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IFPRI Discussion Paper 00750

February 2008

Accelerating Growth and Structural Transformation

Ghana's Options for Reaching Middle-Income Country Status

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ABSTRACT

Ghana is an emerging success story in Africa and in a couple of years will become the first African country to achieve the first Millennium Development Goal of halving its national poverty rate. The government of Ghana has therefore extended its development vision and recently declared the goal of reaching middle-income-country (MIC) status by 2015. To analyze possible pathways and implications of achieving MIC status, this paper examines other countries' experiences on their way to becoming MICs and emphasizes the important role of growth acceleration, export diversification, and economic structural change in the transformation process. The paper further analyzes Ghana's growth options and their structural implications using a dynamic computable general equilibrium model recently developed for Ghana. The results of the model simulation suggest that Ghana's annual GDP growth rate must accelerate from the recent 5.5 percent to 7.6 percent to achieve MIC status by 2015. Unlike in other countries, agriculture in Ghana is likely to remain the mainstay of growth and export earnings, while the role of manufacturing growth in achieving MIC status may be constrained by the manufacturing sector's dependency on agricultural inputs and small size. Services may not become the prime mover of accelerated growth, but improved efficiency in trade, transport, and business services will be a key for growth acceleration in other sectors.

Keywords: Growth and development, middle income country, applied general equilibrium modeling, Ghana, Africa

1. INTRODUCTION

Sustained growth and significant poverty reduction over the last 15 years has made Ghana an African success story. Many factors have contributed to this impressive performance, including improvements in policies and the investment climate, increases in investments and aid inflows, and favorable world cocoa and other commodity prices (Bogetic et al. 2007; McKay and Aryeetey 2004). The 2005–2006 Ghana Living Standards Survey suggests that, based on current trends, the country will reach the first Millennium Development Goal (MDG1) of halving its 1990s poverty rate by 2008 (Ghana Statistical Services 2007). Thus, Ghana will become one of only a few African countries able to achieve the MDG1 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-country (MIC) status by 2015, which will require Ghana to double its per capita GDP from the 2005 level of US$454 to US$1,000 over the next 10 years.

The strong commitment of the government to pursuing its new vision is expressed in several recently published policy documents. Ghana's Second Growth and Poverty Reduction Strategy emphasizes the need for a "rapid and radical transformation of the structure of Ghana's internal production and foreign trade" (National Development Planning Commission 2005). Policies and programs required for achieving these objectives include reforms of the financial sector, investments in the transportation and energy sectors, and a focus on agricultural modernization. The emphasis on agriculture is further underlined by Ghana's commitment to the Comprehensive African Agricultural Development Program (CAADP) of the New Partnership for Africa's Development. The policies the government is currently implementing and the continued strong performance of the economy provide optimism to support the ambitious goal of reaching MIC status.[1] However, challenges still exist: It is not yet clear how the transformation of the economy will occur, what roles various sectors will play in the transformation process, and what policies are needed to support economic transformation.

Experiences from successful developing countries show that reaching MIC status usually involves a process of economic transformation that can be defined as a combination of accelerated growth, rapid expansion of exports, economic diversification, and structural change. Economic transformation is a dynamic process that involves the gradual evolution of labor productivity of the sectoral composition of output and employment (Pieper 2003). In this process, new sectors can emerge and lead economywide growth. The transformation from a traditional economy to a modern one is also accompanied by capital accumulation, technological change, and productivity growth. In this process, economic sectors less dependent on natural resources, such as manufacturing, are associated with greater

[1] For example, underlining the new emphasis on agricultural growth, the government has raised the share of spending on agriculture in total spending from 2.8 percent in 2001 to 9.7 percent in 2006.

potential for economies of scale and hence for more rapid growth (Adelman 2001). Accordingly, nonagricultural sectors usually grow faster and become increasingly important in the transformation process (Chenery 1980; Kuznets 1971; Syrquin 1988). However, the transformation of traditional agriculture into a modern sector has occurred alongside growth of nonagricultural sectors driven by advances in mechanical and biological technologies (Hayami and Ruttan 1985). While the importance of intersectoral dynamics for growth has long been recognized (Fei and Ranis 1961, 1964; Hirschman 1958; Jorgenson 1961), the path along which a country realizes structural transformation depends on many country-specific factors.

Modeling alternative development paths contributes to our understanding of the constraints, trade-offs, and linkage effects of country-specific growth options. In this regard, general equilibrium theory is a particularly relevant tool for understanding structural change because of its ability to incorporate intersectoral and economywide links. Accordingly, a number of economists in recent years have empirically studied structural change using general equilibrium models. For example, Irz and Roe (2005) built a two-sector growth model and calibrated it to an archetype low-income economy. They found that low agricultural productivity can be an important bottleneck to overall growth because it results in high food prices and low savings rates. Echevarria (1997) developed a Solow-type dynamic general equilibrium model to study changes in sectoral composition and found that structural change is driven by consumer preferences. Diao et al. (2005) explicitly included international trade in their intertemporal general equilibrium model to demonstrate the importance of openness for structural change and growth.

Most studies, however, analyze structural change in an aggregate economy. Irz and Roe's (2005) model aggregates its archetypal economy into two sectors, agriculture and nonagriculture. Echevarria's (1997) model considers three sectors: primary, manufacturing, and services, for several countries in the Organization for Economic Co-operation and Development. Diao et al.'s (2005) Thailand model includes four sectors: agriculture, exportables, importables, and nontradable nonagriculture. While highly aggregated general equilibrium models are helpful for understanding the general driving forces of structural change, they ignore many country-specific factors critical to 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 the set of choices facing different countries.

To address this gap in the literature and to help Ghana in diagnosing its strategic options for reaching MIC status, we developed a dynamic general equilibrium model based on the most recent data available. The model includes many economic sectors, some of which are currently important for the national economy or for subnational regions, and some are expected to become more important during the

transformation process. The model is calibrated to economic data reflecting the conditions of Ghana in 2005. In the next section, we first highlight some stylized facts about economic transformation by comparing Ghana with six reference countries: Brazil, Malaysia, Thailand, China, India, and Vietnam. The countries selected as references have reached or are close to reaching MIC status within a span of approximately 10 years, which is the period in which Ghana is planning 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 sources of growth in recent years and the current economic structure of Ghana. Some key characteristics of factor markets and household structure are also described in this section. 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 various agricultural subsectors; and in scenario 6, we combine the first five 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 MIC 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) compiled a volume on successful growth stories, where various authors identify the causes of prosperity and growth in eight countries. Although over the past decades many countries have reached MIC status (and some lost it), not all those countries provide valuable lessons for Ghana.[2] Therefore, we based our country selection on two major criteria: (1) MIC status was reached or almost reached within a 10-year period, starting at income levels similar to Ghana's 2005 level and (2) rapid growth was not driven by booms in natural resources, such as oil or other minerals. Thus, we selected six countries for the comparative study. Internal and external conditions may have changed since these countries reached MIC status, but their success stories nonetheless show many similarities to the stories of countries still striving to attain that goal.

Brazil, Malaysia, Thailand, and China passed the US$1,000 per capita GDP benchmark in a relatively short period (about 10 years). Although India and Vietnam have not yet reached the benchmark, rapid growth in those countries indicates they will do so within the next few years. Tables 1–4 give an overview of structural changes in the six reference countries and compare them with Ghana's current conditions. Several issues emerge from the 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 MIC status within 10 years. However, the required average annual GDP growth rate varied from 6–7 percent in Malaysia and Thailand to 9–10 percent in China and Brazil (Table 1). Because per capita income is measured in current U.S. dollars, the required growth rate is also influenced by nongrowth factors, such as changes in real exchange rates or population growth rates. These are the two main reasons for the variation in required growth rates among the studied countries.

Although available natural resources differ significantly across the countries, rapid growth was accompanied by significant structural changes in Brazil, Malaysia, Thailand, and China. The share of agriculture in total GDP declined in all six reference countries during the transformation period. In terms of initial sectoral structure, Malaysia and Thailand are the most comparable to Ghana because of the importance of agriculture in their economies. However, despite similar initial agricultural shares in their

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

economies, Malaysia and Thailand experienced different structural changes. In Malaysia, agriculture grew an average of 5.9 percent annually and acted as a driver of GDP growth (see Table 1). At the same time, the importance of industry in the economy significantly increased because of the much higher growth rate in manufacturing compared with all other sectors, which caused the share of services to decline more than that of agriculture. By contrast, Thailand's transition period was characterized by a much stronger decline in agriculture's GDP share—the strongest decline in the reference group. Nevertheless, the agricultural sector continued to grow between 3.2 percent and 5.9 percent per year in five of the six reference countries, indicating its important contribution during the transformation period. Only in India did agriculture grow more slowly, at an average of 2.3 percent annually.

In most countries, the decline in agriculture's GDP share resulted from 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. Manufacturing's GDP share in Ghana has been as low as it was in Malaysia before that country's transformation, with similarly high shares of agriculture in both Ghana recently and Malaysia then. At a rapid annual growth rate of 5.9 percent, agriculture's share in the Malaysian GDP was almost constant as the country strove to reach MIC status. Compared with that of the six reference countries at the time when their per capita GDP levels were around US$400, the share of agriculture in total GDP was much higher in Ghana in 2005 than in the initial years of the six studied countries (i.e., 39 percent compared with 19–31 percent; see Table 1). This indicates the relatively important role that agriculture will have to play in Ghana's overall economic growth over the next 10 years. Conversely, and with exception of China, Ghana's service sector was relatively small in 2005 compared with those of the reference countries in their initial years. Although the size of the service sector has been large, it seems to have played a supporting rather than a driving role in the transformation process for most reference countries. The exception is India, where the service sector's share in GDP increased from 42 percent to 52 percent (driven mainly by the information technology sector).

Driven by different growth rates across sectors, the export structures of the reference countries also changed during the transformation period. Agricultural exports as a share of total exports declined in all six countries, while the share of manufacturing exports increased substantially (Table 2). Brazil had a similar export structure in 1965 as Ghana had in 2005. However, nine years later, in 1974, the share of manufacturing exports in Brazil reached 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, because 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 per capita was around US$400	GDP per capita in that year (current US$)*	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
Ghana	2005	454	5.5 (last 5 years)	2.3	5.5	39		*10*	33
	Year when GDP per capita reached US$1,000	GDP per capita in that year (current US$)	Number of 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 Bank, World Development Indicators, http://www.worldbank.org.

* GDP per capita is in current U.S. dollars, which is consistent with the MIC status goal of Ghana.

[†] Because of high inflation in Brazil, the current value of GDP departs from constant value (both in U.S. dollars). We therefore chose 1965 as the initial year for Brazil, although GDP per capita in that year was US$258. However, the number of years to reach US$1,000 should be read in caution for Brazil.

[‡] We chose 1993 as China's beginning year because it's GDP per capita in 1994 was significantly higher than US$400.

[§] We chose 1997 as Vietnam's beginning year because it is the first year with available data.

[‖] India and Vietnam have not yet reached MIC status. Therefore, we used data for the latest year for which data are available.

Table 2. Change in export structure of selected countries

	Year when GDP per capita was around US$400	Total exports per capita in that year (current US$)	Annual growth in exports during transition (%)	Share of merchandise 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 per capita reached US$1,000	Total exports per capita in that year (US$)	Share of merchandise 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 Bank, World Development Indicators, http://www.worldbank.org.
* India and Vietnam have not yet reached MIC status. Therefore, we used data for the latest year for which data are available.

Structural change also occurred within agriculture, causing the change in agriculture's export structure. We observed that agricultural exports became more diversified in the six reference countries (Table 3). As in Ghana in 2005, agricultural exports used to be dominated by a few products at the start of the reference 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 those products in total agricultural exports declined during the countries' transformation periods. Again, the only exception was Malaysia, where rubber continued to dominate agricultural exports, accounting for 79.1 percent of total agricultural exports in 1974 nine years after the start of its transformation. However, it should be noted that Malaysia's agricultural sector has experienced larger structural changes since 1974 (i.e., after achieving MIC status), when the country developed its palm oil industry and became the world's largest palm oil exporter.

Brazil saw the most significant change in its agricultural export structure. Although the share of coffee in Brazilian total agricultural exports in 1965 is comparable to the share of cocoa in Ghana recently, nine years later in 1974, coffee only accounted for 31 percent of Brazil's total agricultural exports. Brazil remains one of the world's largest coffee exporters, with a highly productive and competitive coffee sector. However, the diversification of agricultural exports is the reason Brazil became one of the world's most important agricultural exporters of many other commodities. Although we do not report the growth of nontraditional 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 was also characterized by higher growth rates in the livestock sector compared with the crops sector (Table 4). Contrary to the trend observed 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 was 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 US$400. As shown in Table 4, among the six reference countries, 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 also have been lower in Ghana recently 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 (%)				
	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, vegetables*	1993	15.6	2001	20.9
India†	1992	15.9	2005	8.7	Fruits, vegetables*	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: Data from the United Nations Statistical Division, http://unstats.un.org/unsd/default.htm.
Note: Processing agriculture is included in agricultural exports.
* Agricultural exports in China and India diversified even in the beginning years. We selected fruit and vegetable exports to demonstrate this.
† India and Vietnam have not yet reached MIC status.

Table 4. Annual growth in agricultural output and input

		Agricultural output		Agricultural input	
	Period	Livestock	Crops	Labor	Crop land
Brazil	1965–1974	3.6	2.5	1.2	3.7
Malaysia	1965–1977	6.5	5.0	0.9	1.1
Thailand	1976–1987	3.9	2.5	1.6	1.7
China	1993–2001	6.9	4.0	0.2	2.0
India*	1992–2003	3.8	2.0	1.3	0.0
Vietnam*	1997–2003	7.1	5.2	1.1	3.6
Ghana	1995–2003	3.3	5.1	2.5	3.9

Sources: Calculated from Nin Pratt (2007) based on data from the Food and Agriculture Organization (2007)
* India and Vietnam have not yet reached MIC status.

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 based on data from the Food and Agriculture Organization (2007).
* *First Year* and *Final Year* refer to the years of each country's transformation period (see Table 1)
* India and Vietnam have not yet reached MIC status.

Several strategic issues and questions emerge from our comparison of the reference countries. First, successfully transforming countries have experienced significant structural changes and declining shares of their agricultural sectors. Will Ghana undergo similar structural changes as it makes its way toward the goal of attaining MIC status? How will the composition of demand, trade, and production and the allocation of factors change between and within sectors? Second, successful countries have also experienced high growth rates during transformation. How much growth will be needed in Ghana, and how will growth in different sectors contribute to economywide growth? Third, rapid export growth has typically supported the transformation processes of successful countries. Export growth rates were higher than overall economic growth rates in the countries we analyzed. Must exports play a key role in Ghana's efforts to reach MIC status? If so, 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 for Ghana to reach MIC status? Finally, Ghana has a much more open economy than did the reference countries at the start of their transformation periods during the 1960s to 1990s. To what extent can Ghana meet the challenge of competing with imports in key commodities? In the following sections, we used an economywide model to investigate these questions.

3. A DYNAMIC COMPUTABLE GENERAL EQUILIBRIUM MODEL FOR GHANA

We developed a dynamic computable general equilibrium model to assess the potential of sector-specific growth options and their structural impact in the Ghanaian economy in the next 10 years. The computable general equilibrium 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 A.1 in Appendix A).[3] Agriculture is disaggregated into 27 subsectors, including 20 crops, five 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 five agriculture-related processing sectors and 13 light and heavy manufacturing sectors. The service sector is divided into six private subsectors and four public and community subsectors. The contribution of each sector to national GDP is calculated using a set of data that 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). The detailed sector structure in the model formulation allows us to analyze sector- and subsector-specific growth strategies and their contributions 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 appendixes B through E for parameter calibration and estimation and Appendix F for sensitivity analysis). To capture existing differences in Ghana's labor market, the model further classifies employed labor in various subcategories, including self-employed agricultural workers, unskilled workers in both agriculture and nonagriculture, and skilled nonagricultural workers. Information on sector-level input and output is derived from MOFA's 2006 crop-level farm budgets for the agricultural sectors and its 2003 Industrial Census for the industrial production. Additional information on employment and wages by sector and region is taken from the 2005–2006 Ghana Living Standards Survey (GLSS5). To capture various agricultural production patterns and technologies at the subnational level, the model further disaggregates 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 the Ashanti, western, and central regions; the southern savannah includes Brong Ahafo and part of Volta; and the northern savannah includes the upper west, upper east, and northern regions. Constrained by the data, we did not disaggregate nonagricultural production 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.

[3] The social accounting matrix has been jointly constructed by Ghana Statistical Services (GSS) and the International Food Policy Research Institute (Breisinger et al. 2007).

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 workforce, the model accounts for the rural labor force moving from working on the smallholders' 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 the 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 the GLSS5 (see Appendix E 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. The government 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. SOURCES OF GROWTH AND ECONOMIC STRUCTURE IN GHANA

An understanding of the sources of recent growth as well as the sectoral and regional economic structure of Ghana is necessary to develop a model that captures the initial conditions and behavior of the economy. Several recent papers have examined sources of growth in Ghana over the past decade, and in the first subsection that follows, we draw extensively on that literature. Subsequent subsections summarize our analysis of the GLSS5 and the 2005 Ghana social accounting matrix.

4.1. Sources of Recent Growth

The growth accounting analysis by Bogetic et al. (2007) shows that total factor productivity (TFP) has been increasingly important in explaining Ghana's recent economic growth, but that growth from 1970 through 2005 was driven by factor accumulation (Table 6). The contributions of labor force growth and human capital accumulation (i.e., average school years of the labor force) have steadily declined over the past three decades. Fixed capital accumulation has been a major contributor to growth and showed an increasing trend during 1970–2000, but this has increasingly been replaced by TFP since 2000. We used the results of this growth accounting analysis for 2000–2005 to calibrate the baseline or "current growth path" scenario, which is described in greater detail in Section 5.

Table 6. Growth rates and sources of growth in Ghana

	1970–2005	1991–1995	1996–2000	2001–2005
Average annual growth rate (%)				
Real GDP[a]	2.7	4.0	4.2	5.2
Fixed capital accumulation	2.1	4.3	5.9	3.9
Labor force	2.7	2.8	2.3	2.5
School years of the labor force	0.8	0.8	0.9	1.0
Total factor productivity	–0.26	0.05	–0.07	1.6
Contribution to growth (%)				
Fixed capital accumulation	31.6	43.7	56.2	29.8
Labor force	61.3	42.6	32.8	28.5
School years of the labor force	16.9	12.4	12.7	11.1
Total factor productivity	–9.9	1.3	–1.6	30.6
Total	100.0	100.0	100.0	100.0

Source: Bogetic et al. (2007).
Note: The share of capital (α) in the Cobb–Douglas production function is assumed to be 0.4, while the depreciation rate is 4 percent.

4.2. Sectoral Structure of GDP

Our analysis of Ghana's sectoral and regional economic structure is based on the 2005 social accounting matrix (Breisinger et al. 2007). Until 2005, the agricultural sector was the largest contributor to GDP in Ghana, followed by services and industry (Table 7). 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 7. 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
Agriculture-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	100.0		100.0	100.0

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, among the most important sectors. Construction accounts for 35.2 percent of industrial GDP, followed by mining at 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.

4.3. 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 8). 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, root crops are evenly distributed across zones.

Table 8. Regional agricultural output

	Share of total (%)						
	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
Southern savannah	19.2	32.3	25.0	26.4	14.1	27.6	26.1
Northern savannah	44.2	30.7	25.9	2.4	38.5	2.0	20.8
Total*	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: 2005 Ghana social accounting matrix.

4.4. Employment Structure

Labor is the dominant source of income for a majority of Ghanaian households (Table 9) and is mainly employed in the agricultural and service sectors because of 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 the highly capital-intensive mining and energy subsectors.

Although incomes from agricultural activities dominate the rural economy, nonagricultural income is becoming an important part of rural households' livelihoods—equivalent to one-third of household expenditures. Analysis of GLSS5 data reveals that off-farm employment income is equivalent to roughly 20–40 percent of total expenditures for rural households, and that share generally increases among higher-income households (Table 10). Off-farm employment income for rural households in the lowest income quintile is equivalent to 16.3 percent of total expenditures, and that share more than doubles for rural households in the highest income quintile. Although nonagricultural income shares are high in all regions, they are highest in the northern savannah (41.8 percent in total). However, the share for all rural households in the region may be misleading, because more than 40 percent of rural households in the northern savannah belong to the poorest household group (the lowest income quintile), and for those households, the nonagricultural income share in total expenditure is the lowest among all income groups and across various zones in the country (14.3 percent). On the other hand, only 11 percent

of rural households in the northern savannah are in the highest income group, for whom the nonagricultural income share in total expenditure is as high as 76.8 percent.

Table 9. Factor allocation and factor intensities by sector

	Share of GDP (%)		Share of sector's 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	100.0	100.0	67.5	24.9	7.6	100.0

Source: 2005 Ghana social accounting matrix.

Table 10. Nonagricultural incomes by region and rural household income group

	Share of total expenditures (%)					
	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
Southern savannah	21.6	21.6	18.4	30.2	41.5	32.6
Northern 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: 2005–2006 Ghana Living Standards Survey.

4.5. 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 foods, are also large, accounting for 19.2 percent of total imports (see Table 7). However, those sectors are also Ghana's major nonagricultural export 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 nontraditional 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, indicating that an import substitution strategy will be just as important as an export-promoting strategy in stimulating agricultural growth. As in many other developing countries, Ghana's service sector is domestically oriented. However, export-oriented services, such as tourist-related hotels and other services, do exist. With its service sector contributing 8.3 percent to total exports, Ghana may, like India, experience service-sector-led growth.

4.6. Domestic Consumption Structure

Because domestic demand for most agricultural and nonagricultural products is still the dominant source of total demand in Ghana, we report household consumption patterns based on the GLSS5 (Table 11). In 2005, urban households spent more than 40 percent of income on food, and 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 show 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 estimated household marginal budget shares, which show the percentage of each unit of incremental income that households will spend on various commodities or groups of commodities. A marginal budget share that is smaller than the current average budget share, as in the case of maize, indicates that households will spend less of any additional income on that commodity than they have done in the past. Although this does not imply that total maize consumption will fall with increased growth, it does indicate that demand for maize as a staple food grows more slowly than income growth. The ratio of a marginal budget share over the average budget share is the income elasticity of demand. An elasticity that is less than 1 shows 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, suggesting that demand for chicken grows more rapidly than income growth in the country. Table 11 reports households' budget allocations among different items, but it does not capture indirect consumption effects. In the case of chicken, increased consumption induces indirect demand for maize used as chicken feed. That type of production linkage is captured by input–output coefficients included in the social accounting matrix and is analyzed in the model scenarios.

Table 11. 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 staples	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
Nonfoods	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 2005–2006 Ghana Living Standards Survey.

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 middle-income-country (MIC) status. We have seen that although doubling incomes in 10 years is ambitious, it is not unprecedented. However, all the countries we selected as references experienced significant structural changes while undergoing a period of rapid growth. All six reference countries saw 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 the decline was small in Malaysia. We also observed that exports grew more rapidly than overall economic growth in the reference 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-country status and that the contribution of various sectors during each country's transformation process depends on, among other factors, 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 used the dynamic computable general equilibrium model introduced in Section 3 to quantitatively explore alternative growth options for Ghana and their potential contribution to reaching MIC status by 2015. In scenario 1, we examine whether Ghana's current strong performance will be sufficient to achieve MIC 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 goal of becoming a middle-income country. In scenarios 4 and 5, we argue that accelerated growth in agriculture is equally important given Ghana's unique economic structure. Finally, in scenario 6, we combine the effects of accelerating growth in all three sectors and focus on the possible structural change facing Ghana as it strives to become a middle-income country.

5.1. Scenario 1: Growth along Ghana's Recent Growth Path

The model's base-run scenario simulates a Ghanaian economy that continues to grow along its current path at an average annual growth rate of 5.6 percent until 2015. While growth accelerated from 2003 to 2006, we assumed a longer-term average growth rate in the base-run scenario. We also assumed that the balanced growth trends observed in recent years in the country will continue. In other words, if the economy continues to grow along current trends, similar annual growth rates will occur across the three aggregate sectors of the economy: agriculture, industry, and services (Table 12, part A). However, growth

varies at the subsector level. Given the average annual population growth of 2.2 percent observed in recent years and assumed in the model, per capita GDP, measured in 2005 U.S. dollars, increases from US$454 in 2005 to US$774 by 2015 (Table 12, part D).[4] 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 12, part B). As expected under this balanced growth scenario, the economic structure does not change significantly. The share of agriculture in total GDP increases slightly, from 38.7 to 40.9 percent, as a result of small increases in agricultural prices relative to the nonagricultural prices driven by domestic demand and terms-of-trade appreciation (Table 12, part C).

Table 12. Base-run and accelerated growth scenarios

	Initial value in 2005	Base-run scenario	Scenarios with accelerated growth in:				
			Industry	Services	Export agriculture	Other agriculture	Com-bined
		(1)	(2)	(3)	(4)	(5)	(6)
Part A. Annual growth rate, 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 by 2015 (current 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 computable general equilibrium model results.

Simulated growth is driven by increases in labor supply, expansions of agricultural cropland, capital accumulation, and productivity growth. Increases in labor supply for various labor categories are set exogenously between 2 percent 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 cropland 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

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

percent and for land productivity are 2.5 percent. The increase in labor and land supply, combined with improvements in factor productivity, stimulate investment and result in an average annual capital accumulation growth rate of 6.5 percent. Table 13 summarizes the contribution of each factor to total GDP growth. Increases in labor explain 30.8 percent of the base-run scenario's overall economic growth from 2006 to 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 scenario, which is consistent with World Bank estimates using data from the last five years (Bogetic et al. 2007).

Table 13. Sources of GDP growth from model results

	Base-run scenario	Scenarios with accelerated growth in:				
		Industry	Services	Export agriculture	Other agriculture	Combined
	(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 computable general equilibrium model results.

According to the country's national accounts, the investment-to-GDP ratio was 31.7 percent in Ghana in 2005 (Table 14). The model calibrates to this ratio as an initial condition. In the base-run scenario, the ratio increases slightly to 33.6 percent by 2015. The data show that 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, and 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 14. Sources of investment from model results

	Initial share in 2005	Base-run scenario	Scenarios with growth in:				
			Industry	Services	Export agriculture	Other agriculture	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 computable general equilibrium model results.

The base-run scenario shows the need to accelerate growth in Ghana over the next decade if the country aims to more than double its 2005 per capita income by 2015. To understand how each sector's growth contributes to that goal and how economic structure changes under accelerated growth at the sector level, we exogenously and sequentially increased growth in various sectors: manufacturing (scenario 2), private services (scenario 3), and agriculture (scenarios 4 and 5). In the final scenario (scenario 6), we combine scenarios 2 through 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-country status. For example, when Thailand's per capita GDP increased from about US$400 in 1976 to US$970 in 1987 (see Table 1), its average annual manufacturing growth rate was twice as high as agricultural growth. A similar situation occurred in Brazil, where the manufacturing growth rate was three times the agricultural 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 increased 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 increased foreign inflows to support increased investment demand in the capital goods necessary for accelerated capital accumulation.

The industrial sector constituted 27.9 percent of Ghana's GDP in 2005, with the manufacturing sector accounting for 9.7 percent (see Table 7). 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 with Ghana's in 2005. Ghana's manufacturing accounted for only 35 percent of industrial GDP and was dominated by activities heavily dependent on agricultural inputs, such as food and wood processing. Agriculture-related manufacturing accounted for 22 percent of industrial GDP. Construction was another large industrial sector, accounting for 35 percent of industrial GDP, and mining accounted for 20 percent.

In scenario 2, we accelerated 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 the 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. In 2005, manufacturing as a whole exported 16.4 percent of its production (Table 15), generating 15.4 percent of the country's total exports (Table 16, part A). Agriculture-related manufacturing's share in export intensity was higher, equivalent to 25.8 percent of the sector's output value (Table 15, part A). On the other hand, domestic demand for manufacturing was heavily dependent on imports, which accounted for 58.2 percent of domestic manufacturing consumption in 2005 (Table 15, part B), and 84.3 percent of total imports (Table 16, part B). The share of imports in agriculture-related manufacturing consumption was relatively low but still amounted to 44.2 percent of domestic consumption (see Table 15, part B). 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 average annual growth rates of 8.3 percent in the manufacturing sector and 10.2 percent in the agriculture-related manufacturing sector from 2006 to 2015 (Table 18). Compared with the base-run scenario, the growth rate for manufacturing in scenario 2 is 3.2 percentage points higher and for agriculture-related manufacturing is 4.0 percentage points higher.

Exports of manufactured goods grow more rapidly than the sector's production as a whole in this scenario, which is consistent with what we have observed empirically in the six reference countries, as described in Section 2. Total manufacturing and agriculture-related manufacturing exports both grow at 11.6 percent and 11.7 percent annually, respectively, compared with 7.6 percent and 7.5 percent in the base-run scenario (see Table 17). This results in manufacturing sector exports increasing to 21.0 percent and agriculture-related manufacturing exports increasing to 32.6 percent (see Table 15, part A). The growth rate of total manufacturing imports is also modestly higher, rising from 6.0 percent to 6.8 percent per year. However, the annual growth rate of agriculture-related manufacturing imports declines from 4.4 percent to 3.0 percent in this scenario (see Table 17). 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 15, part B).

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 agricultural raw materials, such as cocoa and forestry products, are also export goods. Rapid growth in the processing sectors

increases their demand for raw materials and hence reduces the availability of the raw materials for direct export. If the raw materials are used in export-oriented processing sectors, 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 percent and 46.8 percent of agriculture-related manufacturing exports in 2005, respectively. Growth in these sectors' exports leads to declines in the growth rate of cocoa and forestry exports (from 7.2 percent to 5.2 percent for cocoa and from 7.5 to 6.6 percent for forestry annually; see Table 17). Growth in processed exports of these commodities increases from 7.5 percent to 11.7 percent annually on average. As a consequence, some exports of agricultural raw materials are replaced by exports of agriculture-processing goods with higher value-added content. Other labor-intensive manufacturing that uses agricultural goods as inputs also grow, such as meat and fish processing, textiles, clothing, and footwear. Compared with the base-run scenario, scenario 2 shows the share of agricultural exports in total exports falling 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 with 30.1 percent in base-run scenario (see Table 16).

Table 15. Relationship between trade and domestic production and consumption

	Initial value in 2005	Base-run scenario	Scenarios with accelerated growth in:				
			Industry	Services	Export agricultu re.	Other agricultu re	Com-bined
		(1)	(2)	(3)	(4)	(5)	(6)
Part A. Exports (%)							
Total exports to GDP	35.5	38.4	36.3	37.7	39.7	38.6	36.8
Total agriculture exports to value of agriculture 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
Nonagricultural exports to nonagricultural 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
Agriculture-related manufacturing exports to agriculture-related manufacturing production	25.8	29.5	32.6	28.1	29.0	30.4	32.4
Part B. Imports (%)							
Total imports to GDP	63.5	65.9	66.8	65.9	66.3	66.1	67.3
Total agricultural imports to value of agricultural 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
Nonagricultural imports to nonagricultural 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
Agriculture-related manufacturing imports to agriculture-related manufacturing consumption	44.2	42.5	35.7	42.8	44.0	41.8	36.3

Source: Ghana computable general equilibrium model results.

Table 16. Trade structure

	Initial value in 2005	Base-run scenario	Scenarios with accelerated growth in:				
			Industry	Services	Export agriculture	Other agriculture	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
Nonagricultural 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
Manufacturing exports	14.7	16.4	23.5	14.8	14.2	17.1	21.3
Agriculture-related manufacturing	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
Nonagricultural imports	93.3	93.2	92.5	93.0	93.1	95.2	94.1
Manufacturing imports	84.3	84.8	84.0	85.2	84.5	86.5	85.8
Agriculture-related manufacturing	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 computable general equilibrium model results.

Table 17. Growth in trade

	Base-run scenario	Scenarios with accelerated growth in:				
		Industry	Services	Export agriculture	Other agriculture	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
Agriculture-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
Agriculture-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 computable general equilibrium model results.

Table 18. Structure of industry and its subsectors' contribution to industrial growth

	Initial value in 2005	Base-run scenario	Scenarios with accelerated growth in:				
			Industry	Services	Export agriculture	Other agriculture	Com-bined
		(1)	(2)	(3)	(4)	(5)	(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
Agriculture-related manufacturing	21.9	22.2	23.8	21.6	21.7	23.4	24.7
Other manufacturing	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
Agriculture-related manufacturing		6.1	10.2	6.4	5.6	6.8	11.2
Other manufacturing		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 contribution		29.4	37.9	29.8	41.1	28.7	34.7
Contribution to industry 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
Agriculture-related manufacturing		23.1	27.6	21.6	21.6	25.7	29.3
Other manufacturing		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 computable general equilibrium model results.

Under scenario 2, Ghana experiences a relatively large structural change within the industrial sector, with the share of manufacturing in industrial GDP rising from 34.8 percent in 2005 to 39.0 percent by 2015 (Table 18, part A). However, the overall economic structure does not change substantially. The share of industry in the overall economy increases only slightly, from 27.9 percent of total GDP in 2005 to 29.0 percent in 2015 (see Tables 12 and 18). 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, respectively, during the country's transformation periods (1976–1987). That increase occurred even though the country's

industrial growth rate averaged only 7.3 percent during the period—lower than the average annual growth rate of 8.3 percent in Ghana in scenario 2.

There are four main reasons 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 with what we observed in the reference countries discussed in Section 2. First, the agricultural sector accounts for a much larger share in Ghana's economy than in all the reference countries at the time they started to transform their economies from low- to middle-income-country status. Because of the difference in Ghana's initial economic structure, relatively rapid growth in the agricultural sector seems to be a precondition 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 scenario was designed to reflect the current trend in economic growth, 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 reference countries during their transformation periods. The only exception is Malaysia, where agriculture grew at 5.9 percent annually between 1965 and 1977 (see Table 1). Accelerated manufacturing growth does not negatively affect growth in agriculture. On the contrary, some sectors, such as cocoa, benefit from such growth. Therefore, agriculture in Ghana continues to grow at 5.1 percent. That 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 the manufacturing industry in China and Vietnam. However, those subsectors are quite small in Ghana, accounting for 6 percent of total manufacturing output value. Therefore, even with 10–15 percent annual growth in production in the subsectors, their share in total manufacturing rises to only about 10 percent by 2015 under this scenario.

The third reason is related to demand constraints for certain food-processing products. Many food-processing products are created for domestic markets. Without additional growth in other sectors,

especially in agriculture, the incomes of most rural households that depend on agriculture for their livelihoods cannot grow at a similar speed as growth in the supply of processed foods. As a result, prices for some food-processing sectors 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. Under the base-run scenario, the sector grows around 2.9 percent on average each year. Additional growth in the mining sector is constrained by natural resources. Mining growth ranges from 2.7 percent to 3.6 percent annual growth in all scenarios (see Table 18). Because mining in Ghana accounts for about 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 MIC 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 nonagricultural goods. To speed up manufacturing growth rates significantly beyond agriculture's growth rates, the country will have to develop more export-oriented manufacturing. Those sectors should be less reliant on agricultural inputs, like 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 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 the 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 toward MIC status. Even during Malaysia's transformation period, when services did not grow as rapidly as agriculture and manufacturing, the large size of the service sector meant that its contribution to the economy was important for sustaining high overall growth. Therefore, unlike scenario 2, which focused on accelerating industrial growth, scenario 3 shows how accelerated growth in Ghana's service sector can contribute to the country achieving MIC status.

The service sector already forms a large part of the Ghanaian economy, accounting for a third of total GDP. However, the sector is smaller than that of most of the reference countries at a time when they had per capita GDP similar to Ghana's. Only China had a smaller service sector in 1993, when its GDP per capita was US$374. However, it is difficult to compare the service sectors of various countries given the diversity of its subsectors: public and private, traded and nontraded, and high and low value. In Ghana, the government and community service sector (other services) is the largest component of services, accounting for almost half of the overall sector (Table 19, part A). 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. Although 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 we reviewed in Section 2. Therefore, in this scenario, we did 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 to the contribution of manufacturing and construction together (see Table 7).

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 (see Table 14). Together these assumptions cause service GDP growth to increase from 5.7 percent under the base-run scenario to 7.1 percent per year (see Table 12, part A). 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: US$835 compared with US$824 under the scenario 2 (see Table 12, 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 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 the 2005–2006 Ghana Living Standards Survey, private services make up 12.1

percent of the average household's consumption basket, and households tend to spend a greater share of their incomes on private services as their incomes rise. Therefore, expanding growth in private services has a significant effect on economywide growth that is beyond the service sector itself.

The most important channel through which rapid growth in services affects nonservice sectors is the lowering of the service prices following improvements in the service sector's productivity. Service sector prices fall by an average of 1.2 percent per year and by as much as 3.5 percent annually for trade and transport. That 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. The intersectoral growth-linkage effect is especially pronounced for nonagriculture-related manufacturing, where trade and transport inputs account for 12.4 percent of total costs. Through such intersectoral linkage effects, industrial growth accelerates from 5.9 percent under the base-run scenario to 6.4 percent per year in the service-led growth scenario (see Table 12, part A). The positive effect on agriculture's growth rate is less pronounced, given that services also compete with the agricultural sectors for labor resources.

While lowered service prices stimulate growth in the nonservice sectors, it offsets growth in services measured in its current prices. Thus, the substantial growth of services in real terms does not result in an increase in the share of services in GDP. We observed that the contribution of services to GDP growth rises from 31.8 percent in the base-run scenario to 35.1 percent, while its share in GDP stays almost the same (Table 19, 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 generated 11.1 percent of Ghana's export earnings in 2005, and there is potential to expand services further (see Table 16, part A). However, in total, Ghana is currently a net importer of traded services, and foreign companies often provide transport-related services for imports. Expanding exportable services has considerable potential, mainly in other fields, such as tourism, hotels, and business services.

Under the scenario 3, we assumed that labor productivity in export-oriented services would increase such that the subsector's average growth rate would increase from 6.4 percent per year under the base-run scenario to 10.6 percent per year (Table 19, part B). Service exports grow even more rapidly, accelerating from 5.3 percent to 12.5 percent per year (see Table 17). However, the growing demand for imported services resulting from faster economic growth outpaces service sector growth, and service imports grow slightly more rapidly. On the other hand, total imports grow more slowly because of the positive effect of falling prices for services in agriculture and nonagriculture-related manufacturing. Although faster growth in export services under scenario 3 accounts for 21.2 percent of total service

sector growth compared with only 13.4 percent in the base-run scenario (see Table 19, part C), the small size of that subsector prevents it from being the major driver of growth in the overall service sector.

Table 19. Structure of services and its subsectors' contribution to services growth

	Initial value in 2005	Base-run scenario	Scenarios with accelerated growth in:				
			Industry	Services	Export agriculture	Other agriculture	Com-bined
		(1)	(2)	(3)	(4)	(5)	(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 contribution		31.8	30.4	35.1	29.5	30.1	29.8
Contribution to services 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 computable general equilibrium model results.

In summary, the service growth scenario clearly demonstrates the significant contribution of the service sector to helping Ghana achieve MIC status by 2015. Ghana undoubtedly has the potential to expand export services, such as tourism and business services, and provide substitutes for imported services. However, this subsector is currently very small compared with 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 economywide 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 transformations.

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$1,000 per capita GDP by 2015. Growth led by the industrial and service sectors can raise per

capita GDP by only US$50 and US$61 over the next 10 years, respectively. To reach beyond those 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 the previous scenarios and MIC status. To assess various growth options for agriculture, we designed two scenarios. Scenario 4 focuses on the role of agricultural exports, and scenario 5 focuses on growth in staple foods, including food crops and livestock. In the agricultural export promotion scenario (scenario 4), we assumed 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 assumed that, unlike in the base-run scenario, no additional investment is financed by foreign capital inflows because the agricultural sector is less capital intensive.

Growth in export agriculture is modeled by increasing land productivity and expanding cropland 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 with the base-run scenario). In scenario 4, total land productivity is 7 percent higher by 2015 compared with the base-run scenario; and by 2015, the cropland area expands by 2.5 percent more than under the base-run scenario.

Under these assumptions, growth in both traditional and nontraditional agricultural exports is accelerated, which results in a growth of 9.5 percent in total agricultural exports annually compared with 7.5 percent in the base-run scenario (see Table 17). Growth in exports of fruits, vegetables, and fish is especially high, ranging from 14 percent to 21 percent. In total, excluding cocoa and forestry products, nontraditional agricultural exports (including fish) grow at 12.1 percent annually, and growth in cocoa and forestry exports is 11.6 percent and 10.8 percent per year, respectively. Export-led growth brings the annual agricultural GDP growth rate up to 6.0 percent—0.7 percentage point higher than its base-run level (Table 20, part B). Production of exportable agricultural goods accounts for about 40 percent of agricultural GDP (including forestry and fish). Despite this volume, the relatively weak links 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 scenario (see Table 12, part A). Thus, export-led growth alone will only make a small contribution toward achieving MIC status. It generates an additional US$17 of per capita GDP over the base-run scenario's 2015 level of US$774 (see Table 12, part D).

Table 20. 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 agriculture	Other agriculture	Com-bined
		(1)	(2)	(3)	(4)	(5)	(6)
Part A. Structure of agriculture (%)							
Agriculture share of GDP	38.7	40.9	39.2	40.5	42.6	39.7	39.4
Share in agricultural 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 (%)							
Agriculture growth contribution		38.8	31.7	35.1	44.5	41.1	35.5
Contribution to agricultural 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 computable general equilibrium 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 few years. These conditions could 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 21. Yield gaps for selected crops

	Yields (metric tons per hectare)	
	Achieved (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. Estimates from the Ministry of Agriculture (2006, 2007)

In scenario 5, we focused on staple crops to evaluate their potential contribution to reaching MIC status. As in 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 the livestock sector increases in a comparable way. We also assumed the productivity growth rate to be high for those commodities with high import-to-consumption ratios, such as rice and poultry. Land productivity was assumed to be 54 percent higher by 2015 compared with the base-run scenario and more than 90 percent higher compared with 2005. Total land area is expanded by 3 percent by 2015 compared with the base-run scenario and is comparable to scenario 4. Significant yield gaps exist for most crops in Ghana. For example, the Ministry of Agriculture (2006, 2007) estimates achievable yields of 5.0 metric tons per hectare for maize and 6.5 tons for rice; achieved average yields have been only 1.6 ton per hectare for maize and 2.0 ton for rice (Table 21). Under our model's assumptions regarding land productivity growth, maize and rice yields reach 2.3 tons and 3.5 tons per hectare by 2015, respectively (Table 22), still much lower than the achievable yields. As in scenario 4, no additional investments are financed by foreign capital inflows.

Imports account on average for one-third of agriculture-related consumption in the domestic market, but the ratio is significantly higher for rice and poultry, accounting for 68 percent and 97 percent of total consumption in 2005, respectively (see Table 15). In the base-run scenario, the imports-to-consumption ratio is projected to shift further in favor of imports for rice and poultry. In scenario 5, we assumed that the domestic production of rice and poultry grows at 12 percent 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 scenario to –0.6 percent in scenario 5 (see Table 17). The imports-to-consumption ratio falls to 41.9 percent from 68.3 percent in 2005 (see Table 15). At the same time, domestic consumption of rice increases, and its growth rises to 5.9 percent annually from 5.0 percent in the base-run scenario. 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 compared with 6.1 percent in the base-run scenario (see Table 17).

Because of high income elasticity, poultry imports continue to grow rapidly, at the same growth rate as in the base-run scenario. Despite very high growth rates of 18 percent per year, 95.1 percent of the domestic demand for poultry continues to depend on imports (see Table 15). Although 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). The maize-to-chickens ratio is higher than 2 to 1 in the country; that is, more than 2 kg of maize are needed to produce 1 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 (falling by less than 7 percent in total over the 10-year period) from a 6 percent annual growth rate of maize production.

Table 22. Final-year yields for selected crops

	Initial yields in 2005	Yields in 2015 (metric tons per hectare)					
		Base-run	Scenarios with accelerated growth in:				
			Industry	Services	Export agriculture	Other agriculture	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 computable general equilibrium model results.
Note: Initial yields are calculated using production data from the Ministry of Agriculture (2006)

Additional annual growth of 5–7 percent in staple crop and livestock production results in an additional 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 scenario (see Table 12, part

A). Many empirical studies show that staple-led agricultural growth has strong multiplier effects; that is, 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 that finding. Growth in staple crop and livestock sectors accelerates growth in industrial sectors in scenario 5, while in scenario 4, in which growth is led by agricultural exports, the nonagricultural growth rate falls slightly. GDP annual growth rate increases to 6.0 percent, which is 0.4 percentage points higher than growth under the base-run scenario. Therefore, per capita GDP increases to US$813 by 2015—US$39 more than the base-run scenario's result (see Table 12, part D).

5.5. Scenario 6: Combining Growth in All Three Sectors

Results from scenarios 2 through 5 show that rapid growth in one sector alone will not lead to a significant increase in per capita income. Therefore, combined growth across sectors will be necessary for Ghana to double incomes by 2015. In scenario 6, we combined the labor, land, capital, and productivity growth assumptions we applied in the previous five scenarios to evaluate the joint impact of accelerated growth at the sector level and for the economy as a whole. This scenario shows each sector's GDP growth rate accelerating through enhanced intersector linkage effects, although we applied the same assumptions as we applied separately in scenarios 2 through 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 12, part A).

Structural change, in terms of sectoral composition, remains limited, despite differing growth rates across sectors. Although the annual growth rate of agriculture is the lowest 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. The service sector's growth rate is higher than agricultural growth, but the service's share of GDP falls, from 33.4 percent in 2005 to 30.9 percent in 2015. This "inconsistency" between the sector's contribution to GDP growth and its share in GDP is the result of 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; by contrast, service prices fall, making the sector's share of GDP smaller.

Accelerated growth needs to be supported by productivity growth. Factor contributions to growth fall for the three factors of land, labor, and capital, with the largest decrease occurring in labor; by contrast, productivity's contribution rises to 46.9 percent, more than 10 percentage points higher than that in the base-run scenario (see Table 13). Accelerated growth is also supported by capital accumulation. Increases in investments raise the investment-to-GDP ratio to 38 (see Table 14). Although this is higher than the 2005 ratio of 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 recurrent government spending grows relatively more slowly than economic growth, at 5.2 percent annually, allowing increased government revenues generated from economic growth to be channeled into investment. However, if increasing recurrent spending is favored instead of increasing public investments, the result will be either increased foreign inflows or reduced capital accumulation caused by 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 the 2005 per capita income of US$454 (see Table 12, part D). The increase in per capita GDP is measured in 2005 U.S. dollars. If we take into account a continuation of the currency appreciation that occurred over recent years (i.e., 2–5 percent during 2000–2006), the objective of reaching a per capita income of US$1,000, as part of the goal of reaching MIC status by 2015, appears to be within reach with an average annual GDP growth rate of 7.6 percent over the next 10 years.

6. CONCLUSIONS

Sustained growth in Ghana has translated into significant poverty reduction, and the government of Ghana has declared the new development goal of reaching MIC status by 2015. In this paper, we have reviewed growth and structural transformation experiences in countries with similar initial per capita incomes and reaching MIC status within a similar time span targeted by the government of Ghana. 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 MIC status is a process of economic transformation in which significant structural changes often take place.

Ghana's target to reach MIC 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. These six countries have undergone significant transformations of their economies, including structural changes, rapid export growth, and export diversification, especially within agriculture during the period of rapid overall economic growth. 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 are among the new challenges that developing countries like Ghana face.

Structural transformation in resource-rich countries is usually more difficult when prices for raw materials are high. World market prices for cocoa and gold, Ghana's two most important export commodities, are projected to remain at their current high levels over the medium term, and price volatility is expected to be relatively modest (World Bank 2007d). High export prices for these two commodities provide Ghana with an opportunity to continue its current growth momentum and for cocoa to continue playing an important role as it has done over recent years. For these reasons, diversifying Ghana's export and economic structure during the country's transformation to MIC status may prove difficult. Moreover, global competition in nontraditional exports and manufacturing is also fiercer in the classic "starter industries," such as textiles and other types of low-skilled, labor-intensive manufacturing. With these challenges in mind, this paper has analyzed various growth scenarios and their structural implications to determine how Ghana might develop over the next 10 years.

6.1. Summary of Model Results

The results from our model show that the level and type of growth that Ghana has experienced in recent years will increase per capita incomes by about 70 percent by 2015 compared with 2005. Therefore, growth will have to be accelerated in Ghana for it to attain MIC status. Based on the experience of other developing countries that have successfully transitioned from low- to middle-income-country status in a relatively short period, we first considered the role of accelerated growth in manufacturing in the country's transformation, with an emphasis on 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; therefore, the sector's growth is constrained by agricultural growth. The development of export-oriented, labor-intensive manufacturing that is not heavily dependent on agriculture, such as textiles, 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 critical 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 that developing in India. Expansion of tourism in Ghana may also be possible. However, the benefits of service sector growth are not limited to its contribution to exports. Services geared toward 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 service sector through improvements in efficiency and productivity. The results indicate that the most important contribution of services is its links 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.

It is impossible to achieve rapid economywide growth without accelerating agricultural growth, given that sector's large initial share in the Ghanaian economy. Significant yield gaps exist for most crops produced in the country, and many livestock products are heavily dependent on imports for domestic consumption. Promoting further growth in both traditional and nontraditional exports is also possible. Moreover, the use of modern inputs is much lower in Ghana than in the successful countries 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 did in its transformation process. Agricultural exports already account for a large share of the sector in Ghana, and more rapid growth is also possible in nontraditional exports targeting niche markets. However, because of the high cocoa price, the model simulation does 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 links to the rest of economy, which will limit its impact on overall economic growth.

A considerable opportunity to promote growth in staple foods is possible if Ghana improves productivity and increases the competitiveness of import-intensive sectors. More than 60 percent of rice and 90 percent of chicken consumed by Ghanaians are imported, and both commodities, especially chicken, have relatively high income elasticities, implying that imports may grow more rapidly than incomes. 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" links, the substitution of imports 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 remains the dominant source of domestic chicken consumption, and imports decrease only marginally. 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 the growth in the agriculture, industry, and service sectors 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 2005 U.S. dollars, per capita GDP will reach $956 by 2015. Variations between per capita GDP measured in constant and current U.S. dollars are possible and were observed in other developing countries as well as in Ghana in recent years. Taking that possibility into account, there seems no doubt that 7.6 percent GDP growth will allow the country to meet its target of $1,000 per capita by 2015 (measured in current U.S. dollars). However, reaching MIC status should be understood as a development goal that cannot be measured using just one number. Development and transformation is a process, and each country will have its own path to follow. In Ghana, agriculture is expected to play a more important role in the process than it did in other successful developing countries in the past.

6.2. Caveats and Areas for Further Research

Several caveats should be mentioned for readers interpreting our results. First, because of its specification of household demand, the model cannot fully capture demand dynamics driven by both income growth and time. In the model, the income elasticity of demand is econometrically estimated using data from the 2005–2006 Ghana Living Standards Survey; and subsistence consumption has been taken into account in the demand functions, which are defined at the subnational 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. Thus, the model is unlikely to capture significant nonlinear shifts in demand structure over time, which is commonly observed in developing countries as they move from low- to middle-income-country status with rapid and broad-based growth (as in China). Second, similar to most computable general equilibrium models, production technology is calibrated to the initial economic structure, and this technology remains fixed over time. The model simulations thus 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 the 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 computable general equilibrium 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 nontraditional and import-substitutable agriculture and new manufacturing activities to structural change during a rapid growth period.

Besides the model's caveats, challenges exist 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 recent years (British Broadcasting Corporation 2007). Revenues from exploiting oil resources can boost public expenditure and foreign currency earnings, enabling the country to finance investment using its own savings, instead of remaining highly dependent on foreign inflows, as Ghana does currently. However, with increased oil exports, it will be important for Ghana 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 economywide losses of soil degradation can reach up to 5 percent of agricultural GDP between 2006 and 2015, but we did not account for such potential negative effects in our model. Third, large regional disparities continue in Ghana, especially between the lagging northern regions and the rest of the country. These disparities are expected to persist and might negatively impact growth in the country both at the regional and sectoral levels (Al-Hassan and Diao 2007; Bogetic 2007). Finally, the country has faced severe energy shortages involving regular electricity cuts during most of 2007, although the situation eased at the end of the year because of extensive rainfalls. 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 significant negative impacts on manufacturing and services. Further analysis is needed to account for energy shortages and assess the effects of energy shortages and energy allocation efficiency on Ghana's economic growth.

6.3. Looking Forward

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 MIC status.

Second, 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 a more dynamic international demand.

Although Ghana's past economic successes have afforded it the opportunity to reach for MIC status, encouraging modernization and diversification will require careful coordination between increasingly complex macroeconomic, industrial, and financial market policies. Therefore, the achievement of Ghana's more ambitious goal will 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.

APPENDIX A: SUPPLEMENTARY TABLE

Table A.1. Sectors and commodities in the computable general equilibrium model for Ghana

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
Cocoyams	Textiles	Community and 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 B: SETS, PARAMATERS, AND VARIABLES

Table B.1. Sets, parameters, and variables of the computable general equilibrium model

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 B.1. Continued

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 nongovernment institution (exogenous variable)	$qinv_c$	Base-year quantity of private investment demand
pwm_c	Import price (foreign currency)	$trnsfr_{if}$	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 B.1. Continued

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 nongovernment 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 C: EQUATIONS

Table C.1. Equations of the computable general equilibrium model

Production and price equations	
$QINT_{ca} = ica_{ca} \cdot QINTA_a$	(1)
$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$	(2)
$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot (\alpha_{fa}^{vaf})^{-\rho_a^{va}} \cdot \left(QF_{fa} \right)^{-\rho_a^{va}-1}$	(4)
$QVA_a = iva_a \cdot QA_a$	(5)
$QINTA_a = inta_a \cdot QA_a$	(6)
$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$	(7)
$QXAC_{ac} = \theta_{ac} \cdot QA_a$	(8)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(9)
$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$	(10)
$PXAC_{ac} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1}$	(11)
$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c}$	(12)
$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}}$	(13)
$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PD_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}}$	(14)
$QX_c = QD_c + \sum_r QE_{cr}$	(15)
$PX_c \cdot QX_c = PD_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr}$	(16)
$PM_{cr} = pwm_{cr} \cdot (1 + tm_{cr}) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c}$	(17)

Table C.1. Continued

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

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

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

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

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

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 C.1. Continued

$\sum_{r\ c\in CMNR} pwm_{cr}\cdot QM_{cr} = \sum_{r\ c\in CENR} pwe_{cr}\cdot QE_{cr} + \sum_{i\in INSD} trnsfr_{i\,row} + fsav$	(35)
$\sum_{i\in INSDNG} mps_i\cdot\left(1-\overline{tins}_i\right)\cdot YI_i + GSAV + EXR\cdot fsav = \sum_{c\in C} PQ_c\cdot QINV_c + \sum_{c\in C} PQ_c\cdot qdst_c$	(36)
Factor accumulation and allocation equations (applies to capital only)	
$AWF^a_{f\,t} = \sum_a \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}}\right)\cdot WF_{f\,t}\cdot wfdist_{f\,a\,t}\right]$	(37)
$\eta^a_{f\,a\,t} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}}\right)\cdot\left(\beta^a\cdot\left(\frac{WF_{f,t}\cdot wfdist_{f\,a\,t}}{AWF^a_{f\,t}}-1\right)+1\right)$	(38)
$\Delta K^a_{f\,a\,t} = \eta^a_{f\,a\,t}\cdot\left(\frac{\sum_c PQ_{c\,t}\cdot qinv_{c\,t}}{PK_{f\,t}}\right)$	(39)
$PK_{f\,t} = \sum_c PQ_{c\,t}\cdot\frac{qinv_{c\,t}}{\sum_{c'} qinv_{c'\,t}}$	(40)
$QF_{f\,a\,t+1} = QF_{f\,a\,t}\cdot\left(1+\frac{\Delta K^a_{f\,a\,t}}{QF_{f\,a\,t}}-\upsilon_f\right)$	(41)
$QFS_{f\,t+1} = QFS_{f\,t}\cdot\left(1+\frac{\sum_a K_{f\,a\,t}}{QFS_{f\,t}}-\upsilon_f\right)$	(42)

APPENDIX D: PARAMETER CALIBRATION AND ESTIMATION

Calibration of the Ghana computable general equilibrium (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, 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 export and import intensity parameters ($icm_{cc'}; ice_{cc'}$) in the trade functions—can be directly calculated from the social accounting matrix. Table B.1 provides a complete list of such parameters.

A set of elasticity coefficients is also required for the model. These coefficients include (a) elasticities of substitution between factors in the production function, (b1) elasticities of substitution between imports and domestically produced goods and services in the Armington function and (b2) 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.

As in most other CGE models, the elasticities in (a) and (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 the International Food Policy Research Institute (Diao et al. 2007; Löfgren et al. 2002; Thurlow 2004). The income elasticity of demand is estimated econometrically using data from the 2005–2006 Ghana Living Standards Survey (GLSS5). The estimation procedure is further discussed in Appendix E, while Table D.1 reports the value of elasticities in (a) and (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 D.1. 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 elasticities to be 4.0, consistent with other IFPRI computable general equilibrium 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 conducted a series of

sensitivity tests for the key elasticities applied in the model. Detailed results are reported in Appendix F. 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 E: INCOME ELASTICITY OF DEMAND AND MARGINAL BUDGET SHARES IN THE DEMAND SYSTEM

As shown in Appendix C, 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 are available. Using data from the GLSS5 and the method suggested in King and Byerlee (1978), we first estimated the demand elasticity of income for representative rural and urban households, respectively, at the national level (Table E.1). We then applied these elasticities to the average commodity expenditure shares of representative households at the regional level, s_i (see Table E.2), which can be calculated from the GLSS5, to obtain the marginal budget shares, β_i, which we finally used in the model (see equation 28 in Table C.1). The subsistence level of each agricultural commodity, γ_i, in equation 28 is drawn from the home consumption data provided by the GLSS5.

Table E.1. Income elasticities of demand at the national level

	Maize	Rice and 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 E.2. Average budget share (%) of representative households in the model

	Maize	Rice	Sorghum and millet	Other cereals	Cassava
Rural					
Coast	3.1	3.7	0.0	0.2	7.2
Forest	1.7	4.1	0.0	0.0	5.2
Northern savannah	8.6	3.2	5.3	0.1	1.6
Southern savannah	4.6	3.4	0.3	0.2	6.2
Urban					
Accra	0.3	3.0	0.0	0.1	0.8
Coast	0.6	4.5	0.0	0.1	2.2
Forest	0.5	3.9	0.1	0.0	2.1
Northern savannah	8.6	4.1	1.1	0.1	0.5
Southern 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 E.2. Continued

	Yams	Cocoyams	Cowpea	Soya beans	Groundnuts
Rural					
Coast	0.9	0.2	0.2	0.0	0.4
Forest	2.4	0.9	0.2	0.0	0.5
Northern savannah	8.0	0.1	0.8	0.1	3.7
Southern savannah	4.0	1.0	0.4	0.0	0.5
Urban					
Accra	1.3	0.1	0.2	0.0	0.2
Coast	1.1	0.2	0.2	0.0	0.3
Forest	2.1	0.3	0.1	0.0	0.3
Northern savannah	5.0	0.0	0.4	0.0	1.9
Southern 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 E.2. Continued

	Fruit	Vegetables	Plantains	Other crops	Palm oil
Rural					
Coast	1.0	6.6	2.8	0.1	1.0
Forest	0.8	5.8	4.7	0.1	0.7
Northern savannah	0.6	16.1	0.0	1.4	0.1
Southern savannah	1.0	7.5	3.2	0.1	0.9
Urban					
Accra	1.6	4.0	0.9	0.0	0.2
Coast	1.7	4.9	2.3	0.0	0.5
Forest	1.3	5.1	2.2	0.0	0.2
Northern savannah	0.9	5.9	0.1	0.5	0.1
Southern 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 E.2. Continued

	Other nuts	Chicken broiler	Eggs and layers	Beef	Sheep and goat meat
Rural					
Coast	0.0	0.9	0.6	0.8	0.3
Forest	0.0	0.6	0.5	1.5	0.2
Northern savannah	0.0	0.6	0.2	1.3	0.6
Southern savannah	0.0	1.1	0.5	1.3	0.4
Urban					
Accra	0.0	1.0	0.6	1.5	0.7
Coast	0.0	0.7	0.7	1.3	0.2
Forest	0.0	0.8	0.9	2.8	0.4
Northern savannah	0.0	0.2	0.3	3.2	0.9
Southern 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 E.2. Continued

	Other meats	Fishery	Formal food processing	Informal food processing	Dairy products
Rural					
Coast	0.5	3.5	8.0	7.1	0.8
Forest	1.3	2.1	5.9	4.1	0.7
Northern savannah	1.0	1.6	7.1	4.7	0.8
Southern savannah	1.1	2.5	7.5	5.0	0.7
Urban					
Accra	0.3	1.7	8.1	4.8	1.6
Coast	0.6	2.9	8.5	6.2	1.5
Forest	0.7	2.1	7.4	4.2	1.5
Northern savannah	0.6	1.0	6.9	7.4	1.7
Southern 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 E.2. Continued

	Meat and fish processing	Textiles	Clothing	Leather and footwear	Wood products
Rural					
Coast	12.2	1.4	4.5	1.5	1.2
Forest	10.1	1.6	5.9	2.0	0.9
Northern savannah	3.8	1.1	3.6	1.1	1.1
Southern savannah	10.4	1.5	4.6	1.6	0.7
Urban					
Accra	5.2	1.3	4.7	1.5	1.2
Coast	6.3	1.5	4.9	1.7	1.9
Forest	5.2	1.8	5.8	2.2	2.1
Northern savannah	3.5	1.5	5.0	1.4	4.0
Southern 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 E.2. Continued

	Paper, publishing, and printing	Petroleum	Diesel	Other fuels	Fertilizer
Rural					
Coast	0.4	0.2	0.0	3.1	0.0
Forest	0.4	0.7	0.1	2.9	1.1
Northern savannah	0.2	1.8	0.4	3.9	0.1
Southern savannah	0.4	0.2	0.4	3.2	0.1
Urban					
Accra	0.7	2.8	1.1	0.4	0.0
Coast	1.8	3.6	0.0	1.9	0.0
Forest	0.6	1.1	0.1	1.3	0.0
Northern savannah	0.6	1.8	0.1	2.1	0.1
Southern 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 E.2. Continued

	Chemicals	Metal products	Machinery and equipment	Water	Electricity
Rural					
Coast	5.4	1.0	2.9	0.1	0.0
Forest	5.6	1.5	5.9	0.1	0.0
Northern savannah	4.2	0.6	3.2	0.0	0.0
Southern savannah	5.2	1.0	3.9	0.1	0.0
Urban					
Accra	3.8	0.6	12.5	0.5	0.0
Coast	5.0	0.7	7.8	0.4	0.1
Forest	5.3	0.9	8.7	0.5	0.0
Northern savannah	5.6	0.7	6.5	0.1	0.0
Southern 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 E.2. Continued

	Trade services	Transport services	Communication	Banking and business	Real estate
Rural					
Coast	7.0	3.3	1.2	0.3	2.1
Forest	6.8	3.9	1.4	0.4	1.5
Northern savannah	2.6	1.0	0.4	0.2	1.9
Southern savannah	5.1	3.1	0.7	0.3	1.7
Urban					
Accra	10.1	7.7	2.5	0.9	5.3
Coast	6.5	5.4	3.3	0.5	2.5
Forest	9.7	4.7	3.6	0.5	2.7
Northern savannah	6.3	2.1	1.1	0.5	2.3
Southern 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 E.2. Continued

	Community and other services	Public administration	Education	Health
Rural				
Coast	1.6	0.0	0.1	0.6
Forest	2.1	0.0	0.1	0.9
Northern savannah	1.3	0.0	0.0	0.3
Southern savannah	2.0	0.0	0.1	0.5
Urban				
Accra	3.5	0.0	0.1	0.3
Coast	2.6	0.0	0.0	0.4
Forest	3.1	0.1	0.0	0.8
Northern savannah	2.6	0.0	0.0	0.9
Southern 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 F: SENSITIVITY TESTS

We focused our sensitivity test on the model results of scenario 6, the combined scenario. Specifically, we conducted four sensitivity 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, 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, we reran the model with all other assumptions the same as applied in the combined scenario.

Table F.1 reports the test results for some variables expected to be most sensitive to the choices of various elasticities. As the table shows, however, the model is very robust to changes in the values of elasticities, both in the trade and production functions. For example, halving the elasticities used in the trade functions changes the GDP per capita of 2015 by about US$0 or US$5, compared with the results from the original scenario. Lowering elasticity values in the production function causes a decrease of GDP per capita 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. We observed similar modest changes for the other variables, as reported in Table F.1. Given this robustness to changes of key elasticities to different levels in the model, we have confidence in the model results.

Table F.1. 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 per capita in 2015 (current 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 (%)	38.3	38.7	38.5	37.6	39.5
Sources of growth (%)					
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

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