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Agriculture for Development in Ghana

New Opportunities and Challenges

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[2] IFPRI Discussion Papers contain preliminary material and research results. They have not been subject to formal external reviews managed by IFPRI's Publications Review Committee but have been reviewed by at least one internal and/or external reviewer. They are circulated in order to stimulate discussion and critical comment.

Contents

List of Tables

List of Figures

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ABSTRACT

This paper has been prepared in support of the Comprehensive Africa Agriculture Development Program (CAADP) roundtable in Ghana. The study also takes a fresh perspective on the role of agriculture for development in light of the global food crisis. It addresses two main questions: what are the impacts of Green-revolution type agricultural growth to reach the CAADP goal in Ghana? Given the large investments required to achieve such productivity-led growth, what is the sector's contribution to the overall economy? Results from the dynamic computable general equilibrium model suggest that by closing the existing yield gaps in crop production and supporting essential growth in the livestock sector Ghana can achieve CAADP's 6 percent growth target. In this process, agriculture supports the rest of the economy through substantial and largely invisible monetary transfers to the nonagricultural sectors, which are primarily driven by the reduction of domestic food prices. Thus, CAADP growth benefits both rural and urban households, and reduces poverty by more than half within 10 years. However, widening regional disparities between the North and the rest of Ghana will increasingly pose a challenge for the development. Additional measures more targeted towards generating growth in the lagging North will be necessary to bridge the income gap and reach Ghana's poorest of the poor.

Keywords: CAADP, agriculture, poverty, Africa, Ghana, CGE

1. INTRODUCTION

The direct goal of this paper is to provide analytical support for the preparation of Ghana's roundtable under the Comprehensive Africa Agriculture Development Program (CAADP), an initiative of African heads of states to promote agriculture for development.[1] Our research goes beyond this direct demand and also responds to renewed interests in understanding the role of agriculture for development. While several fresh studies on the role of agriculture have been published recently (see, for example, Irz and Roe, 2005; Tiffin and Irz, 2006; Diao et al., 2007; World Bank, 2007a, Coady and Fan, 2008; Breisinger and Diao 2008), many questions remain unanswered. Despite the absence of explicit arguments against the promotion of agriculture, some economic scholars and policymakers harbor doubts regarding agriculture's ability to drive growth and transformation, particularly in Africa. However, the recent sharp rise in global food prices underscores the need to improve our understanding of both the role of agriculture and the ways to support agriculture. In this regard, we view CAADP as a good opportunity to support African policymakers in their effort to promote agricultural growth and redirect financial resources to the sector.

In this context, Ghana deserves special attention and serves as a good case study. Ghana has experienced two decades of sound and persistent growth and belongs to a group of very few African countries with a record of positive per capita GDP growth over the entire period of the last 20 or more years. Ghana is also bound to become the first Sub-Saharan African country to achieve the first Millennium Goal (MDG1) of halving poverty and hunger before the targeted year of 2015. On the other hand, Ghana is still an agriculture-based economy; agriculture accounts for 40 percent of GDP and three quarters of export earnings, and employs 55 percent of the labor force. The country's recent development process is characterized by balanced growth at the aggregate economic level, with agriculture continuing to form the backbone of the economy (McKay and Aryeetey, 2004). Agricultural growth in Ghana has been more rapid than growth in the non-agricultural sectors in recent years, expanding by an average annual rate of 5.5 percent, compared to 5.2 percent for the economy as a whole (Bogetic et al., 2007).

However, it may be difficult for the country to sustain and accelerate this growth. First, some indicators suggest that the past agricultural growth has primarily been driven by extensive forces (e.g. land expansion) rather than increases in productivity.[2] Second, Ghana's export structure has not changed over time, and still depends on traditional exports like gold, cocoa and forestry (Breisinger et al., 2008). Third, favorable climatic conditions have contributed to recent agricultural growth, meaning that climate variability may impact sustained and accelerated growth. Fourth and last, past growth and development has been accompanied by increased income inequality and poverty in lagging Northern Ghana (Al Hassan and Diao, 2007). To address these development challenges while recognizing the importance of agriculture in promoting inclusive growth and poverty reduction, the Government of Ghana is in the process of preparing for the CAADP roundtable discussion. Options for reaching CAADP's target of 6 percent annual agricultural growth in Ghana exist either as new growth opportunities, such as continued diversification of non-traditional exports (Jackson and Acharya, 2007), or from the prospects of relatively stable world cocoa prices and high world food prices (von Braun 2007, World Bank, 2007a). However, in order to achieve the CAADP goals, agricultural transformation must go beyond export agriculture, since export production is often spatially concentrated, and is therefore unlikely to reach the majority of small and poor farmers.

Broad-based growth is not only necessary but also possible, given that Ghana's 2005/2006 yields are 20 to 60 percent lower than the achievable yields for most staple crops (MoFA, 2007a). Productivity-led agricultural transformation is consistent with the CAADP framework and the Millennium

[1] CAADP is an initiative of the New Partnership for Africa's Development (NEPAD). CAADP provides an integrated framework of development priorities aimed at sustaining agricultural growth, rural development and food security in the African region. The main target of CAADP is the achievement of 6 percent agricultural growth per year supported by the allocation of at least 10 percent of national budgetary resources to the agricultural sector.

[2] Section 2 of this paper will decompose agricultural growth by land expansion and yield growth

Development Goals (MDGs), as well as the goal to become a middle-income country by 2015, which was announced in Ghana's second Growth and Poverty Reduction Strategy Paper (GRSPII). However, accelerating agricultural growth will require Green-revolution type of investments, including rural transport infrastructure, irrigation, access to improved seeds and fertilizer, extension services and agricultural R&D. This transforming of agriculture will be key to permanently reducing poverty, ending hunger and substantially improving the wellbeing of smallholder farmers, now and in the future. Even when a country has reached middle-income status, growth in agriculture remains important to reducing rural-urban income disparities, extending agricultural development to lagging regions and eradicating extreme rural poverty (World Bank 2007a).

To assess the role of agriculture for broad income growth and poverty reduction under the CAADP framework in Ghana, we herein develop and discuss a dynamic computable general equilibrium (DCGE) model that synergizes the growth projections among different agricultural commodities and sub-sectors and evaluates their combined effects at the national and regional levels, as well as across rural and urban areas. The remainder of the paper is structured as follows. Section 2 looks beyond Ghana's recent growth history and analyzes region-specific sources of agricultural growth to establish a realistic baseline growth path. Section 3 presents the structure of the model and the utilized data. Section 4 discusses economy-wide growth and poverty reduction effects under the base-run growth path, while Section 5 focuses on the impacts of agricultural growth acceleration under CAADP on income growth and poverty reduction. Section 6 summarizes the major findings and concludes.

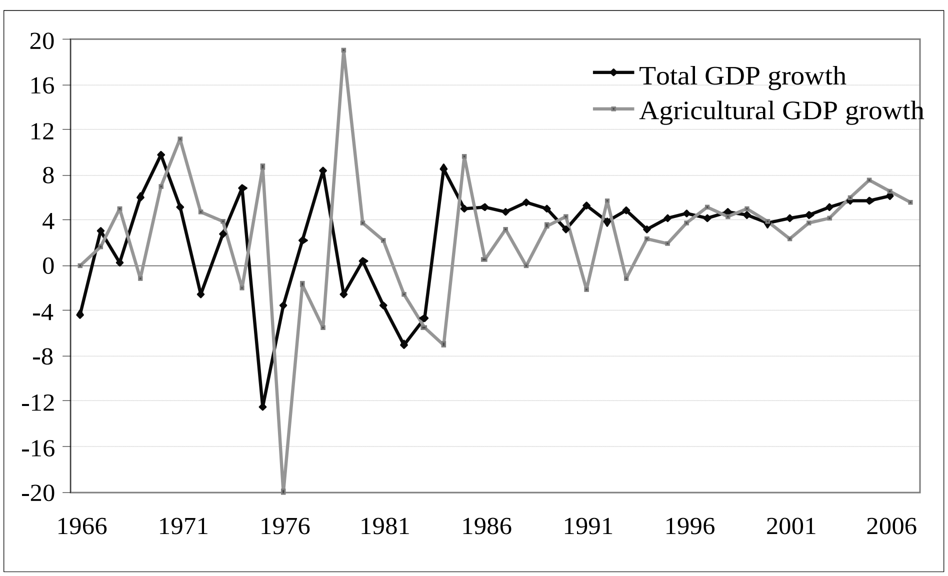
2. AGRICULTURAL PERFORMANCE: NATIONAL AND REGIONAL PERSPECTIVES

Growth, Structural Change and Trade

The recent discussion on Ghana's successful agricultural growth has largely been based on the sector's performance at the national level over the past five years. However, agricultural growth during this period has been heavily influenced by favorable weather conditions and world market prices for cocoa, which is the country's most important agricultural export product. Obviously, these growth patterns are unlikely to be sustained when external conditions change. In addition, the actual agricultural performance has differed significantly across regions due to the heterogeneity of agricultural structures across the various agro-ecological zones. In the following section, we therefore take a longer-term perspective and a more region-specific approach to examine Ghana's agricultural development and establish a more realistic baseline for our modeling analysis.

Prior to embarking on its recent and relatively long-term growth period, Ghana historically suffered from economic stagnation with wide fluctuations in GDP growth. In the 23 years between 1961 and 1983, only 10 years showed positive GDP growth rates. Growth fluctuations were especially serious in the 1970s and early 1980s, when growth was never sustained for longer than two consecutive years (Figure 1). As a consequence, total GDP only increased by 20 percent between 1961 and 1983, implying an annual GDP growth rate of close to zero (0.8 percent) and a negative per capita GDP growth. After this period of stagnation, Ghana's economy entered a period of more steady growth, which has continued for more than two decades. The average growth rate between 1984 and 2006 was 4.9 percent, while per capita GDP increased by close to 2 percent annually.

Figure 1. GDP and agricultural GDP growth rate in Ghana, 1966-2006

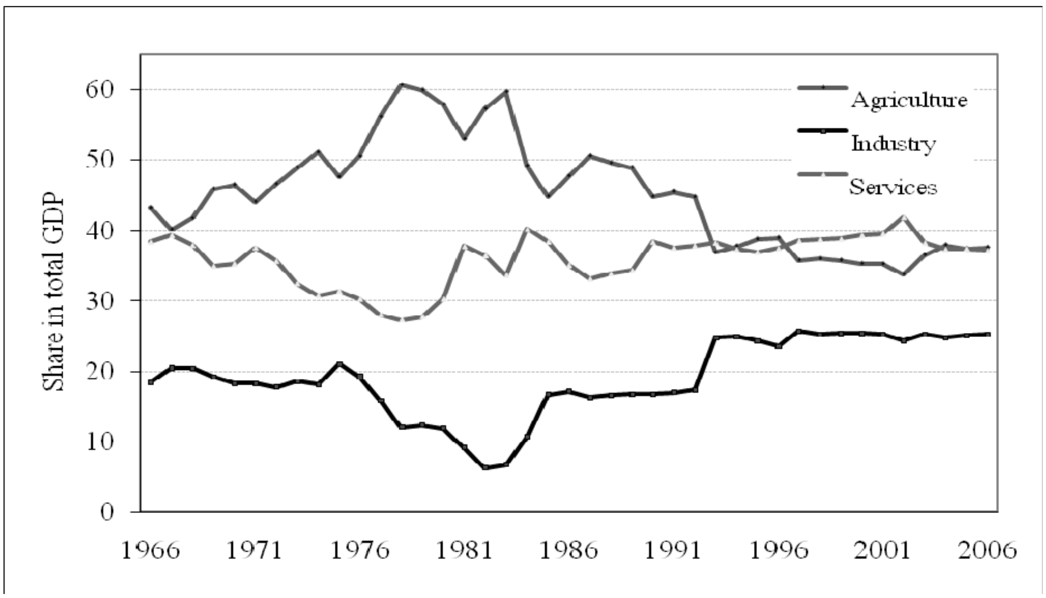


Source: World Bank 2007b and Ghana Statistical Services 2007b.
Note: Data from 1966-2002 are from World Bank 2007b and those for 2003-2006 are from the Government of Ghana (2007).

Figure 1 also shows three distinct periods characterizing the growth relationship between the agricultural sector and overall economic performance in Ghana. Over the period of 1966-1984, overall growth fluctuations closely followed the fluctuations in agricultural growth, indicating the dominant role of agriculture and the economy's high dependence on this sector's performance. In the second period, from 1985 to 1996, economy-wide growth appeared to be better able to withstand fluctuations in agricultural growth. In 1990 and 1992, for example, the economy grew by more than 3 percent despite negative agricultural growth rates. Finally, between 1996 and 2006, the relationship was characterized by stable growth in both agricultural and non-agricultural sectors.

Ghana’s economy has long been dominated by the agricultural sector, and this has continued to hold true until recent years. Previously, whenever the overall economy performed poorly, the share of the agricultural sector in the economy rose due to the basic need characteristics of agricultural production. The share of agriculture in the overall economy reached its peak in the late 1970s and early 1980s, when the sector contributed about 60 percent to total GDP. The subsequent decline of the agricultural share in total GDP mirrors the growth recovery of non-agricultural sectors, particularly the industrial sector (Figure 2). From the beginning of the 1990s onwards, the share of all sectors in the economy has remained relatively stable, indicating an extended period of balanced growth over the last decade.

Figure 2. Structure of economic growth in Ghana, 1966-2006



Source: World Bank 2007b (WDI) and Ghana Statistical Services 2007b .
Note: Data from 1966-2002 are from WDI and data for 2003-2006 are from the Government of Ghana (2007). All prices reflect constant 1995 prices.

Foreign trade, particularly exports, has played an important role in economic growth, especially during Ghana’s growth acceleration period. The ratio of trade to GDP increased four-fold between the mid 1980s and the period of 2000-2005. During the same time, the contribution of exports to growth doubled (Table 1). However, while exports and imports grew in parallel between 1985 and 1995, import growth has started to overtake export growth in the past decade, leading to a widening trade deficit. In addition, while imports have become more diversified as a result of income growth, urbanization, and trade liberalization, the export structure has remained largely unchanged. These trends together suggest that Ghana may face significant challenges when seeking to maintain macroeconomic stability and sustain growth in the future.

Table 1 Growth in trade and its contribution to overall economic growth

	Initial ratio to GDP		Annual Growth Rate		Export Contribution to Growth (% of GDP growth)
Period	Exports	Imports	Exports	Imports	
1985-90	10.7	13.6	9.0	8.0	22.0
1990-95	16.9	25.9	7.6	5.5	29.1
1995-00	24.5	32.9	10.4	11.7	75.2
2000-05	48.8	67.2	4.1	5.0	40.3

Source: Authors' calculations from World Development Indicators.

In recent years, the comeback of Ghana as the second largest cocoa producer has been the main driver of the country's agricultural export growth. Between 1995 and 2003, cocoa exports increased 1.2-fold and showed an annual growth rate higher than 10 percent. Between 2002 and 2006, cocoa exports grew even more rapidly, driven by favorable international prices. In 2005, exports of cocoa beans and cocoa products accounted for 28 percent of total exports (24.3 and 3.8 percent, respectively) and a half of agricultural exports including forestry and fishery. Nontraditional exports actually grew more rapidly, albeit from a small base. According to the Ministry of Food and Agriculture (MoFA) data, nontraditional agricultural exports amounted to US$ 230 million in 2002, had an annual growth rate of 20 percent, and were responsible for 30 percent of increased agricultural exports.

Growth Performance at the Agricultural Sub-Sector Level

While agricultural growth has accelerated over the past decade, significant differences remain in both the sub-sectors' growth rates and their contribution to overall growth (Table 2). Forestry and cocoa reached double-digit growth rates in the late 1990s and early 2000s, and these sectors contributed around 24-28 percent to agricultural growth in the respective periods. Growth rates in crops other than cocoa have been more modest and ranged between 1.5 and 4.5 percent during 1991-2005. However, due to the sub-sector's large size, staple crops have contributed more than 50 percent to total agricultural GDP growth.

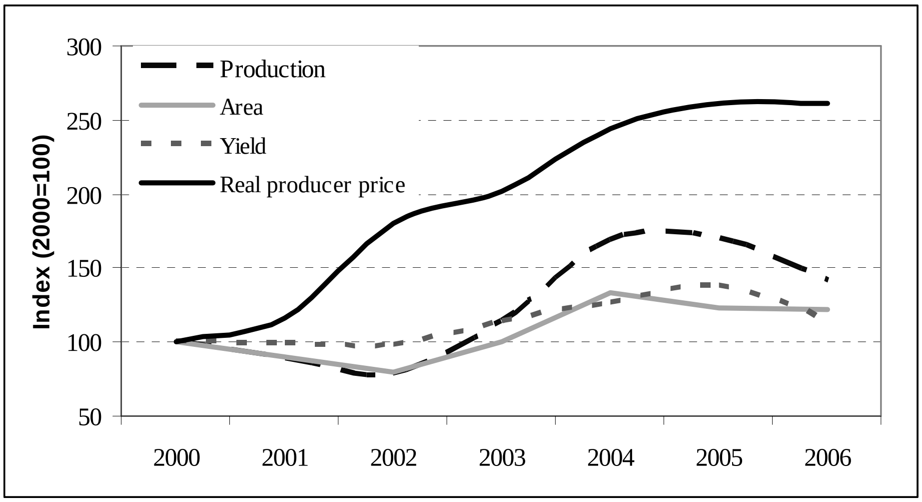
Table 2. Agricultural GDP growth and contribution to agricultural GDP growth

	1991-95	1996-2000	2001-05	2006
Growth (annual %)	2.0	3.9	5.5	5.6
Crops other than cocoa	1.5	3.4	4.5	5.8
Cocoa production and marketing	7.0	6.0	14.8	8.3
Forestry and logging	1.9	10.8	5.1	2.5
Fishing	1.8	0.6	3.0	3.6
Share of AgGDP (%)				
Crops other than cocoa	69	68	68	66
Cocoa production and marketing	8	9	10	13
Forestry and logging	7	9	10	10
Fishing	15	14	12	11
Contribution to agricultural GDP growth (%)				
Crops other than cocoa	51	60	55	69
Cocoa production and marketing	28	14	28	19
Forestry and logging	7	24	9	4
Fishing	14	2	7	7

Source: Ghana Statistical Service data, adopted from Coulombe and Wodon 2007.

Despite its relatively small size, the cocoa sector has become a major driver of agricultural growth in recent years due to its rapid growth. Cocoa production more than doubled from 395,000 MT in 2000 to 740,000 MT in 2006. Producer prices rose about 2.6-fold between 2000 and 2006 (Figure 3), driven by the surge in world prices before 2003 and a reduction of marketing margins initiated by the Government of Ghana thereafter. Cocoa yields increased by almost 40 percent between 2000 and 2004, but this growth has slowed in recent years (Cocoa Board, 2007). As a result, the share of cocoa in Ghana's agricultural GDP rose from 10 percent in 2001-2005 to 13 percent in 2006. The Cocoa Board's promotion of technological packages and improved access to credit, together with a partial liberalization of cocoa marketing, have improved cocoa farmers' abilities and incentives to raise productivity. Production increases have been supported by an increased use of family labor (Vigneri, 2007), and favorable weather conditions have been a major source of yield increases.

Figure 3. Trends of major cocoa indicators in Ghana (Index 2000=100)



Source: Authors' calculation based on data from Cocoa Board 2007 , FAO 2007 and IMF 2007.

Potential for further improvements in cocoa productivity still exists. FAO and MoFA estimate that achievable yields for cocoa are around 1-1.5 tons per hectare, 100 percent higher than average yield levels reported in 2005 (FAO, 2007; MoFA, 2007a). Given this yield growth potential, cocoa will continue to play an important role in the economy in the medium term. However, long-term dependency on cocoa exports as a major source of growth may further deteriorate Ghana's income distribution, especially across regions. Moreover, international market risks are likely to rise with a further expansion of cocoa production and exports in Ghana and countries such as Cote d'Ivoire, Indonesia, Cameroon, Nigeria, Brazil and others.

Regional Patterns of Agricultural Growth

Agricultural structure and the regional distribution of agricultural GDP significantly differ across Ghana's agro-ecological zones. These regional differences have important implications for sub-sector-level agricultural growth strategies, which will be explored further in sections 4 and 5. The Forest Zone remains the major agricultural producer, accounting for 43 percent of agricultural GDP, compared to about 10 percent in the Coastal Zone, and 26.5 and 20.5 percent in the Southern and Northern Savannah Zones, respectively (Table 3). The Northern Savannah zone is the main producer of cereals and livestock. More than 70 percent of the country's sorghum, millet, cowpeas, groundnuts, beef and soybeans come from the Northern Zone, while the Forest Zone supplies a large share of higher-value products, such as cocoa and livestock (mainly commercial poultry).

Table 3. Agricultural structural and regional contribution

	Contribution to national total				
	Coast	Forest	S. Savannah	N. Savannah	Total
Cereals	13.2	24.5	28.3	34.0	**100.0**
Maize	22.2	32.9	30.6	14.3	100.0
Rice	13.4	43.9	5.0	37.7	100.0
Sorghum and millet	0.1	1.5	37.7	60.7	100.0
Roots	3.8	31.8	32.6	31.8	**100.0**
Cassava	4.1	25.2	45.3	25.4	100.0
Yams	2.8	32.3	25.2	39.6	100.0
Cocoyam	8.2	60.4	17.2	14.2	100.0
Other staples	8.9	29.9	31.6	29.6	**100.0**
Cowpea	0.5	9.9	10.4	79.2	100.0
Soybean		10.6	24.8	64.6	100.0
Plantains	13.2	54.2	25.1	7.6	100.0
Groundnuts	7.7	9.5	7.2	75.6	100.0
Other crops	13.8	20.1	8.3	57.8	100.0
Fruit (domestic)	8.8	36.5	8.7	46.0	100.0
Vegetables (domestic)	8.5	25.7	44.5	21.3	100.0
Non-traditional exports	30.4	33.9	25.1	10.6	**100.0**
Fruit (export)	42.4	41.3	3.0	13.3	100.0
Vegetables (export)	92.0	8.0	0.0	0.0	100.0
Palm oil	9.8	40.7	49.5	0.0	100.0
Tree nuts	7.9	26.1	8.0	57.9	100.0
Export industrial crops	72.2	18.4	0.9	8.5	100.0
Cocoa	2.6	68.9	28.5	**0.0**	**100.0**
Livestock	12.1	35.1	14.2	38.6	**100.0**
Chicken broiler	19.2	40.0	36.4	4.5	100.0
Eggs and layers	37.0	39.0	5.0	19.0	100.0
Beef	7.1	16.3	6.4	70.2	100.0
Sheep and goat meat	12.7	39.5	11.8	36.0	100.0
Other meats	3.7	41.5	24.4	30.5	100.0
Forestry	1.0	68.6	29.1	1.4	**100.0**
Fishing	61.5	10.7	24.4	3.4	**100.0**

Source: Authors' calculations using Ghanaian DCGE model results.

The heterogeneous agricultural production structure also indicates differences in the agricultural income structure across regions. The Forest Zone generates about half its agricultural income from two of Ghana's major export goods (cocoa and forestry). Including non-traditional exports and fishery, export agriculture also plays an important role in total agricultural income for the Coast and Southern Savannah Zones. In contrast, 90 percent of agricultural income in the Northern Zone comes from staple crops and livestock. Domestic demand for many of these staple crops is income inelastic, meaning that strong growth can lead to price deterioration. An exception is livestock, where demand can be expected to experience a sharp increase with rising national incomes (Table 7). Therefore, growth in agricultural sub-sectors will have strong region-specific income and poverty effects. These effects will be further analyzed in the following sections, based on the DCGE model simulations.

Table 4. Within-region agricultural income by sub-sector

	Total AgGDP within region is 100			
	Coast	Forest	S. Savannah	N. Savannah
Cereals	14.1	6.4	10.6	18.4
Maize	11.5	4.2	5.6	3.7
Rice	2.6	2.1	0.3	3.8
Sorghum and millet	0.0	0.1	4.7	10.9
Roots	8.4	17.5	25.6	36.1
Cassava	3.6	5.5	14.2	11.5
Yams	3.3	9.2	10.3	23.3
Cocoyam	1.5	2.8	1.1	1.3
Other staples	17.3	14.1	21.6	28.4
Cowpea	0.0	0.2	0.3	2.9
Soybean		0.0	0.1	0.6
Plantains	4.7	4.8	3.1	1.4
Groundnuts	1.3	0.4	0.4	6.3
Other crops	0.5	0.2	0.1	1.1
Fruit (domestic)	1.7	1.7	0.6	4.5
Vegetables (domestic)	9.1	6.8	16.9	11.7
Non-traditional exports	9.9	3.0	2.9	2.6
Fruit (export)	3.2	0.8	0.1	0.5
Vegetables (export)	1.8	0.0	0.0	0.0
Palm oil	1.5	1.5	2.7	0.0
Tree nuts	0.5	0.4	0.2	1.9
Export industrial crops	2.8	0.2	0.0	0.2
Cocoa	4.1	26.6	15.7	0.0
Livestock	7.7	5.5	3.2	12.5
Chicken broiler	0.1	0.0	0.0	0.0
Eggs and layers	3.7	1.0	0.2	1.0
Beef	1.0	0.6	0.3	4.9
Sheep and goat meat	2.1	1.6	0.7	3.0
Other meats	0.8	2.3	2.0	3.6
Forestry	1.5	25.3	15.3	1.0
Fishing	37.0	1.6	5.1	1.0
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: Authors’ calculations using the Ghanaian DCGE model results.
Note: The share of chicken output in total regional GDP is 0.06, 0.03, 0.04, and 0.01 for the Coast, Forest, Southern Savannah, and Northern Savannah, respectively.

At the regional level, the contribution to agricultural growth from land expansion and yield increases between 1992 and 2005 varied across crops. However, the general trend suggests that land expansion contributed more than yield increases to the growth of most crops, with the exception of cassava and yam in the Coastal Zone (Table 5). In some cases, yield growth has been negative over the past 13 years, as in the cases of maize, sorghum, and yam in the Northern Savannah, and cocoyam, plantain and yam in the Forest Zone. The deterioration of land quality caused by over-farming and the low application rates of fertilizer partly explain the declines in land productivity (FAO 2005). Under these conditions, the further expansion of land implies a growing risk of environmental degradation.

Table 5 Average annual growth in production, yield and land (1992-2005)

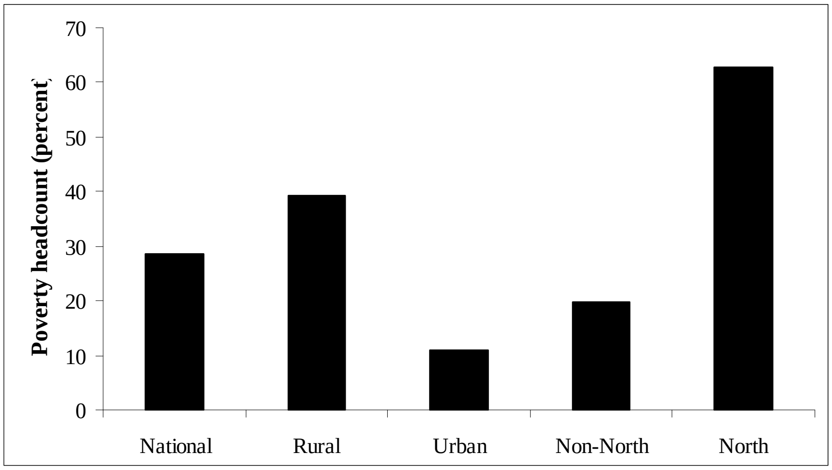
Crop	Output	Yield	Land	Crop	Output	Yield	Land
Maize	3.9	0.8	3.2	Yam	4.8	-4.1	9.3
Coast	4.2	3.0	1.2	Coast	4.3	4.3	0.0
Forest	4.0	0.5	3.5	Forest	8.8	-3.0	12.3
N. Savannah	-0.6	-0.4	-0.3	N. Savannah	1.9	-2.3	4.3
S. Savannah	8.7	-0.2	8.9	S. Savannah	6.1	-3.6	10.0
Rice	5.9	2.1	3.7	Cocoyam	2.3	-1.8	4.2
Coast	5.9	-3.4	9.6	Coast	0.7	-1.1	1.8
Forest	8.3	3.5	4.6	Forest	2.3	-1.7	4.1
N. Savannah	4.8	1.9	2.9	N. Savannah			
S. Savannah	5.3	4.8	0.5	S. Savannah	3.6	-4.1	8.0
Millet	-1.7	-2.1	0.5	Plantain	5.6	-1.2	6.9
Coast				Coast	10.8	1.2	9.5
Forest				Forest	5.4	-1.2	6.8
N. Savannah	-1.7	-2.1	0.5	N. Savannah			
S. Savannah				S. Savannah	4.0	-1.9	6.0
Sorghum	-0.7	-1.3	0.6	Cowpea	10.6	0.0	10.6
Coast		-0.5		Coast			
Forest				Forest			
N. Savannah	-0.8	-1.3	0.5	N. Savannah	10.0	-0.4	10.5
S. Savannah	6.7	0.4	6.3	S. Savannah			
Cassava	5.4	-0.8	6.2	Groundnuts	11.8	0.9	10.9
Coast	6.8	3.4	3.3	Coast			
Forest	4.2	-1.0	5.3	Forest			
N. Savannah	13.9	2.8	10.9	N. Savannah	11.8	0.9	10.9
S. Savannah	5.0	-3.9	9.4	South Savannah			

Source: Authors' calculations from MoFA's district-level data.

Poverty Reduction and the Lagging North

Steady, persistent and sectorally-balanced economic growth has helped the country significantly reduce poverty. Ghana's national poverty rate has fallen from 51.7 percent in 1991/92 and 39.5 percent in 1998/99 to 28.5 percent in 2005/06, for a total decline of 23.3 percentage points over 14 years. Even more poverty reduction has been achieved in rural areas, both in absolute and relative terms. The rural population accounts for more than 60 percent of the total population, and the rural poverty rate fell from 63.6 percent in 1991/92 to 39.2 percent in 2005/06, a decline of 24.4 percentage points. During the same period, the urban poverty rate decreased from 27.7 percent in 1991/92 to 10.8 percent to 2005/06, a decline of 16.9 percentage points. However, regional inequality significantly increased, mainly due to a more modest decline of poverty in the poorest Northern Zone. The poverty rate remained as high as 62.7 in the Northern Zone by 2005/06, whereas it had dropped to 20 percent in the rest of Ghana (Figure 4**).**

Figure 4 Poverty rates in Ghana in 2005/06



Source: Author's calculation using Ghana Living Standard Survey 5 (GLSS5).
Notes: "North" includes all rural and urban households from the Upper West, Upper West and Northern Regions. Non-North includes all other households.

Potentials for Accelerating Agricultural Growth

As discussed in the previous sections, Ghana still faces significant challenges in sustaining and accelerating agricultural growth to meet the CAADP target. However, opportunities exist. For example, income growth in many Asian countries is likely to create fresh demand for Ghana's traditional agricultural exports, and high world food prices combined with rising domestic demand through urbanization and income growth should offer new market opportunities for staple crop producers. Ghana currently depends on imports of rice, wheat, livestock products and processed food for domestic consumption, and the demand for these commodities continues to rise.[3] To take advantage of emerging opportunities, it will be necessary to increase agricultural competitiveness, regain domestic market shares and expand international market shares. An increase of agricultural productivity can be achieved by closing the existing gaps between current and achievable yields (Table 6). This will likely involve a set of agricultural and other policies and investments, but these are not the main thrust of the present paper.

Broad-based agricultural growth is mainly generated by increasing demand from domestic markets. Analyzing household consumption patterns and trends in Ghana can therefore improve our understanding of market opportunities and constraints.[4] In 2005, urban and rural households spent 40 and 50 percent, respectively, of their incomes on food (Table 7). However, this does not imply that urban households consume less food than rural households in absolute terms. The per capita income of an average urban household is 1.3 times higher than that for a rural household, implying that the average urban household consumes more food products in absolute terms than the average rural household. Continued increases in urban food demand will provide farmers the opportunity to increase food supplies. To get a more quantitative handle on this, we econometrically estimate households' marginal budget shares (MBS) to evaluate the potential demand for agricultural products in the domestic markets. MBS show the percent change of each unit of incremental income that households will spend on different commodities or groups of commodities. For example, if the value of MBS for maize is positive but smaller than maize's current average budget share (ABS), this indicates that an average household will spend less of its additional income on maize than it has done in the past. The total maize consumption of the household will continue to increase if the value of MBS is positive, but the demand for maize will grow more slowly than the household's income. The ratio of MBS over ABS therefore reflects the

[3] Current here and in other parts of the paper refers to 2005/2006.
[4] We use the recent national household survey, GLSS5 2005/06 for the analysis.

‘income elasticity of demand.’ An income elasticity of demand of less than one for a particular agricultural product indicates that consumption of this agricultural product will grow more slowly than incomes (at given prices). For example, we see a very high income elasticity for chicken in the case of both rural and urban Ghanaian households, indicating that demand for chicken will grow more rapidly when incomes increase. However, while the comparison of MBS and ABS provides information on market opportunities for food products directly consumed by households, it does not capture indirect demand effects. In the case of chicken, for example, increased consumption induces indirect demand for chicken feed such as maize. While direct consumption of maize may grow slowly, total maize demand may grow rapidly as the poultry sector becomes more competitive and increases its output. These production-side linkage effects are captured in our model through input-output coefficients and will be analyzed further in the model scenarios (Sections 4 and 5).

Table 6 Yield gaps in Ghana

Crop	Average yields	Achievable yields	Yield gap	Yield gap (%)
Maize	1.5	2.5	1.0	40.0
Rice - rainfed	2.1	3.5	1.4	40.0
Rice - irrigated	2.8	5.0	2.2	44.0
Millet	0.8	1.5	0.7	46.7
Sorghum	1.0	1.5	0.5	33.3
Cassava	11.9	28.0	16.1	57.5
Cocoyam	6.7	8.0	1.3	16.3
Yam	12.4	20.0	7.6	38.0
Plantain	8.1	10.0	1.9	19.0
Sweet Potato	8.5	18.0	9.5	52.8
Cowpea	1.0	1.3	0.3	23.1
Groundnut	0.8	1.0	0.2	20.0
Soybean	0.8	1.0	0.2	20.0
Pawpaw	25.0	40.0	15.0	37.5
Pineapple	60.0	100.0	40.0	40.0
Tomato - rainfed	25.0	35.0	10.0	28.6
Tomato - irrigated	30.0	65.0	35.0	53.8
Cocoa	0.4	1.0	0.6	60.0
Oil palm	12.0	15.0	3.0	20.0

Source: Authors’ calculations based on MoFA 2007b.

Table 7 Household budget shares and income elasticity

	Current budget share		Marginal budget share		Income elasticity	
	Urban	Rural	Urban	Rural	Urban	Rural
Foods	43.5	52.0	34.6	49.0	0.8	0.9
Maize	0.8	1.8	0.4	1.2	0.4	0.7
Rice and wheat	3.7	4.3	2.6	4.4	0.7	1.0
Roots	3.0	2.6	2.2	3.3	0.7	1.3
Other food	7.2	8.6	5.2	7.3	0.7	0.8
Plantain	1.2	1.1	0.9	1.3	0.8	1.3
Chicken	1.6	1.1	2.0	1.5	1.2	1.3
Other livestock	10.8	15.6	8.5	14.4	0.8	0.9
Fish	1.9	2.1	1.8	2.3	1.0	1.1
Other foods	13.3	14.7	10.9	13.2	0.8	0.9
Non-foods	46.1	37.0	56.6	40.0	1.2	1.1
Clothing	10.4	11.0	8.9	11.0	0.9	1.0
Other manufactures	7.0	9.6	6.9	9.7	1.0	1.0
Fuels	3.8	5.1	8.0	3.5	2.1	0.7
Durable equipment	9.4	4.8	20.9	7.6	2.2	1.6
Water and electricity	0.5	0.1	0.7	0.2	1.4	2.1
Services	25.4	17.4	20.0	19.0	0.8	1.1

Source: Authors' estimates using the 2005/06 Ghana Living Standards Survey (GLSS5).

3. MODELING AGRICULTURAL GROWTH

The Model

To capture the growth and poverty linkages of the agricultural sector, we herein develop and discuss a dynamic computable general equilibrium (DCGE) model for Ghana. This model explicitly captures the following: agricultural production technology at the sub-sector level across agro-ecological zones; agricultural input demand, including demand for factors and intermediates; output distribution, i.e. for exports and domestic markets; and incomes from agricultural production. All detailed agricultural activities are modeled at the level of four agro-ecological zones, thereby accounting for regional heterogeneity. We use 20 crops and five livestock categories, together with forestry and fishing to form the sectoral structure of agriculture in the model. While these 27 agricultural sub-sectors are explicitly included in the model, we also discuss the model results using seven broad agricultural categories, namely cereals, roots, other staples, export crops, livestock, fishery, and forestry (see the agricultural part of Table 8 for the corresponding sub-sectors in each of the seven categories).

Table 8. Sectors/commodities in the Ghanaian DCGE model

Agriculture	Industry	Services
Cereal crops	***Mining***	***Private***
Maize	***Food processing***	Trade services
Rice	Formal food processing	Export services
Sorghum and millet	Informal food processing	Transport services
Other cereals	Cocoa processing	Communication
Root crops	Dairy products	Banking and business
Cassava	Meat and fish processing	Real estate
Yams	***Other manufacturing***	***Public and community***
Cocoyam	Textiles	Community, other services
Other staple crops	Clothing	Public administration
Cowpea	Leather and footwear	Education
Soybeans	Wood products	Health
Groundnuts	Paper, publishing and printing	
Fruit (domestic)	Crude and other oils	
Vegetables (domestic)	Petroleum	
Plantains	Diesel	
Other crops	Other fuels	
Export crops	Fertilizer	
Palm oil	Chemicals	
Other nuts	Metal products	
Fruit (export)	Machinery and equipment	
Vegetables (export)	***Other industry***	
Cocoa beans	Construction	
Industrial crops	Water	
Livestock	Electricity	
Chicken broiler		
Eggs and layers		
Beef		
Sheep and goat meat		
Other meats		
Forestry		
Fishery		

The 27 agricultural sub-sectors are further disaggregated into the four agro-ecological zones of the Coast, Forest, Southern Savannah and Northern Savannah. Broadly speaking, the Coastal Zone covers the Eastern and Volta regions; the Forest Zone includes Ashanti, Western and Central regions; the Southern Savannah comprises Brong Ahafo and part of Volta; and the Northern Zone includes the Upper West, Upper East and Northern regions.[5]

All agricultural sub-sectors have extensive backward linkages and use inputs from the industrial sectors (such as fertilizer, machinery, etc.) and service sectors (such as trade, transportation, and financial services). Thus, it is important to include economic activities other than those of the agricultural sector. The detailed non-agricultural sub-sectors included in the model are presented in Table 8. With such an economy-wide setup, the model also captures forward linkages from agriculture to other sectors that use agricultural raw materials as inputs; these include many of the agricultural processing sectors detailed in Table 8, such as formal and informal food processing, cocoa processing, dairy and meat product processing, and wood product processing.

It is important for an economy-wide model to capture demand-side effects when analyzing agricultural growth potential and market constraints. The demand side of the model consists of two representative households groups (rural and urban) in each of the four agro-ecological zones, together with an urban household group representing Greater Accra, the capital city of Ghana, for a total of nine household groups. The rural households earn their incomes from employment of factors in agricultural production; these may include family labor, unskilled, mobile labor, capital and land. Rural households also earn their incomes from participating in non-farm activities. Urban households are assumed to earn their incomes solely through non-agricultural activities.[6]

The DCGE model links to a micro-simulation model that allows the endogenous estimation of growth impacts on poverty reduction. All GLSS5 sample households are included in the micro-simulation model and their total expenditures and expenditures on each commodity or commodity group are linked to each of the nine representative households included in the DCGE model according to their locations. The linkages between the DCGE and micro-simulation models allow for the analysis of micro changes in representative households' consumptions induced by changes in their incomes, market prices, and other factors. The endogenous changes derived from the DCGE model for the nine representative households are used to recalculate the consumption expenditures for their corresponding households in the survey dataset. New levels of total consumption expenditures are recalculated based on individual households' budgets, and the new poverty rates for each region's, household group (rural or urban), and the national total are obtained by comparing expenditure levels (in real terms) to the official poverty line defined for GLSS5.

The Data

The data used to calibrate the model are drawn from various sources. The core dataset underlying the DCGE model is a new 2005 social accounting matrix (SAM). This new SAM was jointly produced by Ghana Statistical Service (GSS) and the International Food Policy Research Institute (IFPRI) and was constructed using data/information from various sources (Breisinger et al. 2007). The aggregated national-level information includes national accounts (GSS) and balance of payments (the Bank of Ghana). Zone-level agricultural production is aggregated from the district-level production and area data provided by MoFA, and regional-level market price data are also from MoFA. The DCGE model is therefore consistent with official crop areas and yields at the zonal level. Non-agricultural production is compiled from the Industrial Census and employment data are from GLSS5. The income and expenditure patterns for the various household groups are aggregated from GLSS5. The DCGE model is therefore based on the most recent available data for Ghana.

[5] The Northern Zone is also referred to in the text as the "North", the Coastal Zone as "Coast", and the Forest Zone as "Forest" in this paper.

[6] We use GLSS5 data for the rural and urban classification. While some urban households also participate in agricultural production activities, we adjust their income source such that agricultural income goes only to rural households in the model.

4. BASE-RUN SIMULATION ALONG GHANA'S CURRENT GROWTH PATH

We first use the DCGE and micro-simulation models to generate Ghana's current growth path and examine the economy-wide impact of economic growth on various indicators, including income and poverty at both the national and regional levels. In addition to the data discussed in the previous section, information is required to capture the production trends for various agricultural and non-agricultural sub-sectors. We therefore draw on Ghana's past growth patterns to inform this 'business-as-usual' scenario simulation. Ghana experienced accelerated growth over the past five years. However, over longer period of time, growth (and particularly agricultural growth) has been more erratic. As shown in Table 1, the agricultural growth rate fluctuated significantly; it was as low as 2.1 percent in 2000 and as high as 7.5 percent in 2004. Between 1990 and 2006, there were two years (1990 and 1992) in which agricultural growth was negative, and six years in which the growth rate was below 4 percent. Given that agricultural growth depends heavily on rainfall patterns and current growth is still driven by land expansion, we target a more modest annual growth rate of 4.2 percent for the next 10 years (2006-2015) in the base-run scenario. This growth rate is actually consistent with the average annual growth rate during 1990-2006. On the other hand, the base-run scenario assumes relatively higher growth rates for the non-agricultural sectors. The targeted growth rates for the industrial and service sectors are 5.6 percent and 5.2 percent, respectively. These growth rates are equivalent to the annual average growth in 2001-2006 for both sectors.

We assume different land expansion rates for each of the four agro-ecological zones, and different productivity growth rates for each individual crop or agricultural sub-sector. Such region-specific growth assumptions for both land and productivity are consistent with available district-level historical data for land expansion and yield growth during 1992-2005 (MoFA, 2007b). Sector-specific productivity growth rates are also assumed exogenously for the non-agricultural sub-sectors. Exogenous land expansion rates and growth in sector productivity result in endogenous economy-wide growth that reflects the targeted overall growth rates for the agricultural and non-agricultural sectors in the model's base-run.

National Level Results of the Base-Run Simulation

Combining these exogenously assumed productivity growth rates and regional land expansion with exogenous growth in the supply of labor (2 percent per year), and endogenous growth in capital accumulation (5.4 percent per year on average), the DCGE model is solved to produce an equilibrium path from 2005 to 2015 (2005 is the base year of the model). Along this equilibrium path, a series of variables that describe the national or regional economies are endogenously determined at their new equilibrium levels. Table 9 shows the results for the aggregate sectors at the national level; the table also includes the results for the CAADP scenario, which are discussed in the next section.

Table 9. GDP and sectoral growth in the base-run and CAADP scenarios

	Data	Simulation results	
	2001-2006 average (%)	Base-run	CAADP
Annual growth		2006 – 2015 annual average (%)	
GDP		4.9	5.8
AgGDP	4.2*	4.2	6.0
Industry	5.6	5.6	6.0
Services	5.2	5.2	5.5
Contribution to GDP growth			
AgGDP		31.8	39.4
Industry		31.7	28.4
Services		36.5	32.3
Share of GDP	2005	2015	
AgGDP	38.7	37.6	38.1
Industry	27.9	27.9	27.5
Services	33.4	34.5	34.4

Source: Ghanaian DCGE model simulation results.
* AgGDP annual growth rate is the average of 1990-2006.

As the largest sector in the economy, agriculture accounted for about 39 percent of national GDP in 2005. Although the 4.2 percent average agricultural annual growth is lower than those of the two non-agricultural sectors in the base-run, the size of agriculture in the economy only falls slightly to 38 percent by 2015. This is partially due to favorable trade effects on agriculture. In the face of slightly slower agricultural growth, agricultural prices rise for some products produced for domestic markets, especially those that are income elastic, such as rice, high-value products and poultry. Moreover, agriculture continues to contribute almost one-third to total economic growth, due to its large initial size in the economy. To analyze agricultural performance in more detail, we further aggregate agricultural GDP into six sub-sectors. Table 10 reports agricultural growth at the sub-sector level, and gives each sub-sector's contribution to overall agricultural growth. Agricultural sub-sector growth levels differ due to differences in the assumed productivity growth rates at the crop and agricultural commodity group levels, endogenous factor allocation, and endogenous changes in domestic prices driven by demand-side constraints or opportunities. Livestock grows most rapidly in the base-run (5 percent per year, Table 10), mainly due to very rapid growth assumed for the poultry sector. On the other hand, cereals (e.g. maize, sorghum and rice) grow much slower at 3.7 percent per year, which is in line with the modest levels of their current yield growth. However, despite the rapid growth of the livestock sub-sector, its small initial share in agricultural GDP (6.4 percent in 2005, Table 10) means that it contributes only 8 percent of agricultural growth, which is the smallest contribution of all six sub-sectors. On the other had, a modest 3.9 percent annual growth rate in root crops accounts for 21.1 percent of overall agricultural growth, due to the sub-sector's large initial share of 23 percent in agriculture (Table 10).

Table 10. Agricultural sub-sector growth in the base-run and CAADP scenarios

		Annual growth rate of 2006-2015 (%)	
		Base-run	CAADP
AgGDP		4.2	6.0
Cereals		3.7	5.6
Root crops		3.9	5.2
Other staple crops		4.5	6.1
Export crops		4.4	8.1
Livestock		5.0	6.9
Fishery and forestry		3.9	4.6
	Sub-sectors' share in AgGDP in 2005	Contribution to AgGDP growth in 2006-15 (%)	
		Base-run	CAADP
Cereals	10.8	9.1	9.6
Root crops	22.6	21.1	18.4
Other staple crops	19.4	21.8	19.3
Export crops	19.4	20.4	29.7
Livestock	6.4	8.0	7.4
Fishery and forestry	21.3	19.6	15.5

Source: Ghanaian DCGE model simulation results.

We also analyze the sources of growth across different factors. This analysis shows that more than 65.8 percent of national GDP growth and 62.5 percent of AgGDP growth in the base-run comes from factor accumulation (Table 11). In terms of overall agricultural growth, land expansion explains almost 40 percent of AgGDP growth. Consistent with this, land expansion drives growth at the crop level, and is especially pronounced for staple food crops. For example, more than 70 percent of the projected growth in rice, sorghum, yam, cocoyam and almost 70 percent of growth in maize and cassava can be explained by exogenous land expansion in the base-run (Table 12), a situation reflecting the historical trends over the last 10 years. In the base-run, total crop land increases by 36 percent over the next 10 years, at an average of 3.1 percent per year.

Table 11. Sources of growth in the two simulations

	Decomposition of GDP growth		Decomposition of AgGDP growth	
	Base-run	CAADP	Base-run	CAADP
Labor	26.9	22.4	15.0	10.8
Land	12.7	8.7	39.5	27.5
Capital	26.2	22.2	7.9	5.3
Productivity	34.2	46.7	37.5	56.4

Source: Ghanaian CGE model simulation results.
GDP and AgGDP annual growth rates sum to 100.

Table 12. Crop-level growth in the base-run

	Annual growth rate in Base-run (%)			Contribution to output growth	
	Output	Land	Yield	Land	Yield
Maize	4.4	2.8	1.5	67.5	32.5
Rice	6.0	4.1	1.8	71.6	28.4
Sorghum	3.4	2.4	0.9	73.4	26.6
Cassava	4.4	3.0	1.4	69.9	30.1
Yam	4.2	3.1	1.1	75.7	24.3
Cocoyam	4.3	3.2	1.1	76.2	23.8
Cowpeas	3.9	3.0	0.9	79.3	20.7
Soybeans	5.4	4.6	0.7	88.1	11.9
Oil palm	3.5	2.7	0.8	78.0	22.0
Groundnuts	5.5	3.7	1.8	69.3	30.7
Other nuts	4.3	3.2	1.1	76.1	23.9
Fruits (domestic)	4.4	3.5	0.8	82.9	17.1
Fruits (export)	7.0	5.2	1.7	78.5	21.5
Vegetables (domestic)	4.7	3.8	0.9	83.5	16.5
Vegetables (export)	6.7	4.5	2.1	69.9	30.1
Bananas	4.0	3.3	0.7	84.2	15.8
Cocoa	4.2	2.8	1.3	68.3	31.7
Other crops	5.7	4.3	1.3	79.1	20.9
Other export crops	8.3	6.4	1.8	81.4	18.6

Source: Ghanaian DCGE model simulation results.

Regional-Level Results of the Base-Run Simulation

To support our analysis of regional-level effects of agricultural growth, the model includes four agro-ecological zones. Based on the different initial conditions and historical trends in crop production across the zones, we exogenously apply different land expansion rates for the various regions, and use different productivity growth rates for the various crops/agricultural sub-sectors across the four zones in the base-run scenario. The model then endogenously solves the overall land expansion for total crop production and productivity growth for agriculture. We find that although total national crop land grows at 3.1 percent annually in the base-run, the exogenous annual average land expansion is 2 percent on the Coast, 1.6 percent in the Southern Savannah, 3.2 percent in the Forest, and 4.2 percent in the Northern Savannah (Table 13). Due to the different initial conditions and land growth trends, growth in the agricultural sector's demand for labor and capital also varies endogenously across zones. A lower land-to-labor ratio is seen in the Coastal Zone compared to the other three zones, making the share of labor in agricultural total value-added (including livestock) highest in the Coastal Zone. In contrast, there is a much higher land-to-labor ratio in the Northern Savannah, where land accounts for 65 percent of total agricultural value-added (Table 13, first part). Given these diverse initial conditions and differences in land expansion dynamics, the growth rates of other production factors also vary across the agricultural sectors of the four zones. As shown in Table 13 (second part), capital accumulation and increased labor demand play a more important role in the Coastal Zone's agricultural growth, while land expansion seems to be a driving force for agricultural growth in the North.

Table 13. Differential factor growth in agriculture across zones in the base-run

	Land/labor ratio in 2005 (National = 1.0)	Initial share in agricultural value-added in 2005 (%)		
		Land	Labor	Capital
Coast	0.7	40.5	51.5	8.0
Forest	0.8	47.5	43.4	9.2
S. Savannah	0.9	57.9	33.6	8.4
N. Savannah	1.6	65.0	29.9	5.1
National	1.0	53.3	38.7	8.0
	Annual growth rate in base-run (%)			
	Productivity	Land	Labor	Capital
Coast	2.7	2.0	2.2	6.1
Forest	1.8	3.2	1.5	3.6
S. Savannah	2.1	1.6	1.4	4.5
N. Savannah	0.7	4.2	1.9	6.0
National	1.6	3.1	1.6	4.5

Source: Ghanaian DCGE model simulation results.

Differences in the between-zone results across the agricultural sectors in the base-run are also explained by differences in productivity growth rates, which are simulated according to their zone-specific historical trends. Table 14 reports these agricultural GDP growth trends and the sources of growth across the four zones in the base-run. On the Coast, agriculture has a relatively high productivity growth, which contributes 53.1 percent to agricultural growth in this zone, resulting in 5 percent annual average growth in the zone's agricultural GDP. In contrast, agricultural growth in the North is driven mainly by land expansion, which explains 64 percent of agricultural GDP growth in this zone. Because of its relatively low productivity growth (0.7 percent annually, Table 13), agricultural GDP in the North only expands by 4 percent annually. The Southern Savannah has the lowest annual agricultural growth rate (3.8 percent) due to low growth of labor demand and land expansion (1.4 and 1.6 percent, respectively, Table 13). In contrast, the productivity growth rate is fairly high in this zone at 2.1 percent (Table 13).

Table 14. Differential sources of agricultural growth across zones in the base-run

	AgGDP annual growth (%)	Contribution to agricultural growth in base-run (%)			
		Land	Labor	Capital	Productivity
Coast	5.0	15.4	22.0	9.5	53.1
Forest	4.3	35.8	15.0	7.9	41.3
S. Savannah	3.8	23.8	12.1	9.7	54.3
N. Savannah	4.0	64.0	13.4	7.2	15.4
National	4.2	39.5	15.1	7.9	37.5

Source: Ghanaian DCGE model simulation results.

Due to differences in agro-ecological conditions and other socio-economic factors, the initial agricultural structure varies significantly across the four zones. As shown in Table 15 (part one), fishery and forestry constitute the largest sub-sector in the Coastal Zone's agricultural sector, export crops are the most important sub-sector in the Forest Zone, and root crops are the largest sub-sectors in both the Southern and Northern Savannahs. Growth rates also vary among the four zones within and across the agricultural sub-sectors. For example, growth in cereals mainly occurs in the Coastal and Northern Zones, whereas the growth rate of root crops is highest in the Forest and Southern Savannah, but negative in the North. When comparing different crops within a given zone, we see that the Coastal Zone will benefit mainly from growth in cereals and export crops, while the Forest zone benefits from growth in all crops except cereals. In the Southern Savannah, growth mainly occurs in the staple crops sectors, except for cereals. In the North, most crops show high growth, but growth in root crops is negative.

Table 15. Agricultural sub-sector growth in the base-run across the four zones

	Sub-sectors' share in AgGDP in 2005 (%)			
	Coast	Forest	S. Savannah	N. Savannah
Cereals	14.1	6.4	10.8	17.8
Root crops	8.4	17.5	26.1	35.0
Other staple crops	17.3	14.1	22.1	27.5
Export crops	14.0	29.5	16.8	5.5
Livestock	7.7	5.5	3.2	12.1
Fishery and forestry	38.5	26.9	20.9	2.0
	Sub-sectors' annual growth rate in base-run, 2006-2015 (%)			
	Coast	Forest	S. Savannah	N. Savannah
Cereals	8.6	-0.9	0.6	6.0
Root crops	2.7	4.8	6.2	-0.2
Other staple crops	1.1	5.2	3.4	5.9
Export crops	4.4	5.1	1.7	5.0
Livestock	5.7	4.4	5.4	5.3
Fishery and forestry	5.5	3.4	3.9	4.5
	Sub-sectors' contributions to AgGDP growth in base-run (%)			
	Coast	Forest	S. Savannah	N. Savannah
Cereals	30.1	-	1.1	29.4
Root crops	3.7	21.2	49.7	-
Other staple crops	2.9	18.9	19.3	45.7
Export crops	11.5	36.3	5.7	7.1
Livestock	9.0	5.5	4.7	16.6
Fishery and forestry	42.8	18.9	19.6	2.2

Source: Ghanaian DCGE model simulation results.

The model allows for the reallocation of land from one crop to another within each zone; such reallocation is driven by productivity growth and changes in relative prices across agricultural products as an outcome of different market demand for each commodity. Due to inelastic demand, land is usually released from staple crop production (except for rice), because productivity growth in staple crop production can cause the prices for some crops to fall. On the other hand, export crops (such as cocoa or nontraditional exportable crops) or import substitutable crops (such as rice) often face less demand-side constraints and more stable domestic prices. Land released from staples moves into these sectors if their productivity improves. With similar productivity growth, export crops can easily compete with other crops for land, given that prices for export crops are not strongly affected by domestic demand. In addition, land reallocation is also affected by factors other than demand-side constraints/opportunities. The factor intensity across crops is one of these factors. If the initial land-to-labor ratio is high in a specific crop, more land can be released from this sector and reallocated to other sectors once its production becomes more productive and its demand is inelastic.

Table 16. Growth in household income in the base-run

	Share of agricultural 2005 (%)	Growth in agricultural Annual average, 2006-2015 (%)	Growth in total
Urban			4.98
Accra			5.15
Coast			4.92
Forest			4.94
S. Savannah			4.88
N. Savannah			4.98
Rural	82.6	4.43	4.53
Coast	65.3	5.02	4.95
Forest	96.6	4.47	4.48
S. Savannah	74.5	4.21	4.43
N. Savannah	81.9	4.32	4.49

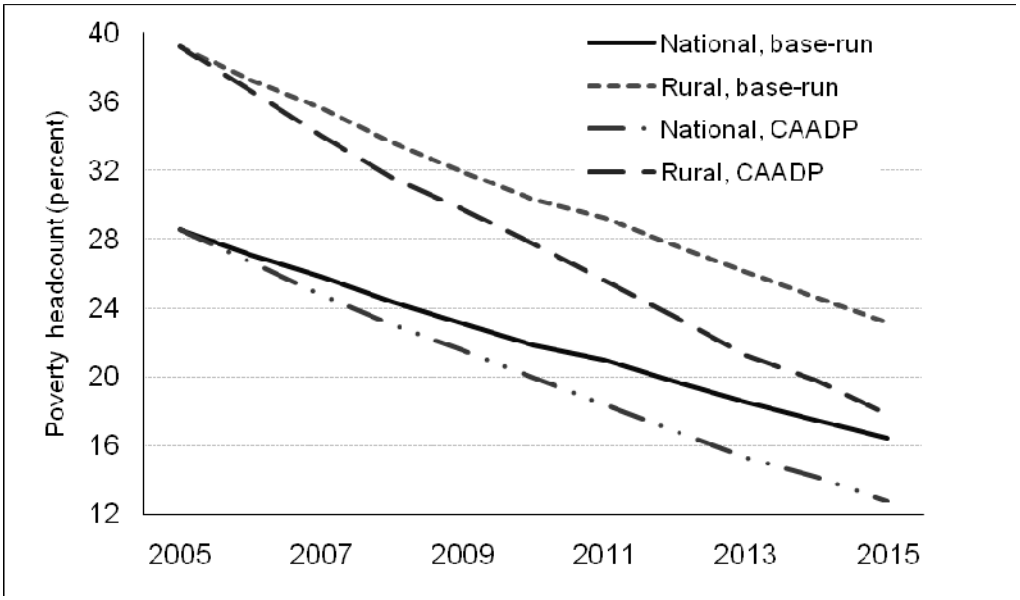
Source: Ghanaian DCGE model simulation results.
Note: Income is measured in current Ghana cedis.

Rural households also generate incomes from non-agricultural sectors. The first column of Table 16 displays the share of agricultural income in total income for the four rural representative households in the model. Some urban households, especially those in small towns, are also involved in agriculture and earn incomes from agricultural production. However, the share of agricultural income in the total income of the urban household group is small; hence, we adjust the income sources such that agricultural income goes only to rural households. After this adjustment, agricultural income accounts for 82.6 percent of total rural income. This share is lower in the Coastal Zone and higher in the Forest and Northern Savannah. Measured as returns to factors in current prices, including returns to labor, land and capital, the growth rate of total rural agricultural income is 4.43 percent, while the growth rate of total rural income is 4.53 percent in the base-run. In all zones except for the Coast, growth in agricultural incomes is usually slower than total income growth, as non-agricultural sectors grow more rapidly than agriculture in the base-run.

Ghana Will Meet MDG1 to Halve Poverty In 2008

Ghana has significantly reduced poverty over the past 10 years. The 2005/06 Ghana Living Standards Survey suggests that, based on current trends, the country will reach the first Millennium Development Goal (MDG1) of halving its 1990s poverty rate by 2008 (Ghana Statistical Services, 2007). If this comes to pass, Ghana will become the first African country to meet MDG1 before the targeted year of 2015. Our base-run poverty reduction result supports this prediction, projecting that the national poverty rate will fall to 24.3 percent in 2008 as compared to 52 percent in 1991/92. Furthermore, the rural poverty rate will also be halved before 2015. According to GLSS5, the rural poverty rate was 39.2 percent in 2005/06 (compared to 63.6 percent in 1991/92). The base-run simulation result shows that the rural poverty rate of 1991/92 will be halved by 2009 (Figure 5).

Figure 5. Changes in poverty rates under simulations (percent)



Source: Ghanaian DCGE model simulation results.

Table 17. Poverty rates in the base-run

	Data		Simulation results	
	2006	2008	2009	2015
North	62.7	58.9	57.2	48.6
Rest of the country	19.7	15.6	14.5	8.6
National	28.5	24.3	23.1	16.4
Rural	39.2	33.6	31.9	23.2

Source: Ghanaian DCGE model simulation results.

Despite this success in poverty reduction on the national level, however, sharp regional differences in poverty rates persist. Poverty rates are much higher in the North; for example, the Northern poverty rate was 62.7 percent in 2005/06 compared to 19.7 percent in the rest of Ghana. Driven by differences in income growth rates between the North and the rest of Ghana, poverty reduction is projected to be slower in the North compared to the rest of the country. This exacerbates regional differences and accelerates the diverging trend between the North and other regions of Ghana. As a result, while both the national and total rural poverty rates are halved by 2008 or 2009 in the base-run, the poverty rate in the North will remain as high as 59 and 57 percent in these two years. The model results also show that halving the poverty rate in the North remains a distant target; in this region, poverty will still be at a high level of 49 percent by 2015.

Summary of this section

Drawing on historical growth trends at the crop and sub-sector levels across different agro-ecological zones, this study uses a DCGE model to simulate Ghana's base-run development path between 2006 and 2015. Under this base-run, the agricultural sector grows at 4.2 percent annually over the next 10 years, a relatively modest growth rate compared with the accelerated growth observed during 2001-2005. However, this growth rate is similar to Ghana's average agricultural growth rate between 1990 and 2006 and might therefore adequately reflect longer-term trends. Relatively high growth rates are targeted for the non-agricultural sectors. Following recent growth trends in the industrial and service sectors between 2000 and 2006, the base-run of the model targets 5.6 percent and 5.2 percent annual growth for the two sectors, respectively.

Ghana has significantly reduced poverty over the past 10 years, and the country is expected to become the first African country to meet MDG1. The base-run simulation supports this prediction, indicating that the national and rural poverty rates will both be halved (from their 1991/92 levels) in the next two years. However, little progress in poverty reduction can be expected in the North; the poverty rates in this lagging region will remain at high levels, and regional income divergence will increase.

Several reasons could explain why the North is lagging behind the rest of the country in income growth and poverty reduction. This region suffers from geographic disadvantages, including relatively low rainfall, savannah vegetation, and the inaccessibility of large parts of the region, which has less well-developed rural road networks compared to those in the rest of Ghana (ODI and CEPA, 2005). Historical reasons can be found in the heterogeneity of the Northern society, as well as colonial policies, which treated the North as a pool of labor for the South and have not been changed in the wake independence (Shepherd and Gyimah-Boadi, 2004). In addition, agricultural growth is constrained by limitations on access to credit, inputs (e.g. fertilizer), and land. These unfavorable conditions have left the North in its current situation, and mean that even if the North grows at rates similar to those projected for the rest of country, poverty reduction will still be much slower. Notably, the base-run simulation suggests that growth in the North will remain even slower than that in most other regions, further widening the income gap and exacerbating the differences in poverty levels between the North and the rest of country. Thus, we pay specific attention to income growth in the North in our analysis of agricultural growth acceleration under the CAADP framework.

5. AGRICULTURAL GROWTH UNDER THE CAADP FRAMEWORK

The previous section presented a baseline scenario, under which agriculture grows at a rate similar to the past decade's trend of 4.2 percent. In this section we go beyond this "business as usual" scenario and examine the growth, distributional and poverty effects of agricultural growth acceleration. More specifically, we analyze the potential contribution of additional agricultural growth from different sub-sectors to achieve the 6 percent agricultural growth target set by the CAADP initiative. We model accelerated crop production by increasing land productivity such that the yield targets set by MoFA are realized by 2015. Table 6 shows the gaps between current and targeted yields for the major crops on which the model simulations are based. In addition, the model considers additional growth in the different livestock sub-sectors. Productivity growth in the fishery and forestry sub-sectors is set at levels that prevent significant increases in the domestic prices for these products. Due to a lack of information at the regional or zonal levels for crop yield targets, we assume that additional growth beyond the base-run growth rate is the same across all zones for each crop or agricultural commodity group.

Targeted Yields Support the Desired 6 Percent Agricultural Growth

The model simulation shows that if the targeted yields set by MoFA combined with reasonable additional growth in the livestock, fish and forestry sectors are gradually achieved by 2015, Ghana's agricultural sector will reach an average annual growth rate of 6 percent over the next 10 years. Table 18 compares initial crop yield levels with the 2015 yields projected by the two model simulations. The yields for individual crops are the result of a combination of exogenous increases in land productivity (defined at the regional level) and supply-side responses to endogenously changing prices, which lead to new general equilibrium outcomes. The model results show that in order to achieve MoFA's crop yield targets by 2015, additional annual growth of approximately 2 percent will be required for maize, rice, groundnuts and plantain, and increases of approximately 3 percent will be needed for yams and cassava (see Table 19, column 4).

Table 18. Crop yields in the simulations (mt/ha)

	Actual yield in 2005	Simulation result by 2015	
		Base-run	CAADP
Maize	1.7	1.9	2.4
Rice	1.9	2.3	2.9
Sorghum	0.9	1.0	1.3
Cassava	15.3	17.6	23.4
Yam	11.9	13.3	18.7
Cocoyam	7.4	8.2	10.3
Cowpeas	1.0	1.1	1.4
Soybeans	0.9	1.0	1.4
Oil palm	0.3	0.3	0.4
Groundnuts	0.9	1.1	1.4
Other nuts	0.8	0.9	1.0
Fruits (domestic)	3.3	3.5	4.8
Fruits (export_	6.3	7.5	9.0
Vegetables (domestic)	4.4	4.8	6.5
Vegetable (export)	6.8	8.4	10.2
Bananas	10.1	10.8	15.5
Cocoa	0.5	0.6	0.7
Other crops	0.5	0.6	0.8
Other export crops	0.9	1.1	1.2

Source: Ghanaian DCGE model simulation results.

National-Level Results of the CAADP Scenario

An average agricultural growth rate of 6 percent, combined with slightly higher than baseline growth in the two non-agricultural sectors accelerates national annual GDP growth to 5.8 percent under the CAADP scenario, compared to 4.9 percent in the base-run (Table 9). The contribution of the agricultural sector to total GDP growth increases to 39.4 percent, from the base-run's 31.8 percent. Growth accelerates in all sub-sectors and is driven by productivity improvements[7] rather than by land expansion, which has been the main contributor to growth in the past. The three staple crop groups grow at an additional 1.4-2.0 percent per year, while the additional annual growth is 3.7 percent for the export crops, 1.8 percent for livestock and 0.6 percent for fishery/forestry. The contribution of the combined staple crops to agricultural growth remains a dominant factor under CAADP, but its role declines slightly compared to the base-run. While 52.4 percent of agricultural growth in the base-run is attributed to growth in staple crops, this share falls to 46.4 percent under the CAADP simulation. Export crops largely fill this gap; their contribution to agricultural growth rises from 20.4 percent to 31.6 percent.

Table 19. Productivity contribution to crop growth in the CAADP simulation

	Annual growth rate (%)			Additional yield growth from base-run	Contribution to	
	Output	Land	Yield		Land	Yield
Maize	6.3	2.4	3.8	2.3	37.6	62.4
Rice	10.8	6.3	4.2	2.4	62.5	37.5
Sorghum	4.8	1.1	3.7	2.7	20.7	79.3
Cassava	5.5	1.2	4.3	2.9	18.9	81.1
Yam	5.4	0.8	4.6	3.5	12.1	87.9
Cocoyam	5.0	1.5	3.4	2.3	28.0	72.0
Cowpeas	5.0	1.4	3.6	2.7	26.3	73.7
Soybeans	7.6	3.6	3.8	3.1	48.3	51.7
Oil palm	7.1	3.5	3.5	2.7	49.4	50.6
Groundnuts	7.8	3.6	4.0	2.3	46.8	53.2
Other nuts	6.8	4.3	2.4	1.3	66.2	33.8
Fruits (domestic)	4.8	0.9	3.9	3.0	16.7	83.3
Fruits (export)	11.4	7.5	3.6	1.9	71.6	28.4
Vegetables (domestic)	6.3	2.2	4.0	3.1	33.6	66.4
Vegetables (export)	11.1	6.7	4.1	2.0	64.8	35.2
Bananas	5.2	0.7	4.4	3.7	12.6	87.4
Cocoa	7.9	4.7	2.3	1.7	62.4	37.6
Other crops	9.7	5.4	4.1	2.8	58.2	41.8
Other export crops	11.0	7.5	3.2	1.5	73.9	26.1

Source: Ghanaian DCGE model simulation results.

Since additional growth in the CAADP simulation is driven by improvements in productivity, the contribution of factor accumulation to both national and agricultural GDP declines. As shown in Table 11, productivity explains 46.7 percent and 56.4 percent of GDP and agricultural GDP growth under the CAADP scenario, respectively, compared to 34.2 percent and 37.5 percent, respectively, in the base-run. At the crop level, productivity growth becomes the dominant factor in the production growth for maize, sorghum, cassava and yam, contributing 60-80 percent of output growth in these crops (Table 19). Obviously, productivity-led agricultural growth requires a series of efforts on many levels, from farming

[7] Productivity growth for different factors (including land) is an exogenous variable in the model.

systems and post-harvest management to the input and output marketing systems. Moreover, policies and investments aimed at enhancing productivity should account for the substantial differences in agro-ecological conditions across regions and crops/livestock products. Additional studies will be required to address these extremely important issues.

Measuring the Role of Agriculture for Development

As agriculture is the largest sector in Ghana's economy, the impacts of agricultural growth acceleration under CAADP will reach beyond the agricultural sector. Measuring agriculture's contribution to economy-wide growth not only contributes to a better understanding of the role of agriculture, but can also provide powerful arguments for developing and implementing pro-agriculture policies and increasing agricultural investments.

In the following, we measure the agricultural sector's contribution to the economy as the surplus transferred from agriculture to non-agriculture. This definition is based on the insights of development economists in 1950s and 1960s who characterized the dynamics of the economic development process as a dual system (Lewis, 1954; Fei and Ranis, 1961; Jorgenson 1961). According to this theory, agriculture supports the rest of the economy by transferring a surplus from agriculture to non-agriculture. Some of these transfers are visible, i.e. they can be directly observed. Visible transfers include the agricultural trade surplus, which often provides the foreign exchange needed to finance imported capital and intermediate goods used by non-agricultural sectors. However, the majority of the surplus transferred from agriculture to non-agriculture is invisible. An important invisible transfer stems from decreases in domestic agricultural prices, which often result from improved agricultural productivity. However, the invisible nature of these transfers has often led to underestimation of the role of agriculture in economic development. Moreover, the policy and investment priorities of governments typically focus on the role of agriculture in providing visible surpluses. For example, African countries are still emphasizing and promoting agricultural exports, even though this leads to a policy and investment bias towards export agriculture and a neglect of staple crops and livestock.

To contribute to this discussion, we use a method developed by Winters et al. (1998) to measure both the visible and invisible transfers of agriculture to the non-agricultural sectors in Ghana. To understand the specific contributions and transfers of different agricultural sub-sectors, where possible we assess the role of export agriculture versus staple agriculture in providing surplus transfers to non-agricultural sectors. Table 20 gives an overview of selected aggregate economic indicators defining the linkages between agriculture and non-agriculture, and between rural and urban households. As the distinction between rural and urban households may be somewhat arbitrary, we herein define these groups by their income source. Rural is defined as the group of households who derive their income mainly from agricultural activities, while urban households are assumed to earn their income from non-agricultural activities.

The growth levels under the CAADP scenario indicate that agricultural GDP will be 19.3 percent higher than the baseline in 2015, while non-agricultural GDP will be 3.3 percent higher (Table 20). This increase in agricultural GDP is the result of agricultural productivity growth at the crop and individual product level, while increased non-agricultural GDP is the result of linkage effects, i.e. spillovers from agricultural growth to non-agricultural sectors. Productivity growth in agriculture raises agricultural exports and lowers agricultural imports. As shown in Table 20 agricultural exports increase by 25.7 percent and imports fall by 6.3 percent in 2015 under the CAADP scenario versus the baseline. On the other hand, non-agricultural exports increase and imports increase even more. Another contrasting result is seen with regard to changes in consumer prices. The agricultural price index falls by 4.5 percent, while non-agricultural prices rise by 5.2 percent by 2015 under the CAADP versus baseline scenarios. Consequently, the agricultural terms of trade decline in the domestic market, falling by 3.9 percent by 2015 under the CAADP scenario. In addition, despite much higher increases in agricultural GDP compared to non-agricultural GDP, the increases in rural and urban incomes are quite similar (measured in real terms). Incomes increase by 12.2 and 10.2 percent for the rural and urban household groups, respectively, by 2015 (both are deflated by the consumer price index).

Table 20. Aggregate economic indicators for the agriculture/rural and non-agriculture/urban groups

	Agriculture/rural			Non-agriculture/urban		
	Annual growth rate		% Increase from base by 2015	Annual growth rate		% Increase from base by 2015
	Base	CAADP		Base	CAADP	
GDP	4.2	6.0	19.3	5.4	5.7	3.3
Production	4.3	6.1	18.8	5.5	5.9	4.3
Exports	3.6	6.0	25.7	5.7	6.2	4.3
Imports	4.7	4.1	-6.3	4.9	5.8	9.0
Consumer price index by 2015 (% change)	2.7	-1.9	-4.5	-2.0	3.0	5.2
Wage rate of labor	2.9	4.1	12.1	2.7	3.9	12.1
Real household income	4.6	5.8	12.2	5.0	6.0	10.2
Savings	4.5	5.8	13.2	5.1	6.1	10.3
Terms of trade for agriculture	4.9		-3.9			

Source: Ghanaian DCGE model simulation results.

Keeping these aggregate indicators in mind, Tables 21 and 22 present detailed surplus transfers between agriculture and non-agriculture under the CAADP scenario through domestic commodity and factor market linkages. To assess surplus transfers in the commodity market, we disaggregate increased direct demand for agricultural goods (consumer goods) and agricultural goods used as intermediate inputs (investment goods). We measure all the transfers, both visible and invisible, in financial terms (i.e. in billion cedi) and also report the results as a percentage of total increased GDP either between 2006 and 2015 or in 2015 alone, under the CAADP scenario versus baseline.

The first part of Table 21 displays surplus transfers from agriculture to non-agriculture through intermediate demand. These transfers can be further distinguished by increased demand for agricultural goods from non-agricultural sectors and by demand for non-agricultural goods from the agricultural sector, which often implies a negative transfer from agriculture to non-agriculture. Measured in nominal terms (at current prices), increased input demand for agricultural goods from non-agricultural sectors under the CAADP scenario will amount to more than 9,000 billion cedi over the next 10 years (2006-2015) and to about 2,000 billion cedi in 2015 alone. Measured as a percentage increase in GDP, these visible transfers are equivalent to 14.9 percent over 2006-2015 and 16.0 percent in 2015. Within agriculture, these transfers can be mainly attributed to export agriculture, which accounts for about 11.1 percent and 11.8 percent of additional GDP during 2006-2015 and in 2015, respectively. However, this situation changes when we look at the invisible transfers, which depend on the decreases in agricultural prices incurred by non-agricultural sectors from the purchase of agricultural inputs. While improvements in agricultural productivity lowers the prices for agricultural goods produced for domestic markets, prices for exported agricultural goods and imported substitutable agricultural goods do not necessarily fall, and may even rise due to real exchange rate appreciations. Table 21 shows that an invisible surplus is transferred from staple agriculture to non-agriculture (1,648 billion cedi in 2006-2015), but a deficit (i.e. a negative transfer) develops from export agriculture to non-agricultural sectors (-1,094 billion cedi in 2006-2015). This is because prices for staple agriculture fall while prices for export agriculture rise, both measured in domestic currency. Moreover, we observe that in the case of staples, the invisible transfer is larger than the visible transfer. This underlines the importance of taking invisible transfers into account. Ignoring the impact of changing prices will distort any assessment of the role of agriculture in the development process.

Table 21. Financial transfers between agriculture and non-agriculture in domestic commodity markets under the CAADP scenario

	Billion cedi (2006-15)	% Increased GDP in 2006-15	Billion cedi (by 2015)	% Increased GDP in 2015
Part 1: Transfer from agriculture to non-agriculture through intermediate goods				
Agr. goods used in non-agr. prod. at current P	9,172	14.9	2,087	16.0
Staples	1,351	2.2	316	2.4
Import substitutable staples	1,014	1.7	227	1.7
Export agriculture	6,807	11.1	1,543	11.8
Invisible transfer through lowered agr. P paid by non-agr.	555	0.9	81	0.6
Staples	1,648	2.7	345	2.6
Import substitutable staples	1	0.0	1	0.0
Export agriculture	-1,094	-1.8	-265	-2.0
Non-agr. goods used in agr. at current P	-22,260	-36.2	-4,694	-36.0
In staple prod.	-7,408	-12.1	-1,603	-12.3
In import substitutable staple prod.	-2,543	-4.1	-545	-4.2
In export agricultural prod.	-12,309	-20.0	-2,546	-19.5
Invisible transfer through higher non-agr. P paid by agr.	4,283	7.0	911	7.0
In staple production	1,757	2.9	371	2.9
In import substitutable staple production	244	0.4	55	0.4
In export agricultural production	2,281	3.7	484	3.7
Part 2: Transfer from agriculture to non-agriculture through consumer goods				
Urban consumer demand for agr. goods at current P	2,885	4.7	667	5.1
Demand for staples	-348	-0.6	-10	-0.1
Demand for import substitutable staples	2,001	3.3	421	3.2
Demand for export agricultural goods	1,233	2.0	256	2.0
Invisible transfer through lowered agr. P paid by urban consumers	4,595	7.5	930	7.1
Demand for staples	5,542	9.0	1,129	8.7
Demand for import substitutable staple	-315	-0.5	-66	-0.5
Demand for export agricultural goods	-631	-1.0	-133	-1.0
Rural consumer demand for non-agr. goods at current P	-25,372	-41.3	-5,299	-40.7
Invisible transfer through higher non-agr. P paid by rural	6,700	10.9	1,402	10.8
Agr. demand for non-agr. goods in investment at current P	-2,076	-3.4	-430	-3.3
Invisible transfer through higher non-agr. P in agr. invest.	1,411	2.3	286	2.2
Part 3: summary of transfer from agriculture to non-agriculture in domestic commodity markets				
Visible transfer from agr. to non-agr. at current P	-37,649	-61.3	-7,668	-58.9
Invisible transfer fr. agr. to non-agr. in dom. comm. market	17,544	28.6	3,610	27.7

Source: Ghanaian DCGE model simulation results. Note: P is an abbreviation for prices, non-agr. stands for non-agricultural and agr. for agriculture

An increase in agricultural production often increases the use of non-agricultural products as inputs, which constitutes a transfer from non-agriculture to agriculture (and hence the corresponding numbers are reported as negative in Table 21). Measured in nominal terms, this transfer from non-agriculture to agriculture is greater than the transfer from agriculture to non-agriculture, equivalent to 36.2 percent of increased GDP in 2006-2015 and 36.0 percent in 2015. This negative transfer is also often referred to as a backward linkage, which describes a situation wherein increased agricultural production creates additional demand for goods and services produced by non-agricultural sectors. However, the invisible transfer remains positive in this case, due to an increase in non-agricultural prices incurred by the agricultural sector. As shown in Table 21, this transfer is positive and quite large, equivalent to 7 percent of increased GDP in 2006-2015.

The second part of Table 21 shows the transfers from agriculture/rural to the non-agriculture/urban through increased consumer demand. Growth in non-agricultural production raises the incomes of urban households, and part of this increased income is spent on agricultural products. This visible transfer from agriculture is equivalent to 4 percent of increased GDP in 2006-2015, measured in current prices. However, decreased agricultural prices constitute an invisible transfer from agriculture to urban consumers; this is equivalent to 7.5 percent of increased GDP in 2006-2015, and is substantially larger than the visible transfer. Within agriculture, the visible transfer from staple agriculture is negative, whereas the invisible transfer is positive and equivalent to 9 percent of increased GDP in 2006-2015. A negative transfer from staple agriculture implies that urban consumers pay less for consuming the same or larger amount of staple foods.

Agricultural productivity growth also raises the incomes of rural households, and part of this income increase is spent on consumption of non-agricultural goods. Following the same logic, increased rural demand for non-agricultural goods constitutes a negative transfer from agriculture. Rural incomes grow rapidly under the CAADP scenario, leading to a sharp increase in rural demand for non-agricultural products; this is equivalent to 41.3 percent of increased GDP in 2006-2015 (measured at current prices) and represents the largest backward linkage effect to non-agriculture under the CAADP scenario. However, rural consumers pay higher prices for purchasing non-agricultural goods, creating an invisible transfer from the rural to urban groups; this transfer is equal to about 10.9 percent of increased GDP in 2006-2015. Finally, a visible transfer from agriculture to non-agriculture (which is negative) can result from an increase in capital investments in the agricultural sector. Again, higher prices for capital goods lead to a positive and invisible transfer from agriculture to non-agriculture.

Table 22. Financial transfer between agriculture and non-agriculture in factor markets under CAADP

	Billion cedi (2006-15)	% Increased GDP in 2006-15	Billion cedi (by 2015)	% Increased GDP in 2015
1. Physical flows of factors from agriculture to non-agriculture	-376	-0.6	-93	-0.7
From staple sectors	1,491		276	
From import substitutable staple sectors	-180		-37	
From export agricultural sectors	-1,687		-332	
2. Rural factors moving into non-agr. production at current P	-9,493	-15.5	-1,987	-15.3
From staple sectors	-242		-70	
From import substitutable staple sectors	-396		-83	
From export agricultural sectors	-8,855		-1,834	
3. Invisible transfer through higher factor P paid by agr.	9,117	14.8	1,894	14.5
From staple sectors	1,733		347	
From import substitutable staple sectors	215		46	
From export agricultural sectors	7,169		1,502	

Source: Ghanaian DCGE model simulation results. Note: P is an abbreviation for prices, non-agr. stands for non-agricultural and agr. for agriculture

Part 3 of Table 21 summarizes the transfers occurring in the domestic commodity markets. The net visible transfer from agriculture to non-agriculture is negative, while there is a positive invisible transfer through changes in both agricultural and non-agricultural prices.

Transfers also occur in domestic factor markets, as shown in Table 22. Growth in agricultural productivity often releases agricultural labor from domestic market-oriented agriculture. However, if productivity growth occurs in export agriculture without demand-side constraints in international markets, export agriculture often attracts additional labor and capital. This leads to higher labor wages and results in a negative transfer from agriculture, since more factors move into agriculture instead of being released from agriculture. This is the situation we observe under the CAADP growth scenario. As shown in the first part of Table 22 agricultural productivity growth causes labor and capital to move out of domestic staple agriculture, while more factors are employed by export agriculture, resulting in a small net inflow of labor and capital into agriculture.

By competing with the non-agricultural sectors for labor and capital, export agriculture pushes factor prices up, resulting in a large visible negative transfer (Table 22, Part 2). This negative visible transfer is equivalent to 15.5 percent of increased GDP in 2006-2015.

Table 23. Summary of visible and invisible transfers of financial surplus from agriculture under the CAADP scenario

	Billion cedi accumulated 2006-2015	As % of accumulated increases in GDP 2006-2015	Billion cedi, 2015	As % of GDP in 2015
Financial transfer out of agriculture due to CAADP	**7,915**	**12.9**	**1,567**	**1.09**
Net visible transfer from agriculture	***-15,807***	***-25.7***	***-3,297***	**-2.29**
Through domestic markets	-47,142	-76.8	-9,656	-6.71
Through foreign trade	31,335	51.0	6,359	4.42
Net invisible transfer from agriculture	***23,722***	***38.6***	***4,865***	***3.38***
Through lowered agricultural prices	5,150	8.4	1,011	0.70
Through increased non-agricultural prices	12,394	20.2	2,599	1.81
Through increased factor prices	9,117	14.8	1,894	1.32
Through change in the exchange rate	-2,939	-4.8	-640	-0.44
Corresponding monetary value of net physical flows out of agriculture	**7,915**	**12.9**	**1,567**	**1.09**
Product contribution	***8,291***	***13.5***	***1,660***	***1.15***
Net transfer through domestic markets	*-20,105*	*-32.7*	*-4,059*	*-2.82*
Net transfer through foreign markets	*28,396*	*46.2*	*5,719*	*3.98*
Factor contribution	***-376***	***-0.6***	***-93***	***-0.06***
From staples	1,491	2.4	276	0.19
From import substitutables	-180	-0.3	-37	-0.03
From export agriculture	-1,687	-2.7	-332	-0.23

Source: Ghanaian DCGE model simulation results.

Table 23 summarizes the results of the visible and invisible transfers of financial surplus from agriculture under the CAADP growth scenario. The total financial transfer out of agriculture under CAADP amounts to about 7,915 billion cedi in 2006-2015, which is equivalent to 12.9 percent of increased GDP or 1.09 percent of total GDP over the same period. However, the visible transfer is actually negative at -15,807 billion cedi in 2006-2015. With 31,335 billion cedi of accumulated increases in the agricultural trade surplus over the 10-year period, the visible transfer through foreign markets is huge. However, the transfer from non-agriculture to agriculture is also substantial (47,142 billion cedi over 10 years), which leads to a negative transfer out of agriculture in terms of product contribution.

The huge invisible transfer out of agriculture dominates the negative visible transfer. In total, 23,722 billion cedi in 2006-2015 (or 4,865 billion in 2015 alone) are transferred from agriculture to non-agriculture through price effects. These price effects can be further distinguished by cause, including lowered agricultural prices, increased non-agricultural prices, increased factor prices and changes in the exchange rate. Increased agricultural exports cause a real exchange rate appreciation, leading to a negative factor in the invisible transfer (-2,939 billion cedi during 2006-2015). Because factors move into agriculture, increased factor prices constitute a positive invisible transfer, as agriculture has to pay a higher price for the increased employment of factor inputs (9,117 billion cedi during 2006-2015).

The net physical flows out of agriculture also have a corresponding monetary value; this equals the financial transfer out of agriculture, although the contribution of products and factors can also be distinguished. The factor contribution is negative, since more factors are employed in agriculture under CAADP. This is driven by increased factor demand in export agriculture, while more factors are released from staple agriculture.

Distinguishing export and staple agriculture can therefore further help us understand the different roles of these two agricultural sub-sectors in economic development. The results given in the previous three tables show that transfers of financial surplus from staple agriculture are often invisible and mainly stem from lowering food and intermediate inputs prices, which directly benefits urban consumers and non-agricultural activities. Productivity growth in staple agriculture implies that a country can produce more food and agricultural materials using less labor input. This further lowers the cost of labor and allows labor to migrate from rural to urban sectors and engage in non-agricultural growth. As observed during the development experiences of many Asian countries [Breisinger and Diao 2008], this supply of low-cost labor is critical to support the development of labor-intensive manufacturing and services. Furthermore, surplus transfer of export agriculture is often highly visible, and the provision of additional foreign exchange earnings helps the non-agricultural sectors through financing capital and consumer good imports. However, without productivity growth in staple agriculture, growth in export agriculture can raise the demand for food, which can result in either higher food prices in domestic markets or the need for more food imports. Also, without a corresponding decrease in product prices, increased demand for labor and capital to support growth in export agriculture can inflate factor prices. Under these conditions, it often becomes difficult to develop labor-intensive manufacturing and services such a situation could significantly slow the structural transformation of Ghana.

The quantitative analysis of visible and invisible agricultural surplus and its contribution to economy-wide growth is very important in allowing us to better judge the role of agriculture in economic development and to make informed policy decisions. It highlights the importance of agriculture beyond its direct growth effects and may make an important contribution to guiding and prioritizing public investments and agricultural policy.

Regional-level results from the CAADP simulation

Regional differences in agricultural growth remain under the CAADP scenario, but the growth gap becomes smaller compared to the base-run (Table 24 column 1). While we assume additional productivity growth at the crop and individual livestock product level to be the same across zones in the CAADP scenario, the combination of agricultural production activities differs substantially among the four zones (Tables 3 and 4), and land productivity improves differentially among the crops under the CAADP scenario. For example, the additional yield growth rate reaches as high as 2.9 percent for cassava and 3.5 percent for yam (Table 19 column 4). However, since root crops only account for 8.4 percent of the Coast Zone's agricultural value-added (Table 15), this high growth in root crops has a relatively small impact on the zone's agricultural growth under the CAADP scenario (Table 25). Despite having the smallest additional growth compared to the other zones, though, total agricultural GDP growth in the Coast Zone is still the second highest after that in the Northern Savannah (Table 24 column 2).

Table 24. Agricultural growth across zones in the CAADP simulation

	AgGDP annual growth rate	Additional annual growth from base-run	Contribution to agricultural growth (%)			
			Land	Labor	Capital	Productivity
Coast	6.1	1.1	12.4	19.0	7.5	61.1
Forest	6.0	1.7	27.1	11.6	5.4	56.0
S. Savannah	5.5	1.7	16.6	9.4	5.8	68.3
N. Savannah	6.8	2.8	39.6	8.8	4.7	46.9
National	6.0	1.9	27.5	10.8	5.3	56.4

Source: Ghanaian DCGE model simulation results.

Similar to the base-run results, as a result of differences in agro-ecological conditions, the sources of growth in the CAADP scenario are quite different across the four zones. While productivity is the most important factor in explaining the regional agricultural growth in the CAADP scenario, the contribution of land expansion still accounts for 40 percent of agricultural growth in the North Savannah (compared to 64 percent in the base-run). On the other hand, land continues to be the smallest factor for explaining agricultural growth in the Coast Zone, accounting for only 12.4 percent of agricultural growth under the CAADP scenario in this zone.

Table 25. Additional sub-sector growth across the four zones under the CAADP scenario

Part 1	Additional annual growth from the base-run (%)			
	Coast	Forest	S. Savannah	N. Savannah
Cereals	0.2	2.7	1.5	2.7
Root crops	-0.4	0.6	0.3	4.2
Other staple crops	1.5	0.6	1.9	2.2
Export crops	3.8	3.3	5.0	4.0
Livestock	1.7	1.8	2.5	1.6
Fishery and forestry	0.6	0.6	0.6	0.6
Part 2	**Sub-sectors' contributions to additional AgGDP growth from base-run (%)**			
	Coast	Forest	S. Savannah	N. Savannah
Cereals	22.2	1.2	2.8	25.8
Root crops	2.0	13.4	31.0	15.8
Other staple crops	5.1	12.1	20.0	35.4
Export crops	22.7	52.8	24.8	9.4
Livestock	9.2	5.3	5.2	12.3
Fishery and forestry	38.9	15.1	16.3	1.4

Source: Ghanaian DCGE model simulation results.

The contribution of various sub-sectors to regional agricultural growth also differs by zone under the CAADP scenario. As shown in Table 25 (part two), fishery and forestry contribute the most to additional agricultural growth in the Coast Zone, while export crops are the most important contributors to the Forest Zone's additional agricultural growth. In the North, additional growth in agriculture mainly comes from the three staple crop groups, while root crops are the most important factor for additional agricultural growth in the Southern Savannah.

Impact of CAADP Growth on Regional Income and Poverty

Accelerating agricultural growth to 6 percent per year and its spillover effects to non-agricultural sectors also accelerates poverty reduction. Our model results suggest that both the national and rural poverty rates will be halved one year earlier under the CAADP scenario compared to the baseline. By 2015, the national poverty rate will fall to 12.5 percent under the CAADP scenario, compared to 16.4 in the base-run. The rural poverty rate will fall to 17.5 percent by 2015, substantially lower than the 23.2 percent in the base-run's 2015 solution. This translates into an additional 850,000 people (mostly from rural areas) moving out of poverty by 2015 under the CAADP simulation.

Table 26. Growth in household income in the CAADP simulation

	Growth in agricultural income	Additional growth in agricultural income from the base-run	Growth in total income	Additional growth in total income from the base-run
Urban			6.09	1.11
Accra			6.28	1.14
Coast			5.97	1.09
Forest			5.94	1.08
S. Savannah			5.93	1.08
N. Savannah			6.14	1.12
Rural	5.76	1.33	5.82	1.29
Coast	6.19	1.17	6.08	1.14
Forest	5.89	1.42	5.88	1.40
S. Savannah	5.25	1.04	5.49	1.06
N. Savannah	5.93	1.62	6.02	1.53

Source: Ghanaian DCGE model simulation results.
Note: Income is measured in current prices.

The model results show that poverty reduction is the result of increased incomes and lowered food prices driven by productivity growth in the agricultural sector. Thus, urban households share the gains from agricultural growth acceleration under CAADP, with rural and urban incomes growing at similar rates; sector linkages and price effects mean that total urban income grows at 6.09 percent annually, compared to 6.08 for rural incomes. However, rural households benefit more than urban households in terms of additional income growth (1.29 vs. 1.11 percent, respectively) under the CAADP scenario compared to the base-run. Among the urban household groups, Accra and Northern urban households are the major beneficiaries from CAADP. Annual incomes increase by 6.28 and 6.14 percent for these two household groups, respectively. The additional income growth is highest for these two groups of households, too (Table 26). Among the rural household groups, income growth in Northern rural households catches up with income growth in the other regions. As shown in Table 26, the additional annual growth for Northern rural households is 1.62 percent of their agricultural income and 1.53 percent of their total income; both are the highest among the regional income growth rates.

This relatively high income growth rate for the Northern rural households suggests that poverty reduction in the North might speed up. As shown in Table 27, the additional poverty reduction in 2015 under the CAADP scenario is 7.9 percentage points in the North, versus 5.7 percent for rural households nationally and 3.9 percent for the national total. However, given the high initial poverty rate in the North, the poverty rate in this region will remain at a high level of 40.6 percent by 2015 even under the CAADP scenario, increasing the gap between poverty (and income) levels in the North versus the rest of the country, and further exacerbating regional divergence.

Table 27 Poverty reduction under the CAADP scenario

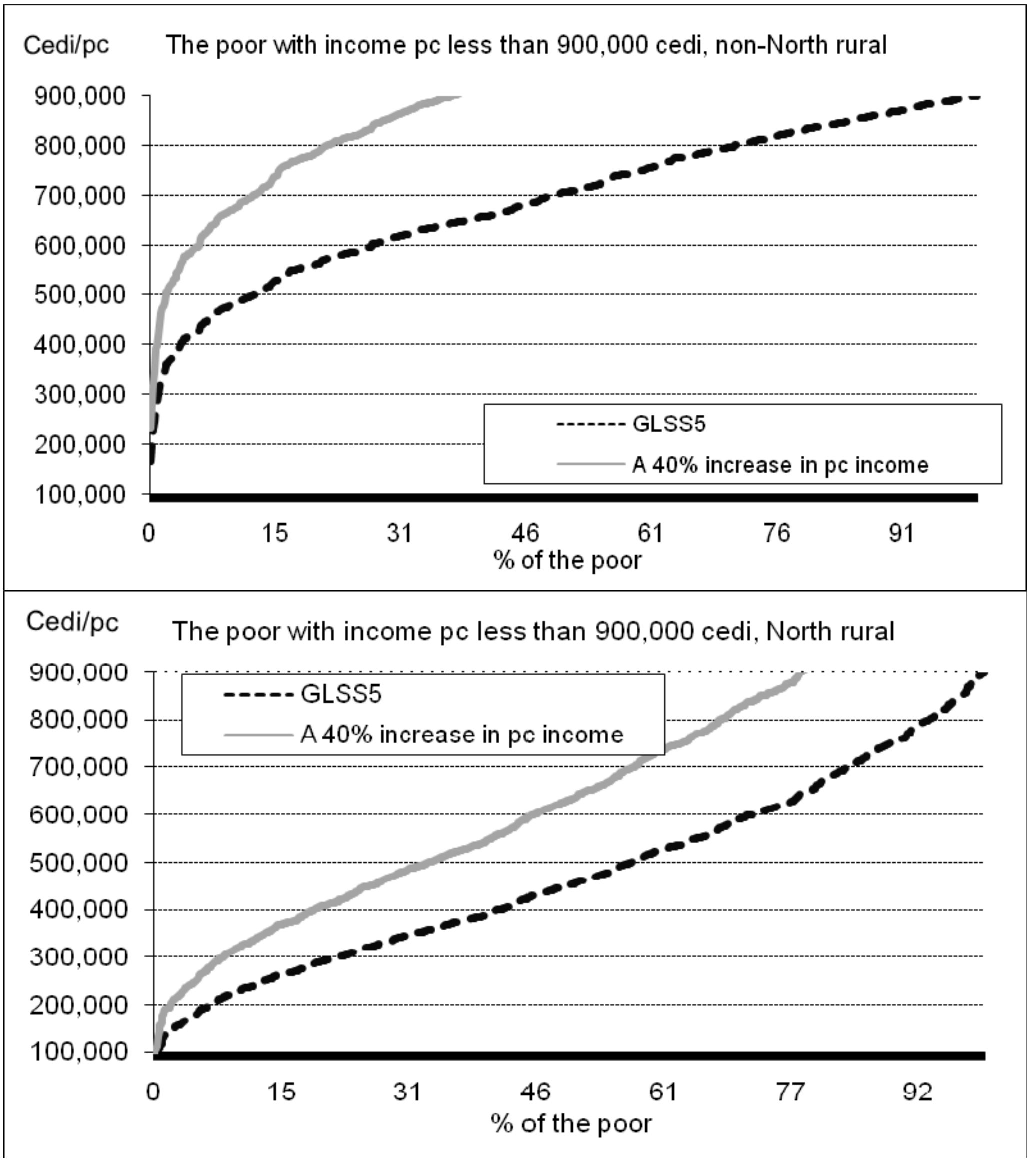
	Data, 2005	Base-run, 2015	CAADP-run, 2015	Additional poverty reduction by 2015
North	62.7	48.6	40.6	7.9
Rest of the country	19.7	8.6	5.6	2.9
National	28.5	16.4	12.5	3.9
Rural	39.2	23.2	17.5	5.7

Source: Ghanaian DCGE model simulation results.

It is important to emphasize the need for further poverty reduction in the North, but this discussion has often concentrated on a single poverty line. In order to better understand the challenge of reducing poverty in the North and design more appropriate policies, an analysis should go beyond the poverty line definition in order to better understand the size and nature of this challenge. Cross-country empirical studies show that the elasticity of poverty reduction to income growth is lower for low initial per capita income groups (Easterly, 2007). This finding is supported by the case of poverty reduction in Ghana. We use per capita expenditure data from GLSS5 to illustrate this argument. The two charts included in Figure 6 depict the poverty population distribution in the non-North and North. The rural population under the poverty line of 900,000 cedi (at 1999 prices) is equal to 100 in each region in the figures. The dashed line in each chart shows the poverty population distribution ranking from poor to less poor according to per capita income. If the 6 percent annual AgGDP growth were equally distributed among all rural households in the country, this would be roughly equal to a 40 percent total increase in per capita income for all households (assuming that the population growth rate is 2.5 percent annually). With this equally-distributed growth, households with per capita income between 650,000 and 900,000 cedi in GLSS5 will all be lifted above the poverty line. The solid line in each chart shows the share of the population that stays below the poverty line even after their income has increased by 40 percent. Since the income of almost two-thirds of the poor in the non-North rural households ranges between 650,000 and 900,000 cedi in GLSS5, the poverty rate among the non-North rural households falls to 8 percent, a significant drop from the initial 20 percent. In sharp contrast to that, only 20 percent of the rural poor in the North earned incomes between 650,000 and 900,000 cedi (GLSS5). Applying the same 40 percent income increase per capita to this group therefore leads to significantly lower poverty reduction in the North, where the rural poverty rate will only fall to 53 percent from its initial level of 68 percent.

These results emphasize the special attention that should be paid to populations whose income is far below the poverty line. Obviously, rapid income growth will not be sufficient to lift the poorest of the poor out of the poverty, indicating that more targeted policies and investments are urgently needed. Thus, while halving the poverty rate between 1990 and 2008 will connote a big success for Ghana, the continued fight against poverty in this country will have to increasingly concentrate on the poorest of the poor, most of whom live in the North.

Figure 6. Population distribution under the poverty line



Source: Authors' calculation using GLSS5.

6. SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

Impressive growth and record poverty reduction over the past 20 years have made Ghana an African success story. Agricultural growth has played an important role in this impressive development, and policy-makers and researchers agree that the sector will have to continue to play an important role in Ghana's future development. This paper seeks to enhance our understanding of the role of agriculture in this process, including its potential to drive and support economy-wide growth. We also analyze the sector's contribution to further poverty reduction, paying special attention to the poorest of the poor and the lagging North.

High average agricultural growth rates of 5.5 percent over the past five years have generated excitement about the sector's future potential for leading growth in Ghana, and seem to suggest that it should be easy to reach the CAADP's agricultural growth target of 6 percent. However, critics have noted that recent agricultural growth has been supported by favorable external conditions and driven by land expansion rather than improvements in productivity. Therefore, we herein take a longer-term perspective and examine the period between 1990 and 2006, during which the agricultural sector in Ghana grew at an average annual rate of 4.2 percent. We use this longer-term growth trend as the basis for our model's base-run simulation. This baseline agricultural growth combined with accelerated growth in industry and services according to their trends over the past five years yields an average annual total GDP growth rate of 4.9 percent between 2006 and 2015. This growth performance will be sufficient to reach MDG1 of halving rural poverty before 2015 (actually, this will occur in 2008). However, along this growth path, the country will be unable to reach its more ambitious goal of becoming a middle-income country by 2015 (Breisinger et al., 2008). Moreover, poverty in the North will remain high and the income gap between the North and the rest of country will widen further.

The Government of Ghana participates in CAADP, which provides an integrated framework to support agricultural growth, rural development and food security in the African region. Agricultural growth potentials exist in Ghana, exemplified by significant gaps between achievable and current yields for many crops. We therefore develop a DCGE model and use it to assess the relationship between closing these yield gaps and achieving the CAADP target for overall agricultural growth. The model results show that by closing the yield gaps, together with reasonable growth achieved in the livestock, fishery and forestry sectors, Ghana will be able to reach CAADP's goal of 6 percent annual agricultural growth. Under this scenario, the economy-wide GDP growth rate rises to 5.8 percent per year over the next 10 years. However, increased productivity rather than land expansion has to be the main source of this growth. The model shows that in targeting the 6 percent growth rate of CAADP, productivity explains 47 and 56 percent of GDP and AgGDP growth, respectively. Moreover, we do not find significant demand-side constraints for most staple commodities, as growth in these commodities remains relatively modest and non-agricultural income growth is already high. The only exception is yam, for which the domestic price falls by 10 percent over 10 years, compared to its 2005 level. On the other hand, domestic supply will not be able to meet the increased demand for some food commodities, such as rice and poultry. These products will continue to depend on imports, though domestic farmers do benefit from improved productivity and can increase their competitiveness. Agricultural exports, including both traditional and nontraditional exports such as fruits and vegetables, will play an increasingly important role, with one-third of accelerated agricultural growth occurring through growth in the export sector. However, given their large share in agriculture, staple crops will continue to be the most important driver of agricultural growth.

Agricultural growth continues to support growth in other sectors through visible and invisible transfers. The analysis of these transfers helps us understand the sector's role beyond its direct contribution to growth. We find that explicitly measured surplus transferred from agriculture to non-agriculture amounts to about 8,000 billion cedi between 2006 and 2015, equivalent to 12.9 percent of the increase in GDP during this period. Invisible transfers are the dominant factor, including transfers that come from lowered agricultural prices, as well as increased non-agricultural and factor prices. However, the nature of these transfers differs between export and staple agriculture. The transfer of financial surplus from staple agriculture is often invisible and caused by the lowering of prices for food and intermediate inputs, which directly benefits urban consumers and the growth of the non-agricultural sector. Productivity growth in staple agriculture also implies that a country can produce more food and agricultural materials with less labor. This reduces the cost of labor and allows labor to migrate from rural to urban areas, and participate in non-agricultural growth. The supply of low-cost labor further supports the development of labor-intensive manufacturing and services, which is an important factor in the economic development process. On the other hand, the transfer of surplus out of export agriculture is often more visible and comes through the provision of increased foreign exchange earnings, which helps finance the non-agricultural sector's capital and consumer goods imports. However, without complimentary productivity growth in staple agriculture, growth in export agriculture can raise demand for food, which often results in either higher food prices in domestic markets or increased food imports. In addition, without lowering product prices, the increased use of labor and capital in export agriculture can push factor prices up. In a situation with high labor and food costs, the development of labor-intensive manufacturing and services is likely to become more difficult; if this occurs, it could significantly slow the structural transformation of the Ghanaian economy. The distinction of visible and invisible transfers is therefore a useful concept when we seek to attain more holistic view of the role of agriculture in Ghana's economic development. This understanding will be necessary for guiding and prioritizing public investments and agricultural policies.

Improvements in land and total factor productivity narrow the regional agricultural growth gap under the CAADP scenario. However, large zone-level differences remain in the contribution of different agricultural sub-sectors to total agricultural growth. Growth in export crops becomes increasingly important for the Coast and Forest Zones compared to the base-run. However, staple crops will remain the major source of agricultural growth in the Northern Zone in all scenarios considered.

Agricultural growth benefits both urban and rural households, due to both price effects and linkage effects from agriculture to the non-agricultural sectors. Non-agricultural prices rise relatively more than agricultural prices, benefiting economy-wide factors that are owned proportionally more by urban households versus rural households. However, if the additional income generated under the CAADP scenario is compared to the baseline, we see that rural households benefit more due to stronger growth in agricultural incomes.

Agricultural growth under the CAADP scenario is pro-poor. Income growth in the North starts catching up with that in the rest of country, as zone-level income growth is highest among Northern rural households. However, in terms of the level of annual growth rate, the North still lags behind the Coast Zone.

At the national level, agricultural growth under CAADP will lift 850,000 additional people out of poverty by 2015, compared to the base-run. The national poverty rate declines to 12.5 percent by 2015, down from 28.5 percent in 2006. Accelerated income growth speeds up poverty reduction in the North, which has the largest percentage of poverty reduction. However, given its very high initial level of poverty, CAADP growth will not be sufficient to close the poverty gap between the North and the rest of country. The poverty rate in the North will stay at a high level of 40 percent by 2015, almost 30 percentage points higher than the national average poverty rate. This result indicates that in order to significantly reduce poverty in the North, Ghana will require a more targeted approach in addition to meeting the 6 percent CAADP growth target.

While it is important to emphasize the challenge of further poverty reduction in the North, researchers and policy-makers should not focus on a single poverty line. Cross-country empirical studies show that the elasticity of poverty reduction to income growth is low at low initial per capita income levels. Consistent with this, our analysis shows that even if poor and less poor people benefit equally from 6 percent agricultural growth, poverty reduction will still be slower in the North than in the rest of Ghana. In addition, the distribution of the poor population differs strongly between the North and non-North. Two-thirds of the poor in the non-North rural group have current incomes between 650,000 and 900,000 cedi, implying that most of them can be lifted above the poverty line relatively easily over the next 10 years. In contrast, only 20 percent of the rural poor in the North fall into the current income range of 650,000 to 900,000 cedi. With a similar income growth, poverty reduction will lift only these 20 percent of Northern poor above the poverty line in the next decade, leaving the large majority behind in poverty.

These differences in the distribution of poverty between the North and the rest of Ghana show that it is not enough to focus on poverty reduction measured by a single poverty line. More attention should be paid to the population whose income is far below the poverty line. By showing that even with rapid income growth the majority of these extremely poor people (of whom most live in the North) are unlikely to be lifted out of poverty, the analysis highlights the urgent need for specific policies that go beyond strategies focusing on broad agricultural growth.

Several policy implications emerge from this paper. First, we find that the role of agriculture in the Ghanaian economy goes beyond its ability to act a source of growth and a tool for poverty reduction. The large size of transfers indicates the importance of agriculture for the transformation of the economy. Second, reaching CAADP's target of 6 percent annual agricultural growth is complementary with Ghana's goal of reaching middle-income country status. However, an analysis by Breisinger et al. (2008) shows that 6 percent agricultural growth constitutes the minimum growth rate required to achieve the country's middle-income goal. Third, despite the country's sound agricultural performance over the past five years, it will be challenging for Ghana to sustain and accelerate this growth, particularly if external conditions become less favorable in the future. Fourth, the CAADP target can be reached in the next 10 years by closing existing yield gaps and increasing the efficiency of available land use. However, this will require substantial investments in Green-revolution type of investments, including rural infrastructure (including irrigation), marketing, extension and agricultural R&D. Finally, CAADP growth will not be sufficient to significantly reduce the regional divide and substantially reduce poverty in the lagging North. In order to address this issue, the policies and interventions planned under the CAADP framework should be integrated with interventions targeted toward the North and the poorest of the poor.

APPENDIX: SPECIFICATION OF THE DCGE AND MICRO-SIMULATION MODEL

A computable general equilibrium (CGE) model was developed to assess sector-specific growth options and their poverty impacts. The model is calibrated to a 2005 social accounting matrix (SAM) that provides information on demand and production for 59 detailed sectors (see Table 8). The model further disaggregates agricultural activities across agro-ecological zones using district-level production and price data (see Section 3). Due to data constraints, non-agricultural production is not disaggregated across regions. Based on the SAM, the production technologies across all sectors are calibrated to their current situations, including each sector's use of primary inputs, such as land, labor and capital, and intermediate inputs. To capture existing differences in labor markets, the model classifies employed labor into different sub-categories, including self-employed agricultural workers, unskilled workers working in both agriculture and non-agriculture, and skilled non-agricultural workers. Information on employment and wages by sector and region is taken from the Ghana Living Standard Survey 2005/06 (GLSS5).

Workers in the model can migrate between sectors and regions, although agricultural family labor remains within regions. By assuming that the self-employed agricultural labor force grows more slowly than the rest of the work force, the model accounts for the mobility of rural laborers from working on their own small farms to finding employment through the labor market. Capital moves freely within regions and within the broad agricultural and non-agricultural sectors, and capital is accumulated through investments financed by domestic savings and foreign inflows. Increased capital is allocated across sectors and regions according to their relative profitability. Incomes from employment accrue to different households according to employment and wage data from GLSS5. This detailed specification of production and factor markets in the model allows it to capture changes in scale and technology of production across sectors and sub-national regions, and therefore, how changes in Ghana's structure of growth influences its distribution of incomes.

The growth-poverty relationship is examined by combining a DCGE and micro-simulation model. An important factor determining the contribution of agriculture to overall economic growth is its linkages with the rest of the economy. Proponents of agriculture argue that agriculture has strong growth-linkages. The model captures production linkages by explicitly defining a set of nested constant elasticity of substitution (CES) production functions, thereby allowing producers to generate demand for both factors and intermediates. The DCGE model also captures forward and backward production linkages between sectors. Import competition and export opportunities are modeled by allowing producers and consumers to shift between domestic and foreign markets depending on changes in the relative prices of imports, exports and domestic goods. More specifically, the decision of producers to supply domestic or foreign markets is governed by a constant elasticity of transformation (CET) function, while substitution possibilities exist between imports and domestically-supplied goods under a CES Armington specification. In this way, the model captures how import competition and the changing export opportunities of agriculture and industry can strengthen or weaken the linkages between growth and poverty.

Incomes from production, trade and employment accrue to different households according to employment and wage data from GLSS5. As with production, households are defined at the regional level according to agro-ecological zones, and by rural and urban areas within each zone. Greater Accra is treated as a separate group, given its unique role as national economic hub. Income and expenditure patterns vary considerably across these household groups. These differences are important for distributional change, since incomes generated by agricultural growth accrue differently to households depending on their location and factor endowments. Each representative household in the model is an aggregation of a group of households in GLSS5. Households in the model receive income through the employment of their factors in both agricultural and non-agricultural production, and then pay taxes, save and make transfers to other households. The disposable income of a representative household is allocated to a commodity consumption derived from a Stone-Geary utility function (i.e. a linear expenditure system of demand). In order to retain as much information on the households' income and expenditure patterns as possible, the DCGE model is linked to a micro-simulation module based on GLSS5. Endogenous changes in commodity consumption for each aggregate household in the DCGE model are used to adjust the level of commodity expenditure of the corresponding households in the survey. Real consumption levels are then recalculated in the survey, and standard poverty measures are estimated using this updated expenditure measure.

The model makes a number of assumptions about how the economy maintains macroeconomic balance. These 'closure rules' concern the foreign or current account, the government or public sector account, and the savings-investment account. For the current account, a flexible exchange rate maintains a fixed level of foreign savings. This assumption implies that governments cannot simply increase foreign debt, but instead must generate export earnings in order to pay for imported goods and services. While this assumption realistically limits the degree of import competition in the domestic market, it also underlines the importance of the agricultural and industrial export sectors. For the government account, tax rates and real consumption expenditure are exogenously determined, leaving the fiscal deficit to adjust to ensure that public expenditures equal receipts. For the savings-investment account, real investment adjusts to changes in savings (i.e. savings-driven investment). These two assumptions allow the model to capture the effects of growth on the level of public investment and the crowding-out effect from changes in government revenues.

Finally, the DCGE model is recursive dynamic, which means that some exogenous stock variables in the model are updated each period based on inter-temporal behavior and the results from previous periods. The model is run over the period 2005-2015, with each equilibrium period representing a single year. The model also exogenously captures demographic and technological changes, including those in population, labor supply, human capital and factor-specific productivity. Capital accumulation occurs through endogenous linkages with previous-period investment. Although the allocation of newly invested capital is influenced by each sector's initial share of gross operating surplus, the final allocation depends on depreciation and sector profit-rate differentials. Sectors with above-average returns in the previous period receive a larger share of the new capital stock in the current period.

In summary, the DCGE model incorporates distributional change by: (i) disaggregating growth across sub-national regions and sectors; (ii) capturing income-effects through factor markets and price-effects through commodity markets; and (iii) translating these two effects onto each household in the survey according to its unique factor endowment and income and expenditure patterns. The structure of the growth-poverty relationship is therefore defined explicitly ex ante based on observed country-specific structures and behavior. This allows the models to capture the poverty and distributional changes associated with agricultural growth.

Table A.1. DCGE model sets, parameters, and variables

Symbol	Explanation	Symbol	Explanation
Sets			
$a \in A$	Activities	$c \in CMN (\subset C)$	Commodities not in *CM*
$a \in ALEO (\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CT (\subset C)$	Transaction service commodities
$c \in C$	Commodities	$c \in CX (\subset C)$	Commodities with domestic production
$c \in CD (\subset C)$	Commodities with domestic sales of domestic output	$f \in F$	Factors
$c \in CDN (\subset C)$	Commodities not in *CD*	$i \in INS$	Institutions (domestic and rest of world)
$c \in CE (\subset C)$	Exported commodities	$i \in INSD (\subset INS)$	Domestic institutions
$c \in CEN (\subset C)$	Commodities not in *CE*	$i \in INSDNG (\subset INSD)$	Domestic non-government institutions
$c \in CM (\subset C)$	Aggregate imported commodities	$h \in H (\subset INSDNG)$	Households

Table A.1. Continued

Symbol	Explanation	Symbol	Explanation
Parameters			
$cwts_c$	Weight of commodity c in the CPI	$qdst_c$	Quantity of stock change
$dwts_c$	Weight of commodity c in the producer price index	$\overline{qg}_c$	Base-year quantity of government demand
ica_{ca}	Quantity of c as intermediate input per unit of activity a	$\overline{qinv}_c$	Base-year quantity of private investment demand
$icd_{cc'}$	Quantity of commodity c as trade input per unit of c' produced and sold domestically	$shif_{if}$	Share for domestic institution i in income of factor f
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	$shii_{ii'}$	Share of net income of i' to i (i' ∈ INSDNG'; i ∈ INSDNG)
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	ta_a	Tax rate for activity a
$inta_a$	Quantity of aggregate intermediate input per activity unit	$\overline{tins}_i$	Exogenous direct tax rate for domestic institution i
iva_a	Quantity of aggregate intermediate input per activity unit	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$\overline{mps}_i$	Base savings rate for domestic institution i	tm_c	Import tariff rate
$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tq_c	Rate of sales tax
pwe_c	Export price (foreign currency)	$trnsfr_{i\,f}$	Transfer from factor f to institution i
pwm_c	Import price (foreign currency)		
Greek Symbols			
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		

Table A.1. Continued

Symbol	Explanation	Symbol	Explanation
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		
Endogenous Variables			
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 of commodity c from activity a for household h
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 for commodity
$GSAV$	Government savings	QM_{cr}	Quantity of imports of commodity c
QF_{fa}	Quantity demanded of factor f from activity a		
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

Table A.1. Continued

Symbol	Explanation	Symbol	Explanation
Endogenous Variables Continued			
$PXAC_{ac}$	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 A.2. DCGE model equations

Production and Price Equations	
$QINT_{c\,a} = ica_{c\,a} \cdot QINTA_a$	(1)
$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$	(2)
$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}-1}$	(4)
$QF_{f\,a} = \alpha_{f\,a}^{van} \cdot \left(\sum_{f' \in F} \delta_{f\,f'\,a}^{van} \cdot QF_{f'\,a}^{\;-\rho_{f\,a}^{van}} \right)^{-\frac{1}{\rho_{f\,a}^{van}}}$	(5)
$W_{f'} \cdot WFDIST_{f'\,a} = W_f \cdot WFDIST_{f\,a} \cdot QF_{f\,a} \cdot \left(\sum_{f'' \in F} \delta_{f\,f''\,a}^{van} \cdot QF_{f''\,a}^{\;-\rho_{f\,a}^{van}} \right)^{-1} \cdot \delta_{f\,f'\,a}^{van} \cdot QF_{f'\,a}^{\;-\rho_{f\,a}^{van}-1}$	(6)
$QVA_a = iva_a \cdot QA_a$	(7)
$QINTA_a = inta_a \cdot QA_a$	(8)
$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$	(9)
$QXAC_{a\,c} = \theta_{a\,c} \cdot QA_a$	(10)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(11)
$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{\;-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$	(12)
$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}-1}$	(13)
$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c}$	(14)
$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}}$	(15)
$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PDS_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}}$	(16)

Table A.2. Continued

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

Table A.2. Continued

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

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