle	2.1	5.5	0.6	0.4
Goats &	3.1	5.1	1.4	1.3
Poultry	1.2	5.9	2.8	1.1
Other	0.2	6.1	0.9	0.0
Other agriculture	5.3	5.8	5.1	7.9
Forestry	1.8	4.2	1.5	0.9
Fisheries	3.5	6.5	6.4	7.0

Sources: Nigerian SAM and DCGE model results.

Ten high-value crops are included in the model: cocoa, coffee, cotton, oil palm, sugar, tobacco, nuts, cashew nuts, rubber, and other export crops. Most of these crops are export-oriented; either they are currently important export crops or they have historically been important export crops. The ten crops together account for 4.9 percent of agricultural GDP, making this the smallest agricultural subsector in the economy. High growth is assumed for these crops, driven by the extremely high growth in sugar required to meet the target set in FMARD (2008). As a group, the additional annual growth rate under the CAADP scenario is 12 percent, increasing from a base-run level of 5.6 percent to 17.6 percent under the CAADP scenario. However, given the relatively small share of these crops in the country's agricultural economy, their contribution to accelerated agricultural growth (10.9 percent), which primarily comes from a greater than 30 percent annual growth in sugar production, is less important than the contributions of the food crop subsectors.

Currently, primary livestock production accounts for 6.5 percent of agricultural GDP. Targets for most livestock products are set in FMARD (2008). Consistent with these targets, we model a rapid growth in poultry production, which rises from 5.9 percent per year in the base-run to 8.7 percent under the CAADP scenario. However, the targets set for cattle and goat/sheep products are quite modest, yielding annual growth rates of 6.1 and 6.5 percent, respectively. Because of the modest growth in most non-poultry livestock products, livestock in total contributes only 2.8 percent of agricultural growth.

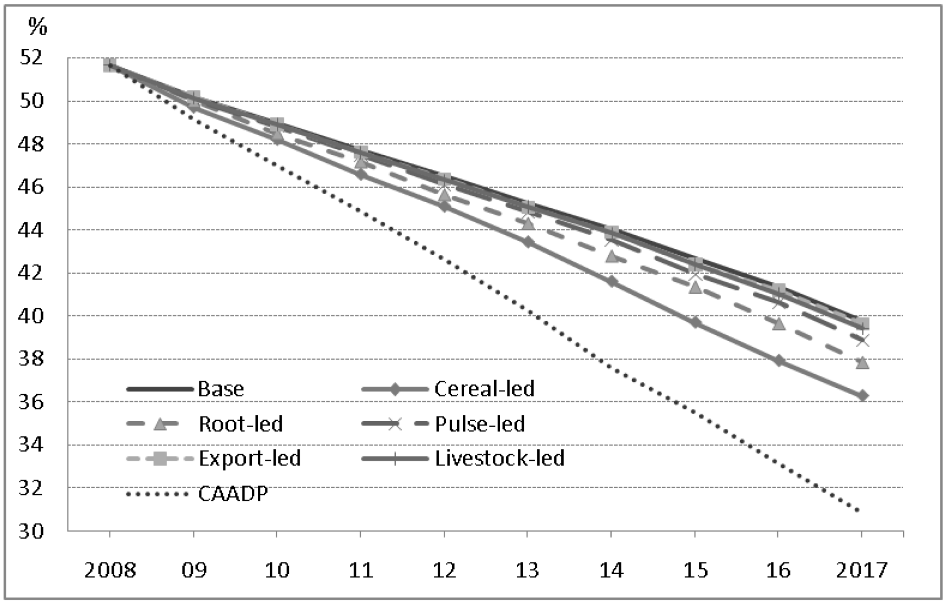
As FMARD (2008) gives fisheries a high output target, our CAADP scenario models a rapid growth in fisheries, at 12.9 percent annually. Fisheries currently account for 3.5 percent of agricultural GDP; given such growth, this subsector contributes 7 percent of the accelerated agricultural growth seen in the simulation. Forestry is the smallest subsector broadly defined within agriculture. Given modest growth, this subsector contributes less than 1 percent of total agricultural growth under the CAADP scenario.

Accelerated Agricultural Growth and Poverty Reduction

The joint effect of the 9.5 percent annual agricultural growth modeled in the CAADP scenario and the spillover effects into nonagriculture cause poverty to decline by 20.8 percentage points by 2017, putting the poverty rate 8.9 percentage points lower than that in the base-run. As shown in Figure 3, the proportion of Nigeria's population living below the poverty line will fall to 30.8 percent by 2017 in this scenario, compared with the baseline scenario's 39.7 percent. Greater poverty reduction occurs in rural areas; the rural poverty rate declines by 23.3 percentage points from 2008 to 2017, to a level that is more than 10.6 percentage points lower than that obtained in the base-run. In urban areas, the poverty rate declines by 17.7 percentage points between 2008 and 2017, to a level that is 6.8 percentage points lower than that obtained in the base-run. If the 1996 national poverty rate of 65.6 percent is chosen as the rate targeted by MDG1, our results show that this poverty rate will be halved by 2017. Indeed, it will be reduced to 35.5 percent in 2015, and to 30.8 percent by 2017. The rural poverty rate was 69.8 percent in 1996. Although poverty reduction has a higher rate in rural versus urban areas, the rural poverty rate under the CAADP scenario will still be as high as 37.3 percent by 2017, and therefore will not reach MDG1. On the other hand, the poverty rate in urban areas will fall to 26.2 percent in 2015 and 22.6 percent by 2017, declining more than 50 percent from its 1996 level. Thus, although high agricultural growth will reduce the poverty gap between rural and urban areas from 20.1 percentage points in 2004 to 14.7 percentage points by 2017, the country must seek to reduce rural poverty more rapidly over the next years.

Achieving the high growth target in agriculture will lift an additional 16.5 million people above the poverty line by 2017, reversing the base-run's trend of an increasing number of poor. Even with an annual population growth of 3.0 percent, the absolute number of poor will fall to 59.7 million by 2017, as compared to the current level of 77 million and the base-run's 2017 projected level of 78.7 million. Food security will also improve, with an additional 140 kg of cereals and 300 kg of root products available per year for each Nigerian citizen by 2017, compared with their current per capita levels.[7] Furthermore, although Nigeria will continue to import some cereal products (e.g., wheat and rice), the ratio of imports in domestic consumption will be substantially lower under the CAADP scenario compared to the base-run.

Figure 3. National poverty rates (%) under alternative agricultural growth scenarios



Source: Nigerian DCGE model results.

Faster agricultural growth benefits the majority of households, but not all households will benefit equally from achieving the crop and livestock growth targets set under the CAADP scenario. For this reason, we also investigate the poverty impacts at the zonal level for the six regions. The results are reported in Table 8; the first two columns show the poverty rates in 1996 and 2004 (drawn from NLSS for these two years), while the third and forth columns report the 2017 poverty rates projected under the base-run and CAADP growth scenarios. To facilitate comparison across regions, the last four columns report the reduction in poverty rates as percentage points and percent-change due to accelerated agricultural growth under the CAADP scenario, both compared with the 1996 and base-run 2017 values. We also include the national poverty rates for the country as a whole and for the rural and urban areas separately in the first part of the table (rows 1-3). As seen in Table 8 and discussed above, there is significant spatial disparity in the distribution of poverty across Nigeria. Although this regional disparity was less significant in 1996, NLSS (2003/04) indicates that the three northern regions had higher poverty rates than the three southern regions during the latter census (Table 8, second and third columns). The regional disparity in poverty distribution does not change under the base-run and CAADP growth scenarios. For example, the highest regional poverty rate in 2004 was found in the Northeast region (72.2 percent). This situation is projected to continue until 2017 in both the base-run and CAADP growth scenarios. The spatial poverty gap, which represents the difference between the highest regional poverty rate (that in the Northeast) and the lowest poverty rate (that in the Southeast) was 45.5 percentage points in 2004. By 2017, the poverty gap is smaller in both the base-run and CAADP scenarios, but remains high at 43.8 and 35.2 percentage points, respectively. It is reasonable to believe that accelerated and high agricultural growth in the southern regions will allow them to achieve MDG1 of halving the 1996 poverty rate by 2015. However,

[7] These figures represent measurements of both direct consumption and primary products used as inputs into food processing and livestock production.

MDG1 is far from being achieved in the three northern regions, where the 2017 poverty rate will still be as high as 42.2 to 43.7 percent.

Table 8. Regional-level poverty reduction under the CAADP scenario

			Simulation results by 2017 (%)		Additional reduction (percentage points)		% Change	
	1996	2004	Base-run	CAADP growth	from 1996	from base 2017	from 1996	from base 2017
National	65.6	54.4	39.7	30.8	-34.8	-8.9	-53.0	-22.4
Rural	69.8	63.3	47.9	37.3	-32.5	-10.6	-46.6	-22.1
Urban	58.2	43.2	29.4	22.6	-35.6	-6.8	-61.1	-23.1
Southsouth	58.2	35.1	21.5	14.0	-44.2	-7.4	-75.9	-34.6
Southeast	53.5	26.7	13.4	8.5	-45.0	-4.9	-84.1	-36.5
Southwest	60.9	43.0	30.0	24.7	-36.2	-5.3	-59.4	-17.6
North central	64.7	67.0	51.5	41.9	-22.8	-9.6	-35.2	-18.7
Northeast	70.1	72.2	55.6	42.2	-27.9	-13.4	-39.8	-24.1
Northwest	77.2	71.2	55.4	43.7	-33.5	-11.7	-43.4	-21.1

Source: Nigerian DCGE model results.

Notably, due to the absence of growth targets at the state or regional level under the CAADP development framework, we have to assume a uniform target for each individual crop or livestock product across the six regions. Obviously, the initial conditions and growth potentials are very different between the north and south. Analysis of the NLSS (2003/04) data shows that the initial production conditions (e.g., access to fertilizer and other growth opportunities) are much worse in the north than in the south.[8] If special attention is not paid to the northern regions in terms of public investment, modern input access, and other input/output market developments, the growth opportunities in Nigeria may further be biased towards the south. Unless such efforts are prioritized by the government, poverty reduction goals will be more difficult to achieve in the north, where the current poverty rate is already higher than in other parts of the country.

Growth Multipliers and Contributions of Subsectoral growth to Poverty Reduction

The previous section highlights the potential contributions of different crops and subsectors toward increasing agricultural growth and poverty reduction. However, in order for the country to design pro-poor growth strategies, we must understand the magnitude of poverty reductions led by the growth of specific sectors in the economy. In this subsection, we further analyze these linkages by calculating poverty-growth elasticities that focus on the pro-poorness of growth, and growth multipliers that allow comparison of the spillover effects of growth in various subsectors. These elasticities and multipliers are endogenous outcomes from our model results. The poverty-growth elasticity is affected by household-level growth, since growth affects individual households differently due to heterogeneities among income sources and consumption patterns. Due to data constraints, we cannot capture differential income structures at the individual household level, nor can we analyze the poverty impacts of such income structures under different growth options. Moreover, the DCGE model groups the households into 12 representative household groups defined by six zones and rural/urban location, and changes in either incomes or consumption occur endogenously only among these 12 household groups. In the absence of

[8] This problem is addressed further in Section 6.

further household disaggregation by other social and economic indicators (e.g., by source of income, type of farm, gender of household head, and so on), the model is unable to take into account many household characteristics that are important to explaining growth and poverty relationships. Keeping these caveats in mind, the poverty-growth elasticities described herein should be seen as a first effort to link growth at the agricultural-subsectoral level with poverty reduction at the national and regional levels within an economy-wide framework.

As briefly mentioned above, the poverty-growth elasticity measures the responsiveness of the poverty rate to changes in per capita GDP growth. More specifically, the elasticity measures the percentage change in the poverty rate caused by a 1 percent increase in GDP per capita. The second column of Table 9 shows the poverty-growth elasticities calculated under the different growth scenarios. For example, the value of -0.928 in the first column indicates that for a 1 percent increase in annual per capita GDP growth led by growth in rice production, the national poverty rate falls by 0.928 percent (not percentage points) per year.

Table 9. Poverty-growth elasticities and growth multipliers

		Growth multipliers	
	Poverty-growth elasticity (Change in poverty rate/ change in GDPpc per year)	Increased GDP/ increased sector output	Increased AgGDP/ increased sector output
Baseline	-0.851		
Growth is:			
Rice-led	-0.928	1.033	1.036
Wheat-led	-0.853	1.013	1.037
Maize-led	-0.914	1.282	1.146
Millet/sorghum-led	-0.915	3.642	2.786
Cereal-led	-1.024	1.305	1.184
Cassava-led	-0.893	1.286	1.120
Root-led	-0.923	1.246	1.088
Pulse-led	-0.892	1.857	1.518
Export-led	-0.814	0.700	0.974
Livestock-led	-0.858		
Fishery-led	-0.896	1.084	1.027
Forestry-led	-0.861		
CAADP	-1.144		
Nonagr-led	-0.730	1.012	

Source: Calculated from the Nigerian DCGE model results.
Notes: The growth multiplier is measured as the number of units of increased real GDP or AgGDP occurring due to a one-unit increase in the output (measured as real terms of value-added) of a specific agricultural subsector.
'Nonagr' refers to nonagricultural.

As seen in the first column, the values of the poverty-reduction elasticities from growth led by different agricultural subsectors are all greater than the base-run elasticity of -0.851, with the exception of growth led by export crops. This confirms that growth in agriculture, particularly in staples, is indeed pro-poor. Comparison of growth led by different agricultural subsectors shows that economy-wide growth driven by growth in cereals is more effective at reducing poverty than growth in the other crop and livestock subsectors. For example, a 1 percent increase in GDP per capita led by increases in cereal production causes the national poverty rate to decline by an additional 1.024 percent from its base-run level. The second highest poverty reduction elasticity is that for root-crop-led growth, which has an elasticity of -0.923 percent.

Notably, the model results show that the poverty-growth elasticities significantly increase under the CAADP scenario, rising to -1.144 percent. This indicates that there is a strong synergy effect in poverty reduction across growth in different agricultural subsectors. For comparison purposes, we also report the poverty-reduction-growth elasticities for overall growth led by growth in the nonagricultural sector (Table 9, bottom). This elasticity is much lower at -0.73 percent. Our results therefore indicate that for the same level of economic growth measured by total GDP, the poverty reduction effect can be 57 percent higher if such growth is led by the agricultural versus nonagricultural sector. This finding has a strong implication for the future design of Nigeria's development strategy and the allocation of public funding to finance its implementation. If public investment requirements are proportional to GDP growth and do not vary by sector, then a nonagriculture-led growth strategy allowing the country to meet with MDG1 would be around 50-60 percent more expensive than an agriculture-led growth strategy. In other words, nonagricultural spending would have to be 50-60 percent more effective than agricultural spending for the two strategies to have equivalent financing requirements. However, there is no evidence suggesting that nonagricultural spending is more effective than agricultural spending. Indeed, the opposite seems to be true: Public agricultural spending seems to be much more effective at achieving growth, as well as being more pro-poor. The public spending required to support an effective agriculture-led development strategy is analyzed further in the next section of this paper.

The growth multiplier is the other important indicator we use to measure the differential contribution of subsectoral-level agricultural growth to economy-wide growth. We omit the multiplier results for livestock and forestry-led growth because the scenarios assume that there is additional productivity growth in the relevant processing sectors. For example, the livestock-led growth scenario includes additional productivity growth in meat and milk processing, while the forestry-led growth scenario considers wood processing growth. Because these scenarios assume additional productivity growth in the relevant nonagricultural subsectors, it is difficult to compare their growth with those led by the crop subsectors and fisheries.

Among the three crop groups, the highest growth multiplier is seen for pulse-led growth. This is true for multipliers measured by gains in both total GDP and agricultural GDP. The results indicate that a one-unit (not percentage, meaning that we can read it as 1 million Naira) increase in pulse production (in terms of real value-added) results in a gain of 1.857 units (1.857 million Naira) for the overall economy, or 1.518 units for agricultural GDP, measured in real terms (Table 9). In addition to the increased pulse output, an additional 0.518 million Naira of agricultural GDP and 0.340 million Naira of nonagricultural GDP are generated through growth in pulse production. Such a high multiplier indicates that there are strong linkages between pulse production and other economic activities. In the root crop group, cassava also has a high growth multiplier; a 1 million Naira increase in cassava production adds 1.246 million Naira to GDP and 1.088 million Naira to agricultural GDP.

At the individual-crop level, millet and sorghum have the strongest multiplier effects. A 1 million Naira increase in the output (value-added) of millet and sorghum generates an additional 1.79 million Naira in agricultural GDP and 0.85 million Naira in nonagricultural GDP, all in the real terms. The linkages on the supply side come from increased demand in intermediate inputs (backward linkages), the provision of more low-cost inputs to other agricultural/food processing subsectors (forward linkages), and the release of resources (e.g., land and labor) for the production of other crops (factor mobility linkages). In a large developing economy such as that of Nigeria, strong demand-side linkages come through increased demand for other agricultural and nonagricultural commodities; this occurs due to the increases in farmers' incomes that come from additional growth in the production of some agricultural subsectors. However, millet and sorghum have the highest growth multipliers due to factor mobility linkage effects. Millet and sorghum are income-inelastic commodities, meaning that households at higher income levels spend less of their incomes to consume additional millet and sorghum, instead preferring to allocate more income to the consumption of other foods (e.g., rice, wheat or livestock products). Growth in the supply of millet and sorghum due to increased productivity is not necessarily the same as yield growth, as less land and labor are needed to produce these crops when their yields increase. When fewer resources are used to produce millet and sorghum without lowering their supply levels, i.e., when some of the land and labor used for millet and sorghum production can be reallocated to the production of other crops (e.g., rice, maize and wheat), a strong growth multiplier is seen. Thus, the model results seem to indicate that too many resources (primarily land) are allocated to the production of millet and sorghum when the productivities of these two crops are low. However, when these two crops become more productive, many other agricultural subsectors and the economy as whole benefit through the strong multiplier effects of these two crops.

As noted above, the value of the growth multiplier measured by gains in GDP for export crop-led growth is less than 1. As shown in Table 9, the increases in GDP and agricultural GDP are 0.700 and 0.974 units, respectively, with a unit of increase in export crop production. A growth multiplier < 1 indicates that, at the given level of resources, growth in other sectors is negatively affected by growth in the targeted subsector (in this case, export crops).[9] This is because domestic prices for export-oriented commodities are mainly determined by the international market. Given this price advantage, export-oriented sectors will compete with other sectors for resources (land, labor, capital, and other inputs). At a given resource level, competition will affect factor prices, making it difficult for many other sectors to increase their production levels. Similarly, as fewer resources are allocated, production falls in other sectors. This finding has important policy implications: Although the development of export-oriented agricultural production is often a governmental priority, our results indicate that this growth will have weak linkages with the domestic economy in the absence of additional resources (land and labor), or if export-oriented production cannot create domestic demand for such products (either through the development of agro-processing or through consumer demand). In addition, focusing on export-oriented crops may also negatively affect growth outside export-oriented production, decreasing the economy-wide gains from such a strategy.

Price Effects of Accelerated Agricultural Growth

Even if productivity-led agricultural growth benefits a majority of households in both rural and urban areas, the negative price effects due to such growth can hurt some farmers. For those farmers who are unable to adopt high-yield technologies, still use traditional farming practices, and still produce the same amount of product, lowered output prices due to increased production from more productive farmers will cause revenues to fall. On the other hand, for those farmers who have adopted the high-yield technology but are facing increased input prices (e.g., higher fertilizer prices), lowered output prices together with higher input prices might decrease profits despite the use of modern technology. Thus, it is necessary to assess the possible price effects from accelerated agricultural growth under the CAADP scenario.

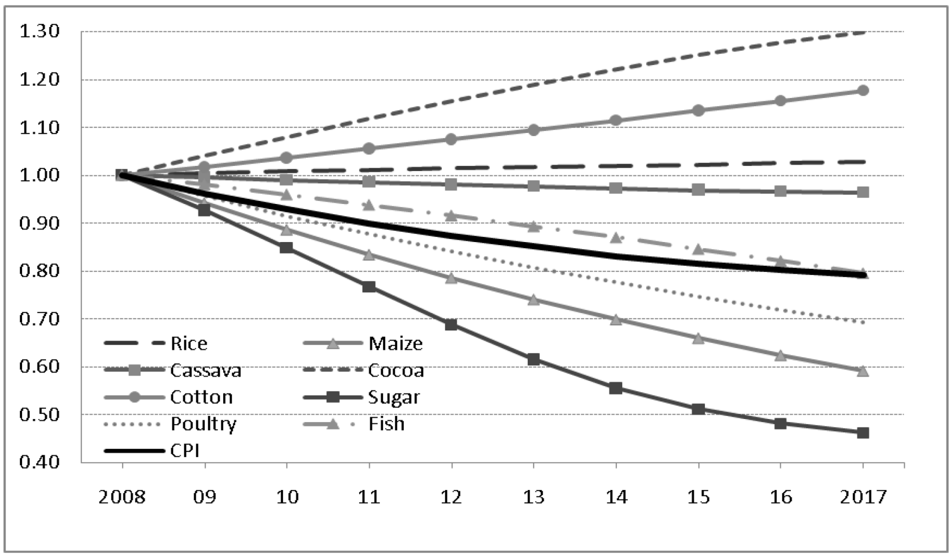
Figure 4 shows the price trends for selected agricultural products under the CAADP scenario. When agricultural production increases, most of the increased product enters domestic markets and the consumer price index (CPI) falls over time. As shown in the figure, the model results indicate that CPI is about 20 percent lower in 2017 than in 2008. In the same figure, the prices for individual agricultural commodities are normalized by CPI, which gives us a change in each individual commodity's price relative to CPI, and represents the overall price level. For example, if the figure shows an up-sloping (down-sloping) trend for a specific commodity (e.g. rice or maize), this means that the real price for rice or maize rises (falls) relative to CPI. In most cases, the price change is highly related to the magnitude of production growth for the given product. Maize, sugar, poultry and fish have annual growth rates between 9 and 32 percent, and the prices for these products fall the most. In contrast, the price for rice, an import-substitutable crop with an annual growth rate of 10.3 percent in the CAADP simulation, actually rises over time relative to CPI. Similarly, the prices (relative to CPI) increase for the export crops (cocoa and cotton), which also have annual growth rates higher than 10 percent in the simulation.

The price trends are further affected by the market demand for different commodities. If a commodity has a high income elasticity, can be substituted by imports, or can be increasingly exported,

[9] In this study, we assume the same amount of additional labor and land is available under all scenarios. In other words, we compare growth multipliers from growth led by different agricultural subsectors, but assume similar amounts of land and labor supply across all of the scenarios. This estimated growth multiplier is much smaller than it would be in the absence of resource and labor constraints.

its price will not be as strongly affected by increased supply. The high income elasticity implies that a consumer experiencing increased income due to growth (in both agricultural and nonagricultural activities) will prefer to allocate more of that income to the consumption of such commodities. The income elasticity for primary agricultural goods is relatively high only in countries with average per capita incomes that are just barely sufficient to meet basic needs. However, in the case of Nigeria, where the average per capita income is higher than $1,000, most primary agricultural products are unlikely to have high income elasticities. Although the income elasticities for foods typically consumed by the poor in rural and urban areas are higher than those for the country as whole, such elasticities are unlikely to become the driving force in determining market demand given the country's current income distribution.

Figure 4. Levels of selected agricultural prices in the CAADP scenario



Source: Nigerian DCGE model results.
Note: Normalized by prices in 2008 and deflated by CPI.

In addition to import substitution (such as seen in the cases of rice and wheat), other agricultural market opportunities exist in the potential development of agro-processing industries and expansion of the export market. While Nigeria has the largest agro-processing industry in West Africa, the addition of specific processes could open up new and promising export opportunities for many staple commodities in both regional and global markets. One example of this is cassava, which accounts for the largest land allocation and highest agricultural value-addition in the country. Cassava chips and flours are excellent inputs for both the feed and agro-processing sectors, and are also in high demand within the international markets. Thailand accounts for 10 percent of world cassava production, exports 80 percent of its cassava products, and currently occupies 70–80 percent of the world cassava market with around 22 million tons of cassava traded annually (mostly as chips and flour). In Nigeria, cassava is presently produced primarily for domestic food consumption. It is therefore reasonable to hypothesize that with the adoption of high yield varieties, more cost-effective processing technologies, and improved market access conditions, Nigeria could successfully export cassava to the rest of the world. Under such a scenario, Nigeria could become a dominant cassava exporter in the world, and both the growth multiplier and poverty-reduction elasticity of cassava-led growth would increase further.

Another example of agro-processing and export opportunities is seen in the poultry sector. Our model results show that poultry prices will fall significantly if high growth in poultry is targeted. Notably, however, current domestic poultry prices are not competitive; without border protection in imports, the domestic poultry price would not be as high as its current level. The model results indicate that Nigeria must improve the productivity of the poultry sector if the country hopes to get rid of its import restrictions and begin exporting poultry to neighboring countries in West Africa. The development of a modern poultry industry would provide not only great export opportunities in poultry products, it would also create more domestic demand for maize and other crops (as poultry feed), further enhancing the linkages and multiplier effects across the entire economy. An example of such a move toward becoming a large poultry exporter was seen in Thailand beginning in the late 1980s. The rapid growth in Thai poultry exports has created a large market for maize. Similar to the situation seen in Nigeria today, feed demand in Thailand prior to the shift accounted for only a small portion of maize production (3-7 percent). Today, following the development of the poultry industry, feed demand in Thailand accounts for 70-80 percent of maize production (a ten-fold increase over two decades). It is therefore reasonable to believe that development of the poultry sector in Nigeria would grow maize production, making it not only an important staple commodity for human consumption but an important cash crop for many smallholder farmers.

Messages Drawn from Section 4

Based on the analysis presented in this section, we believe that the following messages will be helpful in designing an agricultural strategy for Nigeria:

1. As a necessary first step toward creating an agricultural development strategy, growth targets set at the agricultural-subsectoral level should realistically take into account both the initial conditions and the growth potential of the subsector. Agricultural potential is an important condition, but it is not sufficient for target determination. In addition, growth targets should not be productivity driven, especially since increasing agricultural production through land expansion will be a costly proposition that is not likely to be sustainable.
2. The study shows that the following factors should be considered when prioritizing agricultural growth at the subsectoral level: (i) the size of an individual subsector in the current agricultural economy (share in agricultural GDP); (ii) the growth-multiplier effect of the subsector through its linkages with the rest of the economy; (iii) the poverty-reduction-growth-elasticity effect through growth led by that particular subsector; and (iv) the market opportunities and price effects that a subsector's growth could have. Based on these four factors, Table 10 summarizes the findings presented in this section. The discussion of Table 10 is as follows:
    a. While a very high growth goal can be set for a small subsector, the economy-wide impact of this subsector's growth will often be small. Growth in a relatively large subsector generally creates more growth for the economy as a whole. Our model analysis shows that even double-digit growth in a small subsector (e.g., wheat or sugar) may have little or no growth contribution to overall agriculture or the economy. On the other hand, a large agricultural subsector (e.g., rice or cassava) can create a large degree of economy-wide growth if it becomes the leading force in the growth process.
    b. When setting priorities, policy makers should consider the growth-multiplier effect among different agricultural subsectors. A subsector with strong linkages with the rest of the economy can generate more economy-wide gains than a subsector with weak linkages to the economy. A subsector that can stimulate domestic demand either through agro-processing or by generating income for a majority of farmers (e.g., cassava or poultry) often has a stronger multiplier effect on overall growth than a subsector that is only exported as primary materials.
    c. A negative price effect is often an indicator of market opportunities, and market constraints captured by price effects must be taken into account when designing an agricultural strategy. Growth is determined not only by productivity in the production processes of a targeted agricultural subsector, it is also constrained by market

opportunities. Often, both domestic and export (or import substitution) market opportunities are interrelated with the development of agro-processing industries, trade policies in both domestic and international markets, and the market-access conditions faced by the producers. Thus, agricultural growth should be supported by pro-agriculture investments and interventions outside of agriculture. This is a key for the successful implementation of an agricultural strategy.

d. The pro-poorness of an agricultural subsector's growth should be the top agenda when designing an agricultural strategy. Although agricultural growth is generally pro-poor, different types of agricultural growth can lift varying numbers of people out of poverty (in total and in different locations), depending on the country's poverty distribution across regions and households**.** Carefully assessing the linkages between subsectoral-level agricultural growth and poverty reduction at both the national and regional (state) levels and then taking advantage of such linkages are important steps for policy makers to take when seeking to ensure that agricultural growth is pro-poor.

3. Given Nigeria's size and constitutional structure, the country's agricultural performance is not simply dependent on strategies set by the federal government: The state governments are equally important players in determining the direction of agricultural development. Constrained by a lack of information on state-level policies and other economic data, we herein discuss only agricultural growth options for the country as a whole. While additional studies should be conducted at the state level, some of our results on priority setting for a national-level agricultural strategy may also be useful at the state level. Moreover, the inter-linkages between strategies at the state and federal levels are important aspects of strategic analysis for agricultural development.

Table 10. Summary of factors affecting priority setting in an agricultural strategy

	Size in the economy		Growth multiplier		Pro-poorness		Negative price effect		Opportunities
	Qualitative assessment	Ranking	Qualitative assessment	Ranking	Qualitative assessment	Ranking	Qualitative assessment	Ranking	
Growth led by:									
Cereals	Large	2	Large	3	Large	1			
Rice	Large	4	Large	8	Large	2	Small	7	Import substitutable
Maize	Large	7	Large	5	Large	5	Large	2	Feed-industry development
Millet/sorghum	Large	5	Large	1	Large	3	Small	6	Food processing
Wheat	Small	13	Small	9	Large	11	Large	1	Import substitutable
Roots	Large	1	Large	6	Large	3			
Cassava	Large	3	Large	4	Large	7	Small	5	Exports through processing
Pulses	Large	6	Large	2	Large	8			Domestic processing and exports
Export-oriented crops	Small	9	Small	10	Small	12	Small	9	Scale-up the size
Livestock	Small	8	Not measured		Large	9			
Poultry	Small	12	Not measured		Not measured		Large	3	Competitiveness and exports
Fishery	Large	10	Large	7	Large	6	Large	4	Food processing
Forestry	Small	11	Not measured		Large	10	Small	8	Wood processing

Source: Summarized from Nigerian DCGE model results for the CAADP growth scenario.

5. PUBLIC SPENDING IN AGRICULTURE TO MEET ACCELERATED GROWTH AND POVERTY TARGETS[10]

It is well known that the absence of developed local institutions and the underdeveloped state of many markets in developing countries necessitates government involvement in agricultural investment (Hoff, Braverman and Stiglitz 1993; Westlake 1994). Accordingly, based on the DCGE model results, we next estimate the public investments in agriculture that will be required over the next years (2009-17) to support the accelerated agricultural growth and poverty reduction modeled herein. The section is organized as follows: In Subsection 5.1, we first briefly describe the composition and trends of total revenue in Nigeria, and then review the patterns of government spending at the national and subnational government levels. In Subsection 5.2, we turn to a detailed examination of the level and growth of agricultural spending, and then compare agricultural spending to total spending and agricultural GDP, which may provide information on the magnitude of government resource allocation to the agricultural sector. In Subsection 5.3, we present our conceptual framework, data sources, scenarios, and estimation results for required agricultural spending.

Trends and Magnitudes of Aggregate Revenues and Expenditures

Fiscal decentralization and government accountability in Nigeria[11]

Nigeria has a federal system of government in which three tiers of government coexist. In this multi-level system, the authority and responsibility for agricultural investment or spending are vested in all three levels of government. The evolution of the fiscal relationships among the different levels of the Nigerian government was influenced by principles of fiscal federalism, oil revenues, and the centripetal forces of military governments. Following constitutional conferences in 1953 and 1954, Nigeria adopted a federal constitution that included fiscal federalism for revenue sharing, and expenditure assignments between the federal government and the three regional (state) governments. After the country gained independence in 1960, this principle was modified in the interest of national unity. Beginning in 1966, under successive military regimes, the government became increasingly centralized, and the regional allocations of revenues and expenditure responsibilities were engineered at the discretion of the central (military) government. Moreover, during this period, the distribution of national resources was extremely wasteful and inefficient (Bach 1989). From 1960-76, Nigeria was further subdivided from three to 19 states. In 1976, the local governments were recognized as the third tier of government, and were defined as being entitled to statutory allocations from both the federal and state governments. During the following periods of military rule, the number of states almost doubled and the number of local governments also grew significantly.

Currently, the subnational governments of Nigeria include 36 states and the Federal Capital Territory (FCT) at the second tier, and 774 local governments at the third level of government. The existing division of revenue-generating powers and expenditure responsibilities across the three tiers of government in Nigeria is based on the principles of diversity, equivalence, centralized stabilization, the correction of spillover effects, fiscal equalization, and derivation (Ekpo 2004). The current assignment of expenditure responsibilities and functions is based on the second and fourth schedules of the 1999 constitution. Part I of the second schedule includes a list of expenditures for which the federal government is solely responsible, as well as those for which both the federal and state governments share responsibility. The fourth schedule lists the responsibilities of the local governments. Based on the guidelines of the constitution, various legal and policy documents define the specific policy and

[10] This section was written by Vida Alpuerto, Xinshen Diao, and Sheu Salau.

[11] This discussion of the political and economic contexts of decentralization is based on Ekpo (1994; 2004), Eboh, Amakom and Oduh (2006), and Odularu (2008). It was written by Kamiljon Akramov.

expenditure responsibilities of the different tiers of government. Below, we discuss the specific policy and expenditure responsibilities of the government tiers as they pertain to the agricultural sector.

The Nigerian constitution establishes that the vast majority of federally raised revenues must flow to the Federation Account, whereupon a formula is used to allocate the funds among the federal, state and local governments. There are two types of revenue allocation in Nigeria: vertical allocation, which is the sharing of revenue among the three tiers of government; and horizontal allocation, which is the allocation of revenue between state governments and among local governments within states. According to the current vertical allocation formula, 55 percent of total revenue is allocated to the federal governments, 25 percent to the state governments, and 21 percent to the local government authorities. The horizontal allocation of the respective funds across the subnational governments is based on a special formula that includes five components: equality (40 percent); need, as defined by the population size (30 percent); land area (10 percent); social development factors (10 percent); and internal revenue-generating efforts (10 percent).

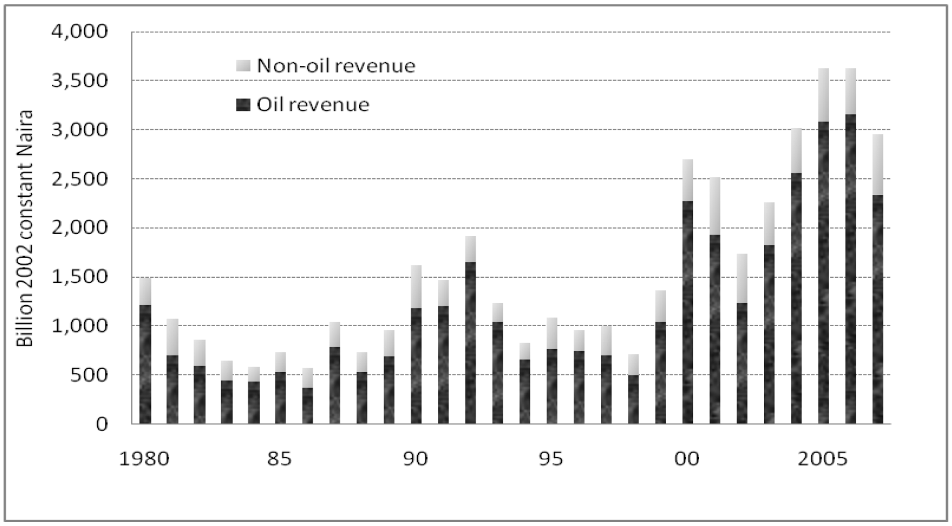
The major concern regarding Nigeria's fiscal federalism is the existence of vertical fiscal imbalance, i.e., a mismatch between the revenue bases and the expenditure needs of the state and local governments. As in many developing countries, the subnational governments in Nigeria have very limited internal revenue bases and have a low potential for cost recovery because they serve largely poor populations. Thus, the subnational governments have limited revenue-generating powers. On the one hand, federally collected revenues usually amount to more than 90 percent of total government revenues, and most states' internal revenues are less than 10 percent of their total revenues. On the other hand, expenditures by state and local governments account for more than 45 percent of total government expenditures. Hence, subnational expenditures are largely financed out of federal transfers. For example, in 2006, federal transfers accounted for 64 percent of the total state revenues. The reliance of local governments on federal transfers is even heavier; in 2006, an overwhelming 83 percent of local government revenues came from the Federation Account.

This heavy dependence on federal transfers creates conditions that may favor a lack of accountability, as subnational governments may attempt to shift the responsibility for service delivery and the blame for failures onto the federal government, which controls the bulk of the government revenues. Furthermore, the local population may not hold the state and local governments accountable because they see them as not having the financial means to deliver services and/or are unaware of the federally allocated resources that are allocated. In this regard, it is important that the federal allocations to state and local governments have a high degree of transparency. In January 2004, the Nigerian Federal Ministry of Finance established a policy that sought to improve transparency at all levels of government, especially the state and local levels. According to this policy, the government was to use major national newspapers and the Federal Ministry of Finance website to publish monthly information regarding allocations from the Federation Account to the federal, state and local governments. State representatives later blocked the funding for the publication of this information in national newspapers, meaning that federal allocations are currently available only on the Federal Ministry of Finance website (World Bank 2008a). This may reflect that it may be difficult to achieve government accountability and efficiency under decentralization when there is a problematic scarcity of public sector administrative, financial, and managerial capacity at the lower levels of government (Collier 2008).

The Nigerian Government's Revenues and Expenditures Highly Depend on Oil

Nigeria's heavy dependence on federal transfers is primarily due to an imbalance in the country's revenue sources, which are dominated by taxes and royalties from mineral resources. Prior to independence, agriculture was a major source of revenue. However, since the discoveries of oil in the 1970s, oil has become the country's most important revenue-generating export (Budina and Wijnbergen 2008; Obinyeluaku and Viegi 2008). In fact, Nigeria has become the largest oil producer in Africa and the eleventh largest producer worldwide (Revenue Watch Institute, n.d.). Despite fluctuations, oil revenues have consistently comprised more than 60 percent of the government's total revenues since 1980, and this value has been as high as 80-90 percent in many years. Figure 5 shows the oil and non-oil revenues between 1980 and 2005 normalized using consumer price index (CPI).

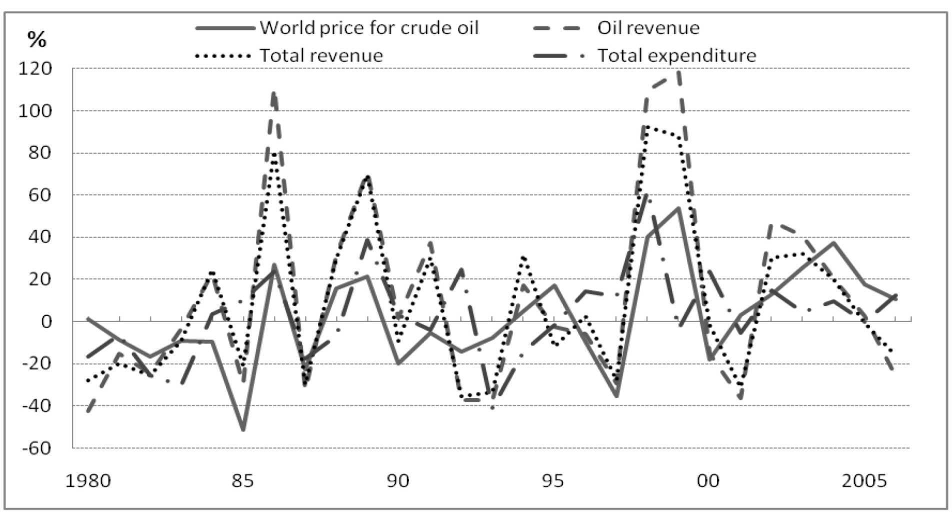
Figure 5. Oil revenue, non-oil revenue, and total government revenue deflated by CPI, 1980-2007



Source: CBN (2009).
Note: The combined height of the bars represents the total revenue.

This extreme oil dependency has led to a historical trend of unstable government revenues and expenditures, since oil revenues naturally follow the unpredictable fluctuations in world oil prices and OPEC-assigned oil quotas (Nigeria has been a member since 1958) (Ukwu et al. 2003; Obinyelauku and Viegi 2008) (Figure 6). Such variability impacts the stable provision of government services and can disrupt public spending to reduce poverty and support the diversification/growth in the non-oil sectors, particularly agriculture (Baunsgaard 2003). If Nigeria maintains its oil dependency and the recent oil price declines continue in coming years, the government will face tremendous challenges when seeking to provide the resources needed to accelerate agricultural growth.

Figure 6. Annual changes in world prices for crude oil, Nigerian government oil revenue, total revenue, and total expenditures, 1980-2007



Source: CBN (2009).

Oil revenues dominate the revenues that go into the Federation Account, and the methods of distributing such revenues are distributed among the three tiers of government have engendered protracted and controversial debates (Uche and Uche 2004). Numerous attempts have been made to devise an acceptable revenue allocation formula; unfortunately, these attempts have largely been remembered more for the controversies they have generated than the issues they have settled (Uche and Uche 2004). The Nigerian constitution mandates that oil revenues should be shared among all tiers of government, with the oil-producing states receiving 13 percent upfront (USAID 2008). After withholding of the so-called "first charges,"[12] the remaining funds are distributed among the federal, state, and local governments as established by the Acts of the National Assembly (USAID 2008). About half of the net proceeds are distributed to the state and local governments according to a formula[13] decided by parliament every five years (Ahmad and Mottu 2002). This makes the state and local governments highly dependent on revenue-sharing arrangements with the federal government. As of February 2008, the remaining funds were to be allocated as follows: 52.7 percent to the federal government, 26.7 percent to the states, and 20.6 percent to local governments (USAID 2008). Controversies and political problems regarding this sharing arrangement often arise when the oil-producing states demand a larger share of the oil revenues, and/or the non-oil producers demand greater redistribution of the oil resources (Ahmad and Mottu 2002).

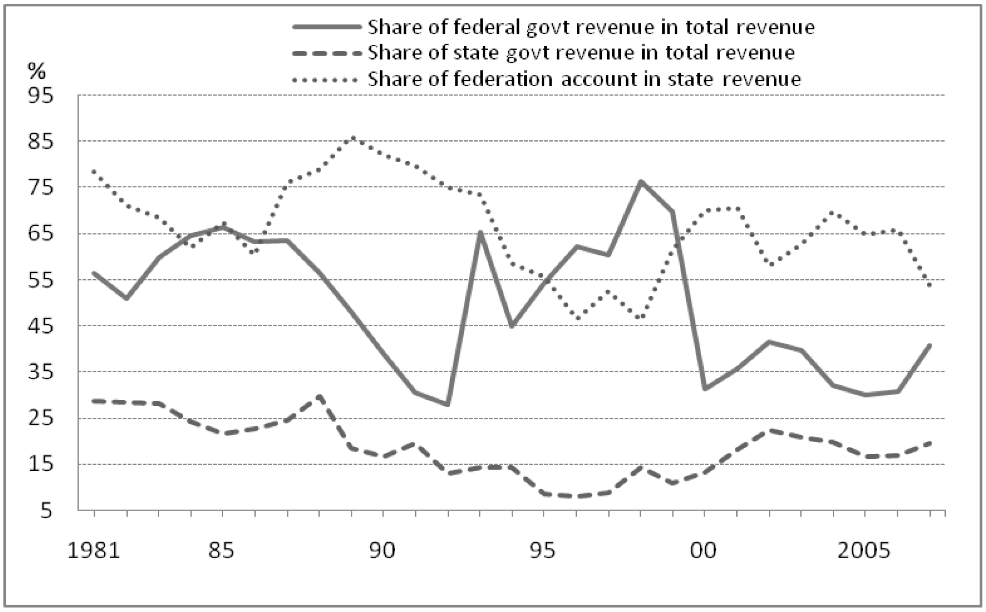
Shares of the Federal and State Government Revenues in Total Government Revenue

Between 1981 and 2007, the shares of the federal and state government revenues in total revenue fluctuated (although the latter fluctuated at a smaller degree), strongly reflecting the volatility of oil as the main government revenue source (Figure 7). After a steep decline in the early 1990s, the share of federal revenue in total government revenue increased sharply between 1993 and 1999, creating a huge deviation in the oil revenue distribution between these two tiers of government. After 1999, the federal share started to decline while the state share increased. The increasing share of state revenue in total government revenue can be attributed to the states receiving a larger share of the Federation Account starting 1999, when civilian rule returned to Nigeria and the constitution was enacted to (in part) mandate oil revenue allocation. In the following years (2000-01) high oil prices further increased the distribution of financial resources from the federal government to the state and local governments, particularly to oil-producing states (Ahmad and Mottu 2002). However, this increased allocation took place without the corresponding assignment of new expenditure responsibilities (Ahmad and Mottu 2003). Law mandates that the state and local governments should provide public services, including education, health, public works, local utilities, and infrastructure. However, many of the subnational governments have failed to maintain information on their budgets, expenditure levels, and expenditure compositions. In addition, some of them have accumulated considerable bank debts (Ahmad and Mottu 2003). This has further constrained the ability of the federal government to stabilize overall expenditure, resulting in the transmission of fiscal volatility throughout the economy (Baunsgaard 2003).

[12] The first charges include the 13 percent allocated to the oil-producing states, the government share of the production cost of oil (called "cash calls"), and funds for priority projects of the national oil company and the external debt service (Ahmad and Mottu 2002).

[13] A detailed discussion of this formula can be found in Ahmad and Mottu (2002, p. 17).

Figure 7. Shares of federal and state government in total government revenue, and share of the Federation Account in state revenue, 1981-2007



Source: CBN (2009).

Trends of Growth in Government Expenditures vs. Economic Growth

Table 11 presents the growth patterns in GDP and government expenditures during the period of 1981-2007. The table displays the annual growth rates and expenditure shares for three periods: the period prior to the structural adjustment program (SAP)[14] (i.e. 1981-85; pre-SAP); the SAP period (1986-94); and the post-SAP period. Given that the SAP period was rather long, we further divide this period into two sub-periods: the late 1980s (1986-90) and the early 1990s (1991-94). We also report the growth rates and shares in the post-SAP period during 2000-07. The data confirm that when GDP grew slowly due to oil price declines, particularly during 1981-85 and 1991-94 (0.3 and 1.1 percent, respectively), the total expenditure growth rate turned negative. After the SAP period, total expenditure experienced a very high growth rate (14.6 percent) even though the average GDP growth during 1995-99 was relatively low (2.8 percent). Isolating the federal and state expenditures during this period reveals that the share of the former was 75.5 percent, while that for the latter was only 18.8 percent, down from 26.1 percent in 1986-90 and 24.6 percent in 1991-94. On the other hand, there were years when the GDP growth rate was high but government expenditure posted negative growths. For example, GDP experienced relatively high growth as a consequence of oil booms in 2000, 2002, and 2006, but the expenditure growth rates were negative during these years.[15]

[14] SAPs are changes in economic policies and conditions implemented by the International Monetary Fund (IMF) and the World Bank in developing countries in response to economic disruptions (oil crisis and debt crisis among others) in the late 1970s. After several failed reform efforts, the Nigerian government adopted a comprehensive SAP in 1986 that emphasized reliance on market forces and the private sector in dealing with economic problems. For a detailed discussion of the causes, processes, and outcomes of SAP in Nigeria, see NCEMA (n.d.) and Ayadi et al. (2008).

[15] The reason for these opposing patterns of growth in GDP and government expenditure is unclear, and hence deserves further investigation.

Table 11. GDP and government expenditure growth (%), 1981-2007

	Pre-SAP	SAP		Post-SAP								
	1981-85	1986-90	1991-94	1995-99	2000	2001	2002	2003	2004	2005	2006	2007
GDP growth rate (%)	0.3	5.9	1.1	2.8	5.1	7.8	3.9	10.2	10.5	6.5	6.0	6.5
Total government expenditure growth rate (%)	-15.1	9.6	-4.3	14.6	-3.4	23.7	-5.1	15.0	4.4	9.5	-0.4	12.5
Share in total expenditure (%)												
Federal	55.5	73.9	71.5	75.5	57.7	57.0	53.2	48.9	47.3	46.9	46.2	45.4
State	44.5	26.1	24.6	18.8	29.6	33.4	37.9	36.7	37.3	38.0	37.9	39.2
Local*	0.0	0.0	3.9	5.7	12.7	9.6	8.9	14.4	15.3	15.1	15.9	15.3
Ratio of total expenditure to GDP (%)	37.7	28.6	29.5	23.2	26.5	37.8	35.2	35.8	26.4	26.7	22.6	23.2

Source: CBN (2009), CBN (2007, 2008)
Notes:1. Local total government and local agricultural expenditures are available from 1993 onward.
2. We distinguish among the later pre-SAP (1981-85), the early (1986-90) and later SAP (1991-94), and the early post-SAP (1995-99) periods. We present average data for each period and provide annual data starting in 2000.

Trends and Magnitudes of Agricultural Spending

We now turn to government agricultural spending, which is the focus of this study. Supporting the agricultural sector is a joint responsibility of the three tiers of governments, as mandated by the 1999 constitution. Federal, state, and local government budget and expenditure information is published by several government agencies in Nigeria, including the Central Bank of Nigeria (CBN), the Office of the Accountant General of the Federation (OAGF), the Federal Ministry of Agriculture (FMA), and the Budget Office of the Federation (BOF). In addition, the Federal Ministry of Agriculture and Rural Development (FMARD) seems to have its own source of data for federal government spending on agriculture.

Inconsistency of Agricultural Spending Figures across Different Data Sources

The lack of good-quality social and economic data is a well-known problem in Nigeria, particularly in the case of expenditure data. First, it is extremely difficult (if not impossible) to gather complete time-series data for both total government and agricultural expenditures from a single source. For instance, federal-level total government expenditure data are available for 1970-2007 from CBN (2009), but the same source only has state- and local-government-level data starting in 1980 and 1993, respectively. With regard to agricultural spending, it is even more difficult to obtain a complete time series for the three government levels from any single source. The only available time series is the budget estimates of the federal government agricultural expenditures between 1980 and 2007 (CBN 2009). The International Monetary Fund (IMF) has published a statistical index for Nigeria in various years, but these indices only contain budgeted (not actual) expenditure data at the federal level for 1992-2003. Moreover, in some years the data reported by IMF differ from those reported by CBN (2009), even though both data series were sourced from CBN. Several studies, including that by Fan et al. (2008), have documented time-series data (1980-2005) on agricultural public spending in Nigeria using combined data reported by IMF, Government Finance Statistics (GFS), and the authors' own projections.[16] In recent years, data reporting

[16] Such data have also been cited by Mogues et al. (2008) and made available through the Regional Strategic Analysis and Knowledge Support System website (http://www.resakss.org). Our discussion on agricultural spending and the respective graphs in this section are similar to those of Mogues et al. (2008). However, our values differ to some extent from those in Mogues et al. (2008) because the latter used agricultural spending data solely from Fan et al. (2008), while we herein combine data from CBN (2007; 2008; 2009), Fan et al. (2008), and IMF (various years).

has significantly improved; the CBN Annual Report and Statement of Accounts began regularly reporting actual agricultural spending data starting in 2002 (it is now available for 2002-07). However, such a short period of actual spending data is not appropriate for use in an econometric estimation.

In cases where data are available, they are often inconsistent across the different data sources. For example, the federal government total spending reported by CBN is 21-65 percent higher than that reported by OAGF-BOF between 2002 and 2005, and this trend holds true for both recurrent and capital expenditures (Table 12). The discrepancy is even more serious when we consider federal agricultural spending, where the data from CBN are 38 to 300 percent higher than those from OAGF-BOF. The second important data inconsistency across different data sources is found in the growth of spending over time. In most cases, CBN only reports expenditure data in current prices, meaning that expenditure growth must be calculated using various deflators. For example, when Nigeria's CPI deflator is applied to CBN data, the calculated average annual growth rates of the federal government total and agricultural expenditures are 7.0 percent and 8.7 percent, respectively, across 2002-05. In contrast, based on the data reported by OAGF-BOF, the calculated average growth rates of the federal government total and agricultural expenditure are -1.0 percent (it declined over time) and 7.6 percent, respectively, during the same period (Table 12).

Mogues et al. (2008) noted that the agricultural expenditures provided by FMA do not correspond with the data provided by OAGF-BOF or CBN for the period 2002-05. As indicated by Mogues et al. (2008), this discrepancy is puzzling since the OAGF database is supposedly prepared based on transcripts provided by FMA. Comparison of the two databases (FMA vs. OAGF-BOF) showed major differences with regard to both budgeted and actual spending. On average, the difference amounted to more than 54 percent of actual spending in agriculture (Mogues et al. 2008). In addition to this inconsistency, the authors were also unable to obtain a complete and detailed breakdown of the data for agricultural expenditure from FMA.

Table 12. Comparison of federal expenditure data from different sources

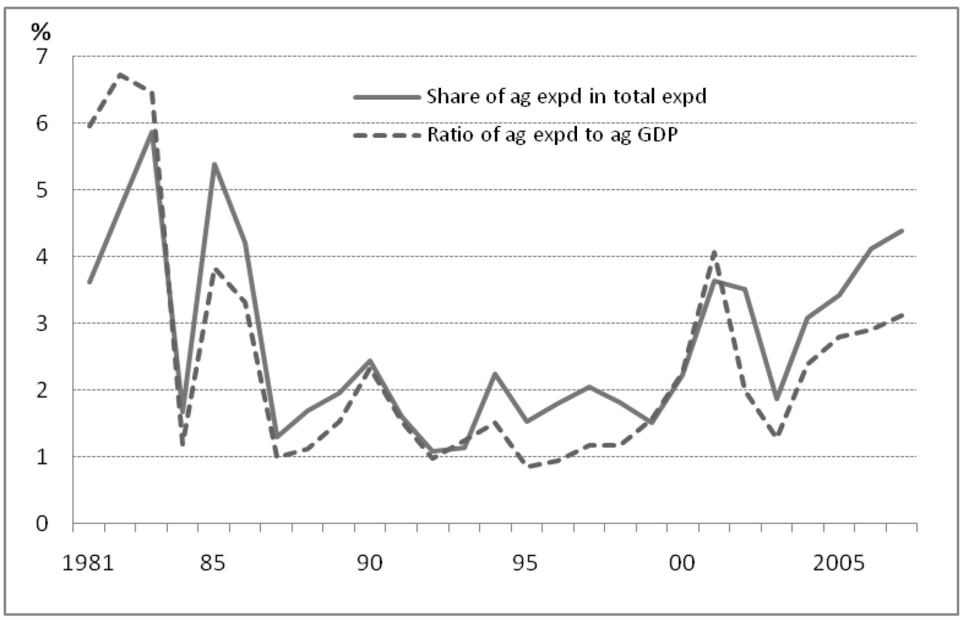
	2001	2002	2003	2004	2005	2006	2007	Growth rate (%)
Federal total expenditure (current billion Naira)								
OAGF-BOF	752	842	743	927	1,263			-1.0
Recurrent	447	524	530	586	770			
Capital	304	318	214	340	493			
CBN		1,018	1,226	1,426	1,822	1,938	2,451	7.0
Recurrent		697	984	1,033	1,224	1,290	1,589	
Capital		321	242	351	520	552	759	
Federal ag expenditure (current billion Naira)								
OAGF-BOF	16	11	12	16	21			7.6
Recurrent	7	6	7	8	13			
Capital	9	5	5	8	8			
CBN		45	16	50	77	107	164	8.7
Recurrent		12	8	11	16	18	28	
Capital		32	9	39	60	90	136	
Share of federal ag expd in total expd (%)								
OAGF-BOF	2.1	1.3	1.6	1.7	1.7			
CBN		4.4	1.3	3.5	4.2	5.5	6.7	

Source: OAGF-BOF is drawn from Mogues et al. (2008), CBN (2007; 2008).
Note: Total spending in CBN (2007; 2008) is not equal to recurrent plus capital because the total includes transfers, which are disaggregated into capital or recurrent expenditures. Annual average growth is the authors' own calculations, using CPI values from World Development Indicators (WDI) published by the World Bank (2008b) as a deflator.

The Share of Agricultural Expenditure in Nigeria Falls behind that in Many Other African Countries, but Growth has Picked up Recently

Despite the data problems discussed above, all sources of data show a consistent phenomenon: The share of agricultural spending in the total government budget of Nigeria is very low, at 1.1 to 5.9 percent. We use data from several sources to present the share of agricultural expenditure in total government spending and as a ratio to agricultural GDP over time. The sources are Fan et al. (2008) for the period 1992-2001, CBN (2009) for 1971-91, and CBN (2007 and 2008) for recent years. The data clearly show that the share of agricultural spending in total spending has experienced large fluctuations (Figure 8). The share, which provides a good indicator of the amount of government attention paid to the agricultural sector, was as high as 5.9 percent in the early-to-mid-1980s, but stagnated to below 2 percent in 1990-2000. In recent years (2001-07), the share of agriculture in total spending rose, fluctuating between 3.1 and 4.4 percent, except in 2004, when it dipped to 1.9 percent. Under the CAADP framework, agricultural spending is targeted to be 10 percent of total government spending, which is twice the actual share in recent years (2002-07). While the recent improvements in budget allocation towards the agricultural sector can be seen in Table 13, Nigeria still lags behind countries such as Burkina Faso, Ethiopia, Mali, Malawi, and Senegal, which have either achieved or are close to achieving the 10 percent CAADP goal (Fan et. al 2009).

Figure 8. Share of agricultural expenditure in total expenditure, and ratio of agricultural expenditure to agricultural GDP, 1981-2007



Source: Fan et al. (2008), IMF (various years), CBN (2009), and CBN (2007; 2008).

We have actual agricultural expenditure data at the federal and state levels only from recent years (i.e., 2002 to 2007), as reported in the CBN Annual Report and Statement of Accounts (CBN 2007; 2008) (Table 13). For comparison purposes, we also show GDP and agricultural GDP during this period. Federal and state agricultural expenditures increased during this period, with annual growth rates of 13.9 and 11.0 percent, respectively. We were unable to find information on local-government agricultural spending, either from CBN or other sources. A collaborative survey by, CBN, and the National Communication Commission (NCC) in 2006 (NBS 2007b) reported that the agricultural and rural development expenditures of local governments amounted to 10 billion Naira in 2006. This is equivalent to about 15 percent of the state-level agricultural spending in the same year. The resources devoted to agriculture by the federal government averaged 4.3 percent of total federal expenditure, while the state government generally allocated 3.6 percent of its total budget to agricultural expenditure during 2002-2007.

Table 13. Level of agricultural expenditure at the federal and state levels, 2002-07

	2002	2003	2004	2005	2006	2007	Annual average growth rate (%) or average share (02-07)
Billion Naira in current price							
GDP	5,439	6,999	11,411	14,562	18,565	23,281	7.8
Ag GDP	1,883	2,136	3,904	4,763	5,940	7,574	7.0
Total government expenditure	1,913	2,509	3,012	3,889	4,191	5,394	8.1
Agricultural expenditure	67	47	93	133	173	237	13.0
Federal	45	16	50	77	107	164	13.9
State	22	31	43	57	65	73	11.0
Share of ag in federal expd (%)	4.4	1.3	3.5	4.2	5.5	6.7	4.3
Share of ag in state expd (%)	3.1	3.3	3.8	3.8	4.1	3.4	3.6
Share of ag in total expd (%)	3.5	1.9	3.1	3.4	4.1	4.4	3.4
Ratio of ag expd to ag GDP (%)	3.6	2.2	2.4	2.8	2.9	3.1	2.8
Ratio of ag GDP to GDP (%)	34.6	30.5	34.2	32.7	32.0	32.5	32.8

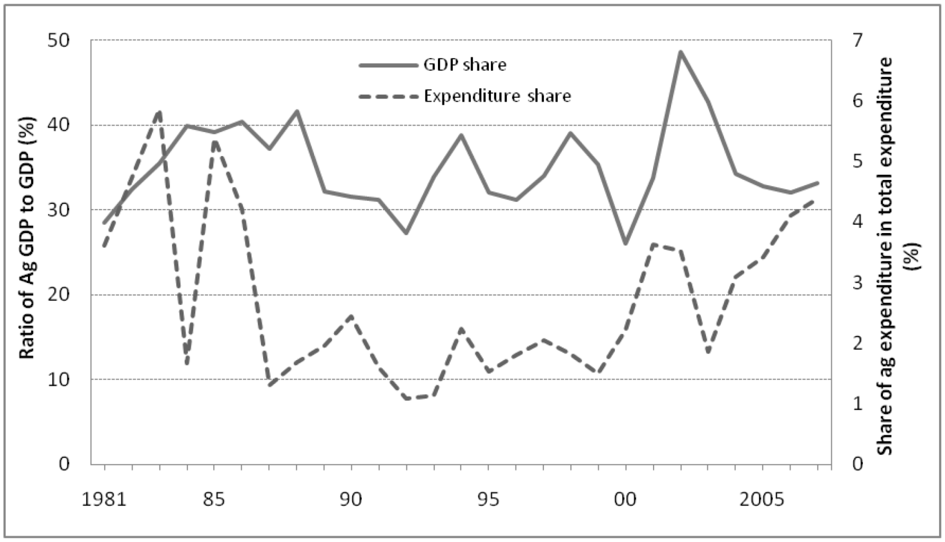
Source: NBS (2007a) and CBN (2007 and 2008) for expenditure data.

Notes: The growth rate is the authors' own calculations. CPI from WDI reported by World Bank (2008b) is used as a deflator for growth in spending, and constant GDP comes from NBS (2007a).
*'ag' refers to agriculture; 'expd' refers to expenditure.

Agricultural spending is further measured as a ratio to agricultural GDP in order to assess their relationship. The ratio of agricultural expenditure to agricultural GDP is low in most years, although it peaked in the early 1980s. Between 1990 and 2000, the indicator stagnated around 1 to 2 percent. As can be seen in Figure 9, the agricultural sector historically accounted for over 30 percent of GDP. Placing the share of agricultural spending in total spending alongside the share of agriculture in GDP illustrates that although these values differ in magnitude, both have followed quite similar trends in some years. For example, when the share of agricultural GDP in the economy increased, so did the share of agricultural spending in total expenditure. In more recent years (2003-07), although the share of agriculture in GDP has declined, increases were seen in the share of agricultural expenditures in the total budget.[17]

[17] The declining share of agriculture in GDP was primarily due to increases in world oil prices, which caused corresponding increases in the oil sector's share in GDP (both measured in current prices). However, growth in agricultural GDP was much more rapid than growth in oil-sector GDP during this period because growth was measured using a constant price.

Figure 9. Share of agricultural expenditure in total expenditure and share of agriculture in GDP, 1981-2007



Source: Expenditure data come from Fan et al. (2008), IMF (various years), CBN (2009), and CBN (2007, 2008). GDP comes from NBS (2007a).

The ratio of the agricultural expenditure share to the agricultural GDP share can be used to better measure the position of the agricultural sector in the country's government budget allocation. A ratio of 1 indicates that the government allocated its budget consistent with the contribution of agriculture to the country's economy (Mogues et al. 2008). If the ratio is smaller than unity, then the agricultural sector did not receive the public funds consistent with its role in the economy. The long-term average during the period 1981-2007 is 0.07, signifying that the share of public resources allocated to the agricultural sector was equivalent to less than one-tenth of this sector's contribution to the country's economy (as measured by its share in GDP).

Agricultural Spending is Highly Concentrated in a Few Programs

Mogues et al. (2008) analyzed the structure and allocation of federal capital spending on agriculture in Nigeria from 2001-05, using data obtained from FMARD, which is the only data source from which such information may be obtained. Their findings indicated that nearly 97 percent of federal-level capital spending supported the crop subsector, while only about 3 percent was spent on livestock and fisheries combined. Moreover, spending is highly concentrated in a few areas; three out of 179 agricultural programs account for more than 81 percent of total capital spending in agriculture. The three dominant programs are: (1) fertilizer market stabilization, with an average annual allocation of 1.25 billion Naira, or 43 percent of total capital spending in agriculture; (2) the food security component of the National Special Program for Food Security (NSPFS), with an average annual expenditure of 0.63 billion Naira, or 22 percent of total capital spending in agriculture; and (3) the Silos Program for construction, maintenance, and market development for the country's strategic grain reserve, with an average annual allocation of 0.46 billion Naira, or 16 percent of total capital spending in agriculture (Mogues et al. 2008). Notably, since the agricultural capital spending from FMARD is equivalent to only about 4.2-16.0 percent of the capital agricultural spending reported by CBN (2009), the same amount of spending on fertilizer subsidies and the other two programs account for a much smaller share of total agricultural spending when using data sourced from CBN. Nonetheless, the country's agricultural investment portfolio is unbalanced, concentrating resources to a small number of interventions while shorting others that are vital for accelerating agricultural productivity and pro-poor growth. These vital yet underfunded public investments include agricultural research and extension, capacity building among agricultural officials and farmers, agricultural financing, irrigation, and agribusiness development (Mogues et al. 2008).

Estimated Spending Requirements for Accelerated Agricultural Growth and Poverty Reduction

The quality of an econometric analysis depends on the availability and reliability of actual time-series data that span a sufficient period. Given the inconsistency of the agricultural expenditure data (see previous discussion), we decided to use data obtained from CBN for the analysis in this section. Although the CBN data cannot be disaggregated into different types of agricultural spending (e.g. spending on research and extension vs. fertilizer subsidies), this data set offers several advantages. First, the CBN data set covers a fairly long time period (1981-2006), and the data are published annually by CBN as part of the CBN Statistical Bulletin (the most recent version of the data was published in 2009). In contrast, the other sources offer government expenditure data over shorter periods; for example, the OAGF-BOF data used by Mogues et al. (2008) covered only 2002-05. The second benefit is that the government expenditure data published by CBN is relatively consistent with the GDP data published by the Nigerian Bureau of Statistics (NBS). As discussed earlier and shown in Table 11, when the GDP growth rates were very low or negative (e.g., during the pre-SAP and SAP periods), growth in government expenditures either stagnated or declined. Conversely, when GDP registered a high growth rate (e.g., in the recent period after 1995), the growth rate in government expenditure was high. Third, the spending data obtained from CBN is consistent with government oil revenue, that is, as oil revenues increase (decrease), the federal government total expenditures increased (decreased) (Figure 6). Given that oil revenue is the dominant income source for the Nigerian government, this correlation is expected. The fourth advantage of utilizing the CBN data is that it includes expenditure at the federal, state, and local levels,[18] whereas the data obtained from other sources (e.g., OAGF-BOF) only provide federal expenditures. This is particularly important for analyzing agricultural spending, as the constitution mandates that state governments must play a role in the agricultural sector. This role has become increasingly important since the late 1990s when the federal government increased the oil revenue allocation to the state governments (see previous discussion, as well as Figure 7 and Table 11).

Conceptual Framework for the Estimation of Required Agricultural Spending

For this analysis, we use agricultural total factor productivity (TFP) to estimate the required agricultural spending based on a conceptual framework in which growth in agricultural TFP is driven by growth-enhancing public investments. If we let Q_t represents aggregate agricultural output, then the production function of agricultural output is:

$$Q_t = \eta_t * f(F_t) \tag{1}$$

where η_t represents the level of TFP and $f(.)$ is the production function with a set of inputs, F_t. Obviously, growth in η_t augments the agricultural output beyond that generated by the increased use of inputs (e.g. labor, land, capital, and other inputs), which is decided on by the producers in a given production process.

Although growth in TFP is not a choice variable for producers, it is often linked to public goods or services that generate positive externality in the growth process, thereby benefiting private agents (farmers). The public goods or services that generate such positive externality to agricultural growth include public investments in education and health (which improve human capital), as well as infrastructure investments and road network development, both of which reduce transportation and other market-related costs. Such public investments benefit the whole economy, including agriculture. However, since such investments do not necessarily target the agricultural sector, their impact on agricultural productivity is often embodied via economy-wide impacts. For example, healthy and

[18] Local-level expenditure data are only available after 1993.

educated people are more productive, (but they do not necessarily work in the agricultural sector), while better road connection and increased road density in rural areas mainly benefit those who directly participate in trading and marketing. While these factors are outside agriculture, agriculture is indirectly benefited; therefore, we define the impact of such investments as indirect effects on agricultural growth.

On the other hand, certain other investments (e.g., agricultural research and extension, irrigation development, land conservation and management) directly increase land productivity (yields) through the development of new technologies and bringing such technologies to more farmers through a public agricultural extension system. These investments directly target the agricultural sector and support the farmers' use of modern technologies in agricultural processes. We define such investments as agriculture-related investments, and consider them to have direct impacts on agricultural productivity growth. Dropping the time factor *t* to simplify the notation, the following equation mathematically describes the relationship between public investment and agricultural TFP, η :

$$\eta = g^{\eta} \left(E_{ag\ exp} , E_{nag\ exp} , X_{\eta} \right) \tag{2}$$

where $E_{ag\ exp}$ captures the direct effect of agriculture-related public spending on agricultural TFP; $E_{nag\ exp}$ captures the indirect impacts of public investment excluding agriculture-related investment (designated 'nonagricultural investment' for convenience) on agricultural TFP; and X_{η} represents the vector of other external factors on the farmers that do not directly relate to the factors of production (e.g., climate and the organization of the production process).

In the present study, we mainly consider the effects of public spending aimed at the agricultural and nonagricultural sectors on growth in agricultural TFP. Since we were unable to obtain any reliable data or estimates for the linkage between agricultural and nonagricultural expenditures, we must ignore this multiplier effect. Assuming that there is a Cobb-Douglas-type relationship between TFP and public investment, the following equation holds:

$$\ln \eta = \varepsilon_{ag\ exp} * \ln (E_{ag\ exp}) + \varepsilon_{nag\ exp} * \ln (E_{nag\ exp}) \tag{3}$$

where:

$\ln \eta$ is agricultural TFP in log form;

$\ln (E_{ag\ exp})$ is the value of agricultural expenditure in log form;

$\ln(E_{nag\ exp})$ is the value of nonagricultural expenditure in log form;

$\varepsilon_{ag\ exp}$ is the elasticity of agricultural TFP with respect to agricultural expenditure; and

$\varepsilon_{nag\ exp}$ is the elasticity of agricultural TFP with respect to nonagricultural expenditure.

Equation (3) can be econometrically estimated using time-series data for agricultural TFP and agricultural and nonagricultural spending to generate the two elasticities. Given these elasticities, the following equation holds after we rearrange and take the total derivative of equation (3)[19]:

$$\dot{E}_{ag\ exp} = \frac{\dot{\eta} - \varepsilon_{nag\ exp} * \dot{E}_{nag\ exp}}{\varepsilon_{ag\ exp}} \tag{4}$$

where $\dot{E}_{ag\ exp}$ is the change in agricultural spending determined by the difference between the change in TFP ($\dot{\eta}$) and the elasticity of TFP growth with respect to nonagricultural expenditure ($\varepsilon_{nag\ exp}$) and change in nonagricultural spending ($\dot{E}_{nag\ exp}$), then normalized by the elasticity with respect to the growth in agricultural spending ($\varepsilon_{ag\ exp}$). Hence, equation (4) is used to assess the growth in agricultural spending required to support the targeted level of agricultural TFP growth.

[19] A dotted variable is differentiated with respect to *t*, i.e., $\dot{E}_{ag\ exp} = \partial E_{ag\ exp} / \boldsymbol{\partial t}$.

Data and Elasticity Estimation

The agricultural TFP data, given as a time series of indices, comes from Nin and Yu (2008), who conducted a non-parametric estimation using aggregated agricultural output and input data for all African countries. If time-series data on agricultural and nonagricultural spending are available, it is possible to econometrically estimate the elasticities, $\varepsilon_{ag\ exp}$ and $\varepsilon_{nag\ exp}$. As discussed above, the quality of Nigerian government spending data (particularly that for agricultural spending) is relatively poor. Thus, we decided to use the results derived from the time-series (1980-2005) expenditure data of Fan et al. (2008). The estimated results show that the elasticity of agricultural TFP growth with respect to agricultural spending growth is 0.24[20]. That is, for every 1 percent growth in government agricultural spending, agricultural TFP grows by 0.24 percent. The value of this elasticity is consistent with that calculated for India (Fan et al. 2000) when agricultural research expenditure was used to estimate its marginal effect on total agricultural growth. Our estimated elasticity is somewhat higher than those obtained from other studies of African countries in which agricultural growth (instead of agricultural TFP growth) was chosen as the dependent variable. For example, the estimated marginal effects of agricultural spending on agricultural growth were 0.15 in a cross-sectional study of African countries as a whole (Benin et al. 2007), 0.17 for Rwanda (Diao et al. 2007), and 0.19 for Uganda (Fan et al. 2004). However, as mentioned above, the dependent variables in these studies were often overall agricultural growth (for which the TFP impact is only part of the story). Hence, it is reasonable to believe that the marginal effect of agricultural spending (particularly on research/extension and any other type of public goods/service provision) on agricultural TFP growth should be higher than that on overall agricultural growth (to which a high use of production inputs often contributes the lion's share). By disaggregating agricultural spending, Fan et al. (2008) obtained an upper bound value of 0.36 when considering the marginal effect of agricultural expenditure on agricultural growth in Sub-Saharan Africa. Taking into account the broad range of elasticities available in the literature, we feel comfortable using our estimated value of 0.24 with respect to agricultural spending. To further analyze the sensitivity of required spending with respect to the choice of elasticity (which partially reflects the efficiency of spending), we also consider a case in which the elasticity is 0.41 (i.e., a 70 percent increase over the estimated result of 0.24).

In contrast, the estimated elasticity of agricultural TFP growth with respect to nonagricultural spending is 0.46, which is much higher than the elasticity of agricultural spending (0.24). Given that the lion's share of public good provision (e.g., investments in infrastructure, education, and health) is counted as nonagricultural spending, such an estimation result is not surprising. This type of spending will benefit the entire economy, including the rural economy and the agricultural sector. However, in terms of the effectiveness of 1 million dollars in spending, nonagricultural spending is not necessarily more effective than agricultural spending in promoting agricultural productivity growth. As discussed above, the value of nonagricultural spending is 20-25 times larger than that of agricultural spending in Nigeria. Thus, each 1 percent of nonagricultural spending is equivalent to 20-25 percent of agricultural spending. Dollar-for-dollar, this comparison indicates that agricultural spending is more effective than nonagricultural spending when looking at agricultural productivity growth.

Even with this explanation, however, we are still not comfortable using the calculated elasticity for nonagricultural spending in our analysis for the following reasons. First, our definition of nonagricultural spending is very broad. Without additional information allowing us to further disaggregate total spending, we must define nonagricultural spending as the difference between total spending and agricultural spending. Thus, part of the spending that is classified into the nonagricultural category may directly target agricultural and rural development. Second, given that the data quality for agricultural spending is poorer than for total spending, and agricultural spending is such a small portion (less than 4 percent in most years) of total spending, our estimates are likely to be biased because we do not fully distinguish between the direct and indirect effects of government spending (as suggested in the conceptual framework discussed above). Furthermore, if we apply the calculated elasticity for

[20] See Appendix B and Table A5 for details.

nonagricultural spending to equation (4), the result is a negative growth rate in required agricultural spending. Past studies such as those of Fan et al. (2004) and Thurlow et al. (2008) have faced similar data quality problems in trying to estimate elasticity in other countries. Hence, following equation (4), we use a calibration method to help us choose an elasticity for nonagricultural spending that is consistent with the historical growth rates of agricultural TFP, agricultural spending, and nonagricultural spending. Specifically, in equation (4), we assign values to $\dot{E}_{ag\ exp}$ and $\dot{E}_{nag\ exp}$ according to the average growth rates of agricultural and nonagricultural spending between 2000 and 2007; $\dot{\eta}$ according to Nin Pratt and Yu (2008); and the estimated agricultural spending elasticity, $\varepsilon_{ag\ exp}$ (which is 0.24) to calculate the nonagricultural spending elasticity, $\varepsilon_{nag\ exp}$. This calculation yields a data-consistent nonagricultural spending elasticity of 0.14, which we use in the following analysis.

Scenarios and Results

As discussed above, the DCGE model's base-run gives an average annual growth of 5.7 percent for agricultural GDP and 6.5 percent for overall GDP, which are consistent with the average growth rates seen over the past seven years in Nigeria. Similar to real events during this period, agricultural growth in the model's base-run is primarily driven by factor accumulation, and TFP only explains about 40 percent of total agricultural growth. The calculated agricultural TFP growth in the base-run is 2.3 percent annually over the simulated period of 2009-17. In the accelerated agricultural growth scenario (the CAADP scenario), the agricultural GDP annual growth rate rises to 9.5 percent. Since accelerated growth is largely led by productivity, the agricultural TFP growth rate rises to 5.6 percent annually over the same period. In this section, we estimate what level of growth in agricultural spending would be required to support the rapid growth modeled in the CAADP scenario.

We consider four investment scenarios in assessing what level of growth in agricultural spending would be required to support the 5.6 percent agricultural TFP growth rate obtained from the accelerated growth scenario of the DCGE model. In the first scenario, we apply the econometrically estimated elasticity of agricultural TFP with respect to agricultural spending (i.e., 0.24). Assuming that the growth rate of nonagricultural spending is the same as the current trend (which is the same as in the base-run), and using an elasticity of 0.14 for nonagricultural spending, our analysis shows that 23.8 percent annual growth in agricultural spending will be required over the next years (2009-17) to support the desired 9.5 percent agricultural growth rate. This result is consistent with the estimation of Fan et al. (2008), who found that 25.1 percent annual growth in agricultural spending would be required in order for Nigeria to achieve MDG1. However, when agricultural spending is assumed to be more efficient (as modeled in the second scenario, where we increase the value of elasticity from 0.24 to 0.41), agricultural spending only needs to grow at 13.6 percent per year (Table 14).

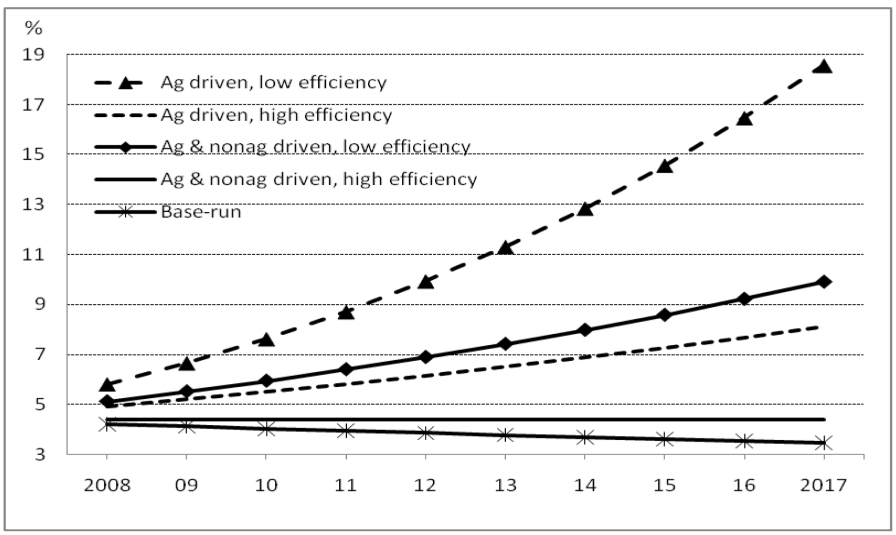
Table 14. Agricultural and total spending requirements under different scenarios

Indicator	Base-run	CAADP Target			
		Agricultural TFP growth driven by agricultural expenditures only		Accounting for indirect effect of nonagricultural expenditures on agricultural TFP growth	
		low efficiency	high efficiency	low efficiency	high efficiency
Annual growth rate in GDP (%)					
GDP	6.5	8.0	8.0	8.0	8.0
Ag GDP	5.7	9.5	9.5	9.5	9.5
Nonag GDP	6.7	7.5	7.5	7.5	7.5
Annual growth rate in TFP (%)					
Total TFP	2.5	3.8	3.8	3.8	3.8
Ag TFP	2.3	5.6	5.6	5.6	5.6
Nonag TFP	2.5	3.0	3.0	3.0	3.0
Annual growth rate in expenditures (%)					
Total spending	7.0	8.6	7.4	9.1	8.5
Ag spending	4.7	23.8	13.6	17.5	8.5
Nonag spending	7.1	7.1	7.1	8.5	8.5
Estimated results					
Share of Ag spending in total spending (%)					
2008	4.2	5.8	4.9	5.1	4.4
2015	3.6	14.6	7.3	8.6	4.4
2017	3.5	18.6	8.1	9.9	4.4
Ratio of Ag spending to AgGDP (%)					
2008	2.9	3.8	3.2	3.5	2.9
2015	2.7	9.1	4.2	5.7	2.8
2017	2.7	11.7	4.5	6.5	2.7
Ratio of total spending to GDP (%)					
2008	21.3	21.0	20.8	21.5	21.3
2015	22.1	21.6	19.9	22.8	21.8
2017	22.3	22.2	19.7	23.3	22.0

Source: Authors' estimates.

With the additional growth in agricultural spending and given the growth in nonagricultural spending, the share of agricultural spending in total government expenditure rises gradually. Currently, agriculture accounts for 4.2 percent of total government expenditure. In the first scenario (low elasticity; i.e. low spending efficiency), this share rises to 14.6 percent by 2015 and 18.6 percent by 2017. Under the second scenario (high elasticity; i.e., improved spending efficiency), the share of agricultural expenditure in total spending is 7.3 percent in 2015 and 8.1 percent in 2017 (Table 14 and Figure 10). In practice, it is important to emphasize that spending efficiency should be improved in order to better support agricultural growth in the face of limited resources. This is also important when we consider the CAADP target of allocating 10 percent of the government's budget to the agricultural sector. If the government can significantly improve the efficiency of its agricultural investments by better allocating and managing public expenditure, much less spending will be required to support similar levels of agricultural and economic growth. Hence, the share of agriculture in total spending may not need to reach the full 10 percent.

Figure 10. Share of agricultural spending in total spending required for accelerated agricultural growth, 2008-17



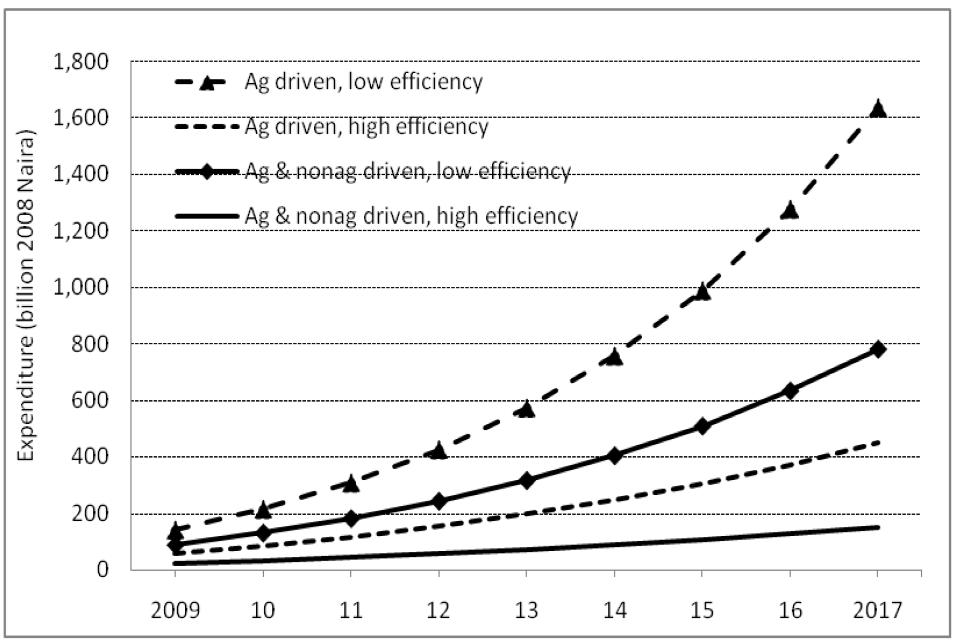
Source: Authors' estimates.

In the first two scenarios, we assume that growth in nonagricultural spending is given at its base-run level, and required agricultural spending is the only driver supporting accelerated agricultural growth. In other words, we ignore the indirect effects of additional nonagricultural spending growth on agricultural growth. In the third and fourth scenarios, however, we consider this factor and re-estimate the required agricultural spending under the low- and high-elasticity scenarios. Increased nonagricultural spending is assumed to be proportional to the nonagricultural sector's TFP growth, which increases from 2.5 to 3.0 percent per year in the base-run (Table 14). This growth in the DCGE model simulation is primarily due to growth linkages between agriculture and nonagriculture (i.e., improvement in the agricultural economy benefits the nonagricultural sector). Consistent with the increase in nonagricultural TFP growth, annual growth in nonagricultural spending needs to rise from 7.1 percent in the base-run to 8.5 percent under the accelerated agricultural growth scenario. Additional nonagricultural spending is not only necessary for growth in the nonagricultural economy, it also indirectly affects growth in agriculture. Given a similar marginal indirect effect (i.e. the elasticity of 0.14 with respect to nonagricultural spending), part of the desired level of agricultural growth can be indirectly supported by additional government spending on the economy as whole. This lowers the required annual growth in agricultural spending from 23.8 percent to 17.5 percent given a low elasticity of agricultural spending (third scenario), and from 13.6 percent to 8.5 percent given a high elasticity (fourth scenario).

Due to this slower growth in required agricultural spending, the share of agricultural spending in total government spending rises at a slower pace than seen in the first two scenarios. Agricultural spending accounts for 8.6 and 9.9 percent of total spending by 2015 and 2017, respectively, given a low elasticity (i.e. "Ag and nonag driven, low efficiency), and it stays at 4.4 percent over the period of 2009-2017 given a high elasticity (i.e. "Ag and nonag driven, high efficiency) (Figure 10). These results further emphasize the importance of addressing the growth linkages between the agricultural and nonagricultural sectors in both overall economic activity and government spending when setting targets for agricultural spending.

Translated into monetary terms, our analysis shows that without taking into account the changes in government nonagricultural spending, under the first scenario (i.e. "Ag driven, low efficiency"), the government needs to increase its current investments in agriculture by 987 billion Naira and 1,635 billion Naira (in 2008 prices) by 2015 and 2017, respectively (Figure 11). When a more optimistic spending efficiency is assumed in the second scenario (i.e. "Ag driven, high efficiency"), additional agricultural spending will be 305 billion Naira by 2015 and 448 billion Naira by 2017, implying that improvements in investment efficiency could allow the government to save more than 4,300 billion Naira in total over a period of eight years (between 2009 and 2017), or more than 400 billion Naira per year on average.

Figure 11. Additional agricultural spending required for accelerated agricultural growth (difference from the base-run), 2009-17

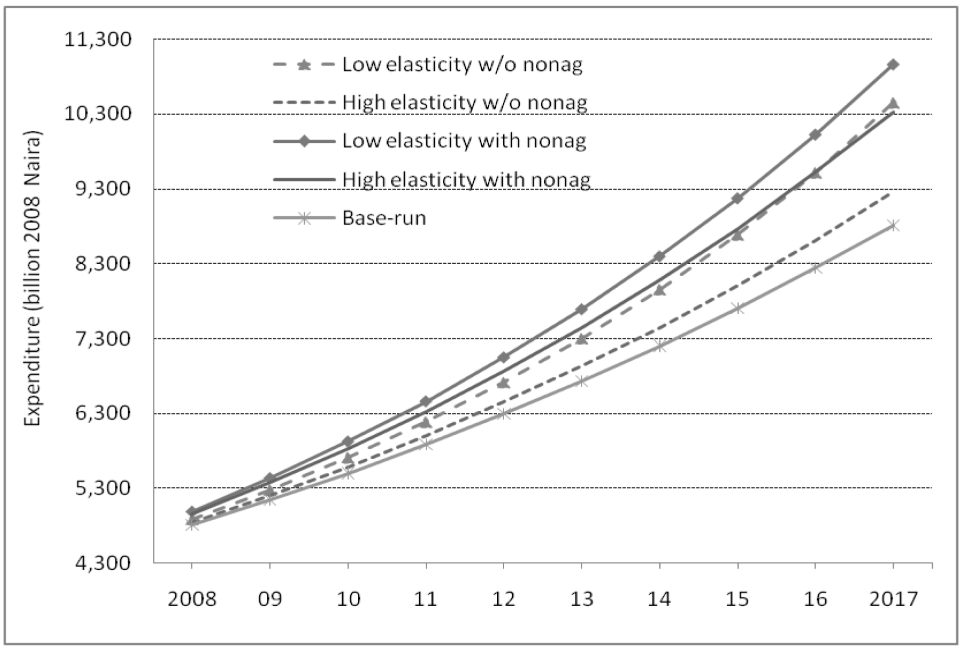


Source: Authors' estimates.

Improvements in agricultural spending efficiency could also reduce the required total government spending. Under the first scenario, the annual growth in total government expenditure rises to 8.6 percent (Table 14) and reaches 10,452 billion Naira by 2017 (Figure 12), in contrast with the base-run's 7.0 percent annual growth and 8,817 billion Naira by 2017. Given a high elasticity (second scenario), the annual growth in total government spending is 7.4 percent and total government expenditure by 2017 is 9,265 billion Naira, only 448 billion Naira more than the base-run's figure for 2017.

When additional growth in nonagricultural spending and its indirect effects on agricultural growth are taken into consideration (third and fourth scenarios), we see a relatively slow growth in the requirement for agricultural spending, implying the need for a relatively lower level of such spending over time. Given a low elasticity (third scenario), additional required agricultural spending reaches 509 billion and 782 billion Naira by 2015 and 2017, respectively, instead of 987 billion and 1,635 billion Naira (Figure 11). With high spending efficiency (fourth scenario), these values become 108 billion Naira by 2015 and 150 billion Naira by 2017 (instead of 305 billion and 448 billion Naira). However, as additional spending on the nonagricultural sector is taken into account, total government spending does not decline from that seen in the previous two scenarios. In fact, with either low or high efficiencies in agricultural spending, the total government spending rises over time (Figure 12). In other words, since nonagricultural spending accounts for a much larger share of total spending than agricultural spending, even with very rapid growth in agricultural spending, spending on the nonagricultural economy will mostly drive the increase in total government spending.

Figure 12. Total spending required for accelerated agricultural growth, 2008-17



Source: Authors' estimates.

Messages Drawn from Section 5

Our results show that both the growth in agricultural spending required to support accelerated agricultural growth and the share of such spending in total government spending depend critically on two important factors: (i) the efficiency of agricultural investments; and (ii) the interaction of agriculture and nonagriculture in both broad economic activities and government investments. Growth in the agricultural sector and the rural economy depends on public investments in both agriculture and nonagriculture, and it is necessary to take into account possible increases in nonagricultural spending (e.g., on infrastructure, education, and health) when estimating required agricultural spending. Estimations of required agricultural spending will be quite different when the possible impacts of increased nonagricultural spending on agricultural growth are not taken into account. Given current (inefficient) agricultural spending patterns, the growth required in agricultural spending is extremely high, at 23.8 and 17.5 percent when considering growth only in agricultural spending (first scenario), or growth in both agricultural and nonagricultural spending (third scenario), respectively. The resources that must be mobilized by the government to support the desired level of accelerated agricultural growth could reach 18 percent of total spending by 2017 (Table 14). Looking at the recent spending trends of the Nigerian government (Table 13), it appears unlikely that agricultural spending could be increased at such a high growth rate over the next years. The higher required agricultural spending growth will, in turn, drive rapid growth in total spending. If we consider the indirect effect of nonagricultural spending on agricultural growth but do not assume improved spending efficiency, the rate of required growth in total spending is even higher (9.1 percent in the third scenario vs. 8.6 percent in the first scenario), although the allocation between agriculture and nonagricultural spending changes dramatically. Clearly, improving investment efficiency through improved budgetary process, timely release of funds, greater transparency, and strengthened accountability of public spending in the sector is a critical channel through which the Nigerian government may be able to effectively support the accelerated agricultural growth needed to meet MDG1. If agricultural investment efficiency is increased by 70 percent (i.e., the marginal effect of spending on agricultural TFP rises to 0.41 instead of the current 0.24), the required growth for both agricultural and total spending will be significantly lower and the share of agricultural spending in the national budget can be less than the 10 percent CAADP requirement.

6. LINKING AGRICULTURAL SPENDING TO FARMERS' RESPONSES[21]

While it is necessary to quantitatively assess the level and growth of public spending in agriculture required to financially support the desired levels of accelerated agricultural growth and poverty reduction, it is equally important to analyze how the government should allocate and spend such funding to promote agricultural public service provision. Improvements in agricultural growth (particularly productivity), may be critically influenced by such efforts. However, a relative lack of data limits our ability to quantitatively analyze the relationship between public fund allocation/public service provision and agricultural growth. Instead, a more innovative approach must be developed for this purpose. Here, we use household-level data from the 2006 Core Welfare Indicators Questionnaire (CWIQ) survey to assess the role of agricultural services in promoting agricultural productivity growth. In particular, we focus on the relationship between agricultural services and the use of modern inputs (fertilizer) by farmers. Given that this survey is representative at the national and state levels and covers more than 75,000 households and 7,700 communities in all LGAs and states of Nigeria, this analysis can provide at least a partial assessment of the efficiency of agricultural spending in terms of agricultural service provision. As a prelude to econometric analysis, we first describe the basic features of the data and discuss some descriptive findings.

The CWIQ survey provides information on agricultural input use and the sources of these inputs, along with community-level information on various social and economic projects. It also includes data on the demographic and socioeconomic attributes of the surveyed households, as well as their access to and use of various social and economic services. The survey design allows indirect assessment of the efficiency of agricultural service provision by the public sector. For the present study "non-agricultural" households were excluded, resulting in a sample size of about 56,600 households nested within 774 LGAs and 37 states (including the FCT). The definitions and descriptive summaries of the variables used in this analysis are provided in Table 15.

The data suggest that only 46.4% of all farm households in Nigeria use modern agricultural inputs such as improved seeds, chemical fertilizers and pesticides. Most of the input-utilizing farm households use chemical fertilizers (42.8 percent of all farmers), while only a few farm households use improved seeds (7 percent) or pesticides (10.5 percent). The majority (87.5 percent) of the farmers that use modern agricultural inputs buy them in the open market, while the remainder purchase their inputs through the public sector. Significant variations in modern input use are seen across the various subnational regions. For example, about 80 percent of all farm households in the Northwest zone use modern inputs, while only 16 percent in the South zone use such inputs. Two important community-level variables measure whether a given community received an agricultural service project during the five years prior to the survey; these projects were divided into those provided by the public (GASP) and private (PASP) sectors. The survey results suggest that the public sector (which includes all government levels and donors) mainly funds projects that provide subsidized inputs to credit and extension services, whereas the private-sector projects mainly focus on agricultural input and output markets. The data show that approximately 42 percent of the surveyed communities received at least one agricultural service project over the five-year period prior to the survey. About 45 percent of the surveyed farm households reside within a community that received at least one agricultural service project. The breakdown by service providers reveals that only 18.8 percent of the surveyed communities (encompassing 21 percent of the surveyed households) received agricultural service projects provided by the public sector, while about 38 percent (encompassing 40 percent of the surveyed households) received such projects provided by the private sector.

[21] This section draws from Akramov, K. 2009. *Decentralization, agricultural services, and determinants of input use in Nigeria*. IFPRI Discussion Paper No. 00941. Washington, D.C.: International Food Policy Research Institute.

Table 15. Descriptive summary of variables

Variable	Mean	Standard deviation	Number of observations
Dependent variable			
Fertilizer use (1 if farmer uses chemical fertilizer, 0 otherwise)	42.8	49.5	56,643
Independent variables			
Community-level variables			
Has access to all-season roads (1 if yes, 0 otherwise)	0.54	0.50	7,489
Had at least one agricultural service project in the prior five years			
Public (GASP = 1 if yes, 0 otherwise)	0.21	0.40	7,497
Private (PASP = 1 if yes, 0 otherwise)	0.40	0.49	7,497
Household characteristics			
Household size (number of people in the household)	5.3	2.9	56,643
Marital status of household head (1 if married, 0 otherwise)	0.84	0.37	56,641
Household head's gender (1 if male, 0 otherwise)	0.90	0.30	56,643
Age of the household head, years	48.2	15.3	56,643
Household head's education (1 if at least primary school, 0 otherwise)	0.43	0.49	55,777
Household member is government employee (1 if yes, 0 otherwise)	0.08	0.28	56,643
Income quintiles			
First	0.26	0.44	56,643
Second	0.22	0.41	56,643
Third	0.20	0.40	56,643
Fourth	0.17	0.38	56,643
Fifth	0.15	0.36	56,643
Agriculture is main activity (1 if yes, 0 otherwise)	0.57	0.49	56,643
Land holdings (hectares)	3.7	6.8	56,643
Of land holdings, amount owned (hectares)	3.3	6.5	56,643
Access to agricultural services			
Credit access (1 if yes, 0 otherwise)	0.18	0.39	55,502
Agricultural extension (1 if yes, 0 otherwise)	0.013	0.11	56,643
Agro-ecological zone			
Sudan savanna (1 if yes, 0 otherwise)	0.43	0.49	56,643
Guinea savanna (1 if yes, 0 otherwise)	0.12	0.33	56,643
Derived savanna (1 if yes, 0 otherwise)	0.18	0.39	56,643
Rainforest (1 if yes, 0 otherwise)	0.27	0.44	56,643

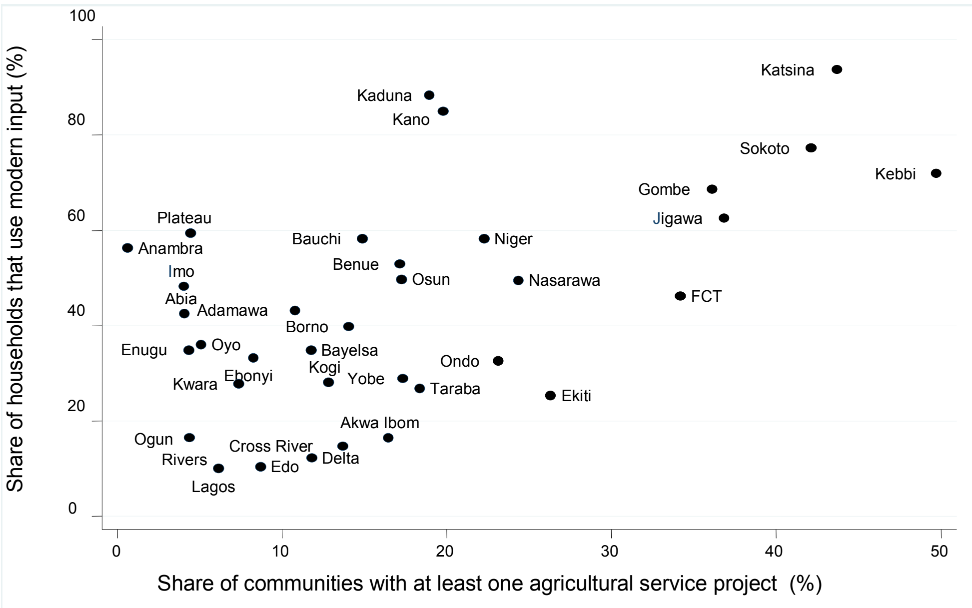
Source: CWIQ (2006)

Concerning the allocation of agricultural service projects across states, the data show significant variations (coefficient of variation = 0.42). For example, only 7 percent of the surveyed communities in Imo state received at least one agricultural service project, while more than 70 percent of the communities in Kebbi state received such projects[22]. There is a sizeable correlation (0.56) between the provision of public- and private-sector agricultural service projects across states, but this correlation is considerably lower (0.34) when measured at the community level. Substantial correlation (0.57) is seen between public agricultural service provision and input use at the state level. Figure 13 shows that states with higher public agricultural service provision are more likely to have higher rates of input use. This correlation,

[22] In this regard, Zamfara state, where more than 90% of communities received at least one agricultural service project, appears to be an absolute outlier.

however, becomes substantially smaller (0.17) when measured at the household level. Overall, all other factors being equal, farmers who live in communities that received agricultural service projects are more likely to use modern inputs.

Figure 13. Public-sector agricultural service projects and input use in Nigerian states



Source: Authors' computations based on CWIQ (2006).

Access to all-season roads is another important community-level variable and it is expected to correlate positively with input use. The data suggest that about 54 percent of the surveyed communities have access to all-season roads. However, the simple descriptive analysis shows no significant correlation between access to all-season roads and agricultural service provision. For example, the pairwise correlation between access to all-season roads (RD) and agricultural service projects provided by public sector (GASP) is equal to 0.09.

Concerning the important household characteristics, such as the use of agricultural extension and credit, the data indicate that very few farmers (1.3 percent)[23] in Nigeria use extension services. This is very low compared to the rates found in many other countries in the region, and seems to support the idea that the withdrawal of World Bank loans has negatively impacted the performance of agricultural extension in Nigeria (Oladele 2004). About 18 percent of the sampled farm households report using credit facilities. However, only 6.8 percent of them use formal or semi-formal credit facilities (e.g., banks, microfinance institutions, and credit cooperatives), while 11.2 percent use informal credit facilities, such as esusu. The descriptive analysis shows that there is considerable variation in access to credit across the geopolitical zones and states of Nigeria. The highest level of credit use is seen in the Southwest (28 percent) and North-central (26 percent) zones, while the Northeast (9 percent) zone has the lowest level of credit use by agricultural households. The ceteris paribus effects of these variables on input use are expected to be positive based on previous research (World Bank 2007). However, the simple descriptive analysis shows no significant correlation between the use of credit/extension services and modern inputs in Nigeria. Also, no significant correlation is seen between these household-level variables and the community-level variables discussed above.

[23] This is the share of surveyed farmers who report using an agricultural extension service.

Access to Agricultural Services and Input Use: The Empirical Results

There is consensus in the literature that increased use of modern inputs (e.g., fertilizer, improved seeds, etc.) is necessary to enhance agricultural productivity in Sub-Saharan Africa. However, as noted above, more than half of the agricultural households in Nigeria do not use such inputs, and there are significant variations in agricultural input use across the Nigerian states. Moreover, there are significant between-state variations in access to infrastructure (roads) and agricultural services. In this regard, we next turn to an examination of whether or not agricultural service provision and public investments can affect agricultural input use in Nigeria.

Assume that the utilization of agricultural inputs, such as fertilizer or improved seeds, is determined by the expected profitability of using such inputs, given their availability. The expected profitability of modern input use is affected by input prices, fixed and variable transaction costs (Jayne et al. 2003; Winter-Nelson and Temu 2005). The relative magnitudes of these transaction costs depend on the farmers' accesses to infrastructure (roads) and agricultural services. For example, subsidized input supply services, if appropriately targeted, can help increase input use among poor farmers, while agricultural extension services might positively influence input use by improving the farmers' knowledge of the benefits of modern inputs. Similarly, access to all-season roads can reduce farmers' travel costs, thereby positively influencing input use (Johnson et al. 2003). Furthermore, access to credit is likely to ease the farmers' financial constraints, consequently increasing input use (World Bank 2007). However, in Nigeria, as in many other developing countries, most farmers lack access to such important services due to inadequate institutions and imperfect markets. This makes the government involvement in the provision of such services desirable (Hoff et al. 1993; Westlake 1994), as the government can improve input use by fixing market failures and reducing the transaction costs associated with input use (Kelly 2006; Gregory and Bumb 2006; Morris et al. 2007).

The actual impact of government involvement in agricultural service provision depends on the effectiveness of the institutional arrangements for the provision of such services. In this regard, decentralization can have important implications. By bringing decision-making closer to the people, decentralization may ensure greater differentiation, efficiency and equity in the provision of agricultural services. This could happen if the subnational governments have greater access to local information regarding the preferences and needs of their residents (World Bank 2007). At the same time, however, decentralization may engender different enabling environments across subnational jurisdictions, due to differences in the socio-economic potential and capacity of each subnational government. These variations across the subnational governments' potentials and capacities are likely to have important implications for agricultural service provision and input use. In a decentralized structure outcomes within the same state are likely to be correlated, and that outcomes within the same LGA are even more likely to be highly correlated. Thus, the empirical model should take into account the hierarchical structure of data where units (households) are nested in clusters (local governments) and clusters are nested in superclusters (states).

This type of data structure requires the use of a multilevel regression framework, in which a nested random effects estimator is used to explicitly model the dependence in the error term (Rabe-Hasketh et al. 2005). This method decomposes the error term into error components. Accordingly, we use the following specification for a three-level mixed effects logistic regression model[24] for agricultural input use for household i, which is nested in local government area k within state h as:

$$Prob(Y_{ijkh} = 1) = \alpha + \beta_h HH_{ijkh} + \beta_g GASP_{ijk} + \beta_p PASP_{ijk} + \beta_r RD_{ijk} + \nu_h + \eta_{kh} + \xi_{ijkh} \quad (5)$$

where:

Y_{ijkh} is a binary variable for the input use for household i, which is nested in community j, local government area k, and state h;

[24] For details of model specification and discussion of related econometric issues, see Akramov (2009).

HH_{ijkh} is a matrix containing household characteristics;

$GASP_{ijk}$, $PASP_{ijk}$, and RD_{ijk} are measured at the community level; $GASP_{ijk}$ and $PASP_{ijk}$ show whether a given community received at least one agricultural service project during the five years prior to the survey, provided by public and private sources, respectively, while RD_{ijk} shows whether a given community has access to all-season roads; and

ν_h represents the state effects, η_{kh} stands for the LGA effects, and ξ_{ijkh} is a mutually independent error term that has a logistic distribution with a variance of $\pi^2/3$.

This is a generalized mixed-model specification with both fixed effects (regression coefficients for household- and community-level covariates) and random effects. The random effects in equation (6) include η_{kh} and ν_h, which represent deviations of local-government specific (level 2) and state-specific (level 3) random intercepts from the mean intercept α, respectively. Thus, equation (6) estimates the impact of access to all-season road and public- and private-sector agricultural service provision on the farmers' modern input use, while controlling for household characteristics and LGA- and state-specific latent effects. The error component for state effects (which is invariant across all farm households within a given state) can be considered to be the combined effect of the omitted covariates and/or the unobserved heterogeneity at the state level. Similarly, the error component for LGA effects (which is invariant across all farm households within a given LGA) can be considered to be the combined effect of the omitted variables and/or the unobserved heterogeneity at the local-government level within a given state. In addition to equation (5), we estimate a random coefficient model by assuming that a slope for all-season road access for each state deviates from the mean slope for this variable. The parameters of these models are estimated using the nested random effects estimator proposed by Rabe-Hasketh et al. (2005).

The descriptive findings presented above show that only a fraction of Nigerian farmers use improved seeds (7 percent) and chemical pesticides (10.5 percent). Moreover, the data indicate that most of the farmers who use improved seeds and pesticides also use fertilizer. Therefore, it is logical to focus on examining the impact of agricultural service provision on fertilizer use. Table 16 shows the maximum likelihood estimates from nested two- and three-level mixed effects (random-intercept and random-coefficient) models, along with those from the standard logit model of fertilizer use. The two-level mixed effects models assume that the households are nested in states, and do not control for deviations across LGAs.

Table 16. Determinants of fertilizer use in Nigeria (Dependent variable = fertilizer use)

Variable	F1	F2	F3	F4	F5
Household size (log)	0.30**	0.31**	0.31**	0.30**	0.30**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Married	0.07	-0.02	-0.01	0.02	0.02
	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Primary school	0.12**	0.10**	0.10**	0.08**	0.08**
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Income quintile 1	-1.06**	-0.76**	-0.79**	-1.02**	-1.04**
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)
Income quintile 2	-0.63**	-0.47**	-0.50**	-0.67**	-0.69**
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)
Income quintile 3	-0.28**	-0.22**	-0.25**	-0.38**	-0.41**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
Income quintile 4	-0.03	-0.05	-0.07	-0.16**	-0.17**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)

Table 16. Continued

Variable	F1	F2	F3	F4	F5
Gender	0.01	-0.10	0.09	0.12	0.12
	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)
Age (log)	-0.26**	-0.28**	-0.29**	-0.29**	-0.30**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
Land holding size (log)	0.14**	0.15**	0.15**	0.18**	0.18**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Credit	0.21	0.27**	0.27**	0.26**	0.25**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Extension	0.45**	0.28**	0.28**	0.44**	0.45**
	(0.09)	(0.10)	(0.10)	(0.11)	(0.11)
GASP	0.43**	0.31**	0.30**	0.29**	0.29**
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
GASP *POOR	0.04	-0.09	-0.09	-0.13*	-0.14*
	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)
PASP	-0.12**	0.11**	0.12**	0.09**	0.08*
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Civil servant	-0.11**	0.10*	0.10**	0.13**	0.13**
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)
Agric. as main activity	0.24**	0.22**	0.23**	0.31**	0.32**
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
All-season road access	-0.24**	-0.08**	-0.14	-0.02	-0.10
	(0.02)	(0.02)	(0.08)	(0.03)	(0.07)
Sudan savanna	0.43**	0.64	0.57	0.78	0.65
	(0.03)	(0.50)	(0.53)	(0.79)	(0.61)
Derived savanna	-0.60**	0.67	-0.61	-0.88	-0.93
	(0.04)	(0.56)	(0.59)	(0.67)	(0.68)
Rainforest	-1.25**	-1.54**	-1.54*	-2.07**	-2.10**
	(0.04)	(0.50)	(0.53)	(0.61)	(0.61)
Constant	0.67	0.19	0.28	0.20	0.37
	(0.14)	(0.44)	(0.46)	(0.52)	(0.53)
State (random intercept)		1.00**	1.05**	1.15**	1.17**
		(0.12)	(0.13)	(0.14)	(0.15)
State (random coefficient for road access)			0.42**		0.37**
			(0.06)		(0.06)
LGA				1.25**	1.25**
				(0.04)	(0.04)
N	53,694	53,694	53,694	53,694	53,694
No. of states		37	37	37	37
No. of LGAs				774	774
Log likelihood	-31425.9	-27421.6	-27315.8	-23781.2	-23729.8
Pseudo R squared	0.14	0.25	0.25	0.35	0.35

Source: Authors' own estimations.

Notes: Standard errors are given in parentheses; ** $p < 0.01$, * $p < 0.05$.

The reference category for the income quintiles is income quintile 5; the reference category for the agro-ecological zones is the Guinea savanna zone.

F1 shows the results from a standard logistic regression model with robust standard errors.

F2 shows the maximum likelihood estimates for a two-level (households nested in states) random-intercept model.

F3 shows the maximum likelihood estimates for a two-level (households nested in states) random coefficients (for access to roads) model.

F4 shows the maximum likelihood estimates for a three-level (households nested in LGAs and LGAs nested in states) random-intercept model.

F5 shows the maximum likelihood estimates for a three-level (households nested in LGAs and LGAs nested in states) random-coefficients (for access to roads) model.

Overall, the estimated nested models reveal significant heterogeneity in the likelihood of fertilizer use across states and LGAs. The two-level (households nested in states) random-coefficient (F3) model suggests that states vary in their intercepts, with an estimated random-intercept standard deviation of 1. The three-level (households nested in LGAs, which are nested in states) random-intercept model (F4) has an estimated random-intercept standard deviation of 1.05, suggesting that its deviations from the mean intercept are even larger. The state-specific random-intercepts (data not shown) are both statistically and practically significant for almost all of the states. The state-specific intercepts suggest that households residing in states such as Kano (with an estimated odds ratio of 3.6), Kaduna (9.5), Katsina (5.3), Zamfara (4.7), and Anambra (3.0) have significantly higher likelihoods of using fertilizer, ceteris paribus. In contrast, households residing in such states as Borno (with an estimated odds ratio of 0.31), Ekiti (0.15), Cross River (0.51), Delta (0.44), Yobe (0.14) and Taraba (0.29) have significantly lower probabilities of fertilizer use, ceteris paribus.

The three-level models also reveal significant variances among LGAs in the farmers' likelihood of fertilizer use; the LGAs vary in their intercepts, with an estimated random intercept standard deviation of 1.25. Overall, the regression diagnostics suggests that the three-level mixed effects logistic regression model fits better than the standard and two-level mixed effects logit models at the 1 percent significance level (using a conservative likelihood ratio test). Furthermore, the same test indicates that the three-level random-coefficient (F5) model fits better than the three-level random-intercept (F4) model at the 5 percent significance level. Thus, the discussion of the findings provided below is mainly based on the findings of the three-level random-coefficient (F5) model.

The empirical results suggest that the provision of agricultural service projects by the public sector positively impacts fertilizer use by farm households in Nigeria. Farm households in communities that had at least one agricultural service project provided by the public sector are about 1.33 times more likely to use fertilizer compared to households in communities that did not receive such projects. However, there is a negative and statistically significant coefficient for the interaction of this variable with the "poor farmer" dummy (representing households in the first and second income quintiles), indicating that poorer farm households are less likely to be targeted. Together, these results suggest that wealthier households are more likely to benefit from agricultural service projects provided by the public sector. This finding has two important implications. First, the differences in the odds ratios of fertilizer use between wealthier and poorer households are much greater in communities that received at least one agricultural service project. Second, all other things being equal, poor households in communities with at least one agricultural service project are likely to have a lower odds ratio of fertilizer use compared to their counterparts in communities without any agricultural service project. Given that these projects mainly focus on the provision of subsidized fertilizer to farmers, one can expect that such projects might have crowded out the private sector, and thus could actually lower the likelihood of fertilizer use by poor farmers. This finding is consistent with previous reports indicating that public-sector efforts at improving input supply can crowd out the private sector and reduces overall fertilizer use in some areas (Xu et al. 2009; Kelly et al. 2003). It is worthy to note that the results also suggest that use of credit and agricultural extension services positively correlate with fertilizer use. The estimates from the three-level random coefficient model suggest that households that report using credit and extension services are about 1.3 times more likely to use fertilizer.

Further, the overall impact of access to all-season roads on fertilizer use appears to be insignificant, which is surprising given previous reports suggesting that access to roads can drastically reduce the cost (and thus increase the use) of modern inputs (Gregory and Bumb 2008; Dercon et al. 2008). However, the results from the two- and three-level random coefficient models suggest that the relationship between road access and fertilizer use is heterogeneous across states. The standard deviation of the slope of access to roads, which can be interpreted as the residual variability in the impact of road access on fertilizer use across states, is estimated at 0.42 (model F3). This deviation slightly decreases to 0.37 when the three-level model is estimated. These findings suggest that although the mean slope for access to all season roads is statistically insignificant, the state-specific slopes vary significantly. The state-specific slopes for road access (which are not reported here) show that the impact of road access on fertilizer use is positive in six states (Adamawa, Bauchi, Borno, Nasarawa, Oyo, and Yobe), negative in eight states (Anambra, Edo, Enugu, Kaduna, Plateau, Rivers, Zamfara, and FCT), and statistically insignificant in the remaining 23 states. Arguably, this heterogeneity might be due to differences in the development of road networks, in that some states may have developed roads in areas of high agricultural potential, while other states may have built roads away from such areas.

Further, the results suggest that household size and the household head's level of education have positive impacts on fertilizer use, while the household head's age has a negative impact on fertilizer use. Moreover, the household income has a positive impact on input use, with the estimated coefficients suggesting that households in the lower income quintiles are significantly less likely to use fertilizer compared to households in the upper income quintiles. For example, all other things being equal, the farm households in the lowest quintile are about three times less likely to use fertilizer compared to farm households in the fifth income quintile. The analysis also reveals that households whose heads practice agriculture as a main activity are 1.4 times more likely to use fertilizer than other households. Households with a civil servant in residence are also more likely to use fertilizer. Furthermore, the operational land holding size is found to positively affect fertilizer use; a unit change in the log of operational land holdings, conditional on the mean values of the other regressors, increases the likelihood of fertilizer use by 1.2 times. Finally, the results also indicate that farmers in the Rainforest zone are less likely to use fertilizer compared to farmers in the other agro-ecological zones. These results are robust and consistent across all estimated models.

7. CONCLUSIONS

Despite Nigeria's relatively impressive growth rate in recent years, poverty remains widespread. The good news is that a key driver of recent growth in the country has been the agricultural sector, which holds the most promise in reducing poverty. Recognizing this, the government has initiated and endorsed many national and international programs to support agricultural growth, including NEEDS II and the recent food security and agricultural development strategy developed under the CAADP framework. This study first analyzes the agricultural growth that will be required among different agricultural subsectors in order to achieve the agricultural development goals set by these programs. To accomplish this, we develop an economy-wide, dynamic general equilibrium (DCGE) model for Nigeria and use this model for a series of scenario assessments. The modeling analysis yields important findings that will be helpful in setting growth priorities among different agricultural subsectors.

First, an agricultural development strategy must set subsectoral-level growth targets that realistically consider both the initial conditions and the growth potential of a given subsector. Agricultural potential is an important condition, but it should not be used alone when determining targets. Furthermore, growth targets should be productivity-driven because increased agricultural production through land expansion is likely to be costly, and may not be sustainable.

This study emphasizes the following four factors as being important when prioritizing agricultural growth at the subsectoral level: (i) the size of an individual subsector in Nigeria's agricultural economy (which can be measured by its share in agricultural GDP); (ii) the growth-multiplier effect of this subsector through its linkages with the rest of the economy; (iii) the poverty-reduction-growth-elasticity of growth primarily led by this subsector; and (iv) the market opportunities and price effects of individual agricultural commodities.

In terms of the first factor, the subsector size matters because if a subsector is small, even setting (and achieving) a very high growth goal may have only a small economy-wide impact. Our DCGE modeling simulations show that even double-digit growth in a small subsector (e.g., wheat or sugar) may have a negligible (or nonexistent) contribution to overall agriculture or the whole economy. On the other hand, a large agricultural subsector (e.g., rice or cassava) can create more economy-wide growth if it becomes the leading force in the growth process.

When setting priorities, policy makers should also consider the growth-multiplier effects among different agricultural subsectors. A subsector that has strong linkages with the rest of the economy can generate larger economy-wide gains than a subsector having weak linkages with the economy. A subsector that can stimulate domestic demand either through agro-processing or by generating income for a majority of farmers (e.g., cassava or poultry) often has a stronger multiplier effect on overall growth than a subsector that is only exported as primary materials.

A negative price effect is often an indicator of fewer market opportunities, and the constraints posed by this situation should be taken into account when designing an agricultural strategy. Growth is not only determined by productivity in the production processes of a targeted agricultural subsector, it is also constrained by market opportunities. Often, both domestic and export (or import substitution) market opportunities are interrelated with the development of related agro-processing industries, trade policies in both domestic and international markets, and the market access conditions faced by producers. Thus, agricultural growth needs to be supported by pro-agriculture investments and interventions outside agriculture. This is key for the successful implementation of an agricultural strategy.

The pro-poorness of an agricultural subsector's growth should be the top agenda in an agricultural strategy. Although agricultural growth is generally pro-poor, different types of agricultural growth can lift varying numbers of people out of poverty (in total and in different locations) depending on the country's poverty distribution across regions and among households. Carefully assessing and taking advantage of the linkages between subsectoral-level agricultural growth and poverty reduction at both the national and regional (state) levels will be important when policymakers seek to ensure that the resulting agricultural growth will be pro-poor.

Given Nigeria's size and constitutional structure, the country's agricultural performance is not solely dependent on the strategies set by the federal government; the state governments are equally important players in determining the direction of agricultural development. Since this study was constrained by the lack of information on state-level policies and other economic data, we herein discuss only country-wide agricultural growth options. While additional studies are warranted at the state level, some of our national-level results may also be useful at the state level, in terms of priority setting in an agricultural strategy. Moreover, the inter-linkages between strategies at the state and federal levels are another important aspect of strategic analysis for agricultural development.

The second part of this study focuses on the public investments that will be required to support the desired agricultural growth acceleration and poverty reduction. Our investment analysis shows that required growth in agricultural spending and the share of such spending in total government spending depend critically on two important factors: (i) the efficiency of agricultural investments; and (ii) the interaction of agriculture and nonagriculture in both broad economic activities and government investments. Growth in the agricultural sector and the rural economy depends on public investments in both agriculture and nonagriculture, and it is necessary to consider possible increases in nonagricultural spending (e.g., on infrastructure, education and health) when estimating required agricultural spending, as the results will be quite different when possible impacts of increased nonagricultural spending on agricultural growth are not taken into account. With the current inefficient agricultural spending patterns in Nigeria, the required growth in agricultural spending is extremely high (between 17.5 and 23.8 percent), and the government resources needed to support the accelerated agricultural growth will reach 18 percent of total spending by 2017. In view of the country's recent spending trends, it is obviously unlikely for the Nigerian government to increase agricultural spending at such a high pace over the next years. The higher required agricultural spending growth will, in turn, drive rapid growth in total spending. If we take the indirect effect of nonagricultural spending on agricultural growth into account, but do not assume improvements in spending efficiency, the rate of required growth in total spending is even higher. Clearly, the Nigerian government must improve its investment efficiency through improved budgetary process, timely release of funds, greater transparency, and strengthened accountability of public spending in the sector in order to effectively support the accelerated agricultural growth needed to help the country meet MGD1. Increasing agricultural investment efficiency by 70 percent (i.e. the marginal effect of spending on agricultural growth rises from the current 0.24 to 0.41) will significantly decrease the required growth in both agricultural spending and total spending, yielding goals that may be more realistically achievable by mobilizing additional resources generated by the economic growth.

The third part of the study uses household-level data to focus on the interaction of agricultural service provisions and the increased use of modern inputs to improve agricultural productivity. This empirical analysis reveals that access to agricultural services (e.g., extension and credit) is still very limited in Nigeria, and that there are considerable variations in such access across the geopolitical zones and states of Nigeria. This situation is obviously not consistent with the targeted growth in agriculture, for which strong public intervention in agricultural service provision is required. Our between-state analysis of the variations in the provision of agricultural service projects shows that about 49 percent of communities in Nigeria received at least one agricultural service project between 2001 and 2005. However, the provision of agricultural service projects varied significantly across the states of Nigeria. There was also a significant correlation (0.62) in the provisions of government-run and private sector-run projects.

We also found a strong positive relationship between agricultural service access and agricultural input (fertilizer) use, further emphasizing the importance of improving agricultural service provision for accelerated agricultural growth. Again, the analysis reveals significant differences in input use across the states of Nigeria. These differences are robust even after we control for important household- and community-level characteristics. The differences in fertilizer use are especially disturbing given that the federal government emphasizes fertilizer distribution and targets sizeable expenditures toward fertilizer subsidies.

While the empirical findings in the third part of the paper could not be directly applied to the public investment estimation in the second part of the paper due to the qualitative nature of the data, certain similarities may be seen in the results of these analyses. For example, the efficiency of spending on agricultural services is low in Nigeria, whether measured by a low growth-to-spending elasticity or by a low access rate of farmers to agricultural services. Obviously, improvements in the efficiency of spending and agricultural service provision among the three tiers of government will be necessary if the country hopes to achieve the agricultural growth and poverty reduction goals set by the federal government.

APPENDIX A: MATHEMATICAL PRESENTATION OF THE DCGE MODEL OF NIGERIA

Table A.1. DCGE model sets and parameters

Symbol	Explanation	Symbol	Explanation
Set			
$a \in A$	Activities	$c \in CT(\subset C)$	Transaction service commodities
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CX(\subset C)$	Commodities with domestic production
$c \in C$	Commodities	$f \in F$	Factors
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$i \in INS$	Institutions (domestic and rest of world)
$c \in CDN(\subset C)$	Commodities not in *CD*	$i \in INSD(\subset INS)$	Domestic institutions
$c \in CE(\subset C)$	Exported commodities	$i \in INSDNG(\subset INSD)$	Domestic non-government institutions
$c \in CEN(\subset C)$	Commodities not in *CE*	$r \in R$	Subnational regions/zones
$c \in CM(\subset C)$	Aggregate imported commodities		
$c \in CMN(\subset C)$	Commodities not in *CM*	$h \in H(\subset INSDNG)$	Households
Parameters			
$cwts_c$	Weight of commodity c in the CPI	$qdst_c$	Quantity of stock change
$dwts_c$	Weight of commodity c in the producer price index	$\overline{qg}_c$	Base-year quantity of government demand
ica_{ca}	Quantity of c as intermediate input per unit of activity a	$\overline{qinv}_c$	Base-year quantity of private investment demand
$icd_{cc'}$	Quantity of commodity c as trade input per unit of c' produced and sold domestically	$shif_{if}$	Share for domestic institution i in income of factor f
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	$shii_{ii'}$	Share of net income of i' to i (i' ∈ INSDNG'; i ∈ INSDNG)
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	ta_a	Tax rate for activity a
$inta_a$	Quantity of aggregate intermediate input per activity unit	$\overline{tins}_i$	Exogenous direct tax rate for domestic institution i
iva_a	Quantity of aggregate intermediate input per activity unit	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$\overline{mps}_i$	Base savings rate for domestic institution i	tm_c	Import tariff rate
$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tq_c	Rate of sales tax
		$trnsfr_{if}$	Transfer from factor f to institution i

Table A.2. DCGE model elasticities, coefficients, and exogenous variables

Symbol	Explanation	Symbol	Explanation
Greek symbols (elasticities and shift coefficients)			
α_a^a	Efficiency parameter in the CES activity function	δ_{cr}^t	CET function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor *f* in activity *a*
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity c for household h
α_c^q	Armington function shift parameter	θ_{ac}	Yield of output c per unit of activity a
α_c^t	CET function shift parameter	ρ_a^a	CES production function exponent
β^a	Capital sectoral mobility factor	ρ_a^{va}	CES value-added function exponent
β_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	ρ_c^{ac}	Domestic commodity aggregation function exponent
δ_a^a	CES activity function share parameter	ρ_c^q	Armington function exponent
δ_{ac}^{ac}	Share parameter for domestic commodity aggregation function	ρ_c^t	CET function exponent
δ_{cr}^q	Armington function share parameter	η_{fat}^a	Sector share of new capital
υ_f	Capital depreciation rate		
Exogenous variables			
$\overline{CPI}$	Consumer price index	$\overline{MPSADJ}$	Savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	Change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_f$	Quantity supplied of factor
$\overline{FSAV}$	Foreign savings (FCU)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	Government consumption adjustment factor	$\overline{WFDIST}_{fa}$	Wage distortion factor for factor f in activity a
$\overline{IADJ}$	Investment adjustment factor		
pwe_c	Export price (foreign currency)	pwm_c	Import price (foreign currency)

Table A.3. DCGE model endogenous variables

Symbol	Explanation	Symbol	Explanation
Endogenous variables continued			
AWF^{a}_{ft}	Average capital rental rate in time period t	QG_{c}	Government consumption demand for commodity
$DMPS$	Change in domestic institution savings rates (= 0 for base; exogenous variable)	QH_{ch}	Quantity consumed of commodity c by household h
DPI	Producer price index for domestically marketed output	QHA_{ach}	Quantity of household home consumption
EG	Government expenditures	$QINTA_{a}$	Quantity of aggregate intermediate input
EH_{h}	Consumption spending for household	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
EXR	Exchange rate (LCU per unit of FCU)	$QINV_{c}$	Quantity of investment demand
$GSAV$	Government savings	QM_{cr}	Quantity of imports of commodity c
QF_{fa}	Quantity of factor demand		
MPS_{i}	Marginal propensity to save for domestic non-government institution (exogenous variable)	QQ_{c}	Quantity of goods supplied to domestic market (composite supply)
PA_{a}	Activity price (unit gross revenue)	QT_{c}	Quantity of commodity demanded as trade input
PDD_{c}	Demand price for commodity produced and sold domestically	QVA_{a}	Quantity of (aggregate) value-added
PDS_{c}	Supply price for commodity produced and sold domestically	QX_{c}	Aggregated quantity of domestic output of commodity
PE_{cr}	Export price (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity c from activity a
$PINTA_{a}$	Aggregate intermediate input price for activity a	RWF_{f}	Real average factor price
PK_{ft}	Unit price of capital in time period t	$TABS$	Total nominal absorption
PM_{cr}	Import price (domestic currency)	$TINS_{i}$	Direct tax rate for institution i (i ∊ INSDNG)
PQ_{c}	Composite commodity price	$TRII_{ii'}$	Transfers from institution i' to i (both in the set INSDNG)
PVA_{a}	Value-added price (factor income per unit of activity)	WF_{f}	Average price of factor
PX_{c}	Aggregate producer price for commodity	YF_{f}	Income of factor f
$PXAC_{ac}$	Producer price of commodity c for activity a	YG	Government revenue
QA_{a}	Quantity (level) of activity	YI_{i}	Income of domestic non-government institution
QD_{c}	Quantity sold domestically of domestic output	YIF_{if}	Income to domestic institution i from factor f
QE_{cr}	Quantity of exports	ΔK^{a}_{fat}	Quantity of new capital by activity a for time period t

Table A.4. DCGE model equations

Production and price equations	
$QINT_{c\,a} = ica_{ca} \cdot QINTA_{a}$	(1)
$PINTA_{a} = \sum_{c \in C} PQ_{c} \cdot ica_{ca}$	(2)
$QVA_{a} = \alpha_{a}^{va} \cdot \left(\sum_{f \in F} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_{a}^{va}} \right)^{-\frac{1}{\rho_{a}^{va}}}$	(3)
$W_{f} \cdot \overline{WFDIST}_{fa} = PVA_{a} \cdot QVA_{a} \cdot \left(\sum_{f \in F'} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_{a}^{va}} \right)^{-1} \cdot \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_{a}^{va}-1}$	(4)
$QF_{f\,a} = \alpha_{f\,a}^{van} \cdot \left(\sum_{f' \in F} \delta_{f\,f'\,a}^{van} \cdot QF_{f'\,a}{}^{-\rho_{f\,a}^{van}} \right)^{-\frac{1}{\rho_{f\,a}^{van}}}$	(5)
$W_{f'} \cdot WFDIST_{f'\,a} = W_{f} \cdot WFDIST_{f\,a} \cdot QF_{f\,a} \cdot \left(\sum_{f'' \in F} \delta_{f\,f''\,a}^{van} \cdot QF_{f''\,a}{}^{-\rho_{f\,a}^{van}} \right)^{-1} \cdot \delta_{f\,f'\,a}^{van} \cdot QF_{f'\,a}{}^{-\rho_{f\,a}^{van}-1}$	(6)
$QVA_{a} = iva_{a} \cdot QA_{a}$	(7)
$QINTA_{a} = inta_{a} \cdot QA_{a}$	(8)
$PA_{a} \cdot (1 - ta_{a}) \cdot QA_{a} = PVA_{a} \cdot QVA_{a} + PINTA_{a} \cdot QINTA_{a}$	(9)
$QXAC_{a\,c} = \theta_{a\,c} \cdot QA_{a}$	(10)
$PA_{a} = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(11)
$QX_{c} = \alpha_{c}^{ac} \cdot \left(\sum_{a \in A} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}{}^{-\rho_{c}^{ac}} \right)^{-\frac{1}{\rho_{c}^{ac}-1}}$	(12)
$PXAC_{a\,c} = PX_{c} \cdot QX_{c} \left(\sum_{a \in A'} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_{c}^{ac}} \right)^{-1} \cdot \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_{c}^{ac}-1}$	(13)
$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_{c} \cdot ice_{c'c}$	(14)
$QX_{c} = \alpha_{c}^{t} \cdot \left(\sum_{r} \delta_{cr}^{t} \cdot QE_{cr}^{\rho_{c}^{t}} + (1 - \sum_{r} \delta_{cr}^{t}) \cdot QD_{c}^{\rho_{c}^{t}} \right)^{\frac{1}{\rho_{c}^{t}}}$	(15)
$\frac{QE_{cr}}{QD_{c}} = \left(\frac{PE_{cr}}{PDS_{c}} \cdot \frac{1 - \sum_{r} \delta_{cr}^{t}}{\delta_{c}^{t}} \right)^{\frac{1}{\rho_{c}^{t}-1}}$	(16)
$QX_{c} = QD_{c} + \sum_{r} QE_{cr}$	(17)

Table A.4. Continued

Production and price equations	
$PX_c \cdot QX_c = PDS_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr}$	(18)
$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c}$	(19)
$PM_{cr} = pwm_{cr} \cdot (1 + tm_{cr}) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c}$	(20)
$QQ_c = \alpha_c^q \cdot \left(\sum_r \delta_{cr}^q \cdot QM_{cr}^{-\rho_c^q} + (1 - \sum_r \delta_{cr}^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}}$	(21)
$\frac{QM_{cr}}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \sum_r \delta_{cr}^q} \right)^{\frac{1}{1+\rho_c^q}}$	(22)
$QQ_c = QD_c + \sum_r QM_{cr}$	(23)
$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + \sum_r PM_{cr} \cdot QM_{cr}$	(24)
$QT_c = \sum_{c' \in C'} \left(icm_{cc'} \cdot QM_{c'} + ice_{cc'} \cdot QE_{c'} + icd_{cc'} \cdot QD_{c'} \right)$	(25)
$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c$	(26)
$DPI = \sum_{c \in C} PDS_c \cdot dwts_c$	(27)
Institutional incomes and domestic demand equations	
$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa}$	(28)
$YIF_{if} = shif_{if} \cdot \left[YF_f - trnsfr_{ro\,wf} \cdot EXR \right]$	(29)
$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR$	(30)
$TRII_{ii'} = shii_{ii'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'}$	(31)
$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot (1 - MPS_h) \cdot (1 - \overline{tins}_h) \cdot YI_h$	(32)
$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m \right)$	(33)
$QINV_c = IADJ \cdot \overline{qinv}_c$	(34)
$QG_c = \overline{GADJ} \cdot \overline{qg}_c$	(35)

Table A.4. Continued

$EG = \sum_{c\in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI}$	(36)
System constraints and macroeconomic closures	
$YG = \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{c\in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c\in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f\in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR$	(37)
$QQ_c = \sum_{a\in A} QINT_{c\,a} + \sum_{h\in H} QH_{c\,h} + QG_c + QINV_c + qdst_c + QT_c$	(38)
$\sum_{a \in A} QF_{f\,a} = QFS_f$	(39)
$YG = EG + GSAV$	(40)
$\sum_{r\ c\in CMNR} pwm_{cr} \cdot QM_{cr} + \sum_{f\in F} trnsfr_{row\,f} = \sum_{r\ c\in CENR} pwe_{cr} \cdot QE_{cr} + \sum_{i\in INSD} trnsfr_{i\,row} + FSAV$	(41)
$\sum_{i\in INSDNG} MPS_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c\in C} PQ_c \cdot QINV_c + \sum_{c\in C} PQ_c \cdot qdst_c$	(42)
$MPS_i = \overline{mps}_i \cdot \left(1 + MPSADJ\right)$	(43)
Capital accumulation and allocation equations	
$AWF^a_{f\,t} = \sum_a \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right]$	(44)
$\eta^a_{f\,a\,t} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{AWF^a_{f\,t}} - 1 \right) + 1 \right)$	(45)
$\Delta K^a_{f\,a\,t} = \eta^a_{f\,a\,t} \cdot \left(\frac{\sum_c PQ_{c\,t} \cdot QINV_{c\,t}}{PK_{f\,t}} \right)$	(46)
$PK_{f\,t} = \sum_c PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}}$	(47)
$QF_{f\,a\,t+1} = QF_{f\,a\,t} \cdot \left(1 + \frac{\Delta K^a_{f\,a\,t}}{QF_{f\,a\,t}} - \upsilon_f \right)$	(48)
$QFS_{f\,t+1} = QFS_{f\,t} \cdot \left(1 + \frac{\sum_a \Delta K_{f\,a\,t}}{QFS_{f\,t}} - \upsilon_f \right)$	(49)

Microsimulation Model

While the impact of agricultural growth on the poor can be partially captured by the DCGE model simulations, assessing the impact of growth on headcount poverty reduction depends on the availability of data that fully capture the country's poverty distribution. A simple microsimulation module that links with the DCGE model was created for this purpose, based on the Nigeria Living Standards Survey (NLSS 2003/04), the most recent national living standard survey in the country. Specifically, as household groups in the DCGE model are aggregated from the sample households in NLSS 2003/04, with their weights defined in the survey, each sampled household (with its weight) in NLSS 2003/04 can be traced to a particular household group defined in the DCGE model. The levels and consumption shares for the same commodities consumed by each sampled household are also defined using the more detailed consumption information included in the survey. Using such information, we create a utility (welfare) function for each sampled household in which the levels of consumption (in real terms) for all commodities become variables, while the by-commodity shares of consumption expenditure are parameters. This group of micro-level utility functions defined for the sampled households (which are the same as those in NLSS 2003/04), together with the household, zone, and rural/urban identifications, form a microsimulation module that we use to re-calculate the poverty headcount in each DCGE model simulation.

Changes in the sampled households' total expenditures[25] over time (measured as changes in the utility function) cause some poor households to eventually become non-poor, when their total expenditure increases to a level above the poverty line. With some poor households moving from the poor to the non-poor group, the country's poverty headcount declines over time. To determine which sampled households' total expenditures eventually rise to a level above the poverty line, it is necessary to link the changes in individual sampled households' total expenditures (as a utility function in the microsimulation module) to the change in households' consumption expenditures in the DCGE model (an endogenous outcome of the model simulation). To do this, we assume that the sampled households' consumption levels for each individual commodity change proportionally to the level of the aggregate household group's consumption of the same commodity, especially given that each household group in the DCGE model is aggregated from the same sampled households in the microsimulation module. This top-down linkage from the consumption pattern of a particular aggregate household in the DCGE model to that of a group of sampled households in the microsimulation module allows the microsimulation module to reflect the differential income and price effects across the sampled households when determining the new levels and patterns of consumption expenditures (and welfare levels). However, as the consumption of the sampled households in a particular group is proportional to that of the particular aggregated household representing them in the DCGE model, the microsimulation module is unable to capture the income-distribution effects within each group. With this caveat in mind, the microsimulation module yields a new level of total expenditure for all sampled households, allowing us to re-calculate the poverty headcount for different types of rural and urban household groups as well as for the country as a whole.

[25] Total expenditure is used to determine whether a particular sampled household is poor or not. Here, the poverty line is defined according to total expenditure instead of household income, as the latter is often less accurate in living standard surveys, compared to the level of total expenditure.

APPENDIX B: ESTIMATED ELASTICITY OF AGRICULTURAL TFP WITH RESPECT TO AGRICULTURAL AND NONAGRICULTURAL SPENDING

We estimate elasticities using time-series data on agricultural TFP from Nin and Yu (2008) as the dependent variable, and agricultural and nonagricultural spending data as the independent variables. Assuming the TFP function to be of the Cobb-Douglas type, we perform Ordinary Least Squares (OLS) regression using the following formula:

$$\ln(\text{TFP}) = \beta_0 + \beta_1 * \ln(E_{ag\ exp}) + \beta_2 * \ln(E_{nag\ exp}) + \varepsilon$$

where β_1 and β_2 are the "agricultural-growth-agricultural-expenditure elasticity" and "agricultural-growth-nonagricultural-expenditure elasticity," respectively, and ε is the error or disturbance term.

For comparison, we used two sets of spending data: (1) data from Fan et al. (2008); and (2) a combination of data from CBN (2009), CBN (2007, 2008), and IMF (various years). We also control for the three sub-periods (pre-SAP, SAP, and post-SAP) in the estimation by assigning dummy variables (i.e. sub-period = 1 if 1984 <= year <=1994; 0 otherwise). In total, we estimate 28 equations (e.g., we use both data sets to estimate 14 equations corresponding to the dummy variables)

The estimated coefficients are shown in Table A5. Even given the acknowledged lack of consistent and good quality agricultural spending data for Nigeria, the estimated elasticity shown under "data from Fan et al. (2008)" for β_1 (with a value of 0.236) seems to be reasonable. As explained in Section 5.3, the value of 0.462 for β_2 is not consistent with the historical trends of growth in agricultural and nonagricultural spending. A value of 0.14 for β_2 is instead used in the analysis and the calibration method used to obtain this value is discussed in Section 5.3.

Table A.5. Estimated elasticities of agricultural TFP with respect to agricultural and nonagricultural spending, 1980-2007

Dummy variable	Data from combined sources				Data from Fan et al. (2008)			
	β_1	P>|t|	β_2	P>|t|	β_1	P>|t|	β_2	P>|t|
(1) No dummy variable	0.033	0.673	0.546	0.008	0.045	0.530	0.520	0.011**
(2) = 1 if 1984 <= year <=1994; 0 otherwise	0.480	0.625	0.490	0.045	0.168	0.043**	0.214	0.357
(3) = 1 if year >= 1995; 0 otherwise	-0.127	0.029**	0.196	0.169	-0.120	0.117	0.156	0.374
(4) = 1 if 1984 <= year <= 1994 & year >=1995; 0 otherwise	-0.031	0.685	0.057	0.758	-0.069	0.852	0.013	0.972
(5) = 1 if year <= 1984; 0 otherwise	0.067	0.363	0.465	0.026**	-0.036	0.561	0.592	0.006***
(6) = 1 if 1984 <= year <= 1995; 0 otherwise	0.092	0.373	0.564	0.025**	0.193	0.021**	0.295	0.206
(7) = year <= 1984 & 1984 <= year <= 1995; 0 otherwise	0.084	0.209	0.081	0.620	0.022	0.646	0.238	0.096*
(8) = 1 if 1984 <= year <= 1996; 0 otherwise	0.174	0.109	0.721	0.006***	0.236	0.004***	0.462	0.045**
(9) = 1 if year <= 1984 & 1984 <= year <= 1996; 0 otherwise	0.086	0.267	0.070	0.711	0.034	0.529	0.257	0.109
(10)=1 if 1986 <= year <= 1994; 0 otherwise	0.043	0.651	0.571	0.011**	0.152	0.067*	0.426	0.037**
(11)= 1 if year >= 1995; 0 otherwise	-0.127	0.029**	0.196	0.169	-0.120	0.117	0.156	0.374
(12)= 1 if 1986 <= year <= 1994 & year >= 1995; 0 otherwise	-0.018	0.749	0.084	0.512	-0.063	0.733	0.003	0.989
(13)= 1 if year >= 1994; 0 otherwise	-0.111	0.023**	0.271	0.030**	-0.083	0.216	0.258	0.107
(14)= 1 if year >= 1996; 0 otherwise	-0.158	0.012**	0.135	0.372	-0.168	0.032**	0.070	0.696

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

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