G S S P Background Paper 7

ACCELERATED GROWTH AND STRUCTURAL TRANSFORMATION: ASSESSING GHANA'S OPTIONS TO REACH MIDDLE-INCOME STATUS

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THE GHANA STRATEGY SUPPORT PROGRAM (GSSP)
BACKGROUND PAPERS

ABOUT GSSP

GSSP is a research, communication, and capacity-strengthening program to build the capabilities of researchers, administrators, policymakers, and members of civil society in Ghana to develop and implement agricultural and rural development strategies. With core funding from the U.S. Agency for International Development (USAID)/Ghana and a mandate to develop a multi-donor-funded Program, IFPRI launched GSSP as a partnership between Ghana and its development partners. IFPRI is working with these stakeholders to generate information, improve dialogue, and sharpen decisionmaking processes essential for effective formulation and implementation of development strategies. GSSP informs stakeholders on the role of agriculture and rural development in the broader economic and policy context in line with the emphasis placed on agriculture in Ghana's Growth and Poverty Reduction Strategy. GSSP supports the development and implementation of a system to monitor and evaluate progress toward achieving Ghana's growth and poverty reduction targets and the Millennium Development Goals.

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TABLE OF CONTENTS

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SUMMARY

Ghana has made considerable progress over the last 20 years in sustaining economic growth and reducing poverty. The Government of Ghana has declared its new development goal of reaching middle-income status by 2015. Achieving this goal will require Ghana to double its per capita income over the next decade. In this paper we explore the growth experiences of other developing countries that have successfully transformed their economies from situations similar to Ghana's today. Based on the past experiences of these fast growing countries, and using a dynamic general equilibrium model developed for Ghana, we evaluate sources of accelerated growth and their contributions to overall growth and transformation. The major findings are:

- It is possible for a country with a per capita income level of US$400 to reach middle-income status within 10 years, if average GDP grows around 6-10 percent annually. Experiences from other countries show that rapid growth is often accompanied by changes in economic structure, employment opportunities, factor and sector productivity, and in export diversification**.** Exports usually grow more rapidly than GDP, indicating the importance of external demand in periods of rapid growth and structural change.
- The CGE model results show that a growth rate of 7.6 percent is needed for Ghana to reach middle-income status. Acceleration of growth in any single sector is unlikely to lead to significant economy-wide growth, underlining the need for broad-based growth in all sectors.
- To make the manufacturing sector an active driver of overall growth, it needs to grow very rapidly. Moreover, with its current within-sector structure, manufacturing growth in Ghana will depend heavily on agricultural growth, which provides inputs to the country's major manufacturing sectors (i.e., food and wood processing).
- Growth in services causes more growth in other sectors, because private services are dominated by domestic-market-oriented activities that provide inputs into other economic activities. Export-oriented services, such as tourism, can grow more rapidly but will be unlikely an important driver for the overall growth given its small initial share in the economy.
- Given its large initial share in the economy, agriculture will be one of the most important drivers of growth if Ghana is to grow fast enough to reach its middle-income goal by 2015. Although opportunities to accelerate growth in export-oriented agriculture exist, domestic market-oriented agricultural sub-sectors, including import-substitutable agriculture such as rice and poultry have much stronger growth-multiplier effects. Driven by improvements in productivity and competitiveness, domestic market-oriented agriculture supports the overall growth through lowering food prices, competing with imports, and providing cheap inputs for manufacturing.

- It is unlikely that the structure of Ghana's agricultural exports, which are dominated by cocoa, will change greatly on the way to middle-income status. Although Malaysia also retained its agricultural export structure during its transformation to middle-income status, Ghana's concentrated export structure will remain vulnerable to external shocks in world cocoa markets.
- Accelerated growth in the next 10 years will continue to be financed by foreign inflows and remain dependent on imported capital goods. Any interruption in these inflows (e.g., reduction in foreign aid and other development partners' support) will significantly constrain growth.
- Both opportunities and threats emerge from the recent oil discovery in Ghana. The impact of exploiting this resource deserves more in-depth analysis on Ghana's future growth and structural change.
- Energy shortages and increased regional divergence in growth also deserve similar in-depth study in order to assess their impact on the growth process.
- Caveats exist in the model, which may cause an underestimation of structural change driven by demand dynamics, newly developed economic activities in both agriculture and non-agriculture and technological spillovers.
- Several policy implications for the design of development strategies emerge from this paper.
    - First, sustainable rapid growth must be accompanied by structural change in which resources and labor move from traditional low-productivity activities into modern sectors. While exploiting natural resources can make some countries rich, resource-based growth often leads to an increase in inequality. Ghana should actively avoid such outcomes along its path to middle-income status.
    - Secondly, modernization of the economy does not need to take place in industrial sectors alone. The modernization of traditional agriculture can be a significant source of accelerated growth and structural change. However, growth in the agricultural sector requires strong support from the government and structural transformation is rarely been purely market-driven in successfully transforming countries.
    - Finally, there are natural limits to export-led growth based on primary products. Diversifying Ghana's export structure is thus vital if exports are to become an engine for accelerated growth and structural change. The government must search for policies that promote private entrepreneurship and investment (foreign and domestic) in new activities facing more dynamic international demand.
- In conclusion, for Ghana to reach middle-income status it will require careful coordination between increasingly complex macroeconomic, industrial and financial market policies,

which also require the improvement of institutional capacity of the government to implement such complex policies.

1. INTRODUCTION

In the last twenty years, Ghana has achieved sustained growth and significant poverty reduction. Many factors have contributed to this successful performance, including improvements in policies and the investment climate, increases in investments and aid inflows, and favorable world cocoa and other commodity prices (Mc Kay and Aryeetey, 2004; Bogetic et al, 2007). The most recent national household survey data (GLSS5 2005/06) suggests that, based on current trends, the country will reach the first Millennium Development Goal (MDG One) of halving 1990's poverty rate by 2008 (GSS, 2007). Thus, Ghana will become one of only a few African countries that are able to achieve 'MDG One' earlier than the target year of 2015. With this success in growth and poverty reduction, the Government of Ghana has declared its new development goal of reaching middle-income status by 2015 in its second Growth and Poverty Reduction Strategy (GPRS II) (NDPC 2005; Coulombe and Wodon 2007). Achieving this goal will require Ghana to double its per capita GDP from its current US$454 to US$1,000 over the next 10 years.

Doubling per capita incomes in 10 years requires rapid growth. Experiences from successful developing countries indicate that the drivers of growth differ across countries. However, reaching middle-income country status usually involves a process of economic transformation in which significant economic structural changes takes place. Structural change (or economic transformation) is a dynamic process that involves the evolution of the sectoral composition of output, employment and labor productivity over time (Pieper, 2001). The transformation from a traditional economy to a modern one is thus accompanied by capital accumulation, technological change and productivity growth.

Economic sectors that are less dependent on natural resources, such as manufacturing, are usually associated with greater potential for economies-of-scale, and hence, for more rapid growth (Adelman, 2001). Accordingly, non-agricultural sectors usually grow more rapidly and become increasingly important in the transformation process (Kuznets 1971, Chenery, 1980, Syrquin, 1988). However, in recent years, the transformation of traditional agriculture into a modern sector has occurred along-side growth of non-agricultural sectors driven by advances in mechanical and biological technological change (Hayami and Ruttan 1985). While the importance of inter-sectoral dynamics for growth has been long recognized (Hirschman 1958; Jorgenson 1961; Fei and Ranis 1961, 1964), the path along which a country realizes structural change and transformation depends on many country-specific factors.

Options exist in Ghana. By promoting growth in different sectors and emphasizing differential roles across sectors, Ghana can reach middle-income status along different paths. The choice of

growth paths will affect the country's development process. A resource-rich country can reach middle-income status without significant structural change and economic transformation. In such countries, the rural economy and agricultural sector can remain under-developed, the poverty rate will probably also remain high, and there will be higher income inequality.[1]

Given Ghana's new development goal, this paper focuses on the importance of economic transformation in achieving middle-income status and the trade-offs between alternative growth paths. More specifically, we evaluate the country's growth options at detailed sectoral level and the potential impact of such growth options on structural change in Ghana over the next 10 years. For this analysis, we develop a dynamic general equilibrium model with detailed agriculture, industry and service sectors. By assuming exogenous productivity growth at sector level, we use the model to assess the contribution of sectoral growth to overall economic growth and structural change.

By taking into account inter-sectoral and economy-wide linkages, general equilibrium theory is obviously very relevant in understanding structural change. In recent years, there have been a lot of efforts among economists to empirically study structural change using general equilibrium models. For example, Irz and Roe (2005) build a two sector growth model and calibrate it to an archetype low-income economy. They find that low agricultural productivity can be an important bottleneck to overall growth, which is caused by resulting high food prices and low savings rates. Echevarria develops a Solow-type dynamic general equilibrium to study changes in sectoral composition and finds that structural change is driven by consumer preferences (Echevarria, 1997). Diao et al. (2005) explicitly include international trade in their intertemporal general equilibrium model for Thailand to demonstrate the importance of openness for structural change and growth.

Most studies, however, analyze structural change in an aggregate economy. For example, Irz and Roe's model includes only two sectors of an archetypal economy (agriculture and non-agriculture), Echevarria's model considers three aggregate sectors for several OECD countries (primary, manufacturing and services), and Diao et al's Thailand model includes four sectors (agriculture, exportables, importables and non-tradable non-agriculture). While highly aggregated general equilibrium models are helpful for understanding the general driving force of structural change, they ignore many country-specific factors that are critical in determining alternative growth paths that countries may follow in their development process. For example, initial economic structures are quite different across countries and such initial conditions often affect a set of choices facing different countries.

[1] For example, Angola used to be a middle-income country in the early 1980s and became middle-income country again in 2006 by exploiting its rich natural resources. However, there is less structural change in its economy and poverty is still very high.

To address this gap in the literature and to help Ghana in diagnosing its strategic options for reaching middle-income status, our model includes 59 economic sectors, some of which are currently important for the national economy or for sub-national regions, and some are expected to become more important during the transformation process. The model is calibrated to economic data reflecting the initial conditions of Ghana in 2005. In the next section, we first highlight some stylized facts about economic transformation by comparing selected countries. The countries selected are those that reached middle-income status within approximately 10 years, which is the time period that Ghana plans to achieve its goal. The country comparison emphasizes both commonality and differences in structural change across countries. The growth and structural change analysis of the Ghanaian economy begins in Section 3, where we describe the data sources and main characteristics of the model. Section 4 describes the current sectoral and regional structure of the Ghanaian economy and characterizes factor markets and households. The model-based simulation analysis, which is the focus of this paper, is the subject of Section 5. Six scenarios are developed: Scenarios 1-3 analyze agriculture- , industry-, and service- driven growth; Scenarios 4-5 look at growth acceleration among different agricultural sub-sectors; and in Scenario 6, we combine the first 5 scenarios to evaluate the joint effect of sectoral growth on the overall economic growth and structural change. Caveats, summaries, and policy implications conclude the paper.

2. GROWTH AND TRANSFORMATION: LESSONS FROM SUCCESSFUL COUNTRIES

To understand alternative growth paths and the structural implications of reaching middle-income status, lessons can be learned from countries that have already reached or are on track to reach this goal. Descriptive comparative studies have become more prominent in recent years. Leipziger (1997) draws lessons from a cross country comparison of East Asian tiger states, and Rodrik (2003) has compiled a volume on successful growth stories, where various authors identify the causes of prosperity and growth in eight countries. In 2006 there were fourteen countries that reached middle-income status through more than ten years' growth.[2] However, we select only six countries that can be more readily compared to Ghana's current conditions and its goal of reaching middle-income status within ten years.

Brazil, Malaysia, Thailand, and China have passed the US$1,000 per capita GDP benchmark in a relatively short time period (about 10 years). While India and Vietnam have not yet reached the benchmark, rapid growth in these countries indicates that they will do so within the next few years. Tables 1-4 give an overview of structural changes in these successfully transforming countries and compare them with Ghana's current conditions. Several issues emerge from these tables that are both encouraging and challenging for assessing Ghana's growth options.

Development experiences show that it is possible for a country with a per capita income level of US$400 to reach middle-income status within 10 years, if average annual GDP growth rates are around 7-10 percent (it varies largely because of different population growth rates). It took China, Brazil, Thailand and Malaysia 8-12 years to increase per capita GDP from US$400 to US$1,000. While natural resource endowments differ significantly across these countries, rapid growth was accompanied by significant structural changes in all the four countries. The share of agriculture in total GDP declined in all reference countries during the transformation period. In terms of initial sectoral structure, Malaysia and Thailand are the most comparable to Ghana today due to the importance of agriculture in their economies. With similar initial agricultural shares in their economies, however, structural change has shown significant differences between the two countries. In Malaysia, agriculture continued to play an important role and acted as a driver of growth with 5.9 percent average annual growth. At the same time, the importance of industry in the economy significantly increased due to the much higher growth rate in the manufacturing, compared with all other sectors, which caused the share of services to decline more than that of agriculture. By contrast,

[2] Low income countries are defined by per capita incomes of less than US$905 GNI per capita at 2006 prices, and middle-income countries range from US$906 to US$11,115. Middle-income countries are further split into lower-middle-income countries, US$906-3,595 pc GNI, and upper middle-income countries, US$3,596-11,115$ (World Bank, 2007).

Thailand's transition period was characterized by a much stronger decline in agriculture's GDP share – the strongest decline in the reference group. But despite the relative decline of agriculture, the agricultural sector continued to grow between 3.2 and 5.9 percent per year in five of the countries, indicating its important contribution during the transformation period. Only in India did agriculture grow much slowly, at 2.3 percent.

In most countries, the decline in agriculture's GDP share has been due to increases in industry's share (especially manufacturing). The share of manufacturing doubled in Malaysia, and significantly increased in Thailand and Vietnam. Malaysia is an interesting case Today's manufacturing's GDP share in Ghana is as low as it was in Malaysia before the country's transformation, with a similar high share of agriculture in both Ghana today and Malaysia then. With rapid annual agricultural growth of 5.9 percent, agriculture's share in Malaysia' GDP was almost constant during its transformation period to reach a middle income status. Given that the current share of agriculture in total GDP is higher in Ghana compared to the six reference countries at the time when their per capita GDP level was around $400, it seems to indicate the relatively important role of agriculture in Ghana's overall economic growth. For most selected countries, the service sectors seem to play a supporting rather than a driving role in the transformation period. The exception is India, where the service sector's share in GDP increased from 42 to 52 percent (driven mainly by the IT sector).

Driven by different growth rate across sectors, the export structure of the reference countries also changed during the transformation period. Agricultural exports as a share of total exports have declined in all the six countries, while the share of manufacturing exports has increased substantially (Table 2). Brazil had a similar export structure in 1965 as Ghana has today. However, 9 years later in 1974, the share of manufacturing exports rose to 24 percent – up from 8 percent in 1965. Growth in exports was typically faster than economic growth, even for the big countries with larger domestic markets. This reflects the importance of external demand in growth accelerations and structural change, since it allows production growth to exceed growth in the domestic demand.

Table 1. Structural change in economic transformation for selected countries

			Annual growth rate during transformation (%)			Share of total GDP in the initial and ending years (%)			
	Year when GDP pc around $400	GDP pc in that year (current US$)	GDP	GDP per capita	Agriculture GDP	Agriculture	Industry	*Manu-facturing*	Services
Brazil	1965	258	9.9	7.2	3.2	19	34	*26*	48
Malaysia	1965	335	7.1	4.5	5.9	29	27	*9*	44
Thailand	1976	401	6.1	4.1	3.6	27	28	*20*	46
China	1993	374	9.2	8.1	3.5	19	47		34
India	1992	406	6.0	4.2	2.3	31	27	*16*	42
Vietnam	1997	356	6.6	5.3	4.0	27	29	*15*	44
	Year when GDP pc reaches $1,000	GDP pc in that year (current US$)	How many years needed			Agriculture	Industry	*Manu-facturing*	Services
Brazil	1974	996	9			13	40	*31*	47
Malaysia	1977	1,089	12			27	36	*19*	37
Thailand	1987	967	11			16	33	*24*	51
China	2001	1,042	8			14	45		41
India	2004*	640	?			21	27	16	52
Vietnam	2004*	550	?			22	40	*20*	38

Source: World Development Indicators (online version)

Notes:
1. GDP pc is in current $US, which is consistent with the middle-income goal of Ghana.
2. Because of high inflation in Brazil, current value of GDP departs from constant value (both in $US). We therefore chose 1965 as the initial year for Brazil, although GDP pc in that year was $258. However, the number of years to reach $1,000 should be read in caution for Brazil.
3. We chose 1993 for China as its beginning year, because its GDP pc in 1994 was significantly higher than $400.
4. 1997 is chosen for Vietnam because it is the first year with available data. Both Vietnam and India have not yet reached GDP pc$1,000.

Table 2. Change in export structure of selected countries

	Year when GDP pc around $400	Total exports pc in that year (current US$)	Export annual growth during transition (%)	Share of merchandize exports (%)			
				Food	Agricultural raw materials	Mining	Manufacturing
Brazil	1965	19	19.4	67	15	9	8
Malaysia	1965	130	15.4	11	49	28	5
Thailand	1976	70	10.6	60	13	7	17
China	1993	78	12.7	11	2	2	81
India	1992	22	9.9	16	2	4	73
Vietnam	1997	122	15.6	30	3	0	44
Ghana	2004	119		72	10	4	14

	Year when GDP pc reaches $1,000	Total exports pc in that year (US$)	Share of merchandize exports (%)			
			Food	Agricultural raw materials	Mining	Manufacturing
Brazil	1974	75	58	6	9	24
Malaysia	1977	474	19	39	12	15
Thailand	1987	223	37	8	2	52
China	2001	209	5	1	2	89
India	2004*	70	10	1	7	73
Vietnam	2004*	312	23	2	1	53

Source: World Development Indicators. Online version

Note: * Countries have not yet reached middle-income status. We use data for the latest year for which data is available.

Structural change also occurred within agriculture, causing the change in agriculture's export structure. We observe that agricultural exports have become more diversified in the six reference countries (Table 3). Similar as in Ghana today, agricultural exports used to be dominated by a few products at the start of these countries' transformations. For example, coffee accounted for 72.4 percent of total agricultural exports in Brazil in 1965, rubber accounted for 84.3 percent in Malaysia in 1965, and rice accounted for 35.3 percent in Thailand in 1976 and 30.2 percent in Vietnam in 1997. The importance of these products in total agricultural exports declined during these countries' transformation periods. Again, the only exception is Malaysia, where rubber continued to dominate agricultural exports, still accounting for 79.1 percent of total agricultural exports nine years later in 1974. However, it should be noted that Malaysia's agricultural sector has experienced larger structural changes since 1974 (i.e., post-middle-income status), when the country developed its palm oil industry and became the world largest palm oil exporter. Brazil has seen the most significant change in its agricultural export structure. While share of coffee in Brazilian total agricultural exports in 1965 is comparable to share of cocoa in Ghana today, nine years later in 1974, coffee only accounted for 31 percent of Brazil's total agricultural exports. Today Brazil remains one of the world's largest coffee exporters with a highly productive and competitive coffee sector. However, it is the diversification of agricultural exports that has made Brazil one of the world's most important agricultural exporters of many other commodities. While we do not report the growth of non-traditional exports for all countries here, it is these commodities, such as fruits and vegetables that have played the most important roles in agricultural export diversification (as in the case of China and India).

Agricultural growth in the reference countries has also been characterized by higher growth rates in the livestock sector compared to the crops sector (Table 4). Contrary to this trend in the reference countries, crop growth has been higher than livestock growth in Ghana. Also, the transformation of the agricultural sector in all reference countries has been characterized by increased use of modern inputs (Table 5). Comparing the ratio of modern inputs to land, all countries had higher ratios than Ghana in the year when their per capita GDP was around $400. Among the six reference countries in Table 4, the lowest fertilizer-to-land ratio at the beginning of the transformation period was for Brazil in 1965. However, even in Brazil, the ratio was 60 percent higher than Ghana's in 2003. The irrigation-to-land and tractors-to-land ratios are also lower in Ghana today than in the reference countries during the early years of their transformations. This indicates a huge challenge for Ghana in raising agricultural productivity growth, which is important for transforming a traditional agriculture to a modern sector.

Table 3. Agricultural exports and structure of agricultural exports

	Agricultural exports in total exports (%)					Selected commodities in total agricultural exports (%)			
Country	Year	Share	Year	Share	Commodity	Year	Share	Year	Share
Brazil	1965	66.1	1974	55.1	Coffee	1965	72.4	1974	31.0
Malaysia	1965	46.0	1977	28.6	Rubber	1965	84.3	1977	79.1
Thailand	1976	69.2	1987	43.8	Rice	1976	35.3	1987	21.4
China	1993	37.9	2001	30.7	Fruits & veg.	1993	15.6	2001	20.9
India*	1992	15.9	2005	8.7	Fruits & veg.	1992	14.8	2005	17.6
Vietnam*	1997	32.1	2003	24.7	Rice	1997	30.2	2003	16.2
Ghana	2004	77.4			Cocoa	2004	83.8		

Source: UN COMTRADE data (unstats.un.org), processing agriculture is included in agricultural exports.
Notes: Agricultural exports in China and India have diversified even in the beginning years. We select fruit and vegetable exports to demonstrate this.

Table 4. Annual growth in agricultural output and inputs

		Agricultural output		Agricultural inputs	
	Period	Livestock	Crops	Labor	Crop land
Brazil	1965-74	3.6	2.5	1.2	3.7
Malaysia	1965-77	6.5	5.0	0.9	1.1
Thailand	1976-87	3.9	2.5	1.6	1.7
China	1993-01	6.9	4.0	0.2	2.0
India*	1992-03	3.8	2.0	1.3	0.0
Vietnam*	1997-03	7.1	5.2	1.1	3.6
Ghana	1995-03	3.3	5.1	2.5	3.9

Source: Calculated from Nin Pratt (2007).

Table 5. Changes in selected agricultural indicators

	Fertilizer-to-land ratio			Irrigated-to-total-land ratio			Tractors-to-land ratio		
	First year	Final year	Annual growth	First year	Final year	Annual growth	First year	Final year	Annual growth
Brazil	0.082	0.386	18.8	0.018	0.021	1.9	0.033	0.050	4.6
Malaysia	0.233	0.672	9.2	0.056	0.066	1.4	0.006	0.015	8.3
Thailand	0.140	0.307	7.4	0.144	0.195	2.8	0.004	0.020	15.3
China	1.901	2.291	2.4	0.378	0.355	-0.8	0.056	0.055	-0.2
India*	0.718	0.951	2.6	0.287	0.329	1.3	0.067	0.149	7.5
Vietnam*	2.043	2.355	2.4	0.417	0.337	-3.5	0.160	0.183	2.2
Ghana	0.021	0.052	12.3	0.007	0.005	-3.8	0.008	0.006	-4.0

Sources: Calculated from Nin Pratt (2007)
Note: 'First' and 'final' refers to the years of each country's transformation period.

Several strategic issues and questions emerge from our comparison of the reference countries:

- Successfully transforming countries have experienced significant structural changes and declining shares of their agricultural sectors. Will Ghana's structural change be similar on the way to middle-income goal? How will the composition of demand, trade and production, and the allocation of factors change between and within sectors? Successful countries also experienced high growth rates during transformation. How much growth will be needed in Ghana, how will growth in different sectors contribute to economy-wide growth, and which sectors or sub-sectors can become drivers of growth?

- Rapid export growth has typically supported the transformation processes of successful countries. Export growth rates have been higher than overall economic growth rates in the analyzed countries. Will exports have to play a key role for Ghana to reach middle-income status? If so, then can traditional exports support such growth? Only Malaysia continued to rely on a single agricultural export commodity during the transformation period. How can cocoa exports support the overall economic growth needed to reach middle-income status?

- Ghana is a much more open economy than our reference countries at the start of their transformation periods during the 1960s to 1990s. To what extent can Ghana meet the challenge of import competition in key commodities? What could be the role of import substitution for poultry and rice in stimulating agricultural and overall growth?

In the following section we present a model to investigate these questions.

3. A DYNAMIC GENERAL EQUILIBRIUM MODEL FOR GHANA

We developed a dynamic computable general equilibrium (CGE) model to assess the potential of sector-specific growth options and their structural impact in Ghanaian economy in the next 10 years. The CGE model is calibrated to a 2005 social accounting matrix that provides information on the demand and production structure for 59 detailed sectors in the economy (see Table A1 in Appendix 1 and technical description). Agriculture is disaggregated into 27 sub-sectors, including 20 crops, 5 livestock categories, and forestry and fishing. Industry is disaggregated across 22 sectors (including mining, construction and energy). Within industry, greater emphasis is given to the manufacturing sector, which includes 6 agriculture-related processing sectors and 13 light and heavy manufacturing sectors. The service sector is divided into 6 private sub-sectors and 4 public and community sub-sectors. The contribution of each sector to national GDP is calculated using a set of data, which includes national accounts provided by Ghana Statistical Services (GSS); crop and livestock data provided by the Ministry of Food and Agriculture (MOFA); and the 2003 Industrial Census for the mining, manufacturing and energy sectors (also from GSS). This detailed sector structure in the model formulation allows us to analyze sector- and sub-sector specific growth strategies and their contribution to economic transformation.

The production technologies across all sectors are calibrated to the current situation, including each sector's use of primary inputs, such as land, labor and capital, and intermediate inputs (see Appendices 2-5 for parameter calibration and estimation and Appendix 6 for sensitivity analysis). To capture existing differences in Ghana's labor market, the model further classifies employed labor in different sub-categories, including self-employed agricultural workers, unskilled workers in both agriculture and non-agriculture, and skilled non-agricultural workers. Information on sector level input and output is derived from MOFA's 2006 crop-level farm budgets for the agricultural sectors and 2003 Industrial Census for the industrial production. Additional information on employment and wages by sector and region is taken from the 2005/06 Ghana Living Standards Survey (GLSS5). To captures different agricultural production patterns and technologies at sub-national level, the model further disaggregate the agricultural activities into four agro-ecological zones using district-level production and price data from MOFA. Broadly speaking, the coastal zone covers the Eastern and Volta regions; the forest zone includes Ashanti, Western and Central regions; the southern savannah is Brong Ahafo and part of Volta; and the northern zone includes the Upper West, Upper East and Northern regions. Constrained by the data, non-agricultural production is not disaggregated across regions. Goods produced and consumed in Ghana are traded in national and international markets. Data on international trade comes from the Bank of Ghana, MOFA and GSS.

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 takes into account for the rural labor mobility from working on smallholder farmers' own land to finding employment opportunities through the labor market. Capital is free to move across sectors and regions, and accumulation of capital is through investment financed by domestic savings and foreign inflows. Increased capital is allocated across sectors and regions according to their relative profitability. Incomes from factor employment accrue to different households, according to employment and wage data from GLSS5. Households are defined at the regional level according to the four agro-ecological zones, and within each zone, by rural and urban areas. Households in Accra are treated as a separate group given the area's unique role as Ghana's metropolitan hub. Household income elasticities for different commodities are estimated using consumption expenditure data in GLSS5 (see Appendix 5 for the detail description of the estimation). The government collects direct taxes from households and indirect taxes from imports, exports and domestic sales, and then supplements its revenues with foreign borrowing and grants from development partners. It uses these funds for recurrent and investment expenditures. Information on government revenues and expenditures was provided by the Ministry of Finance and Economic Planning.

4. THE CURRENT STRUCTURE OF GHANA'S ECONOMY

The model is initially calibrated to the year 2005 and then run forward to 2015. This section describes Ghana's current economic structure based on GLSS5 and the 2005 social accounting matrix, which reconciles the various data sources described in the previous section.

4.1 Sectoral structure of GDP

The agricultural sector remains the largest contributor to GDP in Ghana, followed by services and industry (Table 6). Agriculture's share of total GDP is 38.7 percent, but increases to almost 45.0 percent once agriculture-related manufacturing is included. Within the agricultural sector, root crops, including cassava, yams and cocoyam, account for 23.1 percent of agricultural GDP. Export crops, such as cocoa, palm oil, fruits, vegetables, rubber, and cotton, account for a similar share of agricultural GDP. Cereals account for 11.1 percent and other staple crops 18.8 percent, while the livestock sector contributes 6.4 percent.

Table 6. GDP and trade by sector

	Share of total (%)			
	GDP	Sectoral GDP	Exports	Imports
Agriculture	38.7	100.0	46.7	7.1
Cereals	4.3	11.1	0.0	4.2
Roots	9.0	23.1	0.3	0.0
Other staples	7.3	18.8	0.2	0.1
Export crops	8.9	23.1	27.9	0.0
Livestock	2.5	6.4	0.0	2.8
Fishery and Forestry	6.7	17.4	18.2	0.0
Industry	27.9	100.0	41.7	84.5
Mining	5.4	19.5	26.3	0.0
Construction	9.8	35.2	0.0	0.0
Agric-related manufacturing	6.1	21.9	12.5	19.2
Other manufacturing	3.6	12.9	2.9	26.2
Other industry	2.9	10.5	0.0	39.1
Services	33.4	100.0	11.6	8.3
Private Services	13.5	40.2	0.0	0.0
Export Services	3.7	11.0	11.6	8.3
Other services	16.3	48.8	0.0	0.0
Total	100		100	100

Source: 2005 Ghana social accounting matrix

Industry accounts for 27.9 percent of total GDP, and is dominated by manufacturing and construction. Manufacturing accounts for 34.8 percent of industrial GDP with agriculture-related manufacturing, such as food and wood processing and textiles, as the most important sectors.

Construction accounts for 35.2 percent of industrial GDP, followed by mining with 19.5 percent. Government related services such as administration, health, and education are the most important components of service sector GDP. Private services include trade, transport, communication, real estate, and business services and account for 40.2 percent of service sector GDP. Export services include hotels, restaurants and other private services and contribute 11 percent to service GDP.

4.2 Regional structure of agriculture

A regional perspective on agricultural production reveals that 43.3 percent of agricultural output (in value terms) is produced in the forest zone, 9.7 percent in the coastal zone, and 26.1 and 20.8 percent in the southern and northern savannah zones respectively (Table 7). The northern savannah zone produces 44.2 percent of cereals, including maize, rice and sorghum, while the forest zone supplies a large share of higher-value products, such as cocoa and livestock. With the exception of the coastal zone, roots crops are evenly distributed across zones.

Table 7. Regional shares of agricultural output

	Cereals	Root crops	Other staples	Export crops	Livestock	Fishing & forestry	**Total**
Coast	9.1	3.8	10.8	6.1	12.1	20.1	**9.7**
Forest	27.4	33.2	38.3	65.2	35.2	50.3	**43.3**
South savannah	19.2	32.3	25.0	26.4	14.1	27.6	**26.1**
North savannah	44.2	30.7	25.9	2.4	38.5	2.0	**20.8**
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: 2005 Ghana social accounting matrix

4.3 Employment structure

Labor is the dominant source of income for a majority of Ghanaian households (Table 8), and is mainly employed in the agricultural and service sectors, due to the relatively high labor-intensity of both sectors. On the other hand, production in the industrial sector is much more capital-intensive, and thus, despite its relatively small size, the sector absorbs more than half of total capital, driven especially by highly capital-intensive mining and energy sub-sectors.

While incomes from agricultural activities dominate the rural economy, non-agricultural income is becoming an important part of rural households' livelihoods – equivalent to one-third of household expenditures. The analysis of GLSS5 data shows that off-farm employment income is equivalent to 20-40 percent of rural households' total expenditures for rural households, and this share generally increases amongst higher income households (Table 9). Off-farm labor incomes for rural households in the lowest income quintile is equivalent to 16.3 percent of their total expenditures, while this share more than doubles for rural households in the highest income quintile. Although non-

agricultural income shares are high in all regions, they are highest in northern savannah (41.8 percent in total). However, this share for the all rural households in the region may be misleading, since more than 40 percent of Northern Savannah rural households belong to the poorest household group (the lowest income quintile) and, for these households, the non-agricultural income share in total expenditure is the lowest amongst all income groups and across different zones in the country (14.3 percent). On the other hand, only 11 percent of Northern Savannah rural households are in the highest income group, for whom the non-agricultural income share in total expenditure is as high as 76.8 percent.

Table 8. Factor allocation and factor intensities by sector

	Share of GDP (%)		Share of sectors' GDP (%)			
	Labor	Capital	Labor	Capital	Land	Total
Agriculture	41.6	11.9	72.6	7.7	19.7	**100.0**
Industry	23.4	48.8	56.5	43.5	0.0	**100.0**
Services	35.0	39.3	70.8	29.2	0.0	**100.0**
Total	**100**	**100**	**67.5**	**24.9**	**7.6**	**100.0**

Source: 2005 Ghana social accounting matrix

Table 9. Non-agricultural incomes shares by region and rural household income group

	Lowest quintile	Second quintile	Third quintile	Fourth quintile	Highest quintile	**Total**
Coast	14.8	21.3	48.7	24.8	42.5	**38.0**
Forest	22.5	46.8	23.8	25.6	31.3	**30.2**
South Savannah	21.6	21.6	18.4	30.2	41.5	**32.6**
North Savannah	14.3	35.6	40.1	44.7	76.8	**41.8**
Total national rural	**16.3**	**32.9**	**27.5**	**29.6**	**39.6**	**33.8**

Source: 2005/06 Ghana Living Standards Survey (GLSS5)

4.4 Trade structure

Ghana has a large trade deficit that is equal to 28 percent of GDP and is heavily dependent on imported manufactured goods, such as capital goods, oils, and chemical products (including fertilizer). Agriculture-related manufacturing imports, such as processed food, are also large, accounting for 19.2 percent of total imports (Table 6). However, these same sectors are also Ghana's major nonagricultural exports sectors, raising the question of how far improved competitiveness could lead to import substitution. Exports are dominated by primary commodities, including crops, forestry and gold mining. Cocoa remains the single largest export commodity, although non-traditional export crops have become increasingly important in agricultural exports. While total agricultural exports account for more than a third of agricultural production value, a few agricultural commodities, such as chicken and rice have very high import-to-consumption ratios. This indicates that an import substitution strategy will be equivalently important as an export promoting strategy in stimulating

agricultural growth. Similar to many other developing countries, Ghana's service sector is domestically-oriented. However, there exist export-oriented services, such as tourist related hotel and other services. As the service sector contributes 8.3 percent to total exports, the experience India has had indicates the possibility for service-sector-led growth in Ghana.

Table 10. Household budget shares and income elasticities

	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 2005/06 Ghana Living Standards Survey (GLSS5)

4.5 Domestic consumption structure

Since domestic demand for most agricultural and non-agricultural products is still the dominant source of total demand in the country, we report household consumption patterns based on GLSS5 (Table 10). In 2005, urban households spent more than 40 percent of income on food, while rural households spent more than 50 percent. This does not imply that at the absolute level, urban households consume less food than rural households. The GLSS5 data shows that as per capita income (measured by the total expenditure) for urban households is 1.3 times higher than that for rural households, the average urban household actually consumes more food products in absolute terms than the average rural household. We also econometrically estimate household marginal budget shares (MBS). MBS shows the percentage of each unit of incremental income that households will spend on different commodities or groups of commodities. If the MBS is smaller than the current average budget share (ABS), as in the case of maize, then it indicates that households will spend less of any additional income on this commodity than they have done in the past. While this does not imply that total maize consumption will fall with increased growth, it does indicate that demand for maize as staple food grows more slowly than income growth. The ratio of MBS over ABS is the 'income

elasticity of demand'. When the elasticity is less than one it indicates that, given a set of prices, consumption grows more slowly than income growth. A high income elasticity is observed for chicken for both rural and urban households, indicating that demand for chicken grows more rapidly than income growth in the country. While Table 10 reports households' budget allocation among different items, it does not capture indirect consumption effects. In the case of chicken, increased consumption induces indirect demand for maize used as chicken feed. These 'production linkages' are captured by input-output coefficients included in the social accounting matrix and such production linkages will be analyzed in the model scenarios.

5. ANALYZING ALTERNATIVE GROWTH OPTIONS

In Section 2 we examined the structural transformation of selected developing countries that have successfully moved from situations similar to Ghana's today to their middle-income status. We have seen that, while doubling incomes in ten years is ambitious, it is not unprecedented. However, all the selected countries that underwent a period of rapid growth experienced significant structural changes. These countries have seen rapid increases in the contribution of manufacturing to their overall economies, while only India experienced more rapid service-led growth. A decline in the importance of agriculture can be observed in all countries, although the size of this decline was small in Malaysia. It is also observed that exports grew more rapidly than overall economic growth in these countries, indicating the importance of external demand in structural change. Taken together, the experiences of successful countries suggest that there is no single path from low- to middle-income status, and that the contribution of different sectors during each country's transformation process depends on, amongst other things, unique initial economic structures; existing and new market opportunities; other initial conditions embodied in social and political institutions and government policies; and external conditions in the region and the world.

Based on these findings and the initial economic structure of Ghana described in Section 4 we use the dynamic CGE model introduced in Section 3 to quantitatively explore alternative growth options for Ghana and their potential contribution to reaching the middle-income goal by 2015. In the first scenario we examine whether Ghana's current strong performance will be sufficient to achieve middle-income status by 2015. Based on the experiences of other successful developing countries, we simulate the effects of rapid growth in manufacturing (Scenario 2) and services (Scenario 3) on the overall growth and the contribution to Ghana's middle-income goal. In Scenarios 4 and 5 we turn to agriculture and argue that accelerated growth in agriculture is equally important given Ghana's unique economic structure. In the final scenario we combine the effects of accelerating growth in these three sectors, and focus on the possible structural change facing Ghana as it is to become a middle-income country.

5.1 Scenario 1: Balanced growth along Ghana's recent growth path

The model's base-run simulates a situation where the Ghanaian economy continues to grow along its current growth path at an average annual growth rate of 5.6 percent until 2015. These balanced growth trends observed in recent years in the country, lead to similar annual growth rates of the three aggregate sectors of the economy – agriculture, industry and services (Table 11, Part A, column 2). Given average annual population growth of 2.2 percent, per capita GDP increases from

US$454 in 2005 to US$774 by 2015 (Table 11, Part D, column 2).[3] The results also show that the agricultural sector continues to contribute the most to overall growth, accounting for 38.8 percent of total growth (Table 11, Part B, column 2). As expected under this balanced growth scenario, the economic structure does not change significantly (Table 11, Part C, column 2). The share of agriculture in total GDP increases slightly, from 38.7 to 40.9 percent, due to small increases in agricultural prices relative to the nonagricultural prices driven by domestic demand and terms-of-trade appreciation.

Table 11. Baseline and accelerated growth scenarios

	Initial value in 2005	Base-run scenario	Scenarios with accelerated growth in…				
			Industry	Services	Export agric.	Other agric.	Com-bined
		(1)	(2)	(3)	(4)	(5)	(6)
Part A. Annual growth rate of 2006-2015 (%)							
Total GDP		5.6	6.4	6.3	5.8	6.0	7.6
Agriculture		5.3	5.1	5.4	6.0	6.2	6.9
Industry		5.9	8.3	6.4	5.6	6.0	8.9
Services		5.7	6.0	7.1	5.6	5.7	7.4
Part B. Sector's contribution to GDP growth (%)							
Agriculture		38.8	31.7	35.1	44.5	41.1	35.5
Industry		29.4	37.9	29.8	26.0	28.7	34.7
Services		31.8	30.4	35.1	29.5	30.1	29.8
Part C. Sector share of GDP by 2015 (%)							
Agriculture	38.7	40.9	39.2	40.5	42.6	39.7	39.4
Industry	27.9	27.9	29.0	28.8	26.7	28.6	29.8
Services	33.4	31.2	31.9	30.8	30.6	31.8	30.9
Part D. Per capita income in current by 2015 ($US)							
Total GDP	454	774	824	835	791	813	956
Agriculture	176	316	323	338	337	322	376
Industry	127	216	239	240	211	232	284
Services	152	242	263	257	242	258	295

Source: Ghana CGE model results

Simulated growth is driven by increases in labor supply, expansions of agricultural crop land, capital accumulation, and productivity growth. Increases in labor supply for different labor categories are set exogenously between 2 and 3 percent annually. The supply of agricultural family labor is assumed to grow more slowly than other unskilled and skilled labor. Land expansion is defined at the crop-level and varies across regions according to past trends. The initial annual growth rate of total crop land is 2.7 percent, declining to 1.9 percent by 2015. Productivity growth is exogenously defined for labor and land and varies across sectors. Average annual growth rates for labor productivity are 2.7 percent and 2.5 percent for the land productivity, respectively. The increase in labor and land

[3] The population growth rate in the model starts at 2.25 percent in 2006 and falls to 2.07 percent in 2015.

supply, combined with improvements in factor productivity, stimulate investment and result in an average annual capital accumulation growth rate of 6.5 percent. Table 12 summarizes the contribution of each factor to total GDP growth. Increases in labor explain 30.8 percent of the base-run's overall economic growth during 2006-2015, while land expansion explains 4.7 percent and capital 28.4 percent. More than one-third of growth is explained by productivity growth in the base-run, which is consistent with World Bank estimates using the last 5 years data (Bogetic et al., 2007) (Table 12, column 1).

Table 12. Sources of growth in GDP

	Base-run	Scenarios with accelerated growth in…				
		Industry	Services	Export agric.	Other agric.	Com-bined
	(1)	(2)	(3)	(4)	(5)	(6)
Labor	30.8	27.0	27.5	30.3	29.0	22.9
Land	4.7	4.1	4.3	5.5	4.5	4.2
Capital	28.4	28.7	27.5	27.7	26.9	26.0
Productivity	36.1	40.3	40.8	36.5	39.6	46.9

Source: Ghana CGE model results

Table 13. Sources of investment

	Initial share in 2005	Base-run	Final year values for scenarios with growth in…				
			Industry	Services	Export agric.	Other agric.	Com-bined
		(1)	(2)	(3)	(4)	(5)	(6)
Investment share of GDP	31.7	33.6	37.2	35.0	32.8	33.9	38.3
Shares of investment	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Foreign inflows	64.2	65.0	67.6	65.6	64.3	64.4	67.0
Private savings	11.9	11.3	10.1	10.8	11.6	11.1	9.7
Public savings	23.9	23.7	22.3	23.6	24.1	24.4	23.3

Source: Ghana CGE model results

According to the country's national accounts, the investment-to-GDP ratio was 31.7 percent in Ghana in 2005 (Table 13). The model calibrates to this ratio as an initial condition. In the base-run scenario, this ratio increases slightly to 33.6 percent by 2015 (Table 13, column 2). The data show that current investment in Ghana is primarily financed by foreign inflows (channeled mainly through the government). According to the national accounts, the foreign inflows are responsible for 64.2 percent of investment spending; private savings account for 11.9 percent of investment; while the rest comes from the government investment spending. Along the base-run growth path, investment continues to depend on foreign inflows, and its share in total investment spending remains almost constant at 65.0 percent of total investment (Table 13, column 2).

The base-run scenario shows the need to accelerate growth in Ghana over the next decade if the country aims to more than double 2005's per capita income by 2015. To understand how each sector's growth contributes to this goal, and how economic structure changes under accelerated growth at the sector-level, we exogenously and sequentially increase growth in different sectors: manufacturing sectors (Scenario 2), private services (Scenario 3), and agricultural sectors (Scenarios 4 and 5). In the final scenario (Scenario 6), we combine Scenarios 2-5 to evaluate the total effect of sectoral growth to overall growth and structural change.

5.2 Scenario 2: Accelerated growth in manufacturing

As discussed in Section 2, accelerated growth in the manufacturing sector is often an important driver of overall growth when a developing country moves from low- to middle-income status. For example, when Thailand's per capita GDP increased from $400 in 1976 to $970 in 1987, its average annual manufacturing growth rate was twice as high as agricultural growth. A similar situation is observed in Brazil, where the manufacturing growth rate was three times agriculture's growth rate. Based on these experiences and to evaluate how accelerated growth in manufacturing sectors will contribute to the overall growth and structural transformation in Ghana, we exogenously increase labor productivity in various manufacturing sectors in the model with higher growth in the labor-intensive manufacturing sectors. To finance increased growth in manufacturing, we increase foreign inflows to support increased investment demand in capital goods that are necessary for accelerated capital accumulation.

The industrial sector constitutes 27.9 percent of Ghana's GDP in 2005, with the manufacturing sector accounting for 9.7 percent (Table 6). Both numbers are similar to the corresponding shares in Malaysian GDP in 1965. Industry's share of GDP is also similar to that of Thailand in 1976, India's in 1992, and Vietnam's in 1997. However, the share of manufacturing in these three countries' economies was much higher compared to Ghana's today. Ghana's manufacturing accounts for only 35 percent of industrial GDP and is dominated by activities heavily dependent on agricultural inputs, such as food and wood processing. Agriculture-related manufacturing currently accounts for 22 percent of industrial GDP. Construction is another large industrial sector, accounting for 35 percent of industrial GDP, and mining accounts for 20 percent.

In Scenario 2 we accelerate manufacturing growth, especially in the agriculture-related sectors (i.e., food and wood processing, textiles, clothing and footwear). Most of these sectors are labor-intensive and are expected to generate more labor demand in both rural and urban sectors, which is an important factor explaining the structural change in employment among successfully transforming developing countries. Growth in the manufacturing sector is also expected to increase the sector's

exports and lower its imports, such that more domestic demand is satisfied by domestic production rather than imports. This will further affect the trade structure of the country. Currently, manufacturing as a whole exports 16.4 percent of its production (Table 14, column 1), generating 15.4 percent of the country's total exports (Table 15, Part A, column 1). This share in the export-intensity of agriculture-related manufacturing is higher, equivalent to 25.8 percent of these sectors' output value (Table 14, Part A, column 1). On the other hand, however, domestic demand for manufacturing is heavily dependent on imports, which accounts for 58.2 percent of domestic manufacturing consumption (Table 14, Part B, column 1), and 84.5 percent of total imports (Table 15, column 1). The share of imports in agriculture-related manufacturing consumption is relatively low, but still amounts to 44.2 percent of domestic consumption for these goods (Table 14, Part B, column 1). A precondition for accelerated manufacturing growth in Ghana is therefore improved global competitiveness that increases exports and reduces imports.

By assuming much higher labor productivity in the country's manufacturing sector, growth is stimulated in the more labor-intensive sectors. These sectors are now better able to compete with other sectors for hiring labor and hence for attracting new capital investments. Additional capital growth is financed by increased foreign inflows and more imports of capital goods. With productivity growth and capital accumulation, the model predicts an average annual growth rate of 8.3 percent in the manufacturing sector during 2006-2015. Agriculture-related manufacturing grows at 10.2 percent annually. Compared to the base-run, the manufacturing growth rate is 3.2 percentage points higher and 4.0 percentage points higher in the case of agriculture-related manufacturing (Table 17, part B, column 2 and 3).

Exports of manufactured goods grow more rapidly than the sector's production as a whole in this scenario, which is consistent to what we have observed empirically in the six countries reviewed in Section 2. Total manufacturing and agriculture-related manufacturing exports both grow at 11.6 and 11.7 percent per annum, respectively, compared to 7.6 and 7.5 percent in the base-run (Table 16, columns 1 and 2). This results in an increase in exports in output share in the manufacturing sector to 21.0 percent and 29.5 percent in agriculture-related manufacturing (Table 14, Part A, column 3). The growth rate of total manufacturing imports is also modestly higher, rising from 6.0 to 6.8 percent per year. However, the annual growth rate of agriculture-related manufacturing imports declines from 4.4 to 3.0 percent in this scenario (Table 16, Column 1 and 2). Import substitution thus occurs in the agriculture-related manufacturing sector, and the ratio of imports to domestic consumption falls to 35.7 percent by 2015, down from 44.2 percent in 2005. For the manufacturing sector as a whole, however, imports still account for 56.6 percent of domestic consumption by 2015 – only a slight decrease from 58.2 percent in 2005, driven by increased imports of capital goods to meet investment needs (Table 14, Part B, columns 1 and 3).

While growth in manufacturing exports significantly raises the sector's contribution to total export growth, agricultural export growth is negatively affected. Agricultural raw materials account for a large share of intermediate demand in agriculture-related manufacturing. Some of these agricultural materials are also export goods, such as cocoa and forestry products. Rapid growth in the processing sectors increases their demand for the raw materials and hence reduces the availability of these raw materials for direct export. If the raw materials are used in export-oriented processing sectors, then the declines in raw material exports are substituted by increases in the export of processed goods. As expected, processing adds more value to primary products and hence contributes to accelerated growth.

Closer inspection shows that the increase in manufacturing exports is driven by growth in cocoa processing and wood products, which account for 30.7 and 46.8 percent of agriculture-related manufacturing exports in 2005. Growth in these sectors' exports leads to declines in the growth rate of cocoa and forestry exports (from 7.2 to 5.2 percent for cocoa and from 7.5 to 6.6 percent for forestry annually). Growth in processed exports of these commodities increases from 7.5 to 11.7 percent annual average (Table 16, Column 2). As a consequence, some agricultural raw material exports are replaced by agriculture-processing good exports, with higher value-added content. Also other labor-intensive manufacturing that uses agricultural goods as inputs also grow, such as meat and fish processing, textile, clothing and footwear. Compared with the base-run, the share of agricultural exports in total exports falls from 54.5 percent to 46.3 percent in 2015, driven mainly by a slowdown in cocoa exports. Cocoa exports account for 24.7 percent of total exports by 2015 in this scenario, compared to 30.1 percent in base-run (Table 15, columns 2 and 3).

Table 14. Relationship between trade and domestic production and consumption

	Initial value in 2005	Base-run	Scenarios with accelerated growth in…				
			Industry	Services	Export agric.	Other agric.	Com-bined
		(1)	(2)	(3)	(4)	(5)	(6)
Total exports to GDP	35.5	38.4	36.3	37.7	39.7	38.6	36.8
Total agric. exports to value of agric. Production	31.2	36.0	30.7	34.3	39.6	36.1	32.7
Cocoa quantity exports to cocoa production	86.1	85.9	83.4	86.2	86.5	85.9	84.4
Forestry quantity exports to forestry production	78.2	79.8	76.6	79.1	83.9	79.3	80.6
Non-agric. exports to non-agric. Production	14.6	14.3	14.9	15.1	13.3	14.2	14.6
Manufacture exports to manufacturing production	16.4	18.3	21.0	17.0	17.6	18.7	20.2
Agric-related manu. exports to agric-related manu. production	25.8	29.5	32.6	28.1	29.0	30.4	32.4
Total imports to GDP	63.5	65.9	66.8	65.9	66.3	66.1	67.3
Total agric. imports to value of agric. Consumption	32.8	33.5	32.8	33.7	34.1	33.7	33.6
Rice quantity imports to rice consumption	68.3	71.3	74.1	73.3	73.4	41.9	52.0
Poultry quantity imports to poultry consumption	96.6	97.2	97.3	97.2	97.4	95.1	95.5
Non-agric. imports to non-agric. Consumption	32.8	33.5	32.8	33.7	34.1	33.7	33.6
Manufacture imports to manufactures consumption	58.2	58.1	56.6	58.5	59.1	58.3	57.8
Agric-related manu. imports to agric-related manu. consumption	44.2	42.5	35.7	42.8	44.0	41.8	36.3

Source: Ghana CGE model results

Table 15. Trade structure

	Initial value in 2005	Base-run	Scenarios with accelerated growth in…				
			Industry	Services	Export agric.	Other agric.	Com-bined
		(1)	(2)	(3)	(4)	(5)	(6)
Part A. Sector share in total exports (%)							
Agricultural exports	49.2	54.5	46.3	50.7	61.2	54.3	48.9
Cocoa exports	27.8	30.1	24.7	28.5	30.3	29.9	23.5
Forestry exports	14.8	16.3	14.9	14.7	20.6	15.7	17.0
Non-agric. exports	50.8	45.5	53.7	49.3	38.8	45.7	51.1
Mining exports	25.0	17.6	18.5	16.3	16.1	17.4	15.7
Manu. exports	14.7	16.4	23.5	14.8	14.2	17.1	21.3
Ag-related manu.	12.0	13.2	19.3	12.3	11.7	14.2	18.7
Service exports	11.1	11.5	11.7	18.2	8.5	11.2	14.1
Part B. Sector share in total imports (%)							
Agricultural imports	6.7	6.8	7.5	7.0	6.9	4.8	5.9
Rice imports	3.5	3.2	3.3	3.3	3.3	1.9	2.2
Poultry imports	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Non-agric. imports	93.3	93.2	92.5	93.0	93.1	95.2	94.1
Manu. imports	84.3	84.8	84.0	85.2	84.5	86.5	85.8
Ag-related manu.	18.7	16.1	12.9	16.1	16.5	16.0	13.0
Service imports	9.0	8.4	8.5	7.8	8.6	8.7	8.3

Source: Ghana CGE model results

Table 16. Growth in trade

	Base-run	Scenarios with accelerated growth in…				
		Industry	Services	Export agric.	Other agric.	Com-bined
	(1)	(2)	(3)	(4)	(5)	(6)
Annual growth in total exports	6.4	6.5	7.0	7.2	6.4	7.8
Agricultural exports	7.5	5.9	7.4	9.5	7.5	7.8
Cocoa	7.2	5.2	7.3	11.6	7.1	6.8
Forestry	7.5	6.6	7.0	10.8	7.1	9.3
Others	8.6	6.7	8.6	12.1	9.4	10.6
Nonagricultural exports	5.2	7.1	6.7	4.3	5.3	7.9
Mining	2.7	3.3	2.5	2.5	2.7	2.9
Manufacturing	7.6	11.6	7.1	6.8	8.0	11.9
Ag-related manufacturing	7.5	11.7	7.3	7.0	8.3	12.8
Services	5.3	6.7	12.5	2.4	5.4	10.9
Annual growth in total imports	5.9	6.8	6.8	6.4	5.9	8.1
Agricultural imports	6.1	8.0	7.3	6.7	2.5	6.7
Rice imports	5.0	6.0	6.0	5.5	-0.6	3.3
Poultry imports	6.0	6.7	7.0	6.2	6.0	7.9
Nonagricultural imports	5.9	6.8	6.7	6.4	6.2	8.2
Manufacturing	6.0	6.8	6.9	6.4	6.2	8.3
Ag-related manufacturing	4.4	3.0	5.2	5.0	4.3	4.3
Services	5.1	5.9	6.3	5.5	5.3	7.4

Source: Ghana CGE model results

Table 17. Structure of industry and its sub-sectors' contribution to industrial growth

	Initial value in 2005	Base-run scenario (1)	Scenarios with accelerated growth in… Industry (2)	Services (3)	Export agric. (4)	Other agric. (5)	Com-bined (6)
Part A. Structure of industry							
Industry share of GDP	27.9	27.9	29.0	28.8	26.7	28.6	29.8
Share of industrial GDP							
Mining	19.5	15.4	14.7	13.8	15.1	14.9	12.5
Construction	35.2	36.3	35.0	38.8	37.6	36.2	37.9
Manufacturing	34.8	36.4	39.0	35.8	35.3	37.2	38.7
Ag-related manu.	21.9	22.2	23.8	21.6	21.7	23.4	24.7
Other manu.	12.9	14.3	15.2	14.2	13.7	13.8	14.0
Other industry	10.5	11.8	11.2	11.5	11.9	11.8	10.8
Part B. Average annual growth rate, 2006-2015 (%)							
Industrial growth rate		5.9	8.3	6.4	5.6	6.0	8.9
Mining		2.9	3.6	2.8	2.7	2.8	3.2
Construction		6.4	8.8	7.6	6.4	6.5	10.0
Manufacturing		6.3	9.5	6.6	5.7	6.6	10.1
Ag-related manu.		6.1	10.2	6.4	5.6	6.8	11.2
Other manu.		6.6	8.3	7.0	5.8	6.3	7.8
Other industry		7.4	9.2	7.5	7.2	7.4	9.2
Part C. Contribution to industrial growth, 2006-2015 average (%)							
Industry growth contrib.		29.4	37.9	29.8	41.1	28.7	34.7
Contrib. to ind. growth							
Mining		8.5	8.3	6.9	8.1	7.9	5.7
Construction		39.0	38.5	43.7	41.7	38.3	41.6
Manufacturing		38.3	41.2	36.4	35.6	39.8	41.7
Ag-related manu.		23.1	27.6	21.6	21.6	25.7	29.3
Other manu.		15.2	13.4	14.8	14.0	14.1	12.0
Other industry		14.1	12.2	12.9	14.6	14.0	11.4

Source: Ghana CGE model results

Under this scenario Ghana experiences a relatively large structural change within the industrial sector, with the share of manufacturing in industrial GDP rising from 34.8 to 39.0 percent by 2015 (Table 17, Part A, columns 1 and 3). However, the overall economic structure does not change substantially. The share of industry in the overall economy only increases slightly from 27.9 percent of total GDP in 2005 to 29.0 percent in 2015 (Table 11, Part C, columns 1 and 3). This result is quite different from the historical experiences of the countries reviewed in Section 2. In Thailand, for example, industry's and manufacturing's shares of total GDP increased by 5 and 4 percentage points during the country's transformation period (between 1976 and 1987). This is despite the fact that the country's industrial growth rate averaged only 7.3 percent during this period – lower than the average annual growth rate of 8.3 percent in Ghana in this scenario.

There are four main reasons explaining why the rapid growth in industry simulated in the model, especially in manufacturing, does not result in a significant change in Ghana's economic structure, compared to what we observed in the selected countries discussed in Section 2. The first reason is that the agricultural sector accounts for a much larger share in Ghana's economy today as compared to all of the six countries reviewed in Section 2 at the time when they started to transform their economies from low- to middle-income status. Because of this difference in Ghana's initial economic structure, relatively rapid growth in the agricultural sector seems to be a pre-condition for the accelerated overall economic growth. Without agricultural growth, rapid growth in other sectors will not significantly increase per capita incomes in Ghana. Indeed, observed agricultural growth rates in Ghana in recent years are comparable to growth rates in the other sectors. The base-run has been designed in a way that the economy will continue to grow at its current path, which implies that agriculture will continue to grow in line with other sectors. The 5.3 percent average annual growth rate in the agricultural sector in the base-run scenario is higher than the agricultural growth rate in five of the six countries during their transformation periods. The only exception is Malaysia, where agriculture grew at 5.9 percent annually between 1965 and 1977. Accelerated manufacturing growth does not negatively affect growth in agriculture. On the contrary, some sectors, such as cocoa, benefit from such growth. Agriculture therefore continues to grow at 5.2 percent. This explains why the share of agriculture in the economy under the manufacturing-led scenario remains almost similar to what it is today.

The second reason why industry's share remains relatively constant in this scenario is the high dependency of manufacturing growth on material inputs from the agricultural sector. Agriculture-related manufacturing, such as food, cocoa and wood processing, accounts for more than 60 percent of Ghana's manufacturing industry. This implies that growth in these manufacturing sectors depends on growth in agriculture, which not only provides inputs to manufacturing production but also lowers the cost of inputs, especially if agricultural growth is driven by productivity increases. Textiles, clothing and footwear also use agricultural raw materials as inputs, but are considerably less dependent on agriculture, because labor forms a much larger share of production costs than intermediate inputs. These sectors have played a key role in the rapid growth of China's and Vietnam's manufacturing industry. However, these sub-sectors are quite small in Ghana, accounting for 6 percent of total manufacturing output value. Therefore, even with 10-15 percent annual growth in these sub-sectors' production, their share in total manufacturing rises to only about 10 percent by 2015 in this scenario.

The third reason is due to demand constraints for certain food processing products. Many food processing products are produced for domestic markets. Without additional growth in other sectors, especially in agriculture, incomes for a majority of rural households who depend on

agriculture for their livelihoods cannot grow at a similar speed as growth in the supply of processed foods. This causes prices for some food processing sectors to fall. While this can benefit rural and urban households as consumers, it limits the growth potential of these sectors because their growth cannot deviate greatly from agricultural and other sectors' growth rates. The model includes two kinds of food processing sectors, one of which includes 'informal' or local foods and is located mainly in rural areas. This sector's growth is more constrained by rural income growth, for which the major source is agriculture. Accordingly, growth in informal food processing can only grow at a similar rate as agriculture, which is around 6 percent per year.

Finally, the mining sector plays a limited role in accelerating industrial growth. Currently, this sector grows around 2.9 percent on average each year. Additional growth in this sector is constrained by natural resources. Mining growth ranges from 2.7 to 3.6 percent annual growth in all scenarios. As mining currently accounts for 20 percent of industrial GDP, its slower growth limits the role of industry in overall economic growth.

In summary, this scenario underlines the importance of the manufacturing sector for accelerating growth in Ghana and helping the country reach middle-income status. However, it also shows that the manufacturing sector's growth capacity is constrained by agricultural and rural income growth. Agriculture has to support manufacturing growth by providing cheap raw materials and increasing rural incomes to expand domestic market opportunities for non-agricultural goods. To speed up manufacturing growth rates significantly beyond agriculture's growth rates, the country will have to develop more export-oriented manufacturing. These sectors should be less reliant on agricultural inputs, such as the labor-intensive manufacturing sectors that developed rapidly in China and Vietnam.

5.3 Scenario 3: Accelerated growth in services

All but one of the countries that we reviewed in Section 2 had strong manufacturing growth at the center of their structural transformations. However, the expansion of industry was often accompanied by growth in services. In China and Vietnam, for example, the rise in the contribution of services to GDP during their transformation periods mirrored the relative decline in agriculture's contribution. Moreover, the service sector in India has played a leading role in driving the economy towards middle-income status. Even during Malaysia's transformation period, when services did not grow as rapidly as agriculture and manufacturing, the large size of this sector meant that its contribution to the economy was important for sustaining high overall growth. Therefore, unlike the previous section, which focused on accelerating industrial growth, in this scenario we evaluate how accelerated growth in Ghana's services sectors can contribute to the country achieving middle-income status.

The service sector already forms a large part of the Ghanaian economy, accounting for a third of total GDP. This is however smaller than the size of services in most of the countries that we reviewed at a time when they had per capita GDP similar to what Ghana has today. Only China had a smaller service sector in 1993, when its GDP per capita was $374. However, it is difficult to compare the service sector across countries given the diversity of its sub-sectors: public and private, traded and non-traded, and high- and low-value. In Ghana the government and community service sector is the largest component of services, accounting for almost half of the overall sector (Table 18, part A, column 1). By contrast, export-oriented services, such as tourism and finance, account for only 8.6 percent of service GDP. The remaining 41.7 percent are domestic-market-oriented services, such as wholesale and retail trade, transport, communications, and business services. While government administration is an important employer that can contribute to economic growth, it has not been the primary driver of structural transformation in the successful developing countries that we reviewed earlier. Therefore, in this scenario we do not increase the public sector, opting rather to focus on private sector suppliers of export- and domestic-oriented services. Together, these private services account for 17.2 percent of total GDP in Ghana, which is equivalent to the contribution of manufacturing and construction together (Table 6).

Although services include the more labor-intensive trade and transport sectors, it also contains some of Ghana's more capital-intensive sectors, such as finance and communications. Therefore, in this scenario we model an increase in both labor productivity and capital accumulation. As in the previous scenario, additional capital growth is financed through increased foreign inflows. However, since the service sector as a whole is less capital-intensive than industry, the increase in foreign-financed investment is smaller than what was required in the previous scenario (Table 13, column 4). Together these assumptions cause service GDP growth to increase from 5.7 percent under the Base-run to 7.1 percent per year (Table 11, part A, column 4). Although the increase in service sector growth is smaller than the increase in industrial growth in the previous scenario, the overall effect at the national-level is similar: total GDP growth rises from 5.6 to 6.3 percent per year. Service sector growth also allows Ghana to achieve higher per capita GDP by 2015: $835 compared to $824 under the previous scenario (Table 11, Columns 3 and 4, part D).

The strong growth linkages between domestic-oriented productive services and the rest of the economy is the main reason why service sector growth generates higher per capita incomes than manufacturing growth does. Private services, especially trade and transport, are important sources of employment, responsible for one in every five unskilled jobs in Ghana. Trade and transport services are important inputs for other sectors in the economy, accounting for 7.4 percent of the overall cost of their production. Service-related spending also comprises 13.8 percent of the average cost of investment. Finally, according to GLSS5, private services make up 12.1 percent of the average

households' consumption basket, and households tend to spend a greater share of their income on private services as their incomes rise. Therefore, expanding growth in private services has significant economy-wide growth effect that is beyond the service sector itself.

The most important channel through which rapid growth in services affects the non-service sectors is through lowering the service prices following improvements in service sector's productivity. Service sector prices fall by an average 1.2 percent per year, and by as much as 3.5 percent for trade and transport. This lowers production costs for both agricultural and industrial sectors, whose average cost of intermediate inputs falls by more than 3 percent per year. As a result, both agricultural and industrial growth accelerates. This inter-sectoral growth-linkage effect is especially pronounced for non-agriculture-related manufacturing, where trade and transport inputs account for 12.4 percent of total costs. Through such inter-sectoral linkage effects, industrial growth accelerates from 5.9 percent under the Base-run scenario to 6.4 percent per year in this service-led growth scenario. The positive effect on agriculture's growth rate is less pronounced, given that services also compete with the agricultural sectors for labor resources (Table 11, Part A, columns 2 and 4).

While lowered service prices stimulate growth in the non-service sectors, it offsets growth in services measured in its current prices. Thus, the substantial growth of services in the real terms does not result in an increase in the share of services in GDP. We observe that the contribution of services to GDP growth rises from 31.8 percent in the base-run to 35.1 percent, while its share in GDP stays almost the same (Table 18, parts A and C).

So far we have emphasized the growth-linkage effects of productive services as the main reason why service-driven growth generates higher per capita growth. Export services also contribute positively to faster overall growth. Export services already generate 11.1 percent of Ghana's export earnings and there is potential to expand services further (Table 15, Part A, column 1). However, in total, Ghana is currently a net importer of traded services, and transport-related services for imports are often provided by foreign companies. Expanding exportable services has considerable potential, mainly in other fields, such as tourism, hotels and business services.

In the current scenario, labor productivity in export-oriented services is assumed to increase such that the sub-sector's average growth rate increases from 6.4 percent per year under the Base-run to 10.6 percent per year (Table 18, part B, column 2 and 4). Service exports grow even more rapidly, accelerating from 5.3 percent to 12.5 percent per year (Table 16, Columns 1 and 3). However, the growing demand for imported services resulting from faster economic growth outpaces service sector growth and service imports grow slightly more rapidly (Table 16, column 3). On the other hand, total imports grow more slowly due to the positive effect of falling services prices on agriculture and non-agriculture-related manufacturing. While faster growth in export services now accounts for 21.2

percent of total service sector growth, compared to only 13.4 percent in the Base-run (Table 18, part C, column 2 and 4), its small size prevents it from being the major driver of growth in the service sector.

Table 18. Structure of services and its sub-sectors' contribution to services growth

	Initial value in 2005	Base-run scenario (1)	Scenarios with accelerated growth in… Industry (2)	Services (3)	Export agric. (4)	Other agric. (5)	Com-bined (6)
Part A. Structure of services							
Services share of GDP	33.4	31.2	31.9	30.8	30.6	31.8	30.9
Share in Service GDP							
Productive services	40.2	40.3	40.3	40.4	40.4	40.5	40.6
Export services	11.0	11.2	11.4	11.6	11.8	12.0	12.2
Other services	48.8	48.5	48.3	48.0	47.8	47.5	47.3
Part B. Average annual growth rate, 2006-2015 (%)							
Services growth rate		5.7	6.0	7.1	5.6	5.7	7.4
Productive services		6.0	6.7	8.0	6.1	6.0	9.0
Export services		6.4	6.9	10.6	4.8	6.3	9.6
Other services		5.3	5.2	5.2	5.3	5.2	5.2
Part C. Contribution to services growth, 2006-2015 average (%)							
Service growth contrib.		31.8	30.4	35.1	29.5	30.1	29.8
Contrib. to serv. growth							
Productive services		42.6	46.1	43.8	44.9	42.9	49.7
Export services		13.4	13.1	21.2	10.0	13.4	16.7
Other services		44.1	40.7	34.9	45.1	43.7	33.6

Source: Ghana CGE model results

In summary, the service growth scenario clearly demonstrates the significant contribution of the service sector to helping Ghana achieve middle-income status by 2015. Ghana undoubtedly has potential to expand export services, such as tourism and business services, and substitute for imported services. However, this sector is currently very small compared to domestic-oriented services. Thus even if the growth rate of Ghana's export services were to match that of India, it is unlikely that such growth in its current form could engender significant structural transformation. The benefits of service sector growth are not limited to exports. The model demonstrates that higher economy-wide growth can be stimulated through expanding domestic services, especially in the trade and transport sectors. It is the strong growth linkages of the service sector that explain, at least in part, why countries like Thailand and China have experienced more rapid service sector growth alongside industry-led transformation.

5.4 Scenarios 4 and 5: Accelerated growth in agriculture

Scenarios 2 and 3 show that accelerated growth in both manufacturing and services is far from sufficient to reach US$1000 per capita GDP by 2015. Industrial and service sector led growth can only raise per capita GDP by US$50 and US$61 over the next ten years, respectively. To reach beyond these levels, additional growth will have to come from the agricultural sector. Given its large initial share in the total economy, rapid growth in agriculture can support the country in overcoming the gap between the income levels projected in previous scenarios and middle-income status. To assess different growth options for agriculture, we design two scenarios. Scenario 4 focuses on the role of agricultural exports, while Scenario 5 focuses on growth in staple foods, including food crops and livestock. In the agricultural export promotion scenario (Scenario 4), we assume additional growth only for exportable agricultural goods. These include traditional export commodities, such as cocoa and forestry, and nontraditional export commodities, such as fish, palm oil, fruits, vegetables, tree nuts, and other export crops (including rubber, cotton, and coffee). Groundnuts are both a staple crop and an export crop, especially for the northern savannah zone, and are therefore included in this scenario. We assume that, compared with the base-run, there is no additional investment financed by foreign capital inflows, reflecting the fact that the agricultural sector is less capital intensive.

Growth in export agriculture is modeled by increasing land productivity and expanding crop land for export crop production. The increase in land productivity is equivalent to 0.70 percent additional annual growth, while the additional land expansion is equivalent to 0.26 percent additional annual growth (compared to the base-run). In this scenario, total land productivity is 7 percent higher by 2015 compared to the base-run, and by 2015, the crop land area expands by 2.5 percent more than under the base-run.

Under these assumptions, growth in both traditional and nontraditional agricultural exports is accelerated, which results in a growth of 9.5 percent in the total agricultural exports annually, compared to 7.5 percent in the base-run (Table 16, Columns 1 and 4)). Growth in fruits, vegetables, and fish exports is especially high, ranging from 14 to 21 percent. In total, excluding cocoa and forestry products, nontraditional agricultural exports (including fish) grow at 12.1 percent annually, while growth in cocoa and forestry exports is 11.6 and 10.8 percent per year. Export-led growth brings the annual agricultural GDP growth rate up to 6.0 percent – 0.7 percentage points higher than its base-run level. Production of exportable agricultural goods accounts for about 40 percent of agricultural GDP (including forestry and fish). Despite this volume, relatively weak linkages of these export sectors with the rest of economy result in a limited overall growth impact. Total annual GDP growth rises to 5.8 percent, only 0.2 percentage points higher than growth in the base-run (Table 11, Part A). Thus, export-led growth alone will only make a small contribution towards achieving middle-

income status. It generates additional US$17 of per capita GDP over base-run's 2015 level of US$774 (Table 11, Part D, columns 2 and 5).

Table 19. Structure of agriculture and its sub-sectors' contribution to industrial growth

	Initial value in 2005	Base-run scenario	Scenarios with accelerated growth in…				
			Industry	Services	Export agric.	Other agric.	Com-bined
		(1)	(2)	(3)	(4)	(5)	(6)
Part A. Structure of agriculture							
Agric. share of GDP	38.7	40.9	39.2	40.5	42.6	39.7	39.4
Share in agric. GDP							
Cereals	11.1	9.3	9.6	9.4	8.7	10.1	10.1
Roots	23.1	20.9	22.3	21.5	20.3	19.3	20.3
Other staples	19.2	18.8	20.0	19.9	18.2	17.9	19.6
Export crops	22.8	25.9	22.1	24.6	25.8	26.9	21.8
Livestock	6.4	6.0	7.3	6.1	5.4	6.4	7.5
Forestry and fish	17.4	19.2	18.7	18.6	21.6	19.5	20.7
Part B. Average annual growth rate, 2006-2015 (%)							
Agricultural growth rate		5.3	5.1	5.4	6.0	6.2	6.9
Cereals		2.9	2.8	2.9	2.6	6.2	6.1
Roots		3.6	3.9	3.7	3.6	5.0	5.4
Other staples		4.3	4.6	4.6	4.3	5.2	6.0
Export crops		7.4	6.0	7.4	8.2	7.4	6.8
Livestock		4.1	5.8	4.2	3.5	6.4	8.2
Forestry and fish		7.2	7.0	7.2	9.6	7.0	9.4
Part C. Contribution to agricultural growth, 2006-2015 average (%)							
Agric. growth contrib.		38.8	31.7	35.1	44.5	41.1	35.5
Contrib. to agric. growth							
Cereals		5.5	5.8	5.5	4.4	10.3	9.2
Roots		14.9	17.1	15.4	13.1	16.7	16.7
Other staples		15.4	17.7	16.9	13.6	15.5	16.7
Export crops		34.3	26.7	32.8	33.9	30.1	23.0
Livestock		4.8	7.8	5.0	3.5	6.5	8.0
Forestry and fish		25.0	25.0	24.4	31.5	20.9	26.3

Source: Ghana CGE model results

In this scenario we also assumed that world market prices are fixed (i.e., the model does not capture changes in world market prices). However, Ghana's major export goods such as cocoa have faced favorable prices and exogenous conditions over the last years. These conditions can change and if world prices fall for Ghana's major export commodities in the next 10 years, the export sector's growth (measured at international prices) is likely to fall.

Table 20. Yield-gaps for selected crops

	Yields (mt per hectare)	
	MOFA estimate, (various years)	Achievable

Maize	1.6	5.0
Rice	2.0	6.5
Sorghum	1.0	2.0
Cassava	12.4	28.0
Yam	12.5	20.0
Cocoyam	6.4	8.0
Cowpea	0.8	2.6
Groundnut	0.9	2.0
Plantain	8.5	20.0
Cocoa	0.4	1.0

Source. Ministry of Agriculture (2005 and 2006).

In Scenario 5 we focus on staple crops to evaluate their potential contribution to reaching the middle-income goal. Similar to Scenario 4, additional growth is generated by exogenous growth in both land productivity and modest area expansion in staple crop production. Moreover, labor productivity in livestock sector increases in a comparable way. The productivity growth rate is also assumed to be high for those commodities with high import-to-consumption ratios, such as rice and poultry. Land productivity is assumed to be 54 percent higher by 2015 compared to the base-run's 2015, and more than 90 percent higher compared to 2005. Total land area is expanded by 3 percent by 2015, compared to the base-run, and is comparable than that resulted in Scenario 4. Significant yield gaps exist for most crops in Ghana. For example, MOFA estimates achievable yields of 5 metric ton per hectare for maize and 6.5 ton for rice. Current average yields are only 1.6 ton per hectare for maize and 2.0 ton for rice (Table 20). Under our land productivity growth assumptions in the model, maize and rice yields reach 2.3 and 3.5 ton per hectare by 2015, respectively (Table 21, Column 6), still much lower than the achievable yields. Similar as in Scenario 4, there is no additional investments financed by foreign capital inflows.

While imports account on average one-third of agriculture-related consumption in the domestic market, the ratio is significantly higher for rice and poultry, accounting for 68 and 97 percent of total consumption in 2005, respectively (Table 14, Column 1). In the base-run the imports-to-consumption ratio is projected to shift further in favor of imports for rice and poultry. In this scenario, we assume that the domestic production of rice and poultry grows at 12 and 18 percent annually, mainly through increases in yields (in the case of rice) and total factor productivity (in the case of poultry). These assumptions reflect the existing potential of domestic production to compete with imports. High productivity growth lowers domestic prices for rice and poultry, leading to a partial substitution of imports by domestic production. In the case of rice, the import growth rate falls significantly, from 5.0 percent annually in the base-run to -0.6 percent in this scenario (Table 16, columns 1 and 5). The import-to-domestic consumption ratio falls to 41.9 percent (from 68 percent in 2005, Table 14, column 1 and 6). At the same time domestic consumption of rice increase and its

growth rises to 5.9 percent annually, from 5.0 percent in the base-run. Rice accounts for more than 50 percent of total agricultural imports. Import substitution in rice helps reduce annual growth in agricultural imports to 2.5 percent, from 6.1 percent in the base-run (Table 16, Columns 1 and 5).

Due to a high income elasticity, poultry imports continue to grow rapidly, at the same growth rate as in the base-run. Despite very high growth rates of 18 percent per year, 95.1 percent of domestic demand for poultry continues to depend on imports (Table 14, Column 6). While growth in the poultry sector does not lead to significant import substitution effects, it does support growth of the maize sector by increasing demand for animal feed (chicken feed consists to 60 percent of maize). In terms of chicken, the maize-to-chicken ratio is higher than 2-to-1 in the country, i.e., more than 2kg of maize are needed to produce one kg of chicken meat. About one-third of maize is consumed as intermediates in feed and other sectors. This feed demand supports the expansion of maize and avoids a significant drop in maize prices (that falls by less than 7 percent only in total over the 10 year period) from a 6 percent annual growth rate of maize production.

Table 21. Final year yields for selected crops (mt/ha)

	Initial yields in 2005	Final year yields (2015) (mt/ha)					
		Base-run	Scenarios with accelerated growth in…				
			Industry	Services	Export agric.	Other agric.	Com-bined
		(1)	(2)	(3)	(4)	(5)	(6)
Maize	1.65	1.96	1.98	1.96	1.91	2.34	2.36
Rice	1.92	2.21	2.13	2.26	2.11	3.49	3.43
Sorghum	0.93	1.02	1.02	1.03	1.02	1.04	1.05
Cassava	15.34	18.15	18.63	18.36	18.07	21.14	21.86
Yam	11.91	15.11	15.37	15.22	15.04	17.86	18.04
Cocoyam	7.37	9.19	9.47	9.34	9.15	10.68	11.18
Cowpea	2.03	2.58	2.58	2.66	2.58	2.81	2.93
Soya bean	0.94	1.20	1.42	1.21	1.15	1.29	1.50
Groundnut	1.03	1.22	1.28	1.23	1.14	1.22	1.26
Plantain	10.08	12.77	12.95	13.29	12.76	13.50	14.25
Cocoa	0.51	0.80	0.72	0.80	0.75	0.75	0.63

Source: Ghana CGE model results
Note: Initial yields are calculated using production data from MOFA for 2005.

Additional annual growth of 5-7 percent in staple crop and livestock production results in an additional of 0.9 percent growth in the agricultural sector as a whole. The annual agricultural GDP growth rate rises to 6.2 percent in this scenario – up from 5.3 percent in the base-run. Many empirical studies show that staple-led agricultural growth has strong multiplier effects (i.e., each unit increase in staple production generates more than one unit increase in the total economy) (see Haggblade and Hazell, 1989). Our simulation results confirm it. Growth in staple crop and livestock sectors accelerates growth in industrial sectors in this scenario, while in the agricultural export-led growth

scenario, the nonagricultural growth rate falls slightly. GDP annual growth rate increases to 6.0 percent, which is 0.4 percentage points higher than the base-run growth. Because of this, per capita GDP increases to US$813 by 2015 – US$39 more than the base-run 2015's result.

5.5 Scenario 6: Combining growth in all three sectors

Results from Scenarios 2-5 show that there is no single sector whose rapid growth alone can lead a significantly increase in per capita income. Therefore combined growth across sectors will be necessary for Ghana to double incomes by 2015. Thus, in Scenario 6 we combine labor, land, capital and productivity growth assumptions applied in Scenarios 2-5 to evaluate the joint impact of accelerated growth at the sector-level as well as for the economy as a whole. In this scenario, each sector's GDP growth rate also accelerates through enhanced inter-sector linkage effects, although the assumptions applied are the same as those used separately in Scenarios 2-5. Total GDP growth rises to 7.6 percent per year. Agriculture grows at 6.9 percent, industry at 8.9 percent and services at 7.4 percent (see Table 11 to compare column 7 with column 3 for industrial GDP, column 4 for service GDP and columns 5 and 6 together for agricultural GDP).

Structural change, in terms of sectoral composition, remains limited, despite differing growth rates across sectors. Although agricultural annual growth rate is the lowest one among the three sectors and is 2 percentage points lower than the industrial growth rate, agriculture's share in GDP remains at 39.4 percent. With 8.9 percent annual growth, industry has the highest growth rate, while its share in GDP only rises slightly, from 27.9 percent in 2005 to 29.8 percent by 2015. While the service sector's growth rate is higher than agricultural growth, the service's share of GDP falls, from 33.4 percent in 2005 to 30.9 percent in 2015. This "inconsistency" between a sector's contribution to GDP growth and its share in GDP is due to changes in the relative prices. Compared with the GDP deflator, agricultural prices rise, which causes the share of agriculture in GDP, measured in current prices, to remain constant, while service prices fall, making the sector's share of GDP smaller.

Accelerated growth needs to be supported by productivity growth. Factor contributions to growth falls for all the three factors, land, labor and capital and falls the most in labor, while productivity's contribution rises to 46.9 percent, more than 10 percentage points higher than that in the base-run (Table 12). Accelerated growth is also supported by capital accumulation. Increases in investments raise the investment-to-GDP ratio to 0.38 (Table 13, Column 7). Although this is higher than the current 0.32, it is comparable with that of other high growth developing countries. Investments continue to be financed by large foreign capital inflows. The share of government investments in total investment spending remains relatively stable, comparable with Ghana's current situation. The role of foreign inflows in financing investment increases, from 64.2 percent to 67.0 percent of total investment spending, while the share of private savings in total investment falls. The

model assumes that government recurrent spending grows relatively more slowly than economic growth, at 5.2 percent annually, which allows increased government revenues generated from economic growth to be channeled into investment. However, if increasing recurrent spending is favored instead of increasing public investments, this will result in either increasing foreign inflows or lowering capital accumulation due to lack of investment financing.

The 7.6 percent GDP annual growth rate translates into annual growth in per capita GDP of 5.3 percent, rising from 4.8-5.1 percent in the first four years to 5.2-5.8 percent in the final six years through 2015. With this growth performance, per capita income will reach US$956 by 2015, more than doubling current per capita income of $454.

6. CONCLUSIONS

Balanced and sustained growth in Ghana has translated into significant poverty reduction and the government of Ghana has declared the new development goal of reaching middle-income status by 2015. In this paper, we have reviewed growth and structural transformation experiences in countries with similar initial per capita incomes and reaching middle-income status within a similar time span. The focus of the paper is to evaluate possible sources of accelerated growth and their contributions to overall economic growth and transformation. We have done this using a dynamic general equilibrium model calibrated to the current structure of Ghana's economy. We have emphasized that reaching middle-income status is a process of economic transformation in which significant structural changes often take place.

Ghana's target to reach middle-income status by doubling its per capita income within 10 years is not unprecedented. Examples of successful countries include Brazil, China, Malaysia, and Thailand. India and Vietnam are expected to reach this goal within a similar period of time. These six countries have all undergone a significant transformation of their economies, including structural change, rapid export growth, and export diversification, especially within agriculture. In general, the manufacturing sector has expanded most rapidly in these countries, but agriculture also grew between 3.2 and 5.9 percent (with an exception of India). The experience of Malaysia during 1965-1977 might be most comparable to Ghana's recent development: agriculture grew at about a similar pace as the overall growth, and exports remained relatively dependent on one commodity. However, increased globalization, rapid growth in Asian countries, and continued protection of agricultural markets in many developed countries poses several new challenges to developing countries like Ghana. Structural transformation in resource rich countries might be more difficult when raw materials prices are high. Global competition is also fiercer in the classic 'starter industries', such as textiles and other low-skilled labor intensive manufacturing. Despite these challenges, Ghana has been successful in sustaining growth and reducing poverty over the past 20 years. This paper has analyzed different growth scenarios and their structural implications to determine how Ghana might develop over the next ten years.

6.1 Summary of model results

The model simulation results show that the level and type of growth that Ghana has experienced in recent years will increase per capita incomes by about 70 percent until 2015 as compared to 2005. Growth will therefore have to be accelerated in Ghana. Based on the experience of other developing countries that have successfully transitioned from low- to middle-income status, we first consider the role of accelerated growth in manufacturing in the country's transformation, with an

emphasis on the labor-intensive manufacturing. Exogenously induced rapid productivity growth in the manufacturing sector and accelerated capital accumulation in the economy results in an annual growth rate of as high as 10.3 percent in some manufacturing sectors (food and wood processing and textiles). Such rapid growth in manufacturing will help the country adjust its export structure and reduce its dependency on raw material exports, such as cocoa and forestry products. Given that Ghana is highly dependent on imports for most of its capital and manufactured consumption goods, substantial import substitution for these products seems unlikely, even with high manufacturing growth.

Ghana's current industrial structure constrains the rapid development of manufacturing and an increase in the sector's contribution to overall economic growth and transformation. Almost two-thirds of manufacturing in the country is agriculture-related and its growth is therefore constrained by agricultural growth. The development of export-oriented labor-intensive manufacturing that is not heavily dependent on agriculture, such as textile, clothing, and footwear, seems to be necessary if the country wants to further increase manufacturing growth and create more job opportunities. Attracting more foreign investment in these kinds of sectors will be key for helping Ghana to catch-up with international standards and achieve global competitiveness.

With globalization and market integration, the service sector has begun to play an important role in growth, even among developing countries. Export-oriented services are often technology-intensive, demanding high levels of human capital. As an English-speaking coastal country, Ghana may have the potential to develop an export-oriented service sector, similar to what has occurred in India. It may also have potential to expand tourism. However, the benefits of service sector growth are not limited to its contribution to exports. Services geared towards the domestic market can also play a key role in growth and economic transformation. High transportation and transaction costs are barriers for the private sector to do business and for attracting foreign investment. Thus, the model simulates accelerated growth in the private services sector in order to evaluate its contribution to Ghana achieving middle-income status. The results indicate that the most important contribution of services is through its linkages with the rest of economy, rather than in generating more exports. The industrial sector benefits greatly from a lowering of the cost of transportation and trade through improvements in service sector productivity. Thus, while the share of the service sector in the economy is not expected to increase, accelerated growth in the service sector increases industrial GDP annual growth by 0.5 percent annually and agriculture by 0.1 percent.

Given its large initial share in the economy, it is impossible to achieve rapid economy-wide growth without accelerating agricultural growth. Significant yield gaps exist for most crops produced in the country and many livestock products are heavily dependent on imports for domestic consumption. There is also room to promote further growth in both traditional and nontraditional exports. Also, the use of modern inputs is much lower than in the successful countries that we

reviewed. Thus, it is possible for Ghana to achieve more rapid agricultural growth by transforming its traditional agriculture into a modern sector, similar to what Malaysia had done in its transformation process. Export agriculture already accounts for a large share of agriculture in Ghana, and more rapid growth is also possible in nontraditional exports targeting niche markets. However, the model simulation did not show significant structural changes in agricultural exports over the next 10 years, even when we assumed a much higher growth rate (more than 13 percent) for the nontraditional exports. More than half of agricultural exports will continue to be from cocoa, indicating continued vulnerability to external shocks in world prices or to growth from other countries exporting cocoa. Despite its growth potential, export agriculture seems to have relatively weak linkages to the rest of economy, which will limit its impact on overall economic growth.

There is considerable room to promote growth in staple foods through improving productivity and increasing competitiveness of import intensive sectors. More than 60 percent of rice and 90 percent of chicken consumed by Ghanaians in the country are imported, and both commodities, especially chicken, have relatively high income elasticities, implying that imports may grow more rapidly than income. However, high income elasticities in certain agricultural products can create market opportunities for increasing agricultural growth, if domestic products are able to substitute for imports. Moreover, through 'chicken-to-maize' linkages it can provide growth opportunities for maize and other staple crops used as animal feeds. The model simulation showed the possibility of domestic rice to substitute for imported rice, if yields can be doubled and domestic prices for rice can be lowered by 30 percent. Substituting imported chicken seems to be more difficult. The model indicated that, even with a 20 percent decline in domestic prices caused by improvements in chicken sector productivity, imported chicken remain the dominant source of domestic chicken consumption and imports only marginally decrease. This indicates that additional policies are needed to enable domestic chicken producers to compete with foreign suppliers and to harness this sector as a source of agricultural growth.

Combining growth in all three major sectors showed that growth in Ghana will remain relatively balanced, and that the country's economic structure will not change much by 2015. Industry will only account for an additional 2 percentage points of GDP, largely driven by the displacement of services. Combining agriculture, industry and service sector growth resulted in total GDP growth of 7.6 percent and per capita GDP growth of 5.7 percent annually over the next 10 years. Measured in real $US, per capita GDP reaches $956 by 2015. However, we should note the possible departure between per capita GDP measured in constant and current $US, which was observed in other developing countries, as well as in Ghana in recent years. Taking into account this factor, there seems no doubt that 7.6 percent GDP growth will allow the country to meet its target of US$1,000 by 2015 (measured in current $US). However, reaching middle-income status should be understood as a

development goal that cannot be measured using a single number alone. Development and transformation is a process, and each country will have its own path to follow. In the case of Ghana, agriculture is expected to play a more important role in this process compared to the past experiences of other successful developing countries.

6.2 Caveats and areas for further research

A number of caveats should be mentioned when interpreting these results. First, due to its specification of household demand, the model is unable to fully capture demand dynamics driven by both income growth and time. In the model the income elasticity of demand is econometrically estimated using the data of GLSS5, and subsistence consumption has been taken into account in the demand functions, which are defined at the sub-national regional levels for both rural and urban households and derived from Stone-Geary utility functions. However, the marginal budget shares in this demand system remain relatively constant over time. Because of this, the model is unlikely to capture significant non-linear shifts in demand structure over time, which is commonly observed in developing countries as they move from low- to middle-income status with rapid and broad-based growth (e.g., in China). Second, similar to most CGE models, production technology is calibrated to the initial economic structure and this technology remains fixed over time. Because of this, the model simulations do not capture the effects of substantial changes caused by newly introduced technology embodied in new investments, especially through foreign direct investment, and its possible impact on structural change. As observed in successfully transforming developing countries, the expansion of manufacturing can generate many externalities and spillovers, and social value of new investments can greatly exceed their private value (Rodrik, 2006). However, we have assumed constant returns-to-scale technology in primary factors and fixed coefficients for intermediate inputs to output, which are the commonly applied assumptions in most CGE models. As such, the model does not capture increasing returns-to-scale, technological externalities and spillovers, and may therefore underestimate the contribution of growth in non-traditional and import-substitutable agriculture and new manufacturing activities to structural change during a rapid growth period.

Besides the model's caveats, this paper also faces challenges in how to fully capture new opportunities and constraints in Ghana's future growth. First, Ghana has announced a major oil discovery of 600 million barrels in its offshore territory. This is one of the biggest oil discoveries in Africa in the recent years (BBC, 2007). Revenues from exploiting oil resources can boost public expenditure and foreign currency earnings, which can finance investment using the country's own savings, instead of remaining highly dependent on foreign inflows, as Ghana does currently. However, with increased oil exports it will be important to avoid the 'resource curse' that many resource-rich countries have faced in the past. Second, accelerated growth in agriculture bears the risk of unsustainable resource use, if growth is achieved mainly through land expansion (Jackson and

Acharya, 2007). Diao and Sarpong (2007) estimate that the economy-wide losses of soil degradation can reach up to 5 percent of agricultural GDP between 2006 and 2015, but such potential negative effects were not accounted for in the current model. Third, large regional disparities in Ghana persist, especially between the lagging northern regions and the rest of the country. These disparities are expected to persist and might have negative impacts on growth in the country both at the regional and sectoral levels (Bogetic, 2007; Al Hassan and Diao, 2007). Finally, the country faces severe energy shortages, and is currently in an energy crisis involving regular electricity cuts. The model did not take these shortages into account and hence implicitly assumes that it will not constrain future growth. While agricultural growth is less energy-intensive and is therefore less affected by energy-related constraints, electricity shortages can have significantly negative impacts on manufacturing and services. Further analysis is needed to account for energy shortages and assess the impacts of energy shortages and energy allocation efficiency on Ghana's economic growth.

6.3 Looking forward

Despite its limitations, the model results presented in this paper have clear implications for the design of development strategies. First, sustainable rapid growth must be accompanied by structural change in which resources and labor move from traditional low-productivity activities into modern sectors through increases in capital investment. While exploiting natural resources can make some countries rich, such growth paths often lead to increased inequality and a stagnant economic structure, which will not allow the majority of these countries' citizens to participate in and benefit from the growth process. Ghana should actively avoid such outcomes along its path to middle-income status.

Secondly, not all modernization needs to take place within industrial sectors. In a large agricultural sector with strong comparative advantages, the modernization of traditional agriculture can be a significant source of accelerated growth and structural change. However, to realize this, growth in the agricultural sector needs strong support from the government. Policy and institutional reforms and public investments in Ghana should pay greater attention to raising agricultural productivity and encouraging structural transformation, which have rarely been purely market-driven in successfully transforming countries.

Finally, globalization has greatly increased the role of exportable sectors in accelerating growth. However, there are natural limits to export-led growth based on primary products, while world markets provide near-limitless demand for nontraditional or manufactured exports from developing countries. Diversifying Ghana's export structure is thus vital if exports are to become an engine for accelerated growth and structural change. The government must search for policies that promote private entrepreneurship and investment (foreign and domestic) in new activities facing more dynamic international demand.

While Ghana's past economic successes has afforded it the opportunity to reach for middle-income status, encouraging modernization and diversification will require careful coordination between increasingly complex macroeconomic, industrial and financial market policies. The achievement of Ghana's more ambitious goal will thus hinge, not only on designing policies that build on current economic structures and strengths, but also on improving the institutional capacity of the government to implement more complex policies.

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APPENDICES

Appendix 1

Table A1. Sectors/commodities in the Ghana CGE 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
Coco yams	Textiles	Community, other services
Other staple crops	Clothing	Public administration
Cowpea	Leather and footwear	Education
Soya beans	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		

Appendix 2

Table A2. CGE Model's sets, parameters, and variables

Symbol	Explanation	Symbol	Explanation
Sets			
$a \in A$	Activities	$c \in CEN(\subset C)$	Commodities not in *CE*
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CM(\subset C)$	Aggregate imported commodities
$c \in C$	Commodities	$c \in CMN(\subset C)$	Commodities not in *CM*
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$c \in CX(\subset C)$	Commodities with domestic production
$c \in CDN(\subset C)$	Commodities not in *CD*	$f \in F$	Factors
$c \in CE(\subset C)$	Exported commodities	$h \in H(\subset INSDNG)$	Households
Equation parameters			
cpi	Consumer price index	$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$cwts_c$	Weight of commodity c in the CPI	pwe_c	Export price (foreign currency)
ica_{ca}	Quantity of c as intermediate input per unit of activity a	$shif_{if}$	Share for domestic institution i in income of factor f
$icd_{cc'}$	Quantity of commodity c as trade input per unit of c' produced and sold domestically	$shii_{ii'}$	Share of net income of i' to i (i' ∈ INSDNG'; i ∈ INSDNG)
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	ta_a	Tax rate for activity a
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	$tins_i$	Exogenous direct tax rate for domestic institution i
$inta_a$	Quantity of aggregate intermediate input per activity unit	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
iva_a	Quantity of aggregate intermediate input per activity unit	tm_c	Import tariff rate
mps_i	Base savings rate for domestic institution i	tq_c	Rate of sales tax

Table A2. CGE Model's sets, parameters, and variables (continued, a)

Symbol	Explanation	Symbol	Explanation
Equation parameters, continued			
α_a^a	Efficiency parameter in the CES activity function	δ_{cr}^t	CET function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor *f* in activity *a*
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity c for household h
α_c^q	Armington function shift parameter	θ_{ac}	Yield of output c per unit of activity a
α_c^t	CET function shift parameter	ρ_a^a	CES production function exponent
β^a	Capital sectoral mobility factor	ρ_a^{va}	CES value-added function exponent
β_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	ρ_c^{ac}	Domestic commodity aggregation function exponent
δ_a^a	CES activity function share parameter	ρ_c^q	Armington function exponent
δ_{ac}^{ac}	Share parameter for domestic commodity aggregation function	ρ_c^t	CET function exponent
δ_{cr}^q	Armington function share parameter	η_{fat}^a	Sector share of new capital
υ_f	Capital depreciation rate		
Exogenous Variables			
$fsav$	Foreign savings (FCU)	qg_c	Government consumption demand for commodity
mps_i	Marginal propensity to save for domestic non-government institution (exogenous variable)	$qinv_c$	Base-year quantity of private investment demand
pwm_c	Import price (foreign currency)	$trnsfr_{i\,f}$	Transfer from factor f to institution i
$qdst_c$	Quantity of stock change	$wfdist_{fa}$	Wage distortion factor for factor f in activity a
qfs_f	Quantity supplied of factor		
Endogenous Variables			
AWF_{ft}^a	Average capital rental rate in time period t	$QINTA_a$	Quantity of aggregate intermediate input
$IADJ$	Investment adjustment factor	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
EG	Government expenditures	$QINV_c$	Quantity of investment demand for commodity
EH_h	Consumption spending for household	QM_{cr}	Quantity of imports of commodity c
EXR	Exchange rate (LCU per unit of FCU)	PA_a	Activity price (unit gross revenue)
$GSAV$	Government savings	PD_c	Demand price for commodity produced and sold domestically
QF_{fa}	Quantity demanded of factor f from activity a	PE_{cr}	Supply price for commodity produced and sold domestically
QH_{ch}	Quantity consumed of commodity c by household h	$PINTA_a$	Export price (domestic currency)
QHA_{ach}	Quantity of household home consumption of commodity c from activity a for household h	PK_{ft}	Aggregate intermediate input price for activity a

Table A2. CGE Model's sets, parameters, and variables (continued, b)

Symbol	Explanation	Symbol	Explanation
Endogenous Variables Continued			

PM_{cr}	Unit price of capital in time period t	QX_c	Aggregated quantity of domestic output of commodity
PQ_c	Import price (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity c from activity a
PVA_a	Composite commodity price	$TRII_{ii'}$	Transfers from institution i' to i (both in the set INSDNG)
PX_c	Value-added price (factor income per unit of activity)	WF_f	Average price of factor
$PXAC_{ac}$	Aggregate producer price for commodity	YF_f	Income of factor f
QA_a	Producer price of commodity c for activity a	YG	Government revenue
QD_c	Quantity (level) of activity	YI_i	Income of domestic non-government institution
QE_{cr}	Quantity sold domestically of domestic output	YIF_{if}	Income to domestic institution i from factor f
QQ_c	Quantity of goods supplied to domestic market (composite supply)	K^a_{fat}	Quantity of new capital by activity a for time period t
QVA_a	Quantity of (aggregate) value-added		

Appendix 3

Table A3. CGE model equations

Production and Price Equations

$$QINT_{ca} = ica_{ca} \cdot QINTA_a \quad (1)$$

$$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca} \quad (2)$$

$$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \quad (3)$$

$$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot (\alpha_{fa}^{vaf})^{-\rho_a^{va}} \cdot \left(QF_{fa} \right)^{-\rho_a^{va}-1} \quad (4)$$

$$QVA_a = iva_a \cdot QA_a \quad (5)$$

$$QINTA_a = inta_a \cdot QA_a \quad (6)$$

$$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a \quad (7)$$

$$QXAC_{ac} = \theta_{ac} \cdot QA_a \quad (8)$$

$$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac} \quad (9)$$

$$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}} \quad (10)$$

$$PXAC_{ac} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1} \quad (11)$$

$$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c} \quad (12)$$

$$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \quad (13)$$

$$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PD_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \quad (14)$$

$$QX_c = QD_c + \sum_r QE_{cr} \quad (15)$$

$$PX_c \cdot QX_c = PD_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr} \quad (16)$$

$$PM_{cr} = pwm_{cr} \cdot (1 + tm_{cr}) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c} \quad (17)$$

Table A3. CGE Model Equations (continued, a)

$$QQ_c = \alpha_c^q \cdot \left(\sum_r \delta_{cr}^q \cdot QM_{cr}^{-\rho_c^q} + (1 - \sum_r \delta_{cr}^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}} \quad (18)$$

$$\frac{QM_{cr}}{QD_c} = \left(\frac{PD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \sum_r \delta_{cr}^q} \right)^{\frac{1}{1+\rho_c^q}} \quad (19)$$

$$QQ_c = QD_c + \sum_r QM_{cr} \quad (20)$$

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PD_c \cdot QD_c + \sum_r PM_{cr} \cdot QM_{cr} \quad (21)$$

$$cpi = \sum_{c \in C} PQ_c \cdot cwts_c \quad (22)$$

Institutional Incomes and Domestic Demand Equations

$$YF_f = \sum_{a \in A} WF_f \cdot wfdist_{fa} \cdot QF_{fa} \quad (23)$$

$$YIF_{if} = shif_{if} \cdot YF_f \quad (24)$$

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i\,gov} \cdot cpi + trnsfr_{i\,row} \cdot EXR \quad (25)$$

$$TRII_{ii'} = shii_{ii'} \cdot (1 - mps_{i'}) \cdot (1 - tins_{i'}) \cdot YI_{i'} \quad (26)$$

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih}\right) \cdot (1 - mps_h) \cdot (1 - tins_h) \cdot YI_h \quad (27)$$

$$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m \right) \quad (28)$$

$$QINV_c = IADJ \cdot qinv_c \quad (29)$$

$$EG = \sum_{c \in C} PQ_c \cdot qg_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot cpi \quad (30)$$

$$YG = \sum_{i \in INSDNG} tins_i \cdot YI_i + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR \quad (31)$$

System Constraints and Macroeconomic Closures

$$QQ_c = \sum_{a \in A} QINT_{ca} + \sum_{h \in H} QH_{ch} + qg_c + QINV_c + qdst_c \quad (32)$$

$$\sum_{a \in A} QF_{fa} = QFS_f \quad (33)$$

$$YG = EG + GSAV \quad (34)$$

Table A3. CGE Model Equations (continued, b)

$$\sum_r \sum_{c \in CMNR} pwm_{cr} \cdot QM_{cr} = \sum_r \sum_{c \in CENR} pwe_{cr} \cdot QE_{cr} + \sum_{i \in INSD} trnsfr_{i\,row} + fsav \quad (35)$$

$$\sum_{i \in INSDNG} mps_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot fsav = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c \quad (36)$$

Factor Accumulation and Allocation Equations (Applies to Capital only)

$$AWF^{a}_{f\,t} = \sum_{a}\left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}}\right)\cdot WF_{f\,t}\cdot wfdist_{f\,a\,t}\right] \tag{37}$$

$$\eta^{a}_{f\,a\,t} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}}\right)\cdot\left(\beta^{a}\cdot\left(\frac{WF_{f,t}\cdot wfdist_{f\,a\,t}}{AWF^{a}_{f\,t}}-1\right)+1\right) \tag{38}$$

$$\Delta K^{a}_{f\,a\,t} = \eta^{a}_{f\,a\,t}\cdot\left(\frac{\sum_{c} PQ_{c\,t}\cdot qinv_{c\,t}}{PK_{f\,t}}\right) \tag{39}$$

$$PK_{f\,t} = \sum_{c} PQ_{c\,t}\cdot\frac{qinv_{c\,t}}{\sum_{c'} qinv_{c'\,t}} \tag{40}$$

$$QF_{f\,a\,t+1} = QF_{f\,a\,t}\cdot\left(1+\frac{\Delta K^{a}_{f\,a\,t}}{QF_{f\,a\,t}}-\upsilon_{f}\right) \tag{41}$$

$$QFS_{f\,t+1} = QFS_{f\,t}\cdot\left(1+\frac{\sum_{a} K_{f\,a\,t}}{QFS_{f\,t}}-\upsilon_{f}\right) \tag{42}$$

Appendix 4. Parameter calibration/estimation

The calibration of the Ghana CGE model to Ghana's initial economic structure and base-year data includes the calculation of a set of behavioral parameters. Some of these parameters are calculated from the social accounting matrix (SAM) and others are drawn from the literature or other sources. The parameters related to the initial structure of the economy at the sector level, such as commodity average budget share in the demand system, household savings rate ($\overline{mps_i}$), input-output coefficients (ica_{ca}) and factor intensity parameters in the production functions, and exports and imports intensity parameters ($icm_{cc'}; ice_{cc'}$) in the trade functions, can be directly calculated from the SAM. See the complete list for such parameters in Table A2.

A set of elasticity coefficients is also required for the model. These parameters include: (a) elasticities of substitution between factors in the production function, (b) elasticities of substitution between imports and domestically produced goods and services in the Armington function and between exports and domestically produced goods in the CET function, and (c) income elasticity of demand to drive the marginal budget shares in the consumers' demand function.

Similar as in most other CGE models, the elasticities in (a) – (b) have to be drawn from other sources. The values for CET transformation and CES factor substitution elasticities used in the Ghana CGE model are inspired by several African country case studies conducted by IFPRI (Diao et al., 2007; Thurlow, 2004; Lofgren et al., 2002). The income elasticity of demand is estimated econometrically using data from GLSS5. The estimation procedure is further discussed in Appendix 5, while Table A4 reports the value of elasticities in (a) – (b) used in the model. The Armington elasticities have been adopted from Hertel et al. (2007), who estimated average import substitution elasticities for 40 commodities from a large set of countries.

Table A4. Values for production and trade elasticities

	Elasticity in value-added functions (a)	Armington elasticity (b1)	CET elasticity (b2)
Value	0.75	Estimates from Hertel et al. (2007)	6.00

Notes. Hertel et al. (2007) do not estimate Armington elasticities for services. We assume all service-sector import elaticities to be 4.0, consistent with other IFPRI CGE models.

The fact that most elasticities applied in CGE models are not econometrically estimated using consistent data to support other technical coefficients has been a major criticism among economists (e.g. Shoven and Whalley, 1984). To address this concern, most CGE models are supplemented by sensitivity tests to check the robustness of model results. For the Ghana CGE model, we have conducted a series of sensitivity tests for the key elasticities applied in the model. Detailed results are

reported in Appendix 6. The sensitivity tests show that compared with the model results reported in this paper, there is only a very modest variation in the values of major variables. This result indicates the robustness of the model results.

Appendix 5. Income elasticity of demand and marginal budget shares in the demand system

As shown in Appendix 3 the household demand functions are derived from the Stone-Geary utility function, in which the demand elasticity of income is not unity. Thus, income elasticities need to be estimated if data is available. Using data from the GLSS5 and the method suggested in King and Byerlee (1978), we have first estimated the demand elasticity of income for representative rural and urban households, respectively at national level (see Table A5(1)). We then applied these elasticities on the regional level representative households' average commodity expenditure shares, s_i (see Table A5(2)), which can be calculated from GLSS5, to obtain the marginal budget shares, β_i, which are finally used in the model (see Eq. 33). The subsistence level of each agricultural commodity, γ_i, in Eq. 33 is drawn from the home consumption data provided by GLSS5.

Table A5.1 Income elasticities of demand at national level

	Maize	Rice wheat	Coarse grains	Root crops	Other food crops
Rural	0.7	1.0	0.2	1.3	0.9
Urban	0.4	0.7	1.0	0.7	0.7

	Plantains	Chicken	Other livestock products	Fishery	Formal food processing
Rural	1.3	1.3	0.9	1.1	0.9
Urban	0.8	1.2	0.8	1.0	1.0

	Informal food processing	Clothing	Chemicals	Fuel	Other fuel
Rural	0.9	1.0	1.0	1.6	0.5
Urban	0.6	0.9	1.0	3.0	0.2

	Machinery and equipment	Water	Transport services	Other private services	Public and community services
Rural	1.6	2.1	1.0	1.3	1.2
Urban	2.2	1.4	1.0	0.4	1.1

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model

	Maize	Rice	Sorghum/ millet	Other cereals	Cassava
Rural					
Coastal	3.1	3.7	0.0	0.2	7.2
Forest	1.7	4.1	0.0	0.0	5.2
N. savannah	8.6	3.2	5.3	0.1	1.6
S. savannah	4.6	3.4	0.3	0.2	6.2
Urban					
Accra	0.3	3.0	0.0	0.1	0.8
Coastal	0.6	4.5	0.0	0.1	2.2
Forest	0.5	3.9	0.1	0.0	2.1
N. savannah	8.6	4.1	1.1	0.1	0.5
S. savannah	2.7	3.7	0.0	0.1	2.9
All urban	1.2	3.6	0.1	0.1	1.7
All rural	4.3	3.6	1.2	0.1	4.9
National	2.6	3.6	0.6	0.1	3.3

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model (continued, a)

	Yams	Coco yams	Cowpea	Soya beans	Groundnuts
Rural					
Coastal	0.9	0.2	0.2	0.0	0.4
Forest	2.4	0.9	0.2	0.0	0.5
N. savannah	8.0	0.1	0.8	0.1	3.7
S. savannah	4.0	1.0	0.4	0.0	0.5
Urban					
Accra	1.3	0.1	0.2	0.0	0.2
Coastal	1.1	0.2	0.2	0.0	0.3
Forest	2.1	0.3	0.1	0.0	0.3
N. savannah	5.0	0.0	0.4	0.0	1.9
S. savannah	3.0	0.6	0.3	0.0	0.4
All urban	2.0	0.2	0.2	0.0	0.3
All rural	4.2	0.8	0.4	0.0	1.1
National	2.8	0.5	0.3	0.0	0.7

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model (continued, b)

	Fruit	Vegetables	Plantains	Other crops	Palm oil
Rural					
Coastal	1.0	6.6	2.8	0.1	1.0
Forest	0.8	5.8	4.7	0.1	0.7
N. savannah	0.6	16.1	0.0	1.4	0.1
S. savannah	1.0	7.5	3.2	0.1	0.9
Urban					
Accra	1.6	4.0	0.9	0.0	0.2
Coastal	1.7	4.9	2.3	0.0	0.5
Forest	1.3	5.1	2.2	0.0	0.2
N. savannah	0.9	5.9	0.1	0.5	0.1
S. savannah	1.3	5.8	2.8	0.1	0.5
All urban	1.5	4.8	1.7	0.1	0.3
All rural	0.8	8.6	3.1	0.4	0.7
National	1.2	6.5	2.4	0.2	0.5

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model (continued, c)

	Other nuts	Chicken broiler	Eggs and layers	Beef	Sheep and goat meat
Rural					
Coastal	0.0	0.9	0.6	0.8	0.3
Forest	0.0	0.6	0.5	1.5	0.2
N. savannah	0.0	0.6	0.2	1.3	0.6
S. savannah	0.0	1.1	0.5	1.3	0.4
Urban					
Accra	0.0	1.0	0.6	1.5	0.7
Coastal	0.0	0.7	0.7	1.3	0.2
Forest	0.0	0.8	0.9	2.8	0.4
N. savannah	0.0	0.2	0.3	3.2	0.9
S. savannah	0.0	1.2	0.7	2.8	0.4
All urban	0.0	0.9	0.7	2.1	0.5
All rural	0.0	0.8	0.4	1.4	0.4
National	0.0	0.9	0.6	1.7	0.4

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model (continued, d)

	Other meats	Fishery	Formal food processing	Informal food processing	Dairy products
Rural					
Coastal	0.5	3.5	8.0	7.1	0.8
Forest	1.3	2.1	5.9	4.1	0.7
N. savannah	1.0	1.6	7.1	4.7	0.8
S. savannah	1.1	2.5	7.5	5.0	0.7
Urban					
Accra	0.3	1.7	8.1	4.8	1.6
Coastal	0.6	2.9	8.5	6.2	1.5
Forest	0.7	2.1	7.4	4.2	1.5
N. savannah	0.6	1.0	6.9	7.4	1.7
S. savannah	1.3	1.9	8.0	5.1	1.1
All urban	0.7	1.9	7.9	5.0	1.5
All rural	1.1	2.1	6.8	4.6	0.7
National	0.8	2.1	7.5	5.0	1.1

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model (continued, e)

	Meat and fish processing	Textiles	Clothing	Leather and footwear	Wood products
Rural					
Coastal	12.2	1.4	4.5	1.5	1.2
Forest	10.1	1.6	5.9	2.0	0.9
N. savannah	3.8	1.1	3.6	1.1	1.1
S. savannah	10.4	1.5	4.6	1.6	0.7
Urban					
Accra	5.2	1.3	4.7	1.5	1.2
Coastal	6.3	1.5	4.9	1.7	1.9
Forest	5.2	1.8	5.8	2.2	2.1
N. savannah	3.5	1.5	5.0	1.4	4.0
S. savannah	7.5	1.5	5.1	1.9	2.1
All urban	5.8	1.5	5.1	1.8	1.8
All rural	8.9	1.4	4.9	1.7	0.9
National	7.5	1.5	5.0	1.7	1.4

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model (continued, f)

	Paper, publishing & printing	Petroleum	Diesel	Other fuels	Fertilizer
Rural					
Coastal	0.4	0.2	0.0	3.1	0.0
Forest	0.4	0.7	0.1	2.9	1.1
N. savannah	0.2	1.8	0.4	3.9	0.1
S. savannah	0.4	0.2	0.4	3.2	0.1
Urban					
Accra	0.7	2.8	1.1	0.4	0.0
Coastal	1.8	3.6	0.0	1.9	0.0
Forest	0.6	1.1	0.1	1.3	0.0
N. savannah	0.6	1.8	0.1	2.1	0.1
S. savannah	0.6	0.8	0.0	1.6	0.0
All urban	0.8	2.1	0.5	1.1	0.0
All rural	0.4	0.7	0.2	3.3	0.5
National	0.6	1.4	0.4	2.1	0.2

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model (continued, g)

	Chemicals	Metal products	Machinery & equipment	Water	Electricity
Rural					
Coastal	5.4	1.0	2.9	0.1	0.0
Forest	5.6	1.5	5.9	0.1	0.0
N. savannah	4.2	0.6	3.2	0.0	0.0
S. savannah	5.2	1.0	3.9	0.1	0.0
Urban					
Accra	3.8	0.6	12.5	0.5	0.0
Coastal	5.0	0.7	7.8	0.4	0.1
Forest	5.3	0.9	8.7	0.5	0.0
N. savannah	5.6	0.7	6.5	0.1	0.0
S. savannah	5.5	0.8	6.0	0.3	0.0
All urban	4.7	0.7	9.4	0.4	0.0
All rural	5.1	1.1	4.5	0.1	0.0
National	4.9	0.9	7.0	0.3	0.0

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model (continued, h)

	Trade services	Transport services	Communication	Banking and business	Real estate
Rural					
Coastal	7.0	3.3	1.2	0.3	2.1
Forest	6.8	3.9	1.4	0.4	1.5
N. savannah	2.6	1.0	0.4	0.2	1.9
S. savannah	5.1	3.1	0.7	0.3	1.7
Urban					
Accra	10.1	7.7	2.5	0.9	5.3
Coastal	6.5	5.4	3.3	0.5	2.5
Forest	9.7	4.7	3.6	0.5	2.7
N. savannah	6.3	2.1	1.1	0.5	2.3
S. savannah	7.6	3.5	2.0	0.8	2.4
All urban	8.9	5.6	2.7	0.7	3.6
All rural	5.2	3.0	0.9	0.3	1.7
National	7.3	4.4	1.9	0.5	2.7

Source: Authors' estimation using GLSS5 data

Table A5.2 Average budget share (%) of representative households in the model (continued, i)

	Community, other services	Public administration	Education	Health
Rural				
Coastal	1.6	0.0	0.1	0.6
Forest	2.1	0.0	0.1	0.9
N. savannah	1.3	0.0	0.0	0.3
S. savannah	2.0	0.0	0.1	0.5
Urban				
Accra	3.5	0.0	0.1	0.3
Coastal	2.6	0.0	0.0	0.4
Forest	3.1	0.1	0.0	0.8
N. savannah	2.6	0.0	0.0	0.9
S. savannah	2.6	0.0	0.0	0.7
All urban	3.1	0.0	0.1	0.5
All rural	1.9	0.0	0.0	0.6
National	2.5	0.0	0.1	0.6

Source: Authors' estimation using GLSS5 data

Appendix 6. Sensitivity tests

We focus our sensitivity test on the model results of the "combined scenario," the last scenario discussed in the paper. More specifically, we conducted four such tests. In Test 1, we cut the elasticity in the Armington functions for imports by 50 percent (i.e., reducing the elasticity from its

original value at the commodity level by half) to test how sensitive the import substitution is in explaining the model results. In Test 2, we cut the elasticity in the CET functions for exports by 50 percent to test the sensitivity in export substitutions. In Test 3 we doubled the elasticity of substitution between factor inputs in the production function (from 0.75 to 1.5). In the last test (Test 4), instead of doubling the elasticity in the production functions, as we did in Test 3, we lowered the value by 50 percent to 0.4. For each test, the model is re-run with all other assumptions being the same as applied in the "combined scenario."

Table A6 reports the test results for some variables that are expected to be most sensitive to the choices of different elasticities. Table A6 shows, however, that the model is very robust to changes in the values of elasticities, both in the trade or production functions. For example, halving the elasticities used in the trade functions changes the 2015's per capita GDP by about US$0 or US$5, compared with the results from the original scenario (Table A6, column 1). Lowering elasticity values in the production function causes a decrease of per capita GDP of US$15 by 2015 from the original simulation result. This is the largest deviation from original results observed in all tests, but the difference is only equivalent to 1.6 percent of the total. Similar modest changes are observed for the other variables reported in Table A6. Given this robustness to changes of key elasticities to different levels in the model, we have confidence in the model results.

Table A6. Sensitivity analysis

	Original "combined scenario	Trade function		Production function	
		Test 1 Armington	Test 2 CET	Test 3 High	Test 4 Low
		50% lowered substitution elasticities		doubling substitution elasticities	50% lowered substitution elasticities
GDP pc in 2015 (US$)	956	956	951	970	941
Average annual GDP growth (2006-2015)					
Total	7.6	7.6	7.6	7.7	7.6
Agriculture	6.9	6.9	6.9	7.2	6.5
Industry	8.9	8.8	8.8	8.8	9.1
Services	7.4	7.4	7.4	7.4	7.4
Exports (sector share of total)					
Agriculture	48.9	49.3	50.7	50.7	47.0
Industry	36.9	36.5	37.3	36.0	38.0
Services	14.1	15.0	14.3	13.3	15.0
Imports (sector share of total)					
Agriculture	5.9	5.7	5.7	5.8	6.2
Industry	85.8	86.0	86.1	85.8	85.7
Services	14.1	15.0	14.3	13.3	15.0
Investment to GDP ratio (in %)	38.3	38.7	38.5	37.6	39.5
Sources of growth (in %)					
Labor	22.3	22.3	22.3	21.6	22.9
Capital	7.4	7.4	7.5	8.6	5.8
Land	24.5	24.7	24.6	23.5	26.2
TFP	45.8	45.6	45.7	46.3	45.2