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Options for Agricultural Growth for Poverty Reduction in Nigeria

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Development Strategy and Governance Division
International Food Policy Research Institute (IFPRI)
and
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THE NIGERIA STRATEGY SUPPORT PROGRAM (NSSP)

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- Enhanced knowledge, information, data, and tools for the analysis, design, and implementation of pro-poor, gender-sensitive, and environmentally sustainable agricultural and rural development polices and strategies in Nigeria;
- Strengthened capacity for government agencies, research institutions, and other stakeholders to carry out and use applied research that directly informs agricultural and rural polices and strategies; and
- Improved communication linkages and consultations between policymakers, policy analysts, and policy beneficiaries on agricultural and rural development policy issues.

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Contents

Acknowledgements v
Abstract vi
I. Introduction 1
II. Modelling Agricultural Growth and Poverty Reduction 1
III. Poverty Reduction under Nigeria's Current Growth Path 4
IV. Accelerating Agricultural Growth and Poverty Reduction 13
V. Conclusions 31
References 34
Appendix: Mathematic Presentation of the DCGE Model of Nigeria 36

List of Tables

Table 1 Growth decomposition in model simulations 6
Table 2: GDP growth rates in the baseline and CAADP scenario 9
Table 3: Production targets at the subsector level 15
Table 4: Current and potential yield for selected crops 16
Table 5: Crop yield, area and production and CAADP targets and growth rates at national level 17
Table 6: Model growth scenarios 19
Table 7: Sub-sectors' contribution to agricultural CAADP growth 22
Table 8: Regional level poverty reduction with CAADP growth 25
Table 9: Poverty-growth elasticity and growth multipliers 27
Table 10: Summary of factors affecting priority setting in an agricultural strategy 33
Table 11 : DCGE model sets and parameters 36
Table 12: DCGE model elasticities, coefficients and exogenous variables 37
Table 13: DCGE model endogenous variables 38
Table 14: DCGE model equations 39

List of Figures

Figure 1: Poverty rate in the baseline scenario 12
Figure 2: Regional poverty rate in the baseline scenario 13
Figure 3: National poverty rate (%) under alternative agricultural growth scenarios 24
Figure 4: Level of selected agricultural prices in CAADP scenario 30

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Abstract

This study analyzes growth options in agricultural sub-sectors to accelerate overall economic growth and reduce poverty in Nigeria in the next nine years (2009-17) using an economy-wide, dynamic computable general equilibrium (DCGE) model. The model results show that if the individual agricultural subsectors' growth targets set by the Nigerian government can be achieved, the country will have 9.5 percent of agricultural annual growth and 8.0 percent of GDP growth in the next 10 years. The national poverty rate will fall to 30.8 percent by 2017, more than halving 1996's poverty rate of 65.6 percent, thereby accomplishing the objective for MDG1. The report emphasizes that in designing an agricultural strategy and in prioritizing growth, it is important to consider the following four factors at the subsector level: (i) the size of a subsector in the economy, (ii) growth multiplier effect through linkages of a subsector with the rest of the economy, (iii) poverty reduction – growth elasticity effect through growth primarily led by a subsector, and (iv) market opportunities and price effect for individual agricultural products.

Keywords: agricultural development, poverty reduction, dynamic general equilibrium model, Nigeria

I. Introduction

Poverty in Nigeria has been on the rise, up from 27.2 percent of the population (18 million people) in 1980 to 54.4 percent (69 million people) in 2004 (NBS 2005). Though poverty fell after 1996, in which the poverty rate of 65.6 percent was the highest since 1980, the most recent household survey indicates that the national poverty rate of 54.4 percent in 2004 is still higher than the poverty rate in 1992 (which was 42.8 percent, NBS 2005).[1] On the other hand, relatively impressive economic growth rates from 2000 – 2007 have been recorded. Compared to the periods of 1990 – 1994 and 1995-1999, where the economy grew at 2.6 percent and 3.0 percent per year respectively, GDP annual growth rate rose to 7.3 percent in the period of 2000-2007. While growth is necessary for the country's development, its impact on poverty reduction can be quite different. The good news is that a key driver of the recent growth in Nigeria has been the agriculture sector. Between 1990 and 2006, the agriculture sector accounted for 47 percent of national growth while oil accounted for 39 percent. Hence, in spite of the high dependence of government revenue and national export earnings on the oil sector, the most important source of growth in recent years has been the agriculture sector.

The agricultural sector is not only the most important non-oil economic activity in Nigeria; it is also the single largest employer of labor forces (70 percent according to NBS, 2006). Thus, the agricultural sector is often seen as important for reducing poverty (Agenor et al, 2004]. In recognition of the importance of the agriculture sector in Nigeria, the government has initiated and endorsed many national and international projects, programs, and policies aimed at rapidly growing the sector and reducing poverty. These include the National Economic Empowerment and Development Strategies (NEEDS I and NEEDS II), the implementation of Comprehensive Africa Agriculture Development Program (CAADP), the Seven-Point Agenda, and the National Food Security Program (NFSP), as well as product specific programs, like the presidential initiatives on cassava, rice, and other crops. Despite these accomplishments, further efforts are needed to lift more people out of poverty and to meet MDG1 - that of halving the proportion of the people who live in poverty with income of less than one dollar a day.

Against this background, this study analyzes the agricultural growth options that can 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 policymakers and other stakeholders in making informed long-term decisions, an economy-wide, dynamic computable general equilibrium (DCGE) model for Nigeria is developed and used to analyze the linkages and trade-offs between economic growth and poverty reduction at both the macro- and microeconomic levels.

II. Modeling Agricultural Growth and Poverty Reduction

Previous CGE models for Nigeria

An economy wide CGE model is the proper tool for analyzing agricultural growth and investment options, as such a model captures synergies and trade-offs from accelerating growth in alternative agricultural subsectors and the economic inter-linkages between agriculture and the

[1] There are two more years in 1980s in which poverty rate is available. Poverty rate was 27.2 percent in 1980 and 46.3 percent in 1985. The poverty rate of 1992 is slightly lower than the level in 1985.

rest of the economy. There have been efforts of CGE modeling to study the Nigerian economy in the past and to use the models for analyzing the ability of agriculture and its different subsectors to achieve poverty and growth goals. These include Iwayemi (1995), UNDP (1995), 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 these models are at the national level (i.e., are not disaggregated to the regional economy) and are relatively aggregate in sector structure. Therefore they cannot be used to analyze agricultural policy issues. Iwayemi (1995), for example, discussed a quasi-CGE model designed to check the consistency of targets in the first prospective plan on agriculture during the 1990s. It is not clear if the model was eventually used to analyze agricultural policy issues. The UNDP (1995) CGE model and SAM, which was a follow up of Iwayemi (1995), included 52 sectors, some agricultural. However, there seems to be no policy analysis available using this model.

On the other hand, the NISER (Ajakaiye and Olomola, 2003) and NPC-CEAR (NPC, 2007) models have been successfully used to analyze 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 investment. 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 – 2011.

While the last two studies linked national growth to growth in economic variables and different sectors, they do not consider the agriculture sector in detail. Thus they are limited in their ability to assess the relative roles the different agriculture subsectors can play in accelerating agricultural growth and the economy as a whole. With regard to the poverty impacts, the NISER model was limited to concluding that the daily per-capita income would increase from US$1[2] in 2001 to $4.4 in 2015 given the assumed levels of economic variables and it is not clear how such a result is obtained in the model. As for the NEEDS II analysis, the existing modeling analysis did not clarify the poverty impact expected from the 10 percent economic growth. Another limitation is that both models were unable to apply the analysis to the more disaggregated households and hence, failed to discuss the impact of growth on different types of rural and urban households.

The new dynamic general equilibrium (DCGE) model and a micro simulation module for Nigeria

A new dynamic computable general equilibrium (DCGE) model for Nigeria was developed for this study. A static standard CGE model was developed in the early 2000s at the International Food Policy Research Institute (IFPRI) and has been documented in Lofgren (2000). The recursive dynamic version of the CGE model is based on this standard CGE model with the incorporation of a series of dynamic factors. The early version of this dynamic CGE model can be found in Thurlow (2004), while its recent applications include two country case studies, Zambia and Uganda, in Diao et al. (2007). The new DCGE model has captured trade-offs and synergies 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 also contains information on the non-agricultural sectors. While there are 62 production subsectors in our DCGE model, 10 more subsectors than the Iwayemi (1995) model, our DCGE model covers much more detailed agricultural activities,

[2] All dollars are U.S. dollars.

as more than half of the subsectors are agricultural. The examined agricultural crops fall into four broad groups (with the crops individually modeled): (i) cereal crops comprising: rice, wheat, maize, sorghum, and millet; (ii) root crops, such as cassava, yam, cocoyam, Irish potatoes, and sweet potatoes; (iii) other food crops, including plantains, beans, groundnuts, soybeans, other oil crops, groundnuts, vegetables for domestic, and fruits for domestic; and (iv) higher-value export-oriented crops, which are composed of cocoa, coffee, cotton, oil palm, vegetable for exports, fruit for exports, sugar, tobacco, cashew nut, other nuts, rubber, and other export crops. The DCGE model also identifies four primary livestock sectors, namely cattle, goat and sheep, poultry, and other livestock. To complete the agricultural sector, the model includes forestry and fisheries. Most of the agricultural commodities listed above are not only predominately consumed by households in Nigeria or for exports, but are also used as intermediate inputs into various processing activities in the manufacturing sector. The 10 agricultural processing activities (including eight as food processing) identified in the model are beef, goat and sheep meat, poultry meat, eggs, milk, other meat, beverage, other food, textile, and wood processing. The agricultural sectors themselves also use inputs produced from other non-agricultural sectors, such as fertilizer and transport and trade services crops (see Table 2 for the full list of crops, livestock products and non-agricultural subsectors included in the model).

The most important contribution of our DCGE model is capturing the regional heterogeneity of the Nigerian agricultural economy. In the model, the agricultural production is disaggregated across six zones in Nigeria, wherein representative farmers produce different crops and livestock production 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 and commodity demand and prices by making decisions on how to allocate their land and family labor across different crops and livestock subsectors and to purchase other inputs including 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 that primarily occur in the urban areas or rural towns. Such opportunities are modeled from the demand side, that is, the representative producers in those nonagricultural sectors decide the amount of labor to be hired in making their production decisions, taking market wage rates as given. Thus, by capturing production structure at the sub-national regions, the DCGE model effectively integrates the information on the different agents and activities into an economy-wide model that can assess growth effects at the national and sub national levels. The new DCGE model for Nigeria is therefore an ideal tool for capturing the growth linkages, income and price effects resulting from growth acceleration in different agricultural sectors. The mathematic presentation of the DCGE model can be found in Appendix 1.

Finally, the DCGE model endogenously estimates the impact of alternative growth paths on the incomes of various household groups. These household groups are defined for the six zones and by rural and urban location. In total, there are 12 representative household groups included in the model. Each of the 12 households is aggregated from the Nigeria Living Standards Survey (NLSS 2003/04) such that all sample households in NLSS can be linked directly to their corresponding representative household in the DCGE model. The micro-simulation module that built on the entire NLSS sample households is linked to the DCGE model. In this formulation of macro-to-micro linkage, changes in representative households' consumption and prices in the DCGE model are passed down to their corresponding sample households in the micro-simulation module (the entire sample households of NLSS), where total consumption expenditure for each sample household is recalculated from the new level of consumption by individual commodities. This new level of per capita expenditure for each survey household is compared to the official poverty line and standard poverty measures are recalculated. Thus, the

estimated poverty measures are consistent with official poverty estimates, while changes in poverty draw on the consumption patterns, income distribution, and poverty rates across representative household groups are captured in the analysis.

Data

The data used to represent the base year of the model are drawn from a variety of data sources. The core dataset underlying the DCGE model is a new 2006 social accounting matrix (SAM) constructed using data of the national accounts and other trade data from Nigeria's National Bureau of Statistics (NBS) and information for balance of payments from the Central Bank of Nigeria (CBN). National and state level agricultural production and yield data and market price data are obtained from the Federal Ministry of Agriculture and Water Resources (FMAWR) (previously known as the Federal Ministry of Agriculture and Rural Development (FMARD)). Whenever production data are unavailable for certain crops (e.g., horticulture), information is taken from the Food and Agriculture Organization (FAO) of the United Nations. Agricultural production is then disaggregated across zones by mapping states to the six zones. The DCGE model is therefore consistent with official agricultural production levels and yields at the zonal level. Non-agricultural production, employment, and other value-added components of sectoral GDP data at the national level are compiled from national account tables (NBS, 2007). On the demand side, information on industrial technologies (e.g., intermediate and factor demand) is taken from an earlier SAM for Nigeria (UNDP, 1995), 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.

III. Poverty Reduction under Nigeria's Current Growth Path

Design of a baseline simulation to capture the growth trends

The DCGE model developed for this study is first used to simulate a base-run that captures the current growth and poverty reduction trends, taking into account the changing external environment such as the recent global financial crisis and the sharp decline in world crude oil prices. Recent changes in these external factors are expected to negatively affect Nigeria's economic 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 through their impacts on effective exchange rate, government expenditure, money supply, trade, and inflation (Akpan, 2009). Given that both the global financial crisis and declines in world crude oil prices are expected to last for a longer period, a modest targeted economic growth in the base-run simulation is considered. Such growth target is lower than 7.6 percent of annual growth recorded in 2002 – 2007 (CBN, 2009). Measured in real terms, while the crude oil sector's GDP only grew at 4.4 percent annually in this period, the sector's contribution to the overall economic growth is mainly channeled through increased oil revenue thanks to rising world oil prices. Given that this factor is unlikely to continue to play a key positive role in stimulating growth in the coming years and some of its effects may even become negative (e.g., declines in the government revenue generated from oil may constrain the government to increase growth-simulated related funds allocation), we targeted a modest GDP annual growth rate of 6.5 percent for the next 10 years (2008 – 2017) in the base-run simulation (Table 2). While this targeted base-run growth rate is lower compared with the recent growth performance of the Nigerian economy (2002-2007), it is still relatively high considering current external conditions in the world. Moreover, this growth rate is higher than the average growth rate in Nigeria's long-term history. For example, the average annual GDP growth rate is 5.5 percent in 1995-2007 (CBN, 2009).

A relatively modest growth in the agricultural sector is also considered in the base-run. Besides the reason explained above for the growth projection of the general economy, there is another factor that reminds us to be cautious in projecting agricultural growth. In the national account tables, reported growth in agricultural GDP is high between 2002 and 2007, at 6.7 percent annually. Such rapid growth in agricultural GDP is neither consistent with individual crop production data obtained from the FMAWR nor with the market situation (for example price situation) for major food crops in the domestic markets. In terms of production reported by FMAWR for selected main crops produced by smallholders, the average annual growth rate is 5.5 percent in 2000-2006. Such growth is primarily driven by area expansion, while in terms of yield increase growth is very modest. For example, the FMAWR data shows that cassava yield's annual growth rate is 0.9 percent, and it is 0.3, 0.4 and 0.8 percent for sorghum, millet and maize, respectively for the same period. These four major food crops in total account for more than 50 percent of agricultural area under cultivation in the recent years. With such information taken into account, we chose a set of more realistic growth rates for each individual crop or livestock product, which results in an annual agricultural growth rate of 5.7 percent in the baseline scenario, similar to that in the period of 2000 – 2007.[3]

Factors determining the growth in the model

To model a realistic baseline, it is also important to pay attention to the sources of growth 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 growth in total labor supply is consistent with projected growth in population, which is 3.0 percent annually.[4] Three types of labor are distinguished in the model: (i) rural family labor employed in agricultural production only; (ii) unskilled labor that can freely move across sectors (i.e. can move between agricultural and nonagricultural production); and (iii) skilled labor employed in the nonagricultural sector only. While growth in the total labor supply is consistent with the historical trend (3.0 percent annually), by taking into account more rapid growth in the nonagricultural sector's labor demand, growth in the two economy-wide labor categories,

[3] National Bureau of Statistics has been aware that there might be some problems in agricultural crop GDP calculation in this period, particularly in 2002. This table documented such problems:

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) , National Accounts of Nigeria Pages 61-62

[4] Different population growth rates have been estimated in Nigeria. According to NBS (2007) and the National Population Commission (2002), annual growth rate is 2.83 percent in 1991 – 2005, while the Census figures show a 3.07 percent annual growth between 1991 and 2006.

unskilled and skilled labor, is assumed to be 3.3 percent and 3.4 percent, respectively, while a much slower growth of 2.0 percent annually is assumed for the rural family labor supply.[5]

The total land expansion for 2009-2017 at the zonal level is also 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 the FMARD recorded data in 2001-2006 and land expansion is assumed to eventually fall to 4.2 percent after 2011, which is still relatively high. The average annual growth rate of land expansion, thus, is 4.8 percent (Table 1). Because of the lack of information and knowledge for the existence of land expansion potential at the zonal level, we have to assume a uniform growth rate across the six zones. Given that the agricultural production activities are modeled at the zonal level in our model, it is straightforward to adopt a different land expansion rate once such information is available.

Table 1 Growth decomposition in model simulations

	GDP		**AgGDP**		**NonagGDP**	
	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
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				
Ag labor	2.2	2.1				
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: Nigeria DCGE model results

The capital accumulation is an endogenous outcome of savings and investments, which is modeled recursively in our model. Investment is financed through private savings which is determined by a fixed proportion of total income (an endogenous variable) received by each of the 12 representative households, and government savings which is a residue term between government income (an endogenous variable) and total non-investment spending (an exogenous variable). Both private and public saving rates are calibrated to the 2006 SAM.

5 Without information about growth for different types of labor supply in the country, we have to make such an assumption for labor growth across different categories. This assumption, however, is consistent with the general trends in many developing countries.

Investment is also affected by the foreign capital flows. Since Nigeria has run a trade surplus in recent years, the net foreign capital inflows are negative in the model (which indicates capital outflows). In the recursive dynamic model, such outflow is an exogenous variable and growth of the outflows is assumed to decline due to the expected slow growth in oil exports. With this assumption, more oil revenues are expected to be used in financing domestic investment instead of purchasing foreign bonds or investing in foreign capital markets in the current situation. In the baseline, capital accumulates at 4.6 percent each year in real terms after 5.0 percent of depreciation (Table 1).

While total factor supply grows either exogenously (labor and land) or endogenously (capital), their demand at the sector level is endogenous. Factor demand is determined by the competiveness in factor markets and the profitability of each individual sector. The third part of Table 1 also reports the growth rate in aggregate labor and capital demand by agriculture and non-agriculture. As shown in the table, the model results show that total agricultural labor demand grows at 2.2 percent annually, but it is 3.7 percent for the nonagricultural sector. While growth rate of total agricultural capital demand is higher than that of total nonagricultural capital demand (6.7 percent vs. 4.5 percent, respectively), as agricultural capital accounts for a very small portion of total capital input, even with such rapid growth, share of capital in agricultural GDP is still very small, accounting for less than 5.0 percent of agricultural GDP (while capital accounts for more than 60 percent of nonagricultural GDP, see Table1, first part).

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

While productivity growth is a driving force of growth at the sector level, growth is also affected by demand. If the supply of a specific commodity cannot meet with enough demand either in domestic or foreign markets through trade, price for this commodity in the domestic market falls, resulting in the reduction of factor demanded by the production of this commodity and hence lower growth rate of it.

We calculate the contribution of factors and productivity to the overall economic growth in Table 1. Factor contribution to growth depends on the growth rate of each factor and share of these factors in value-added. 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 growth in GDP in the baseline, 61.3 percent of growth is due to factor accumulation, while 38.7 percent comes from total factor productivity (TFP) growth (Table 1, second part). Growth contribution for agricultural and nonagricultural GDP is reported in the table. In the baseline, almost 60 percent of agricultural growth is due to land expansion, increased labor supply, and capital accumulation, whereas productivity can only explain 40 percent of growth. Within crop sectors, productivity gains come both from improvement in yield and more efficient allocation of land to produce those commodities with higher returns.

Growth at subsector level

While the overall growth in both GDP and the agricultural sector is targeted at 6.5 and 5.7 percent annually between 2009 and 2017 in the base-run, the growth rate is very different across sectors. This is because the input allocation across sectors differs over time as a result of different sectoral productivity growth and changes in prices. For example, while agricultural GDP grows at 5.7 percent annually, growth in total cereal value-added is 5.4 percent. It is 5.1

and 7.3 percent in rice and maize production, respectively, while growth in Irish potatoes is higher at 8.8 percent annually (Table 2)

Table 2 presents the base-run GDP growth rate for the subsectors included in the model, as well as for some groups of subsectors. All these growth rates are the endogenous results of the model. The first column of the table also reports the size of each sector as a share of the total GDP, which represents the initial structure of Nigerian economy in 2006.

Table 2: GDP growth rates in the baseline and CAADP scenario

	Share of GDP (%)	Annual growth rate, 08-17 (%)	
	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
Cocoyam	0.2	4.7	6.0
Potato	0.3	8.8	12.4
Sweet potato	0.6	4.7	7.0
Other food crops	7.6	5.7	8.1
Plantain	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

Table 2. GDP growth rates in the baseline and CAADP scenario (continued)

	Share of GDP	Annual growth rate, 08-17 (%)	
	In 2006	Baseline	CAADP scenario
Livestock	1.9	5.4	6.9
Cattle	0.6	5.5	6.4
Goat &sheep	0.9	5.1	6.5
Poultry	0.4	5.9	8.8
Other livestock	0.0	6.1	7.0
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 meat	0.02	5.7	5.9
Beverage	0.3	7.3	7.7
Other food	0.4	8.1	8.6
Textile	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 industry	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
Hotel and restaurant	1.2	8.2	9.1
Communication	0.8	13.2	14.1
Finance and other business services	1.8	13.8	14.4
Restate	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

Source: Nigeria Social Accounting Matrix and CGE model results

Poverty reduction outcome in the baseline simulation

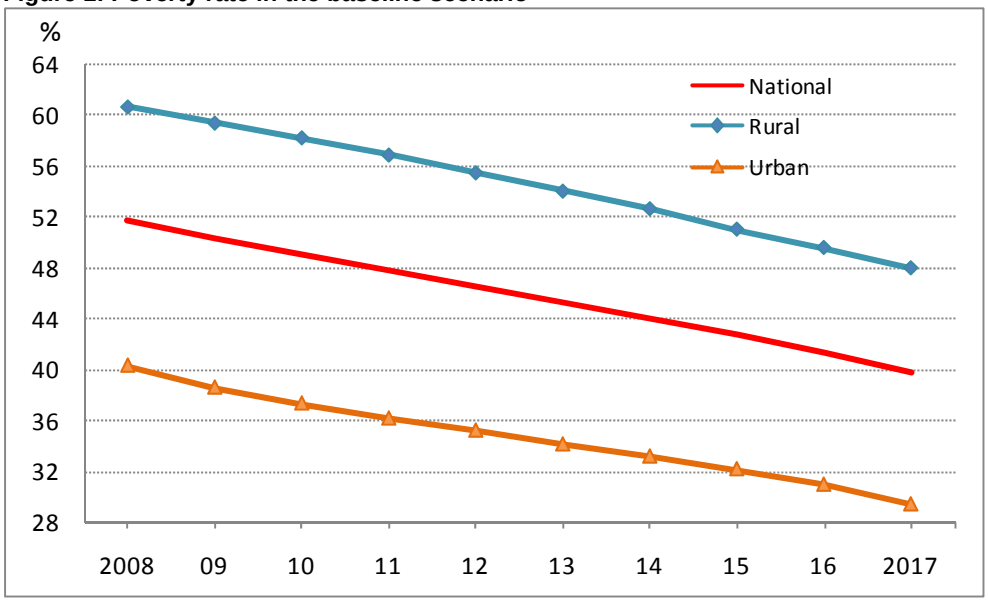
The poverty reduction impact of the economic growth is analyzed using a micro-simulation module in which all sample households of NLSS 2003/04 are included. By taking into account the consumption pattern at the micro level across households, change in the demand at the individual food commodity level for each sample household is determined by linking such demand with the representative households' demand for the same commodity in the DCGE model. As discussed in Section II, the representative households are actually aggregated from the sample households into the six zones and by rural and urban location. While such top-down linkages between the DCGE model and micro simulation module do not allow us to capture the distributional effect of growth within each zone's rural or urban household groups, they do capture certain differential welfare effects across zones and between rural and urban households.

Before the simulation exercise was started, the impact of growth on poverty reduction, using historical poverty data available for 1980, 1985, 1992, 1996, and 2004 at the national level, was assessed. However, because the poverty rate of 65.6 percent in 1996 is much higher than that in 1992 (42.7 percent), it makes the trend analysis difficult for a longer period. For this reason, we focus on the poverty rate in the recent period of nine years 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 in the same period. While the annual growth rate of GDP per capita is 2.5 percent (calculated from the CBN's GDP annual growth of 5.5 percent and population annual growth of 3.0 percent in this period), the total decline in the poverty rate is only 11.2 percentage points in 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 capital GDP (22 percent) in the same seven years, we derive a poverty-reduction-growth elasticity that equals to -0.78. This indicates that for a one percent growth in per capita GDP in Nigeria between 1996 and 2004, the poverty rate will fall by 0.78 percent from the level in 1996. While the elasticity is affected by the initial level of the poverty rate that is high in 1996 and pattern of the income distribution around the poverty income line, such elasticity is comparable with that obtained for other African countries.

The poverty-growth elasticity was also calculated using the results of model simulation for the baseline with the same formula. A similar elasticity, with the value of -0.851, was obtained. That is to say, for a one percent of growth in GDP per capita in the next 9 years along the base-run path in the model, the national poverty rate will fall by 0.851 percent. With such elasticity, the poverty analysis shows that with 6.5 percent of annual growth in total GDP and 5.7 percent of agricultural GDP growth in the next 10 years (2008 – 2017) (together with 3.0 percent of population annual growth in the same period), the national poverty rate would fall from 51.6 percent in 2008[6] to 39.4 percent by 2017 (Figure 1). While such a poverty rate is already lower than the poverty rate in 1992, in which the national poverty rate is 42.7 percent, given the 3.0 percent population growth per year, the number of the poor population will actually increase over time. The base-run result shows that by 2017, there will be 287 thousand more poor people than in 2008.

[6] Poverty rate in 2008 is also a model result.

Figure 1: Poverty rate in the baseline scenario

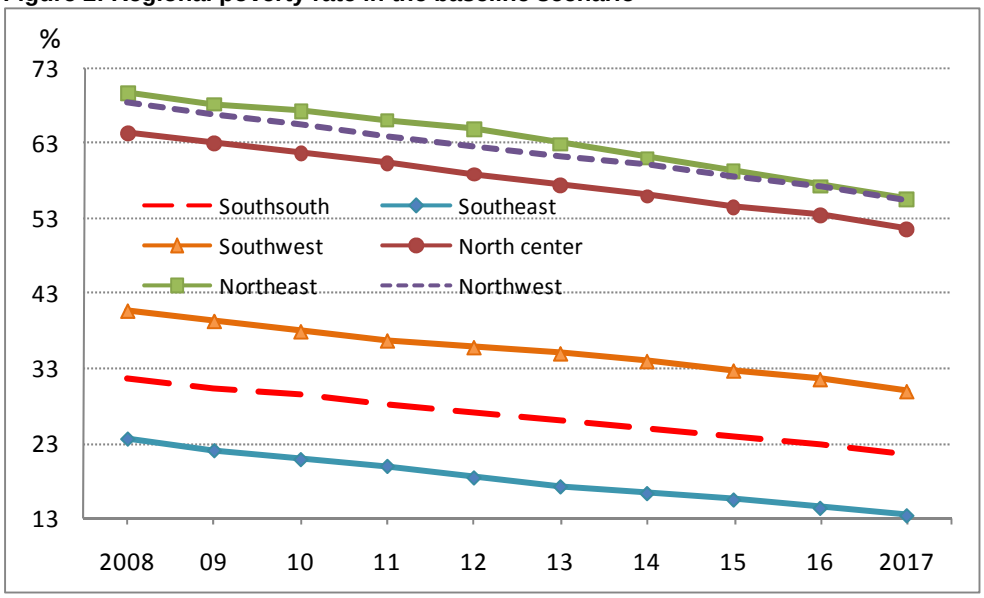


Source: Nigerian DCGE model results

Rural and urban poverty rates at the national level are also obtained in the base-run (Figure 1), as well as rates at the zonal level for the six regions (Figure 2). The NLSS data shows that in 2004, poverty in rural areas (63.3 percent) is worse than in urban areas (43.2 percent). These poverty rates are the starting point in the model and are used to determine the poverty rates in 2008 and subsequent years in the simulation. As shown in Figure 1, with 6.5 percent annual growth in total GDP and 5.7 percent of growth in agricultural GDP, the rural poverty rate falls to 47.9 percent and the urban poverty rate to 29.4 percent by 2017. Because the absolute decline in percentage points in the rural area is slightly higher than that in the urban area (12 vs. 11 percentage points of decline between 2008 and 2017), the poverty gap between the rural and urban is smaller (20.1 in 2008 vs. 18.5 percentage points in 2017).

As discussed in section one, the spatial pattern of poverty distribution shows a south– north disparity in the country, as the three regions in the south have poverty rates ranging from 27 to 43 percent while the range is 67 – 72 percent for the three regions in the north in 2004. Such a regional gap in poverty will continue in the next 10 years. The base-run model result shows that the poverty rate in the three southern regions will fall to 13.4 – 30.0 percent by 2017, but will remain as high as 51.5 – 55.6 percent in the three northern regions in the same year (Figure 2).

Figure 2: Regional poverty rate in the baseline scenario



Source: Nigerian DCGE model results

IV. Accelerating Agricultural Growth and Poverty Reduction

Going beyond the CAADP agricultural growth target

In the previous section, we described the results of the base-run scenario and estimated the impact of a growth path on poverty reduction that takes into account both Nigeria's past growth experience and changing external conditions. In this section, we examine the potential contribution of the different agricultural subsectors to help Nigeria achieve much higher overall agricultural growth and greater poverty reduction.

The CAADP initiative has set a target of 6 percent annual agricultural growth for African countries. Considering that recent agricultural growth in Nigeria is close to this CAADP target, the government has set a higher growth target of 10 percent. To meet the 10 percent of overall agricultural growth, a set of sector-specific growth targets are set for major crops and livestock production (NFSP 2008). Most targets at subsector level are for the sectors' output and growth in productivity (or yield) is only mentioned for cassava. Table 3 summarizes the production targets at the subsector level, together with their current level, both obtained from the drafted document of NFSP (2008).

Given the existence of a large yield gap between the current and potential levels for most crops (Table 4), the potential for agricultural growth in Nigeria is high. However, considering such a short period planned in NFSP (2008), the targeted growth seems to be unrealistic for most food crops if such growth will primarily be achieved by increased productivity. According to a report published by ReSAKSS WA (2009), the potential high yields are often predicted under the more ideal conditions of controlled field trials. It is unlikely to achieve such yields at the national level in a short period. It is also difficult to realize a nationwide adoption of improved seed and modern technology that are the precondition for reaching such high yield potential. Such constraints seem not to have been taken into account when the production targets were designed. For example, in NFSP (2008), cassava yield and production are both targeted to

double in a period of four years (2008 – 2011) nationwide, which indicates an annual growth rate of 19.5 percent. While we design a scenario that we call CAADP growth scenario based on the targets set in NFSP (2008), we apply such targets to a relatively longer period from 2009 to 2017. Hence, to meet a similar target, e.g., in the case of cassava, the annual growth rate is about 8.9 percent in our model. The second part of Table 3 reports the modeled growth rate for the crops and livestock products with government targets.

For the 29 crop subsectors included in the model, there are only 10 crops for which production targets are available in NFSP (2008), together with targets for five livestock products and the fishery sector. To model the accelerated growth in these crop and livestock production in the CAADP scenario, additional land expansion is assumed for some crops (rice, wheat, cocoa, sugar and oil palm), while for the other crops, livestock and fishery, additional growth is assumed only from productivity improvement (increases in yield in the case of crops). While production targets are not available for many other crops included in the model, given that many of them are large subsectors in the agricultural economy (e.g., maize, sorghum, yam, pulses, and oilseed crops), additional productivity growth is also assumed for these crops in this simulation; changes in the land and labor supply are not targeted at the subsector level for them. Instead, such changes will be determined endogenously within the model.

Table 3: Production targets at the subsector level

	Targets defined in NFSP				CGE model results		
	2006 level Million mt	Level by 2011 Million mt	Total increase (08-11, %)	Annual growth (08-11, %)	Level by 2017[7] Million mt	Total increase (09-17, %)	Annual growth (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
Tomato	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 Kernel	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
Goat	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
Pig	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: NFSP (2008) and Nigeria DCGE model results

[7] The base year (2008) level of rice and millet is much higher than that reported in NFSP due to different data sources.

Table 4: Current and potential yield for selected crops

	Current yield (mt/ha)	Potential yield (mt/ha)
Rice	1.9	7.0
Cassava	12.3	28.4
Maize	1.4	4.0
Sorghum	1.1	3.2
Millet	1.1	2.4
Yam	12.3	18.0
Irish Potato	7.6	10.5
Soybean	1.2	2.0
Beniseed	0.6	1.0
Melon	0.4	0.5
Cocoa	0.2	2.0
Cowpea	0.5	2.3
Okra	3.1	5.5

Sources: the current yields are obtained from Nigeria Federal Ministry of Agriculture and Water Resources and the Central Bank of Nigeria; and the potential yields are from a report published by ReSAKSS WA (2009).

Taking maize as an example, according to the data obtained from FMARD (2007), the current yield at the national level is around 1.4 ton per hectare (mt/ha). Under the base-run scenario we assume that average maize yield for the next ten years would grow at 0.3 percent annually, which is consistent with yield growth in the last 9 years (1999-2006) in the country. With such growth, level of maize yield will be unlikely to change in the next 10 years and growth in maize production is going to be primarily driven by area expansion. Under the CAADP scenario, we model a slightly ambitious maize yield improvement with an annual growth rate of 2.9 percent per year (Table 5). This implies that national average maize yields 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 wherein improved technology and practice was employed (Valencia and Breth, 1999). As discussed above, the majority of potential high yields are either achieved under “ideal” conditions in agriculture research stations or on-farm trials. The 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 are different from traditional methods farmers normally use at present (ReSAKSS WA, 2009). Because potential yields require better technology, farming knowledge, and market conditions, we deem it unrealistic to assume that such high levels of yields would be realized at the national level in a period of 10 years. However, despite projecting conservative crop yields in the CAADP scenario, the annual growth rates to achieve such targeted yields are already higher than the historical trends, as shown in Table 5. Clearly, achieving the target yields is a daunting task.

Table 5: Crop yield, area and production and CAADP targets and growth rates at national level

	Crop yields				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
Cocoyam	0.6	2.5	0.8	3.4	5,027	7.0	4.2	4.7	3,047	6.8	8.2
Potato	8.9	5.7	18.8	8.7	226	0.3	2.6	2.7	2,003	8.5	11.6
Sweet potato	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											
Plantain	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 are obtained from Nigeria Federal Ministry of Agriculture and Water Resources and the Central Bank of Nigeria; targeted yields, area, or production are based on a literature review of various Nigerian government documents in which different crop targets are included; growth rates are model results.

In order to assess the contribution of each agricultural product/subsector to the realization of the 10 percent of national growth goal for the overall agriculture and to the poverty reduction goal of MDG1, we design a series of scenarios in which growth in some major crops or a group of crops or livestock products are individually simulated, assuming growth in the rest of the crops/subsectors at their base-run level. Table 6 summarizes these scenarios. Design of these scenarios is based on whether there are specific targets set by the government at either commodity/subsector level in recent years. However, for those commodities in which the target information is not available (e.g., plantain), we consider a reasonable growth rate in the CAADP scenario. The choice of the growth rate is mainly based on the potential market demand driven by household income growth in a way that prices for these commodities will not rise dramatically.

In each scenario listed in Table 6, additional growth in productivity (or yield) is assumed to occur only in the crop production or subsectors targeted, while productivity growth for the non-targeted crops or subsectors is assumed to be the same as those 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 all other crops as well as for any non-crop subsectors and productivity growth in those subsectors other than maize.

While productivity growth in an agricultural subsector can be assumed exogenously, it does not imply that there is no growth impact on any other subsectors in which there is no additional productivity growth exogenously assumed. Other sector's growth is affected through the linkage effects captured in the general equilibrium model. The 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 with increased income. Because of the complex general equilibrium linkages, growth in the subsectors, other than the targeted subsector, can be affected positively or negatively. For example, if increased maize supply can easily find demand in the market (domestically or internationally) and maize price will not fall significantly, maize production will compete with other crop production for more resources (land or labor) and intermediate inputs (fertilizer and so on), such that growth in some crop production, e.g. sorghum or millet, can be negatively affected. On the other hand, if there exist demand constraints in the market, either due to weak income elasticity of demand or lack of export or import substitution opportunities, domestic maize price will fall. So even if maize yield rises, maize output can increase less than the growth in yield. In this case, resources (land, labor and other inputs) will be released from maize production while production of other crops may increase. This complex linkage effect implies that while yield or production targets can be set individually for a specific crop or subsector on the supply side, the realization of such targets is jointly determined by supply and demand in the market. Therefore, policies affecting demand (including market development and access) are equally important for meeting CAADP goal in agricultural growth.

Table 6: Model growth scenarios

	Growth is led by												
	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							×						×
Cocoyam							×						×
Potato							×						×
Sweet potato							×						×
Plantain													×
Beans								×					×
Groundnuts								×					×
Soybeans								×					×
Other oilseeds								×					×
Vegetable, domestic													×
Vegetable, export									×				×
Fruit, domestic													×
Fruit, export									×				×
Cocoa									×				×
Coffee									×				×
Cotton									×				×
Oil palm									×				×
Sugar									×				×
Tobacco									×				×
Nuts									×				×
Cashew nuts									×				×
Rubber									×				×
Other export crops									×				×
Cattle										×			×
Goat &sheep										×			×
Poultry										×			×
Other livestock										×			×
Fisheries											×		×
Forestry												×	×

We first focus on the overall simulation result of comprehensive CAADP scenario for the economy as a whole. If the growth rates set for the individual crops and agricultural subsectors can be achieved in the next 9 years, Nigerian agricultural GDP will grow at 9.5 percent annually in this period, which is more than four percentage points higher than the base-run growth (Table 2). Through the economy-wide effect, additional growth also occurs in the non-agricultural sectors that have close linkages with the agricultural sector. As shown in Table 1, accelerated agricultural growth is mainly driven by productivity. Total factor productivity in the agricultural sector grows at 5.6 percent annually in this scenario, instead of 2.3 percent in the baseline. Contribution of TFP to agricultural GDP growth, thus, rises to 69.4 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 baseline), less labor is employed in the agricultural sector (agricultural labor growth rate falls to 2.1 percent, from 2.2 percent annually in the baseline). Productivity-led agricultural growth also benefits growth in the non-agricultural sector. TFP annual growth in the nonagricultural sector rises to 3.0 percent, from 2.5 percent in the baseline. The pace of capital accumulation also rises, which allows total capital and hence capital employed in the non-agricultural sector to grow more rapidly than that in the baseline.

Sectoral level growth is further discussed in Table 2, in which the detailed list of agricultural subsectors and agriculture-related food processing sectors (beef, goat and sheet meat, poultry meat, eggs, milk, other meat, beverage, other food) and non-food agricultural related sectors (textile and wood processing) is included. The economy-wide impact of CAADP growth (both directly and indirectly) results in an increase in total GDP annual growth rate from 6.5 percent in the base-run to 8.0 percent in the CAADP scenario. More than 75 percent of GDP growth is the direct outcome of accelerated agricultural growth, while the other 25 percent comes from the increase in non-agricultural sectors' growth via the linkages effect.

Subsector's contribution to the accelerated agricultural growth

Table 7 reports the contribution of each agricultural subsector in reaching the 10 percent agricultural GDP growth target (column 5). First, we group the agricultural subsectors into six groups; they are cereals, root crops, other food crops, high-value crops, livestock, and other agriculture. The subsector's contribution to the overall agricultural growth is determined by (i) its size in the economy measured by its share of agricultural GDP, (ii) its baseline growth trend, and (iii) the possible additional growth in the future. All these factors are reported in the table.

The results in Table 7 show that accelerated growth in cereal crop production, particularly in rice, contributes the most to the overall agricultural growth under CAADP scenario. The cereal crop production, as a whole, contributes 30.9 percent of accelerated agricultural growth under CAADP and rice alone contributes 14.5 percent. This is expected given that cereal crops are the second most important agricultural subsector in the economy after root crops (accounting for 25.9 percent of initial agricultural GDP in 2006) and have the highest growth targets in NFSP (2008). For example, the target for rice production by 2017 requires almost 10 percent of annual growth between 2009 and 2017. Among the five cereal crops included in the model, wheat has the highest growth rate in the CAADP scenario because of the self-sufficient target set for wheat in NFSP (2008). To meet such an ambitious target, wheat is modeled to grow at 26 percent each year in the next nine years. However, because the size of this sector is relatively small in total agriculture, even with such extremely rapid growth, its growth contribution to overall growth is the smallest among the cereals (0.8 percent in total).

After cereals, root crops are the second most important group that contributes to agricultural growth, despite the fact that this group is the largest subsector in agriculture, currently comprising 31.6 percent of agricultural GDP. Among the five root crops included in the model, only cassava has a set national target in NFSP (2008). We thus assume modest additional growth in the other four roots and tubers, but because their growth is relatively lower than the growth in most cereal crops, the root crops as a whole only have 2.9 percent of additional annual growth in this scenario. The subsector contributes 29.1 percent of agricultural growth. Given its large size in the agricultural economy, cassava is still the second most important contributor to growth, accounting for 14.1 percent of accelerated agricultural growth and yams ranks third with contribution of 12.2 percent.

With diverse diet and agricultural food production in Nigeria, there are also many food crops that are important for both food security and poverty reduction. We put them into a subgroup called ‘other food crops,’ which, in total, accounts for 25.7 percent of agricultural GDP, the third largest subgroup after roots and cereals. Consistent with its rank in size, the other food crops group is the third most important contributor, with 18.4 percent of accelerated growth in agriculture, explained by the growth in this subsector.

Table 7: Sub-sectors' contribution to agricultural CAADP growth

	Share in AgGDP (%) 2008	Base growth rate (%) 2009-17	Additional growth in CAADP (%) 2009-17	Contribution to AgGDP growth (%) 2009-17
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
Cocoyam	0.7	4.7	1.3	0.3
Potato	1.0	8.8	3.6	1.1
Sweet potato	1.9	4.7	2.2	1.4
Other food crops	25.7	5.7	2.4	18.4
Plantain	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 crops	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
Goat &sheep	3.1	5.1	1.4	1.3
Poultry	1.2	5.9	2.8	1.1
Other livestock	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: Nigeria SAM and DCGE model results

Notes: Share in the first column of the table is calculated from the new Nigerian SAM. The third column is the difference between the baseline and CAADP growth rates in Table 2. The sectoral contr bution to agGDP growth in the last column of the table is roughly equal to the multiplication of columns 1 and 3 normalized by the additional growth of overall agricultural GDP.

There are 10 high-value crops included in the model, namely cocoa, coffee, cotton, oil palm, sugar, tobacco, nuts, cashew nuts, rubber, and other export crops. Most of these crops are export-oriented and they are either currently important export crops or used to be in the past. The 10 crops, all together, account for 4.9 percent of agricultural GDP and they are actually the smallest group of agricultural subsector in the economy. High growth is assumed for these crops driven by the extremely high growth in sugar to meet the target set in NFSP (2008). As a group, the additional annual growth rate under the CAADP scenario is 12 percent, rising from the base-run of 5.6 percent to 17.6 percent in the CAADP scenario. However, with their small sizes in the country's agricultural economy, these crops' contribution to accelerated agricultural growth at 10.9 percent is less important than each subsector of food crops and primarily comes from more than 30 percent of annual growth in sugar production.

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

NFSP (2008) has given fishery a high target in its output. For consistency, the CAADP scenario models a rapid growth in fisheries at 12.9 percent each year. With such growth, fisheries, which account for 3.5 percent of agricultural GDP currently, will contribute 7 percent of accelerated agricultural growth in the simulation. Forestry is the smallest subsector in broadly defined agriculture. With modest growth in this subsector, it only contributes less than one percent of agricultural total growth.

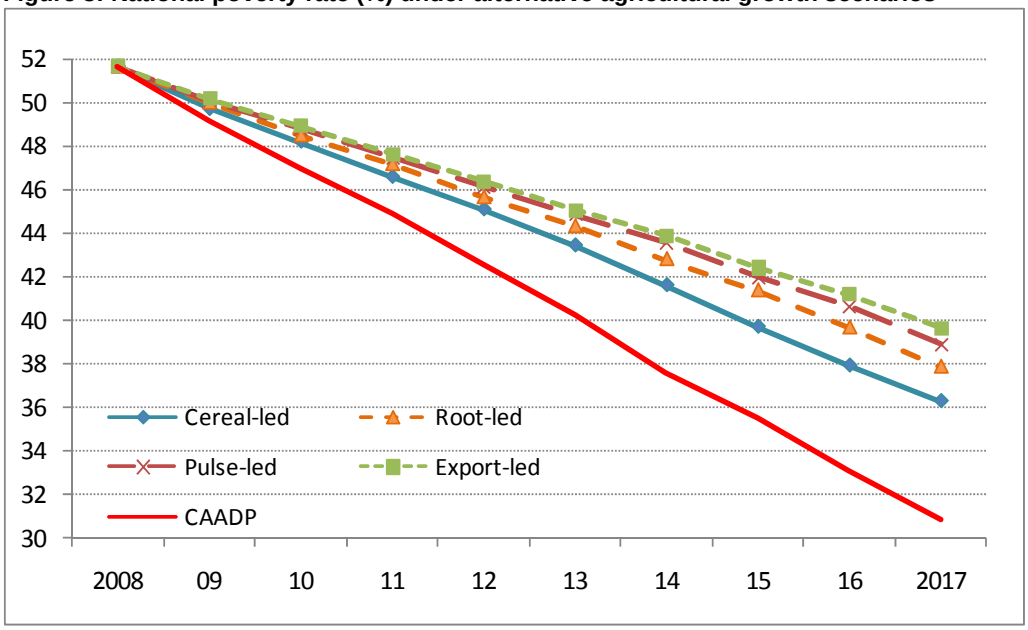
Accelerated agricultural growth and poverty reduction

The joint effect of 9.5 percent per year agricultural growth in the CAADP scenario and the spillover effects into non-agriculture cause poverty to decline by 20.8 percentage points by 2017, which is 8.9 percentage points lower than that in the baseline's 2017. 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. More poverty reduction occurs in the rural areas as the rural poverty rate declines by 23.3 percentage points by 2017 from its level in 2008, more than 10.6 percentage points lower than that in the base-run's 2017. In the urban area, poverty rate declines by 17.7 percentage points by 2017 and is 6.8 percentage points lower than that in the base-run for 2017. If 1996's national poverty rate of 65 percent is chosen as the target for the MDG1, the results show that this poverty rate, indeed, will be halved by 2017, i.e. reduced to 30.8 percent by 2017 (and to 35.5 percent in 2015). The rural poverty rate is 69.8 percent in 1996. Although the speed of poverty reduction in rural areas is faster than in urban, the poverty rate under CAADP scenario will still be as high as 37.3 percent by 2017 and will not reach the MDG1 in the rural area. On the other hand, the poverty rate in urban areas will fall to 22.6 percent by 2017 (and 26.2 percent in 2015), declining more than 50 percent from its 1996 level. Thus, although the high agricultural growth will reduce the poverty gap between rural and urban areas, from 20.1 percentage points initially (in 2004) to 14.7 percentage points by 2017, the country faces the challenge of how to more rapidly reduce rural poverty in the next 10 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 increase in the number of the poor. Even

with 3.0 percent of annual population growth, the absolute number of the poor will fall to 59.7 million by 2017, from the current 77 million and 78.7 million in the base-run's 2017. Food security would also improve, with additional 140 kilograms of cereals and 300 kilograms of root products available for each Nigerian citizen by 2017, compared with their current per capita level.[8] Furthermore, while Nigeria will continue to import some cereal products, such as wheat and rice, the ratio of imports in domestic consumption will be substantially lowered under the CAADP scenario than that under the base-run.

Figure 3: National poverty rate (%) under alternative agricultural growth scenarios



Source: Nigerian DCGE model results

Faster agricultural growth benefits a majority of households. However, not all households will benefit equally from achieving the crop and livestock growth targets under the CAADP scenario. For this reason, we also investigate the poverty impact at the zonal level for the six regions and results are reported in Table 8. The first two columns portray the poverty rates in 1996 and 2004 that are drawn from NLSS surveys in these two years. The third and forth columns report the poverty rates by 2017 in the base-run and CAADP growth scenarios. To make the comparison across regions easy to read, we also report the reduction in poverty rates as percentage points and percent change due to accelerated agricultural growth under the CAADP scenario, both compared with 1996 and base-run's 2017. These numbers are found in the last four columns of the table. We also include the national poverty rates for the country as a whole and for rural and urban areas separately in the first part of the table (rows 1–3). As seen in Table 8 and also discussed in the previous chapter, there exists significant spatial disparity in Nigeria's poverty distribution. NLSS (2003/04) indicates that three regions in the north have higher poverty rates than the other three in the south, although such regional disparity is less significant in 1996 (see columns 2 and 3 of table). The regional disparity in poverty distribution will not be able to change in both the base-run and in the CAADP growth scenario. For example, the highest regional poverty rate in 2004 is in the Northeast (72.2 percent). This situation will continue until

[8] They are measured as primary products used as inputs into food processing and livestock production, as well as directly consumed.

2017 in either the base-run or CAADP growth scenarios. The spatial poverty gap, measured by the difference between the highest regional poverty rate in Northeast and the lowest poverty rate that is in Southeast, is 45.5 percentage points in 2004 (the most recent year in which the poverty information is available). By 2017, the poverty gap is smaller in both the base-run and CAADP scenarios, but will still be as high as 43.8 and 35.2 percentage points, respectively. Measured by the percent change from the 1996 level of poverty, it is reasonable to believe that for the southern regions accelerated high agricultural growth will allow them to achieve the MDG1 goal of halving the 1996 poverty rate by 2015. However, this will not be the case for the three northern regions, in which the poverty rate, by 2017, will still be as high as 42-44 percent. Thus, MDG1 is far away from being achieved for the three northern regions.

Table 8: Regional level poverty reduction with CAADP growth

			Poverty level by 2017 (%)		Poverty reduction (percentage points)		% change in poverty level	
	1996	2004	Base-run	CAADP growth	from 1996	from base-run's 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 center	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

It has to be pointed out that 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, initial condition and growth potential are very different between the north and south. Analysis of the NLSS (2003/04) and Core Welfare Indicator Questionnaire (2006) data shows that initial production conditions, such as access to fertilizer and other growth opportunities, are much worse in the north than in the south. Without special attention paid to the northern regions in terms of public investment, modern input access, and other input/output market development, the growth opportunities may further be biased towards the south. Unless given priority by the government, the poverty reduction goal will be more difficult to achieve in the north, where the current poverty rate is already worse than in other parts of the country.

Growth multipliers and contribution of subsectors' growth to poverty reduction

The previous section highlighted the potential contributions of different crops and subsectors in increasing agricultural growth and poverty reduction. Understanding the magnitude of poverty reduction led by a specific sector's growth in the economy is important for the country to design pro-poor growth strategies. In this sub-section, we further analyze these linkages by calculating poverty-growth elasticity that focuses on the pro-poorness of growth and growth multipliers that allow the comparison of the spillover effect of growth in various subsectors. These elasticities and multipliers are endogenous outcomes from our model results. Poverty-growth elasticity is

also affected by the growth incidence at the household level, as growth affects individual households differently due to heterogeneity in their income sources and consumption patterns. Constrained by the data, we cannot capture differential income structure at the individual household level and analyze the poverty impact of such an income structure with different growth options. Moreover, in the CGE model, the households are grouped into 12 representative household groups defined by six zones and rural or urban location and changes in either income or consumption occur endogenously only among these 12 household groups. Lacking further disaggregation of the representative households in the model, according to other social and economic indicators, e.g. by sources of income, types of farms, gender, and so on, many household characteristics that are important factors explaining growth and poverty relationships are not taken into account in the analysis. Keeping these caveats in mind, the poverty-growth elasticity should be seen as a first effort to link growth at the agricultural subsector level with the poverty reduction at the national and regional levels in an economy-wide framework.

As we briefly mentioned in the previous section, 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 one percent increase in GDP per capita. The second column of Table 9 shows the calculated poverty-growth elasticities under the different growth scenarios. For example, the value of -0.928 in column one indicates that for a one 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 point) per year.

As seen in column one, the value of the poverty reduction elasticities from growth led by different agricultural subsectors is all greater than the base-run elasticity of -0.851, the only exception in which growth is led by export crops. This confirms that growth in agriculture, particularly in staples, is indeed pro-poor. Comparison across 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 other crop and livestock subsectors. For example, a one percent increase in GDP per capita led by increases in cereal production causes the national poverty rate to decline by additional 1.024 percent from its level in the base-run. The second highest poverty reduction elasticity is the growth led by the root crops, with an elasticity of -0.923 percent.

Table 9: Poverty-growth elasticity 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		
Fish-led	-0.896	1.084	1.027
Forestry-led	-0.861		
CAADP	-1.144		
Nonagr-led	-0.730	1.012	

* Growth multiplier is measured by how many units of increased real GDP or AgGDP as the results of one unit increase in the output (measured as real terms of value-added) of a specific agricultural sub-sector.

Source: Calculated from Nigeria DCGE model results

More important is that the model results show that the poverty-growth elasticity significantly increases under the CAADP scenario, rising to -1.144 percent, indicating the strong synergy effect in poverty reduction across growth from different agricultural subsectors. For comparison purpose, we also report the poverty-reduction-growth elasticity for the overall growth led by the growth in the nonagricultural sector in the last row of the table. It shows that the elasticity in this case is much lower, at -0.73 percent. These results 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 sector than led by the non-agricultural sector. Such model results have strong implications in designing Nigeria's development strategy as well as public funding allocations to finance the implementation of the strategy. The model results indicate that to meet the MDG1, a non-agricultural led growth strategy in Nigeria would require more financial supports (around 50 – 60 percent more expensive) than an agricultural growth strategy. Moreover, there is no evidence that non-agricultural spending is much more effective than the agricultural spending in stimulating growth and reducing poverty. Indeed, the opposite seems to be true: public agricultural spending seems to be much more effective at achieving overall growth, as well as more pro-poor growth (Fan et al. 2005). The required public spending to support such an agriculture-led development strategy will be further analyzed in the next section of the paper.

Growth multiplier is the other important indicator to measure the differential contribution of agricultural growth at the subsector level to the broad economy-wide growth. We omit the

multiplier results for the cases in which growth is led by livestock and forestry because we also exogenously assume additional productivity growth in their relevant processing sectors in these scenarios. For example, in the livestock-led growth scenario, additional productivity growth in meat and milk processing is considered, while in the forestry-led growth scenario the wood processing growth is considered. Because additional productivity growth from these non-agricultural subsectors is assumed in these scenarios, it makes them difficult to compare with growth led by the crop subsectors and fishery.

Among the three groups of crops, the highest level of growth multiplier is for the growth led by pulses. This is true for the multipliers measured either by gains in total GDP or in agricultural GDP. The results indicate that a unit (not percentage, e.g. we can read it as one million Nigerian Naira) increase in pulse production (in terms of real value-added) results in 1.857 units (1.857 million Naira) in gains for the overall economy or 1.518 units for the agricultural GDP, all measured in real terms, i.e., additional 0.518 million Naira of agricultural GDP and 0.341 million Naira of non-agricultural GDP other than increased pulse output are generated due to growth in pulse production. Such a high multiplier indicates stronger linkages of pulse production with the rest of economic activities. In the root crop group, cassava has quite a high growth multiplier, as a one million Naira increase in cassava production generates 1.246 million Naira of GDP and 1.088 million Naira of agricultural GDP in the economy.

At the individual crop level, millet and sorghum have the strongest multiplier effect. A one million Naira increase in the output (value-added) of millet and sorghum generates an additional 1.79 million Naira of agricultural GDP and 0.85 million Naira of non-agricultural GDP, all in real terms. Linkages on supply side come from increased demand in intermediate inputs (backward linkages), providing more low cost inputs to other agricultural or food processing production (forward linkages), as well as releasing resources (land and labor) into production of other crops (factor mobility linkages). In a large size developing economy such as Nigeria, demand side linkages are strong and such linkages come through increased demand for other agricultural and non-agricultural commodities as the result of increased farmer incomes from the additional growth in some agricultural subsectors' production. However, in the case of millet and sorghum, for which the highest growth multiplier is obtained in the simulation, the main reason is factor mobility linkage effect. Millet and sorghum are income inelastic commodities, i.e., at higher income level, households spend less income to consume additional millet and sorghum and prefer to allocate more income into consumption of other food such as rice, wheat or livestock products. Growth in millet and sorghum supply due to increased productivity is not necessarily to be the same as growth in the two crops' yield, which implies less land and labor are needed to produce these two crops when their yield increases. When fewer resources are used to produce millet and sorghum without lowering the supply level of these two crops, i.e., when part of land and labor that initially is used for millet and sorghum production can be released and reallocated into production of other crops such as rice, maize, and wheat, the strong growth multiplier occurs. Thus, in the case of millet and sorghum, the model result seems to indicate that resources (primarily land) allocated to the production of these two crops are too much when these two crops' productivity is low. Thus, when these two crops become more productive, many other agricultural subsectors and the economy as whole get benefits through the multiplier effect of these two crops.

However, the value of the growth multiplier measured by gains in GDP in the case of growth led by export crops is smaller than 1. For example, the results in Table 9 show that increases in GDP and agricultural GDP are 0.7 and 0.974 units, respectively, with a unit of increase in export crop production. When the growth multiplier is less than one, it indicates that at the given level of resources, growth in some other sectors is negatively affected by the growth in the targeted

subsectors (export crops in this case).[9] The main reason is that domestic prices for export-oriented commodities are mainly determined in the international markets. With such price advantage, export-oriented sectors will compete with other sectors for resources (land, labor, capital and other inputs). At the given resource level, competition affects the factor prices, which in turn makes it difficult for the many other sectors to increase production. Of course, with fewer resources allocated, production in the other sectors falls. This result has important policy implications. While developing export-oriented agricultural production is often high on the agenda of the government, growth in such production will have weak linkages with the domestic economy, if there are no additional resources (land and labor) available in the country, or if export-oriented production cannot create domestic demand for such products (either through development of agro-processing or through consumers' demand). Focusing on export-oriented crops can also have possible negative effects on the growth outside the export-oriented production, which results in smaller economy-wide gains from such strategy.

Price effect of accelerated agricultural growth

Even if productivity led agricultural growth benefits a majority of households in both rural and urban areas, the negative price effect due to such growth can hurt some farmers. For those farmers who are unable to adopt the high-yield technology and still use traditional farming technology, lowered output prices due to more production from other more productive farmers implies that their revenues from producing the same amount of products 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 price), lowered output prices together with the higher input price, might make them less profitable despite using modern technology. Thus, it is necessary to assess the possible price effect from accelerated agricultural growth under the CAADP.

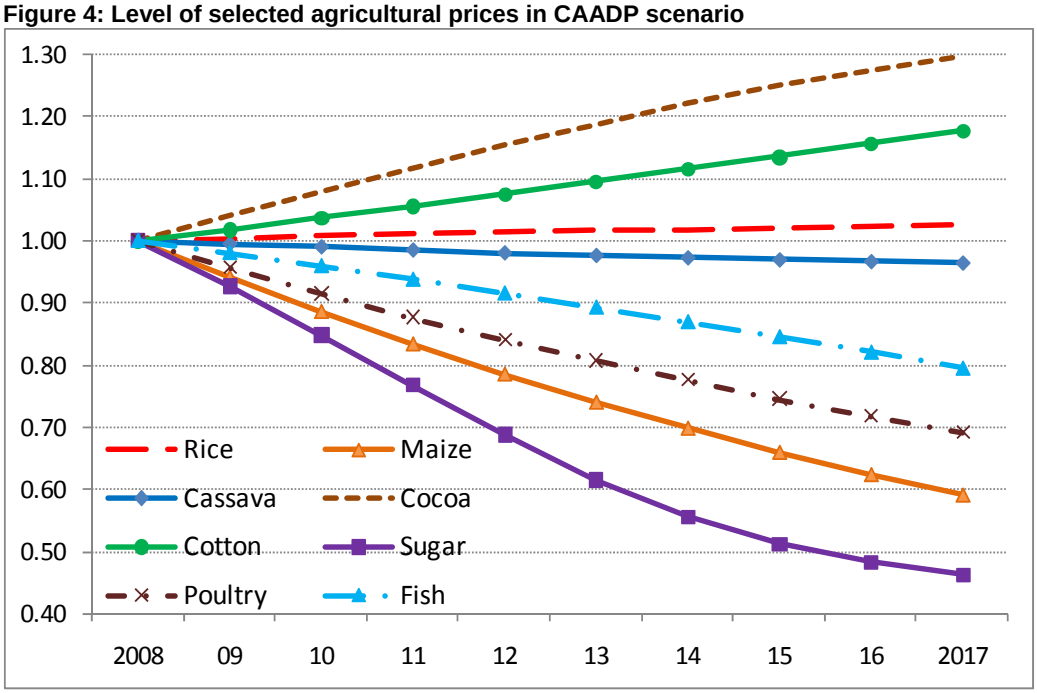
Figure 4 shows the price trends for selected agricultural products under the CAADP scenario. In the figure, prices for individual agricultural commodities are normalized by the CPI, which gives us a change in individual commodity's price relative to CPI, which represents the overall price level. It can be seen that in most cases, change in the prices is highly related to the magnitude of the growth in production of these products. Maize, sugar, poultry, and fish have annual growth rates between 9 and 32 percent and prices for these products fall the most. It also shows that price for rice, an import-substitutable crop with annual growth rate of 10.3 percent in the simulations, actually rises over time relative to CPI. As for export crops (cocoa and cotton) with annual growth rates also higher than 10 percent in the simulation, their prices (relative to the CPI) also rise overtime.

The price trends are also affected by the market demand for different commodities. If a commodity has higher income elasticity, or can be possibly substituted by imports or can be exported in an increased amount, its price will be less affected by the increased supply. The high-income elasticity implies that with increased income generated from growth (both in agricultural and nonagricultural activities), consumers prefer to allocate more of their income to consume such commodities. The income elasticity for primary agricultural goods is relatively high only in countries with average per capita income just barely able to meet the basic needs. However, in the case of Nigeria, with average per capita income higher than $1,000, it is unlikely to have high-income elasticity for most primary agricultural products. Although the income elasticities for the foods consumed by the poor consumers in rural and urban areas are

[9] In this study we assume that additional labor and land that are available in the economy are the same under all scenarios. That is, we compare growth multipliers from growth led by different agricultural subsectors but with similar amount of land and labor supply across scenarios. Thus, the estimated growth multiplier is much smaller than in the case without resource and labor constraints.

higher than that for the country as whole, they are unlikely to become the driving force in determining market demand given the current income distribution in the country.

Figure 4: Level of selected agricultural prices in CAADP scenario



*Note: Normalized by prices in 2008 and deflated by CPI

Source: Nigeria DCGE model results

However, besides import substitution (such as in the case of rice and wheat), there are market opportunities for agriculture by developing agro-processing industries in the country and by expanding the export market. Nigeria has the largest agro-processing industry in West Africa. The good news is that after going through certain processes, promising export opportunities for many staple commodities exist in both regional and global markets. An example is cassava, which accounts for the largest land allocation and highest agricultural value-addition in the country. Cassava chips and flour are excellent inputs for both feed and agro-processing sectors and are highly demanded in international markets as well. For instance, Thailand, which accounts for 10 percent of the world cassava production, exports 80 percent of its cassava products. Currently with around 22 million tons of cassava, traded mostly as chips and flour, Thailand occupies 70–80 percent of the world cassava market. In contrast, cassava in Nigeria is mainly for domestic food consumption. It is therefore reasonable to expect that with the adoption of high yield varieties, 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 growth multiplier and poverty reduction elasticity of cassava-led growth will further increase.

Another example is the poultry sector. The results of our model show that the poultry price will fall significantly when a high growth in poultry is targeted. However, we should also point out that current domestic poultry prices are not competitive and without border protection in imports, the domestic poultry price should not be as high as its current level. The model result actually shows that only through improving the poultry sector's productivity can the country eventually get rid of the import restriction, such that poultry can become an export commodity to neighboring countries in West Africa. Development of a modern poultry industry provides the

country not only great export opportunities in poultry products, but also creates more domestic demand for maize and other crops as poultry feed, which will further enhance the linkage and multiplier effects in the entire economy. The successful experience of Thailand becoming a large poultry exporter since the late 1980s does show such possibilities. The rapid growth in poultry exports has created a big market for maize in the country. Before that, feed demand in Thailand accounted for only a small portion of maize production (3–7 percent), a similar situation in Nigeria today. With the development of the poultry industry, feed demand in Thailand now accounts for 70–80 percent of maize production (a tenfold increase over two decades). It is therefore reasonable to believe that development of the poultry sector in Nigeria offers an opportunity for maize production to grow, making it not only an important staple commodity for human consumption, but also an important cash crop for many smallholder farmers.

V. Conclusions

Based on the analysis in this paper, the following important messages will be helpful in designing an agricultural strategy in Nigeria.

Setting growth targets at agricultural subsector level that realistically take into account both initial conditions and growth potential is a necessary first step of an agricultural development strategy. Agricultural potential is an important condition, but it is not enough in determining the targets. Also, growth targets should be productivity driven, especially since growth through land expansion to increase agricultural production will be costly and unlikely to be sustainable.

The study shows that the following factors are important in prioritizing agricultural growth at the subsector level: the size of an individual subsector in the agricultural economy (share in agricultural GDP), the linkage effect of a subsector to the rest of economy (growth multiplier), the effectiveness of overall growth led by this subsector in poverty reduction (poverty reduction-growth elasticity) , and the market opportunities and price effect of this subsector's growth. Based on these four factors, Table 10 summarizes the findings of our analysis in this paper and the discussion of Table 10 is as following:

While a very high growth goal for a small subsector can be set, the economy-wide impact of this subsector's growth is often small. Growth in a relatively large subsector generally creates more growth for the economy as a whole. The analysis of our modeling simulations shows that even with double digit growth in a small subsector (e.g., wheat or sugar), their growth contribution in the overall agriculture or the whole economy could be insignificant, if at all. On the other hand, a large agricultural subsector, such as rice or cassava, can create more growth in the whole economy if such sectors can become the leading force in the growth process.

Priority setting also needs to consider the growth multiplier effect among different agricultural subsectors. A subsector with strong linkages to the rest of economy can generate more gains in the economy as a whole than a subsector with weak linkages to the economy. A subsector that can stimulate domestic demand, either through agro-processing or through generating income to a majority of farmers (e.g., cassava or poultry), often has stronger multiplier effect to the overall growth than a subsector that is only exported as primary materials.

Negative price effect is often an indicator of the market opportunities and the market constraints captured by the price effect have to be taken into account in an agricultural strategy. Growth is not only determined by productivity in the production process of a targeted agricultural subsector. Instead, it is constrained by market opportunities. Often, both domestic and export

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

The pro-poorness of an agricultural subsector's growth should be the top agenda in an agricultural strategy. While agricultural growth is generally pro-poor, different types of agricultural growth can lift varying number of people out of the poverty (in total and in different locations) depending on a country's poverty distribution across regions and among households. Carefully assessing the linkages between subsector agricultural growth and poverty reduction at both the national and regional (state) levels and taking advantage of such linkages are important steps to ensure agricultural growth be pro-poor.

Finally, given Nigeria's size and constitutional structure, agricultural performance in the country is not only dependent on strategies set by the federal government. The state governments are equally important players in determining the direction of agricultural development. Constrained by the lack of information on state level policies and other economic data, our study discusses only the agricultural growth options for the country as a whole. While more studies are necessary to be conducted at the state level, some of our results, in terms of priority setting in an agricultural strategy at the national level, may also be useful for a state level study. Moreover, the inter-linkages between strategies at the state and federal levels are other 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 Nigeria CGE model results of CAADP growth scenario

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Appendix 1: Mathematic Presentation of the DCGE Model of Nigeria

Table 11 : DCGE model sets and parameters

Symbol	Explanation	Symbol	Explanation
Sets			
$a \in A$	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' $\in$ INSDNG'; i $\in$ 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
		$trnsfr_{i\,f}$	Transfer from factor f to institution i

Table 12: 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 13: DCGE model endogenous variables

Symbol	Explanation	Symbol	Explanation
Endogenous Variables Continued			
AWF_{ft}^{a}	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 $\in$ 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_{fat}^{a}	Quantity of new capital by activity a for time period t

Table 14: DCGE model equations

Production and Price Equations

$QINT_{ca} = ica_{ca} \cdot QINTA_a$	(1)
$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$	(2)
$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}-1}$	(4)
$QF_{fa} = \alpha_{fa}^{van} \cdot \left(\sum_{f' \in F} \delta_{ff'a}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}} \right)^{-\frac{1}{\rho_{fa}^{van}}}$	(5)
$W_{f'} \cdot WFDIST_{f'a} = W_f \cdot WFDIST_{fa} \cdot QF_{fa} \cdot \left(\sum_{f'' \in F} \delta_{ff''a}^{van} \cdot QF_{f''a}^{-\rho_{fa}^{van}} \right)^{-1} \cdot \delta_{ff'a}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}-1}$	(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)
$QXAC_{ac} = \theta_{ac} \cdot QA_a$	(10)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(11)
$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$	(12)
$PXAC_{ac} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1}$	(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)
$PX_c \cdot QX_c = PDS_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr}$	(18)
$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c}$	(19)

$$PM_{cr} = pwm_{cr} \cdot (1 + tm_{cr}) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c} \tag{20}$$

$$QQ_c = \alpha_c^q \cdot \left(\sum_r \delta_{cr}^q \cdot QM_{cr}^{-\rho_c^q} + (1 - \sum_r \delta_{cr}^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}} \tag{21}$$

$$\frac{QM_{cr}}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \sum_r \delta_{cr}^q} \right)^{\frac{1}{1+\rho_c^q}} \tag{22}$$

$$QQ_c = QD_c + \sum_r QM_{cr} \tag{23}$$

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + \sum_r PM_{cr} \cdot QM_{cr} \tag{24}$$

$$QT_c = \sum_{c' \in C'} \left(icm_{cc'} \cdot QM_{c'} + ice_{cc'} \cdot QE_{c'} + icd_{cc'} \cdot QD_{c'} \right) \tag{25}$$

$$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c \tag{26}$$

$$DPI = \sum_{c \in C} PDS_c \cdot dwts_c \tag{27}$$

Institutional Incomes and Domestic Demand Equations

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \tag{28}$$

$$YIF_{if} = shif_{if} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right] \tag{29}$$

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR \tag{30}$$

$$TRII_{ii'} = shii_{ii'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'} \tag{31}$$

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot (1 - MPS_h) \cdot (1 - \overline{tins}_h) \cdot YI_h \tag{32}$$

$$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m \right) \tag{33}$$

$$QINV_c = IADJ \cdot \overline{qinv}_c \tag{34}$$

$$QG_c = \overline{GADJ} \cdot \overline{qg}_c \tag{35}$$

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI} \tag{36}$$

System Constraints and Macroeconomic Closures

$$YG = \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR \tag{37}$$

$$QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + QG_c + QINV_c + qdst_c + QT_c \tag{38}$$

$$\sum_{a \in A} QF_{fa} = QFS_f \tag{39}$$

$$YG = EG + GSAV \tag{40}$$

$$\sum_{r\ c\in CMNR} pwm_{cr} \cdot QM_{cr} + \sum_{f\in F} trnsfr_{row\ f} = \sum_{r\ c\in CENR} pwe_{cr} \cdot QE_{cr} + \sum_{i\in INSD} trnsfr_{i\ row} + FSAV \tag{41}$$

$$\sum_{i\in INSDNG} MPS_i \cdot \left(1-\overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c\in C} PQ_c \cdot QINV_c + \sum_{c\in C} PQ_c \cdot qdst_c \tag{42}$$

$$MPS_i = \overline{mps}_i \cdot \left(1+MPSADJ\right) \tag{43}$$

Capital Accumulation and Allocation Equations

$$AWF^a_{f\,t} = \sum_a \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right] \tag{44}$$

$$\eta^a_{f\,a\,t} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{AWF^a_{f\,t}} - 1 \right) + 1 \right) \tag{45}$$

$$\Delta K^a_{f\,a\,t} = \eta^a_{f\,a\,t} \cdot \left(\frac{\sum_c PQ_{c\,t} \cdot QINV_{c\,t}}{PK_{f\,t}} \right) \tag{46}$$

$$PK_{f\,t} = \sum_c PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}} \tag{47}$$

$$QF_{f\,a\,t+1} = QF_{f\,a\,t} \cdot \left(1 + \frac{\Delta K^a_{f\,a\,t}}{QF_{f\,a\,t}} - \upsilon_f \right) \tag{48}$$

$$QFS_{f\,t+1} = QFS_{f\,t} \cdot \left(1 + \frac{\sum_a \Delta K_{f\,a\,t}}{QFS_{f\,t}} - \upsilon_f \right) \tag{49}$$