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Beyond Agriculture versus Nonagriculture

Decomposing Sectoral Growth–Poverty Linkages in
Five African Countries

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ABSTRACT

The development debate in Africa south of the Sahara is often cast as “agriculture versus nonagriculture.” Yet this view overlooks the heterogeneity within these broad sectors and the synergies between them. We estimate sectoral poverty–growth elasticities using economywide models for five African countries. Our detailed treatment of nonagriculture complements an expanding literature disaggregating the growth–poverty relationship in agriculture. Although our estimated elasticities are higher for agriculture given the importance of farm incomes for the poor, the extent to which this is true varies by country. In fact, elasticities for certain nonagricultural sectors are much closer to those in agriculture. Overall, elasticities are typically higher for trade and transport services and manufacturing (agroprocessing). In some countries, growth led by these sectors is almost as effective at reaching the poor as agriculture is. This confirms the need for a more nuanced treatment of nonagriculture and may explain (and perhaps reconcile) conflicting perspectives on the role of agriculture vis-à-vis nonagriculture.

Keywords: economic growth, poverty reduction, agriculture, nonagriculture, Africa

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1. INTRODUCTION

The traditional dual-economy perspective, that is, agriculture versus nonagriculture, still underpins much of the debate over which sources of economic growth are most important for poverty reduction in African countries south of the Sahara (SSA) (see, for example, Dercon 2009; Diao, Hazell, and Thurlow 2010; Collier and Dercon 2014). This debate is supported by an extensive empirical literature that uses various methods to compare the growth linkages and poverty–growth elasticities (PGEs) of agriculture with those of nonagriculture (see, for example, Christiaensen, Demery, and Kuhl 2011; Diao, Hazell, and Thurlow 2010; De Janvry and Sadoulet 2010; Loayza and Raddatz 2010; Thirtle, Lin, and Piesse 2003). These studies usually find that agricultural growth has larger economywide multiplier effects and stronger linkages to poverty reduction than nonagricultural growth (Bezemer and Headey 2008).

The debate over the role of agriculture became more nuanced over time—focusing now on whether policies should prioritize smallholder or large-scale plantation farming (Hazell 2013; Hazell et al. 2010; Collier and Dercon 2014). Recent empirical studies disaggregate agriculture in order to compare the poverty-reducing effects of *subsectoral* growth. Diao et al. (2012), for example, find that in 10 African countries, agricultural growth led by food crops is more poverty reducing than growth led by export-oriented crops. Because smallholders are more intensively engaged in food production, the authors infer that improving smallholder farming is a priority for poverty reduction. Studies that explicitly compare smallholder and plantation farming reach similar conclusions (see, for example, Arndt et al. 2010). Although these studies have limitations (see Dercon 2009; Collier and Dercon 2014; Dercon and Gollin 2014), their more nuanced perspective on what constitutes *agriculture* is a definite advance in the debate.

Less advanced, however, is our understanding of the effects of nonagricultural growth on poverty reduction. Treating nonagriculture as a single aggregate sector is problematic for at least two reasons. First, most of SSA’s economy is nonagricultural and includes such diverse activities as foreign-owned mining and informal trading. We expect similar if not greater heterogeneity in growth–poverty linkages within nonagriculture as within agriculture. If this is the case, different perspectives on *nonagriculture* might explain divergent views on its relative importance. For instance, proponents of agriculture may compare farming with mining, while its detractors emphasize labor-intensive manufacturing. Second, nonagricultural growth in Africa is uneven. Trade and transport services, for example, accounted for one-third of the economic growth in SSA during the last decade, which is much larger than its share of the economy.¹ This uneven pattern of growth implies that the aggregate growth–poverty relationship in agriculture may change over time, thus cautioning against broad sectoral comparisons based on long-run historical relationships. Quantitative evidence is needed to gauge the importance of different perspectives on nonagriculture and its evolving growth–poverty relationship.

Numerous studies measure growth multipliers for different nonagricultural subsectors (see Haggblade, Hazell, and Dorosh 2007 for a review), and recent studies distinguish between rural areas, towns, and cities (Dorosh and Thurlow 2013, 2014; Adam, Bevan, and Gollin 2014). Few studies, however, explicitly estimate PGEs within nonagriculture. One study by Thirtle, Lin, and Piesse (2003) disaggregates nonagriculture and finds that, unlike for agriculture, no significant relationship exists between poverty reduction and growth in either industry or services. This suggests that separating nonagriculture may be unnecessary. However, Loayza and Raddatz (2010) disaggregate industry and find a significant relationship between growth and poverty for labor-intensive manufacturing and construction, but not for mining. These heterogeneous outcomes at the subsectoral level confirm the need for more detailed analysis of nonagriculture and its linkages to poverty.

¹ Own calculations using data from UNSD (2013) for 31 low-income African countries for the period 2000–2012. Eritrea, Somalia, and Zimbabwe are excluded due to data limitations. The definition of *low-income* is according to 2007 classifications.

In this paper we complement the expanding literature on agricultural growth and poverty by estimating PGEs for different nonagricultural subsectors. This is done using dynamic computable general equilibrium (CGE) models of five low-income African countries, which reflect a range of initial conditions, including a varying importance and composition of agriculture, industry, and services. The models allow us to experiment with alternative patterns of growth and to link growth to poverty using a consistent macro–micro framework. To permit cross-country comparisons, the model’s databases are constructed for a common base year and poverty is defined using a common poverty line. Changes in poverty are measured using microsimulation techniques. The next two sections present our case study countries and describe the models. We then present our simulation results and conclude by summarizing their implications.

2. CASE STUDY COUNTRIES

Our analysis is based on five low-income African countries: Malawi (MAL), Mozambique (MOZ), Tanzania (TZA), Uganda (UGA), and Zambia (ZAM). Table 2.1 reports these countries' economic and demographic characteristics for 2007, which is the base year for the economywide models. The table also includes statistics for all low-income SSA countries.

Table 2.1 Country case study characteristics, 2007

Variable	SSA	MAL	MOZ	TZA	UGA	ZAM
Population (millions)	497.0	12.2	21.5	31.7	27.2	11.7
Rural (%)	73.3	88.7	69.6	75.0	84.6	65.1
GDP per capita (\$)	393	133	342	481	455	950
PPP-adjusted	1,011	358	718	1,402	1,263	1,309
Survey consumption per capita (\$)	n/a	409	558	441	632	509
Gini coefficient	n/a	43.9	45.7	37.6	42.6	54.6
Poverty headcount rate, \$1.25 (%)	50.4	73.9	59.6	84.6	50.3	68.5
\$0.75	23.2	42.7	28.6	64.7	20.2	48.2
Share of total GDP (%)	100	100	100	100	100	100
Agriculture	31.7	32.2	27.7	31.8	21.6	20.1
Mining and utilities	7.4	2.8	7.5	6.5	5.3	8.1
Manufacturing	8.5	11.3	15.4	8.8	7.8	9.7
of which agroprocessing	n/a	6.5	4.2	5.6	3.5	5.9
Construction	5.9	3.9	3.1	7.8	15.8	12.0
Trade and transport	24.7	27.6	24.2	21.9	23.8	29.5
Other services	21.8	22.3	22.1	23.2	25.7	20.6

Source: Authors' own calculations using country CGE models, UNSD (2013) and World Bank (2013, 2014).

Notes: MAL = Malawi; MOZ = Mozambique; SSA = low-income African countries south of the Sahara; TZA = Tanzania; UGA = Uganda; ZAM = Zambia. Poverty rates use \$1/day poverty line adjusted for purchasing power parity (PPP). Consumption and poverty estimates from the survey year closest to 2007 (SSA: 2005; MAL: 2004/05; MOZ: 2007/08; TZA: 2007; UGA: 2006/06; ZAM: 2006).

The five case studies were selected because detailed social accounting matrices (SAMs) are available for these countries for a common base year. Although our small sample of countries accounts for only one-fifth of the total low-income population of Africa, it still reflects the subcontinent's diversity. Malawi and Zambia offer the widest contrast for many of the indicators shown in the table. Malawi's population is overwhelmingly rural, whereas Zambia is one of Africa's most urbanized countries. Gross domestic product (GDP) per capita is seven times higher in Zambia (US\$950)² than it is in Malawi (\$133) and is still more than three times higher after adjusting for purchasing power parity (PPP). Zambia has a large mining sector, which produces three-quarters of the countries' exports. In contrast, agriculture accounts for three-quarters of Malawi's exports and one-third of its GDP. Agroprocessing, which falls under manufacturing and includes the production of food, beverages, and tobacco, is also more important for Malawi than it is for Zambia.³ Overall, the sample includes two predominantly agrarian countries (Malawi and Tanzania) and two countries where mining and heavy industry play more important roles (Mozambique and Zambia). Finally, Uganda is more dependent on construction and services.

The table also reports poverty headcount rates, which measure the share of the population whose daily expenditures fall below the \$1.25 and \$0.75 poverty lines (measured in 2005 PPP-adjusted dollars).

² All dollar amounts are given in US dollars.

³ The level of processing required for an agricultural product to be reclassified as a manufactured product may vary between countries. For example, grain milling by farmers for their own consumption may be treated as agriculture, whereas milling for urban consumers is manufacturing. Our analysis is consistent with countries' own classifications as reflected in national accounts.

Again, the case studies reflect a range of initial conditions. Uganda has the lowest poverty rate in our sample (50.3 percent) due to its higher per capita consumption spending (\$632 per year according to survey data). Conversely, Tanzania has the highest poverty rate (84.6 percent) and lower per capita consumption (\$441 per year). Average consumption measures hide differences in income inequality. Zambia has the most unequal expenditure distribution, that is, the highest Gini coefficient. This explains why Malawi and Zambia have similar poverty rates, despite Malawi's much lower per capita consumption.

The structural heterogeneity discussed above is central to our analysis of growth–poverty linkages. Differing compositions of nonagriculture across countries can cause their aggregate growth–poverty relationships to vary. Mozambique and Zambia, for example, have large mining and metals industries, which are typically associated with weaker employment and poverty linkages (see Thurlow and Wobst 2006). In contrast, agroprocessing plays a larger role in Malawi and Uganda, and this subsector tends to be more labor intensive and less skill intensive than metals or mining. We might therefore expect smaller aggregate nonagricultural PGEs in Mozambique and Zambia than in Malawi or Uganda. The differing compositions of nonagriculture in our five case study countries both motivates and strengthens the analysis.

Differences in a sector's production and consumption linkages can also cause PGEs to vary across countries. Production linkages arise when producers use intermediate inputs from other sectors. For example, when the transport sector expands, it uses inputs like fuels and repair services, thereby stimulating production in other sectors or demand for imported goods. The size of production linkages depends on the technologies and input intensities of sectors. Consumption linkages on the other hand occur when workers' incomes are used to purchase a range of goods and services beyond those produced by the sector in which the workers themselves are employed. The size of consumption linkages depends on the share of labor and capital incomes distributed to households, the composition of consumption baskets, and the share of domestically supplied goods in consumer demand. These deeper structural characteristics are captured in our five country SAMs and hence in the economywide models that we use to measure sector-specific PGEs.

3. MEASURING POVERTY–GROWTH ELASTICITIES

A PGE, as used here, is the percentage change in the poverty rate given a 1 percent change in GDP per capita. One complication in measuring PGEs is that poverty calculations are based on household consumption rather than on GDP. As shown in the national accounting identity below, GDP includes not only private consumption C , but also investment I , government spending G , and the net flow of exports X and imports M . Moreover, consumption is measured at market prices (mp) and therefore includes indirect taxes T . This implies that economic growth, measured using GDP at factor cost (fc), might not lead to proportional changes in household consumption. For example, changes in the growth pattern might alter marginal savings and tax rates, and thus affect investment and public spending differently from household consumption.

$$GDP^{fc} + T = GDP^{mp} = (C + I + G) + (X - M)$$

Most studies in the literature avoid making an explicit link between GDP and consumption. One approach that is often used is to estimate PGEs directly from household surveys by assuming that changes in total reported consumption can proxy for changes in total GDP (see, for example, the studies in Besley and Cord 2007 and Grimm, Klasen, and McKay 2007). Two aspects of this approach are relevant here. First, it assumes that economic growth does not alter macroeconomic structure, that is, there are proportional changes to the trade balance ($X - M$), indirect taxes (T), or the composition of total absorption ($C + I + G$). Second, the focus on household consumption precludes an explicit examination of growth patterns, that is, uneven changes in sectoral GDP at factor cost. Survey-based PGEs are often decomposed only in general terms, such as by treating urban consumption as a proxy for nonagricultural GDP. This constrains the level of sectoral analysis and has prompted studies to overlook spillover effects, such as when agricultural growth benefits both rural and urban consumers.⁴

A purely survey-based approach is therefore not ideal for decomposing PGEs. Instead, we use a combination of CGE and microsimulation models. The CGE models provide a consistent structural framework that explicitly traces the impact pathways between sector-level growth and household-level consumption. The models also allow us to control for changes in macroeconomic structure. The microsimulation module retains one of the major strengths of survey-based approaches, that is, it captures the heterogeneity of household consumption patterns.

Following the approach in Dervis, De Melo, and Robinson (1982), our country CGE models simulate the functioning of a market economy, including markets for land, labor, capital, and products, and offer insights into how accelerations in sectoral growth are mediated through prices and resource reallocations. All resource and macroeconomic constraints are respected, which is an advance over fixed price and semi-input-output multiplier models that are often used to measure agricultural and nonagricultural growth linkages (Haggblade, Hazell, and Dorosh 2007; Thorbecke and Jung 1996). Below we describe the structure and behavior of the models.⁵

Production, Employment, and Trade

The contribution of a subsector to national growth is determined by its initial share of GDP and its linkages to the rest of the economy. If a subsector has strong production and consumption linkages (that is, if it uses inputs from local producers or generates incomes that support domestic consumption), then growth in this sector could generate positive spillover effects. For example, agriculture is said to have strong growth linkages because it supplies raw materials to downstream sectors (forward production linkages), uses locally produced trade and transport services (backward production linkages), and

⁴The cross-country econometric analysis by Christiaensen, Demery, and Kuhl (2011) finds significant intersectoral spillover effects between agricultural growth and poverty reduction.

⁵ See the appendix tables and Diao and Thurlow (2012) for a full specification and description of the CGE models.

generates incomes for households who are more likely to purchase domestic goods (consumption linkages). These linkages are country and sector specific because they depend on local production arrangements and household income and expenditure patterns. Our models capture growth linkages through their calibration to SAMs.

The models include detailed breakdowns of industries and production technologies. Agriculture is divided across subnational regions to capture differences in agroecological conditions and livelihood patterns. Labor markets are segmented by education levels, with labor in each group able to migrate between sectors. One exception is lower-educated workers, whose annual time allocation between farm and nonfarm work is fixed or predetermined. This reflects the seasonal labor constraints facing farm households and ensures that sufficient family labor is available during the growing season. Note that outside of the growing season, farmers can allocate their time to nonfarm activities. We initially assume that employment levels are *unaffected* by productivity growth, that is, labor supply is inelastic and wages adjust to equate demand and supply. However, given possible underemployment outside of the growing period and in urban centers, we will drop this assumption for less-educated nonfarm workers (discussed in the next section).

Linkages between domestic sectors and the rest of the world are important for determining how growth affects prices and incomes. One argument against the need for agricultural growth in Africa, for example, is that food imports are now more readily available than they were at the time of Asia's Green Revolution (see Diao, Hazell, and Thurlow 2010). Conversely, sectors with larger export market opportunities may generate higher returns but fewer indirect linkages to other sectors. The CGE models capture import competition and export opportunities by allowing producers and consumers to shift between domestic and foreign goods depending on changes in their relative prices. We assume that domestic and foreign goods are imperfect substitutes. Finally, world prices are fixed under a small country assumption.

Household Incomes and Poverty

The poverty headcount rate is determined by households with per capita consumption levels close to the poverty line. This implies that GDP growth can raise total consumption without necessarily affecting the poverty rate. This highlights the importance of capturing distributional change. Income changes in CGE models can vary across households depending on the factor intensity of a particular growth pattern and on the claims that households have on factor earnings. Drawing on information on employment and factor endowments from household surveys, the CGE models trace the impact of GDP growth on the returns to different factors and on the level and distribution of incomes and consumption of different household groups.

National surveys are used to define representative households in the CGE models, each of which is an aggregation of survey respondents. We group households according to rural and urban areas, subnational regions, farm and nonfarm status, and per capita expenditure quintiles. To retain as much information as possible on household heterogeneity, the CGE models are linked to survey-based microsimulation modules following the approach described in Arndt et al. (2012). In this specification, each household group in the CGE models is mapped to its corresponding households in the surveys. The CGE model simulations estimate changes in real commodity-level consumption spending for each household group. This information is used to update consumption by individual survey households, assuming that all households within a representative group experience the same proportional change in commodity-level spending. The total level of consumption for each survey household is recomputed and compared with the poverty line to determine if its poverty status has changed.

Macroeconomic Closures

One feature of CGE models is that they can specify macroeconomic behavior. This is done using *closure rules* that determine how macroeconomic balances are maintained. We select closure rules such that changes in total GDP lead to nearly proportional changes in total private consumption. First, changes in the real exchange rate ensure that the trade balance ($X - M$) is fixed in foreign currency. Second, changes in total nominal absorption ($C + I + G$) are distributed proportionally across its components. This is achieved via proportional adjustments to marginal savings and direct tax rates, with indirect tax rates (T) remaining constant. Together these closure rules maintain existing macroeconomic structures, such that our estimated PGEs are primarily determined by micro structure rather than macro behavior. We therefore mimic the assumption underpinning survey-based PGEs, but without losing the ability to isolate growth in particular sectors or capture spillover effects.

Data and Limitations

Most of the CGE models' parameters are derived from SAMs. A SAM is a consistent economywide database that tracks all income and expenditure flows within an economy during a given year (see Breisinger, Thomas, and Thurlow 2009). The SAMs used in this study were produced by the International Food Policy Research Institute.⁶ They draw on a range of datasets, and this process revealed various inconsistencies between sources. In our case studies, as in most low-income countries, national accounts are not fully reconciled with government financial statements or the balance of payments. Total consumption levels also differ in national accounts and in national household surveys. To reconcile these differences, cross-entropy estimation techniques were used to systematically minimize adjustments to the original data (see Robinson, Cattaneo, and El-Said 2001). If both national accounts and household surveys contain useful information, the reconciliation process will have improved the information base of our study. Nevertheless, like most studies in the growth–poverty literature, our analysis depends on the accuracy of sectoral GDP estimates from national accounts and poverty estimates from household surveys.

The models also include behavioral elasticities that influence how consumers and producers respond to changes in incomes and relative prices. Import and export substitution elasticities are based on cross-country estimates from Dimaranan (2006). Income elasticities were econometrically estimated using national household surveys, which also provided information on sectoral employment and wages. When presenting our results, we conduct sensitivity analysis on the models' calibration of labor markets.

⁶ The SAMs and documentation can be downloaded at www.ifpri.org/datasets.

4. SIMULATION RESULTS

Baseline and Simulation Design

We first establish a baseline scenario for the period 2007–2015. This provides a counterfactual for alternative growth scenarios. We adopt the same baseline assumptions for each country. Labor and capital supplies grow at 3 percent per year, cultivated land expands at 0.5 percent per year, and total factor productivity (TFP) grows at a uniform 2 percent per year in all sectors. This generates a fairly balanced growth path in which total GDP expands at roughly 5 percent per year (or 2 percent in per capita terms).

In our analysis we accelerate economic growth by increasing TFP in different sectors, for example, agriculture or manufacturing. This does not imply that growth is restricted to these sectors because spillover effects also exist. We therefore refer to these simulations as being “led” by a specific sector, for example, manufacturing-led growth. To control for the size differences of each sector, we target the same percentage increase in *total* GDP per capita in all sector-led growth scenarios, that is, a 2.5 percent increase relative to the baseline by 2015. Table 4.1 reports the implied increase in total GDP per capita in each country.

Table 4.1 Accelerated growth scenarios

Variable	Change relative to baseline in 2015				
	MAL	MOZ	TZA	UGA	ZAM
Increase in GDP per capita (\$)	3.8	10.1	14.0	13.2	28.1
PPP-adjusted increase	10.3	21.1	40.7	36.6	38.7
Percentage change (%)	2.5	2.5	2.5	2.5	2.5

Source: Authors’ calculations using country computable general equilibrium models.

Notes: GDP = gross domestic product; MAL = Malawi; MOZ = Mozambique; PPP = purchasing power parity; TZA = Tanzania; UGA = Uganda; ZAM = Zambia.

PGEs under a Balanced Growth Scenario

Poverty is initially measured using the \$1.25 per day poverty line. The estimated PGEs are reported in Table 4.2. The *All Sectors* scenario reflects a balanced growth path with a uniform increase in TFP in all sectors relative to the baseline. In Malawi, a 1 percent increase in total GDP led by all sectors causes a 0.76 percent reduction in the poverty rate.⁷ The magnitude of the PGE varies across countries—it is largest in Uganda (1.20) and smallest in Tanzania (0.49).

⁷ Our PGEs can also be interpreted as a percentage change in the number of poor people in 2015, because the size of the total population in 2015 does not vary across baseline and sector growth scenarios.

Table 4.2 Poverty–growth elasticities (US\$1.25 poverty line)

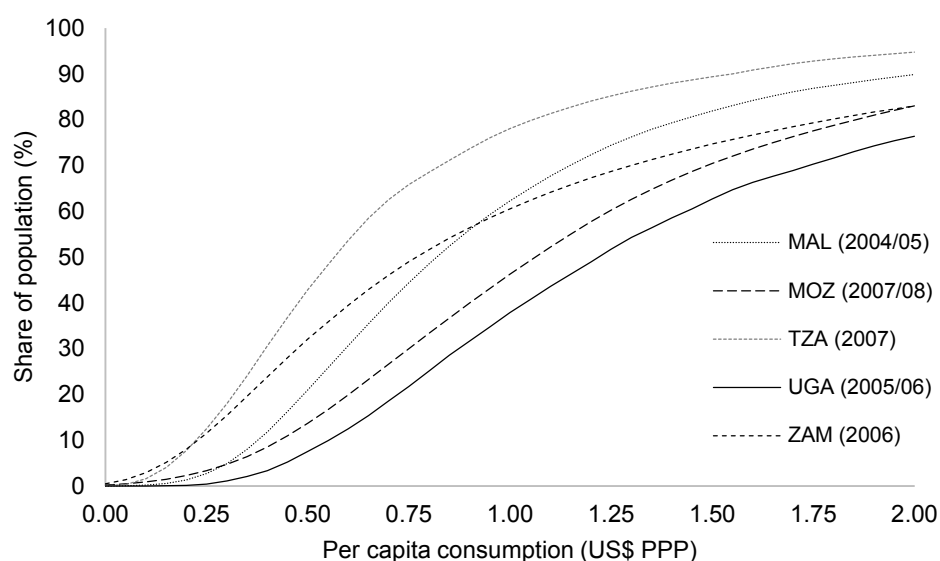
Lead growth sectors	MAL	MOZ	TZA	UGA	ZAM
All sectors	-0.76	-1.11	-0.49	-1.20	-0.97
Agriculture	-1.19	-2.62	-0.89	-2.15	-1.21
Nonagriculture	-0.61	-0.74	-0.33	-1.04	-0.87
Mining	-0.29	n/a	-0.37	n/a	-1.02
Manufacturing	-0.92	-0.88	-0.68	-1.60	-1.47
Agroprocessing	-1.00	-0.83	-0.72	-1.10	-1.67
Construction	-0.20	-0.30	-0.03	-0.12	-0.30
Utilities	n/a	-0.86	-0.36	n/a	-0.90
Trade and transport	-0.87	-0.90	-0.50	-1.41	-1.20
Finance and business	-0.28	-0.87	-0.39	-1.17	-0.87
Government services	-0.03	-0.01	0.07	-0.40	-0.16
Other services	-0.48	-0.47	n/a	-1.07	-0.14

Source: Authors' calculations using country computable general equilibrium models.

Notes: MAL = Malawi; MOZ = Mozambique; TZA = Tanzania; UGA = Uganda; ZAM = Zambia. "n/a" sectors are too small to generate a comparable increase in total gross domestic product.

By design, the variation in PGEs across countries in the *All Sectors* scenario is *not* due to the rate or composition of GDP growth. Moreover, given our closure rules, the 2.5 percent increase in total GDP generates a similar 2.5 percent increase in total private consumption in each country. The variation in PGEs in the *All Sectors* scenario therefore reflects differences in the level and distribution of private consumption. Figure 4.1 shows cumulative distribution functions (CDFs) for per capita consumption. In Uganda, for example, 50.3 percent of the population consume at a level of \$1.25 or less per day, which is equal to the poverty headcount rate reported in Table 2.1. If consumption increases in all households, then the CDF shifts to the right and poverty rates decline.

Figure 4.1 Cumulative distribution of per capita consumption



Source: Authors' own calculations using national household survey data.

Notes: MAL = Malawi; MOZ = Mozambique; TZA = Tanzania; UGA = Uganda; ZAM = Zambia. Surveys are for different years (shown in parentheses). Consumption is converted to US dollars and adjusted for purchasing power parity (PPP).

It is evident from Table 4.2 and Figure 4.1 that the variation in PGEs across countries is strongly related to base-year poverty rates (see discussion in Ravallion and Huppi 1991). This is because the PGE reports a *percentage* change in the poverty rate. Countries with lower poverty rates are more likely to achieve larger percentage changes. Accordingly, the PGE in the *All Sectors* scenario is largest for Uganda, where the base-year poverty rate is lowest. The opposite is true for Tanzania. Therefore, given the way the PGE is calculated, it is not particularly informative to compare the magnitude of PGEs across countries. Instead, we make comparisons across sectors within countries.

Table 4.3 presents observed historical PGEs for our case study countries. These were estimated using information on consumption growth and poverty rates from household surveys that span, as closely as possible, the decade 2000–2010. Our estimated PGEs are consistent with the observed PGEs from household surveys in terms of both country rank and order of magnitude. While this increases our confidence in the PGEs estimated using the CGE models, it should be noted that our baseline is a balanced growth scenario, whereas the historical growth was unevenly distributed across sectors. This is evident in the table, which reports average annual GDP growth rates for agriculture, industry, and services.

Table 4.3 Observed growth–poverty elasticities in case study countries

Variable	SSA (1999– 2010)	MAL (1998– 2010)	MOZ (1996– 2008)	TZA (2000– 2007)	UGA (1999– 2009)	ZAM (1998– 2010)
Annual per capita consumption growth (%)	2.36	3.26	3.96	5.75	4.15	–2.94
Initial poverty headcount rate, \$1.25 (%)	61.38	83.07	80.59	84.57	60.49	55.67
\$0.75	34.8	62.34	55.6	56.8	31.33	34.44
Final poverty headcount rate, \$1.25 (%)	48.96	61.64	59.58	67.87	38.01	74.45
\$0.75	25.73	34.01	32	36.22	13.37	55.63
Poverty–growth elasticity, \$1.25	–0.86	–0.72	–0.67	–0.57	–1.06	–0.83
\$0.75	–1.15	–1.45	–1.20	–1.15	–1.91	–1.39
Annual GDP growth rate (%)	5.04	2.56	8.39	7.02	6.89	5.59
Agriculture	5.06	2.03	6.11	4.49	2.47	2.86
Industry	4.30	3.55	14.44	9.44	8.84	6.92
Services	5.45	3.22	7.75	7.61	8.02	5.59

Source: Survey-based consumption and poverty rates from World Bank (2014); GDP from World Bank (2013).

Notes: GDP = gross domestic product; MAL = Malawi; MOZ = Mozambique; SSA = Africa south of the Sahara; TZA = Tanzania; UGA = Uganda; ZAM = Zambia. Country level poverty–growth elasticities are the rate of change in the poverty rate divided by the per capita consumption growth rate. The elasticity for SSA uses per capita GDP instead of consumption.

Decomposing Sectoral PGEs

Table 4.2 reports PGEs for growth driven by different sectors. The PGE for agriculture-led growth is higher than for nonagriculture-led growth in all five countries. This is consistent with the literature, which typically finds that agricultural growth is more poverty reducing than nonagricultural growth. The extent to which this is true, however, varies by country. In Mozambique, agricultural growth is 3.5 times more effective at reducing poverty than nonagricultural growth, whereas it is only 1.4 times more effective in Zambia. This is due to differences in countries’ structural characteristics, rather than the definition of poverty, which is the same across countries.⁸

⁸ Our results are less favorable for agriculture than those of Christiaensen, Demery, and Kuhl (2011), who find that agricultural growth is 11 times more poverty reducing than nonagricultural growth for resource-poor, low-income countries in Africa south of the Sahara (using a \$1/day poverty line).

Consistent with Loayza and Raddatz (2010), we find that the distribution of the benefits of growth is determined by the factor intensity of production and the factor endowments of households. Changes in relative prices also affect real consumption levels. Table 4.4 shows the ratio of the lowest to the highest household quintiles' real per capita consumption growth. A value greater than 1 implies a narrowing of the gap between top and bottom quintiles. In all countries, this gap narrows under agriculture-led growth and widens under nonagriculture-led growth. This is because agricultural growth generates higher returns for those factors that low-income households are more endowed with, and reduces the real prices of products that low-income households consume more intensively.

Table 4.4 Changes in consumption inequality

Lead growth sectors	Ratio of the lowest to highest household quintiles' per capita consumption growth				
	MAL	MOZ	TZA	UGA	ZAM
All sectors	1.11	1.03	1.15	1.06	0.92
Agriculture	2.21	3.89	1.77	1.83	1.10
Nonagriculture	0.79	0.55	0.79	0.84	0.92
Mining	1.27	n/a	0.17	n/a	0.82
Manufacturing	1.85	0.55	1.08	1.11	1.26
Agroprocessing	2.32	0.40	2.25	2.22	1.49
Construction	0.79	0.44	0.01	0.62	0.75
Utilities	n/a	0.63	0.42	n/a	0.70
Trade and transport	1.13	0.60	1.06	0.84	1.20
Finance and business	0.15	0.54	0.32	0.60	0.53
Government services	0.36	0.12	-0.14	0.61	0.37
Other services	0.51	0.22	n/a	0.51	0.06

Source: Authors' calculations using country CGE models.

Notes: GDP = gross domestic product. MAL = Malawi; MOZ = Mozambique; TZA = Tanzania; UGA = Uganda; ZAM = Zambia. "n/a" sectors are too small to generate a comparable increase in total GDP.

As expected, when nonagricultural growth is decomposed, we find considerable variation across subsectors. The PGEs for growth led by manufacturing are much closer to those in agriculture in Malawi and Tanzania, and they exceed those of agriculture in Zambia. This is mainly due to agroprocessing, which directly employs poorer workers and has strong backward linkages to the types of agriculture that poor households are engaged in. Malawi's tobacco-curing sector, for example, generates demand for raw tobacco inputs, which is mostly supplied by smallholder farmers near the poverty line. Similarly, Zambia's grain-milling sector uses domestically grown maize and wheat. In contrast, almost one-third of Uganda's agroprocessing is in meat and dairy, which generates demand for livestock that tend to be owned by better-off farmers. Finally, agroprocessing in Malawi, Tanzania, and Zambia tends to favor lower-educated workers more than it does in Mozambique and Uganda, where processing is relatively more capital and skill intensive.

Trade and transport services also have stronger growth-poverty linkages. In Zambia, for example, the PGE for these services is very close to that for agriculture. Two reasons explain this strong link. First, increasing the productivity of trade and transport in the CGE models reduces transaction costs for all marketed products. This is particularly beneficial for sectors with products that have high margins, such as agriculture and food. Increasing traders' productivity therefore also increases the profitability of farmers and agroprocessors. This is consistent with Adam, Bevan, and Gollin (2014), who find that reducing transaction costs increases incomes for lower-skilled workers in Tanzania. Second, most trade services in countries like Zambia are produced by relatively low-paid informal traders (Resnick and Thurlow 2014). Trade and transport services therefore have strong direct and indirect linkages to the poor.

We find that growth led by construction and government services tends to have lower PGEs. This is partly due to production technologies. Although government services usually have a high share of labor value added in total GDP, this sector also tends to be one of the most skill intensive in African economies, that is, it employs doctors, teachers, and bureaucrats. Most of the additional labor value added from an expansion in government services therefore accrues to relatively few well-paid workers who are less likely to live close to the poverty line. Moreover, government services such as health and education do not appear as household consumption spending, as they are often freely provided by the government. As such, expanding public services may not translate into higher consumption and hence lower monetary poverty for households. This is true at least over the medium term, before improved health and education have had the chance to raise household earnings.

Our finding that construction has a low PGE differs from that in Loayza and Raddatz (2010). One explanation comes from the way in which growth is modeled in our analysis, that is, as a supply-side increase in productivity rather than an increase in demand. Construction is almost exclusively used for investment, which is in turn determined by the level of savings. A significant portion of the total savings in our case study countries comes from external borrowing and foreign aid, which we assume are fixed in foreign currency. Demand for construction is therefore constrained by the level of domestic savings. Increasing productivity in construction leads to large reductions in its price, or an increase in the *real* price of other goods and services, including those that are consumed by poor households. The low PGE for construction therefore partly reflects our decision not to finance its economic growth through additional foreign borrowing or development assistance. This caveat does not apply to our other sectoral growth scenarios.

In summary, we find that agricultural growth is more effective than aggregate nonagricultural growth in reducing poverty in our five country case studies. However, when nonagricultural growth is decomposed, we find that certain subsectors, such as manufacturing and trade, often have PGEs that are closer to, and sometimes exceed, those in agriculture. The composition of nonagricultural growth is an important determinant of its overall effect on poverty. Consequently, different perspectives on what constitutes *nonagriculture* and its future sources of growth may underpin divergent views on the importance of nonagriculture vis-à-vis agriculture.

Sensitivity Analysis

We conclude our analysis by testing the robustness of our findings to changes in the poverty line and the flexibility of nonfarm labor markets. Table 4.5 reports PGEs estimated using a \$0.75 per day poverty line.

Table 4.5 Poverty–growth elasticities (US\$0.75 poverty line)

Lead growth sectors	MAL	MOZ	TZA	UGA	ZAM
All sectors	-1.72	-2.00	-1.29	-2.36	-1.02
Agriculture	-2.55	-3.75	-2.22	-4.34	-1.25
Nonagriculture	-1.46	-1.18	-0.69	-1.85	-1.00
Mining	-0.90	n/a	-0.38	n/a	-1.06
Manufacturing	-2.31	-1.25	-1.75	-2.69	-1.93
Agroprocessing	-2.57	-1.07	-2.20	-2.70	-2.44
Construction	-0.54	-0.53	-0.08	-0.07	-0.28
Utilities	n/a	-1.24	-0.49	n/a	-0.93
Trade and transport	-1.85	-1.44	-1.26	-2.40	-1.40
Finance and business	-0.53	-1.73	-0.59	-1.97	-0.94
Government services	-0.15	-0.04	0.09	-0.53	-0.14
Other services	-0.92	-0.62	n/a	-1.51	-0.10

Source: Authors' calculations using country CGE models.

Notes: GDP = gross domestic product. MAL = Malawi; MOZ = Mozambique; TZA = Tanzania; UGA = Uganda; ZAM = Zambia. "n/a" sectors are too small to generate a comparable increase in total GDP.

Virtually all PGEs increase when the poverty line is lowered. As discussed earlier, in the *All Sectors* scenario, this increase is mainly due to having lower initial poverty rates. For example, when we switch from the \$1.25 to the \$0.75 poverty line, the decrease in the poverty rate is smaller in Zambia than in Uganda. As such, while Zambia's PGE for the balanced growth scenario remains virtually unchanged, Uganda's increases substantially. Again, our estimated PGEs using a \$0.75 poverty line in the *All Sectors* scenario are consistent in magnitude with the observed PGEs reported in Table 4.3.

Changing the definition of poverty can alter the factor endowment profile of households living near the poverty line, which is important in determining the effectiveness of growth in a particular sector at reducing poverty. In Tanzania, for example, agricultural growth becomes even more effective at reducing poverty relative to nonagricultural growth when the poverty line is lowered. This is because households near the lower poverty line are even more dependent on farm incomes and on consuming agricultural goods than households near the higher poverty line. This is consistent with Christiaensen, Demery, and Kuhl (2011) and Ligon and Sadoulet (2014), who find that agricultural growth has a larger beneficial effect on poorer households. Regardless of these changes, however, the rank order of sectoral PGEs remains virtually unchanged compared with those reported in Table 4.2. Our conclusions are therefore robust to lowering the poverty line.

We also consider whether our results are sensitive to our assumption that nonfarm labor supply is fixed at baseline levels. If underemployment is substantial in Africa's urban centers, as studies such as Roubaud and Torelli (2013, 70–73) suggest, then faster productivity growth may lead to increased employment rather than just higher wages. We therefore introduce a flexible labor supply function in the CGE models. Labor supply for less-educated nonfarm workers is now driven by changes in the wage rate with a unitary elasticity. An increase in economic growth and labor demand will lead to lower underemployment in towns and cities. Note that relaxing resource constraints normally increases the size of growth effects, as demonstrated by fixed-price multiplier models. However, PGEs control for the size of the change in GDP, and so our sensitivity analysis is testing for changes in growth–poverty linkages, which in our case, are primarily driven by spillover effects.

Table 4.6 reports PGEs for the \$1.25 per day poverty line and with more flexible nonfarm labor markets. In all five countries, relaxing the constraints on nonfarm labor supply leads to higher PGEs for nonagriculture and, typically, lower PGEs for agriculture. The impact on sectoral PGEs varies across countries, depending on their production technologies and growth linkages. Overall, however, there is no significant change to the rank order of sectors within countries, and hence to our general conclusion that manufacturing, trade, and transport services have higher PGEs within nonagriculture.⁹

Before concluding, it is worth noting that we have measured the growth–poverty linkages of sectors, but not their growth potential. Sectors with low PGEs can still generate large absolute reductions in poverty if they grow rapidly. Sectors with large multiplier effects, such as agriculture, can generate additional economywide growth effects (Haggblade, Hazell, and Dorosh 2007). There may also be dynamic gains from growth, such as when exporting leads to productivity-enhancing technology transfers. Similarly, agglomeration effects may create virtuous cycles of industrial growth and urbanization (Dorosh and Thurlow 2014). Overall, Africa's uneven growth performance over the last decade—with manufacturing, for example, growing relatively slowly—suggests that the growth potential of sectors can vary widely. Our findings provide a quantitative assessment of the implications of an uneven growth pattern for poverty reduction.

⁹ We also tested sensitivity to changes in factor substitution elasticities, since this is the only behavioral parameter in the models without survey-based or cross-country estimates. Reducing the elasticity from 2.00 to 0.75 in all agricultural sectors generally lowers all PGEs but does not change the rank order of sectors within countries.

Table 4.6 Poverty–growth elasticities with flexible nonfarm labor supply

Lead growth sectors	MAL	MOZ	TZA	UGA	ZAM
All sectors	–0.84	–1.21	–0.47	–1.30	–0.98
Agriculture	–1.19	–1.88	–0.84	–2.02	–1.23
Nonagriculture	–0.73	–0.91	–0.35	–1.10	–0.91
Mining	–0.42	n/a	–0.36	n/a	–1.09
Manufacturing	–0.95	–1.03	–0.67	–1.49	–1.37
Agroprocessing	–0.98	–0.94	–0.75	–1.25	–1.56
Construction	–0.21	–0.33	–0.01	–0.04	–0.21
Utilities	n/a	–0.94	–0.37	n/a	–0.97
Trade and transport	–0.86	–1.02	–0.48	–1.44	–1.18
Finance and business	–0.44	–1.09	–0.40	–1.37	–0.93
Government services	–0.12	–0.03	0.01	–0.64	–0.21
Other services	–0.62	–0.69	n/a	–1.08	–0.30

Source: Authors' calculations using country CGE models.

Notes: GDP = gross domestic product. MAL = Malawi; MOZ = Mozambique; TZA = Tanzania; UGA = Uganda; ZAM = Zambia. "n/a" sectors are too small to generate a comparable increase in total GDP.

5. CONCLUSIONS

We estimated sectoral poverty–growth elasticities for five African countries using CGE and microsimulation models. We find that although these elasticities are higher for agriculture, the extent to which this is true varies across countries. This mainly reflects heterogeneity across nonagricultural subsectors. We find that PGEs for manufacturing, trade, and transport services are often closer to and sometimes exceed those of agriculture. In contrast, the elasticities for construction and government services tend to be much lower. The composition of nonagricultural growth is therefore an important determinant of its overall effect on poverty. So too is the nature of agroprocessing linkages to farmers, which is a key determinant of the growth–poverty relationship of manufacturing. This underscores the synergies between agricultural and nonagricultural growth and their effects on poverty.

Based on our findings, we conclude that different perspectives on what constitutes “nonagriculture” may underpin divergent views on the importance of this sector vis-à-vis agriculture. Our study complements the existing literature by providing quantitative measures that allow us to gauge the importance of these different perspectives. Our findings caution against broad sectoral comparisons based on long-run historical relationships. Instead, a more nuanced debate that goes beyond “agriculture versus nonagriculture” is needed so as to identify which sources of growth are most important for reducing poverty in Africa.

APPENDIX: SUPPLEMENTARY TABLES

Table A.1 Model structures

Country	Structure
Malawi	3 regions (north, center, south); 54 sectors (23 agriculture, 20 industry, 11 services); 14 factors (5 labor, 4 cropland, 3 livestock, 2 capital); 30 households (20 rural, 10 urban)
Mozambique	3 regions (north, center, south); 56 sectors (22 agriculture, 23 industry, 11 services); 15 factors (8 labor, 3 cropland, 3 livestock, 1 capital); 30 households (15 rural, 15 urban)
Tanzania	20 regions (districts); 58 sectors (26 agriculture, 22 industry, 10 services); 10 factors (4 labor, 2 cropland, 1 livestock, 3 capital); 15 households (10 rural, 5 urban)
Uganda	4 regions (center, east, north, west); 64 sectors (20 agriculture, 32 industry, 12 services); 13 factors (4 labor, 4 cropland, 4 livestock, 1 capital); 80 households (40 rural, 40 urban)
Zambia	5 regions (agroecological); 44 sectors (15 agriculture, 18 industry, 11 services); 7 factors (4 labor, 1 cropland, 1 livestock, 1 capital); 15 households (10 rural, 5 urban)

Source: IFPRI SAM and CGE models.

Table A.2 Model indexes, variables, and parameters

Indices			
c	Commodities and activities	h	Representative households
f	Factors (land, labor and capital)	t	Time periods
<i>Exogenous parameters (Greek characters)</i>			
α^p	Production function shift parameter	θ^v	Value-added share of gross output
α^q	Import function shift parameter	π	Foreign savings growth rate
α^t	Export function shift parameter	ρ^p	Production function substitution elasticity
β	Household marginal budget share	ρ^q	Import function substitution elasticity
γ	Nonmonetary consumption quantity	ρ^t	Export function substitution elasticity
δ^p	Production function share parameter	σ	Rate of technical change
δ^q	Import function share parameter	τ	Foreign consumption growth rate
δ^t	Export function share parameter	ν	Capital depreciation rate
ε	Land and labor supply growth rate	φ	Population growth rate
θ^i	Intermediate share of gross output	ω	Factor income distribution shares
<i>Exogenous parameters (Latin characters)</i>			
ca	Intermediate input coefficients	pwm	World import price
cab	Current account balance	qfs	Total factor supply
cd	Domestic transaction cost coefficients	$qgov$	Base government consumption quantity
ce	Export transaction cost coefficients	$qinv$	Base investment demand quantity
ci	Capital price index weights	rf	Factor foreign remittance rate
cm	Import transaction cost coefficients	sh	Marginal propensity to save
cpi	Consumer price index	tf	Factor direct tax rate
cw	Consumer price index weights	th	Personal direct tax rate
ga	Government consumption adjustment factor	tm	Import tariff rate
gh	Per capita transfer from government	tq	Sales tax rate
pop	Household population	wh	Net transfer from rest of world
pwe	World export price		

Table A.2 Continued

Indices			
<i>Endogenous variables</i>			
<i>AR</i>	Average capital rental rate	<i>QG</i>	Government consumption quantity
<i>FS</i>	Fiscal surplus (deficit)	<i>QH</i>	Household consumption quantity
<i>IA</i>	Investment demand adjustment factor	<i>QI</i>	Investment demand quantity
<i>PA</i>	Activity output price	<i>QK</i>	New capital stock quantity
<i>PD</i>	Domestic supply price with margin	<i>QM</i>	Import quantity
<i>PE</i>	Export price	<i>QN</i>	Aggregate intermediate input quantity
<i>PM</i>	Import price	<i>QQ</i>	Composite supply quantity
<i>PN</i>	Aggregate intermediate input price	<i>QT</i>	Transaction cost demand quantity
<i>PQ</i>	Composite supply price	<i>QV</i>	Composite value-added quantity
<i>PS</i>	Domestic supply price without margin	<i>WD</i>	Sector distortion in factor return
<i>PV</i>	Composite value-added price	<i>WF</i>	Economywide factor return
<i>QA</i>	Activity output quantity	<i>YF</i>	Total factor income
<i>QD</i>	Domestic supply quantity	<i>YG</i>	Total government revenues
<i>QE</i>	Export quantity	<i>YH</i>	Total household income
<i>QF</i>	Factor demand quantity	<i>X</i>	Exchange rate

Source: Authors' compilation.

Table A.3 Model equations

Prices	
$PM_{ct} = pwm_c \cdot (1 + tm_c) \cdot X + \sum_{c'} PQ_{c't} \cdot cm_{c'c}$	1
$PE_{ct} = pwe_c \cdot X_t - \sum_{c'} PQ_{c't} \cdot ce_{c'c}$	2
$PD_{ct} = PS_{ct} + \sum_{c'} PQ_{c't} \cdot cd_{c'c}$	3
$PQ_{ct} \cdot (1 - tq_c) \cdot QQ_{ct} = PD_{ct} \cdot QD_{ct} + PM_{ct} \cdot QM_{ct}$	4
$PX_{ct} \cdot QX_{ct} = PS_{ct} \cdot QD_{ct} + PE_{ct} \cdot QE_{ct}$	5
$PN_{ct} = \sum_{c'} PQ_{c't} \cdot ca_{c'c}$	6
$PA_{ct} \cdot QA_{ct} = PV_{ct} \cdot QV_{ct} + PN_{ct} \cdot QN_{ct}$	7
$cpi = \sum_c cw_c \cdot PQ_{ct}$	8

Table A.3 Continued

<i>Production and trade</i>	
$QV_{ct} = \alpha_{ct}^p \cdot \sum_f \left(\delta_{fc}^p \cdot QF_{fct}^{-\rho_c^p} \right)^{-1/\rho_c^p}$	9
$WF_{ft} \cdot WD_{fct} = PV_{ct} \cdot QV_{ct} \cdot \sum_{f'} \left(\delta_{f'c}^p \cdot QF_{f'ct}^{-\rho_c^p} \right)^{-1} \cdot \delta_{fc}^p \cdot QF_{fct}^{-\rho_c^p-1}$	10
$QN_{ct} = \theta_c^i \cdot QA_{ct}$	11
$QV_{ct} = \theta_c^v \cdot QA_{ct}$	12
$QA_{ct} = \alpha_{ct}^t \cdot \left(\delta_{ct}^t \cdot QE_{ct}^{\rho_c^t} + (1 - \delta_{ct}^t) \cdot QD_{ct}^{\rho_c^t} \right)^{1/\rho_c^t}$	13
$\frac{QE_{ct}}{QD_{ct}} = \left(\frac{PE_{ct}}{PS_{ct}} \cdot \frac{(1 - \delta_{ct}^t)}{\delta_{ct}^t} \right)^{1/(\rho_c^t-1)}$	14
$QQ_{ct} = \alpha_{ct}^q \cdot \left(\delta_{ct}^q \cdot QM_{ct}^{-\rho_c^q} + (1 - \delta_{ct}^q) \cdot QD_{ct}^{-\rho_c^q} \right)^{-1/\rho_c^q}$	16
$\frac{QM_{ct}}{QD_{ct}} = \left(\frac{PD_{ct}}{PM_{ct}} \cdot \frac{(1 - \delta_{ct}^q)}{\delta_{ct}^q} \right)^{1/(1+\rho_c^q)}$	17
$QT_{ct} = \sum_{c'} (cd_{cc'} \cdot QD_{c't} + cm_{cc'} \cdot QM_{c't} + ce_{cc'} \cdot QE_{c't})$	18
<i>Incomes and expenditures</i>	
$YF_{ft} = \sum_c WF_{ft} \cdot WD_{fct} \cdot QF_{fct}$	19
$YH_{ht} = \sum_f \omega_{hf} \cdot (1 - tf_f) \cdot (1 - rf_f) \cdot YF_{ft} + gh_h \cdot pop_{ht} \cdot cpi + wh_h \cdot X$	20
$PQ_{ct} \cdot QH_{cht} = PQ_{ct} \cdot \gamma_{ch} + \beta_{ch} \cdot \left((1 - sh_h) \cdot (1 - th_h) \cdot YH_{ht} - \sum_{c'} PQ_{ct'} \cdot \gamma_{c'h} \right)$	21
$QI_{ct} = IA_t \cdot qinv_c$	22
$QG_{ct} = ga_t \cdot qgov_c$	23
$YG_t = \sum_h th_h \cdot YH_{ht} + \sum_f tf_f \cdot YF_{ft} + \sum_c (tm_c \cdot pwm_c \cdot QM_{ct} \cdot X + tq_c \cdot PQ_{ct} \cdot QQ_{ct})$	24
<i>Equilibrium conditions</i>	
$qfs_{ft} = \sum_c QF_{fct}$	25
$QQ_{ct} = \sum_{c'} ca_{cc'} \cdot QN_{c't} + \sum_h QH_{cht} + QG_{ct} + QI_{ct} + QT_{ct}$	26
$\sum_c pwm_c \cdot QM_{ct} + \sum_f (1 - tf_f) \cdot rf_f \cdot YF_{ft} \cdot X_t^{-1} = \sum_c pwe_c \cdot QE_{ct} + \sum_h wh_h + cab_t$	27
$YG_t = \sum_c PQ_{ct} \cdot QG_{ct} + \sum_h gh_h \cdot pop_{ht} \cdot cpi + FS_t$	28
$\sum_h sh_h \cdot (1 - th_h) \cdot YH_{ht} + FS_t + cab_t \cdot X_t = \sum_c PQ_{ct} \cdot QI_{ct}$	29

Table A.3 Continued

<i>Capital accumulation and allocation</i>	
$AR_{ft} = \frac{YF_{ft}}{qfs_{ft}}$	30
$QK_{fct} \cdot \left(\sum_{c'} PQ_{c't} \cdot ci_{c'} \right) = \left(\frac{QF_{fct}}{qfs_{ft}} \cdot \frac{WF_{ft} \cdot WD_{fct}}{AR_{ft}} \right) \cdot \left(\sum_{c'} PQ_{c't} \cdot QI_{c't} \right)$	31
$QF_{fct+1} = QF_{fct} \cdot (1 - v) + QK_{fct}$	32
<i>Land and labor supply, technical change, population growth, and other dynamic updates</i>	
$qfs_{ft+1} = qfs_{ft} \cdot (1 + \varepsilon_f)$	33
$\alpha_{ct+1}^p = \alpha_{ct}^p \cdot (1 + \sigma_c)$	34
$pop_{ht+1} = pop_{ht} \cdot (1 + \varphi_h)$	35
$ga_{t+1} = ga_t \cdot (1 + \tau)$	36
$cab_{t+1} = cab_t \cdot (1 + \pi)$	37

Source: Adapted from Diao and Thurlow (2012).

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