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ESSP2 Discussion Paper 002

Implications of Accelerated Agricultural Growth on Household Incomes and Poverty in Ethiopia: A General Equilibrium Analysis

Paul Dorosh and James Thurlow
with the support of the EDRI/University of Sussex Social Accounting Matrix team

Development Strategy and Governance Division, International Food Policy Research Institute – Ethiopia Strategy Support Program 2, Ethiopia

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IFPRI-Addis Ababa
P.O. Box 5689
Addis Ababa, Ethiopia
Tel: +251-11-646-2921
Fax: +251-11-646-2318
E-mail: ifpri-addis@cgiar.org

IFPRI HEADQUARTERS
International Food Policy Research Institute
2033 K Street, NW • Washington, DC 20006-1002 USA
Tel: +1-202-862-5600
Skype: IFPRIhomeoffice
Fax: +1-202-467-4439
E-mail: ifpri@cgiar.org
www.ifpri.org

THE ETHIOPIA STRATEGY SUPPORT PROGRAM 2 (ESSP2)

DISCUSSION PAPERS

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About the Author(s)

Paul Dorosh Sr. Research Fellow and Program Leader, Ethiopia Strategy Support Program, IFPRI

James Thurlow Research Fellow, Development Strategy and Division Governance, IFPRI

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ABSTRACT

Ethiopia's national development strategy, A Plan for Accelerated and Sustained Development to End Poverty for 2005/06 to 2009/10 (PASDEP) places a major emphasis on achieving high rates of agricultural and overall economic growth. Consistent with the PASDEP, Ethiopia is also in the process of implementing the Comprehensive Africa Agriculture Development Programme (CAADP) together with other African governments. As part of CAADP, the country has committed itself to meeting targets of devoting at least 10 percent of public expenditures to agriculture and to achieving a 6 percent growth rate in agricultural GDP. Ethiopia has already met these targets in recent years. The challenge remains, however, to continue to devote these public resources and to achieve high growth rates through 2015.

This paper analyzes agricultural growth options that can support high levels of agricultural development using a new computable general equilibrium (CGE) model for Ethiopia based on data from the EDRI 2005/06 Ethiopia SAM (Ahmed et al. 2009). The CGE model results indicated that if Ethiopia can meet its targets for crop yields and livestock productivity, then it should be possible to reach and sustain the six percent agricultural growth target during 2006-2015. Even though these yield targets are below the maximum potential yields identified by agricultural field trials, they are still ambitious given the short timeframe of the CAADP initiative (i.e., seven years). Achieving agricultural growth of six percent per year would reduce national poverty to 18.4 percent by 2015, lifting an additional 3.7 million people out of poverty compared to a base simulation using medium term growth rates.

Most households are expected to benefit from faster agricultural growth. However, some agro-ecological zones that grow higher-value cereals and export-oriented crops and which are better situated to larger urban markets (e.g., the rainfall sufficient highlands) stand to gain more than other parts of the country. Both rural and urban households benefit from faster agricultural growth (and thereby overall economic growth), as rural producers benefit from increased agricultural productivity and incomes, while net purchasers of food in both rural and urban areas benefit from moderate declines in real food prices.

Composition of agricultural growth matters, though. Additional growth driven by cereals has larger impacts on poverty reduction, because these crops already constitute a large share of rural incomes and so can contribute substantially to achieving broad-based agricultural growth. Yield improvements in these crops not only benefit farm households directly, by increasing incomes from agricultural production, but also by allowing farmers to diversify their land allocation towards other higher-value crops. Increased productivity of cereals that reduces real cereal prices is also effective at raising rural real incomes and reducing poverty, especially amongst the poorest households. Thus, high priority should be afforded to improving cereals yields and opening market opportunities for upstream processing to reduce demand constraints.

INTRODUCTION

Ethiopia's economy has experienced rapid growth in recent years. Although growth in agricultural GDP from 1998-2007 was less rapid than other parts of the economy, it has also performed well, growing faster than the rural population. However, poverty is still severe in Ethiopia and is concentrated in rural areas. To accelerate growth and poverty reduction, Ethiopia's national strategy affords an important role to agriculture, as a source of both growth and development for the broader economy. This is essential given that agriculture is an income source for most of the population. The sector accounts for more than two-fifths of GDP, three-quarters of merchandise export earnings, and provides key inputs into the manufacturing sectors, whose agricultural processing sectors contribute further to national GDP. In parallel to Ethiopia's agricultural strategy, the New Partnership for Africa's Development (NEPAD) is in the process of implementing the Comprehensive Africa Agriculture Development Programme (CAADP), together with African governments. The CAADP initiative supports the identification of an integrated framework of development priorities aimed at restoring agricultural growth, rural development and food security in the African region. The main target of CAADP is achieving six percent agricultural growth per year.

Since there are choices involved within the agricultural sector, both for the sector as a whole and across sub-sectors, many investment and policy interventions will be designed at the sub-sector level. However, strong inter-linkages occur across sub-sectors and between agriculture and the rest of the economy. To understand these linkages and how sectoral growth will contribute to the country's broad development goals, an integrated framework is needed in order to synergize the growth projections among different agricultural commodities or sub-sectors and evaluate their combined effects on economic growth and poverty reduction.

Moreover, agricultural production growth is often constrained by demand in both domestic and export markets, and demand, in turn, depends on income growth both in agriculture and in the broader economy. While agriculture is a dominant economic activity in Ethiopia and a majority of the population lives in rural areas, both rural and urban sectors need to be included in this framework in order to understand the economy-wide impact of agricultural growth.

This paper analyzes agricultural growth options that can support the development of a more comprehensive rural development component under Ethiopia's agricultural strategy that is also in alignment with the principles and objectives collectively defined by African countries as part of the broader NEPAD agenda. In particular, the paper seeks to position Ethiopia's agricultural sector and rural economy within the country's national strategy. For these purposes, and to assist policymakers and other stakeholders to make informed long-term decisions, a new economywide model for Ethiopia has been developed and used to analyze the linkages and trade-offs between economic growth and poverty reduction at both macro- and micro-economic

levels. The results from the model simulations are intended to guide debate in prioritizing the contribution of different subsectors in helping Ethiopia achieve its broader development objectives.

MODELING SOURCES OF AGRICULTURAL GROWTH AND POVERTY REDUCTION

Dynamic Regional Economywide Model of Ethiopia (DREME)

A new Ethiopian computable general equilibrium (CGE) model was developed to capture (i) trade-offs and synergies from accelerating growth in alternative agricultural sub-sectors; (ii) the economic inter-linkages between agriculture and the rest of the economy; and (iii) the effects of alternative sources of growth on household incomes and poverty. This model is called the Dynamic Regional Economywide Model for Ethiopia (DREME).¹ Although this paper focuses on the agricultural sector, DREME also contains information on the non-agricultural sectors. In total DREME identifies 69 sub-sectors, 24 of which are in agriculture (see Table 1). Agricultural crops fall into five broad groups: (i) cereal crops, which are separated into teff, barley, wheat, maize, and sorghum and millet; (ii) pulses and oilseeds, which is separated into pulses, such as beans, and oilseed crops, such as groundnuts; (iii) horticulture, which is separated into fruits, vegetables, and enset; (iv) higher-value export-oriented crops, which are separated into cotton, sugarcane, tobacco, coffee, tea, and cut flowers; and (v) other crops, which includes chat and other staples, such as root crops. DREME also identifies four livestock sub-sectors, including cattle, milk, poultry, and other animal products.

To complete the agricultural sector, DREME has two further sub-sectors capturing forestry and fisheries. Most of the agricultural commodities listed above are not only exported or consumed by households but are also used as inputs into various processing activities in the manufacturing sector. The seven agricultural processing activities identified in the model include meat and fish processing, dairy, grain milling; sugar refining, beverages, tobacco, and other foods. The agricultural sub-sectors also use inputs from non-agricultural sectors, such as fertilizer from the fertilizer sub-sector and marketing services from the trade and transport sub-sectors.

DREME also captures regional heterogeneity. Farm production is disaggregated across four rural zones, as shown in Figure 1. These include Zone 1a (humid cereals region);² Zone 1b (humid enset region), Zone 2 (drought-prone region); and Zone 3 (pastoralist region). These zones reflect different agro-ecological and climatic conditions across the country.

¹ See Appendix 1 for a discussion of the model equations and parameters. Earlier CGE models for Ethiopia, however, have not included detailed disaggregation of the agriculture sector or households by region (e.g. Gelan, 2002; Lofgren and Bonilla 2005). See Diao and Nin-Pratt (2009) for a fixed-price multiplier analysis using a 1999/2000 Social Accounting Matrix (SAM) of Ethiopia is combined with a detailed regionally disaggregated multi-market model to analyze growth and poverty implications of alternative production scenarios.

² The humid lowland moisture reliable agro-ecological zone shown in Figure 1 is included in Zone 1a (humid cereals), as well.

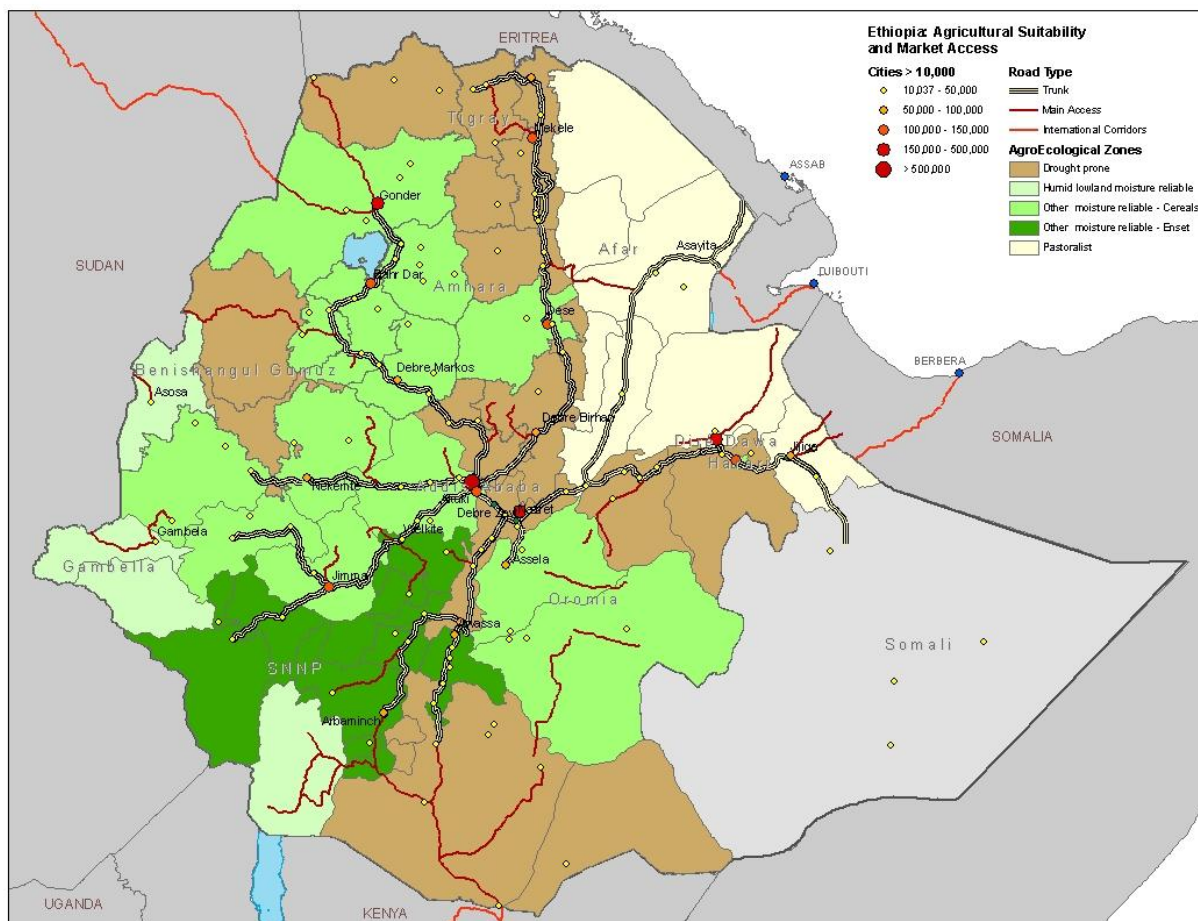
Table 1: Sectors in the DREME model

<u>Agriculture</u>	<u>Non-agriculture</u>
1 Teff	35 Textiles
2 Barley	36 Yarn
3 Wheat	37 Fibers
4 Maize	38 Lint
5 Sorghum	39 Clothing
6 Pulses	40 Leather products
7 Oilseeds	41 Wood products
8 Vegetables	42 Paper and publishing
9 Fruits	43 Petroleum
10 Enset	44 Fertilizer
11 Cotton	45 Chemicals
12 Sugarcane	46 Non-metallic minerals
13 Tea	47 Metals
14 Chat	48 Metals products
15 Tobacco	49 Machinery
16 Coffee	50 Vehicles and transport equipment
17 Flowers	51 Electronic equipment
18 Other crops	52 Other manufacturing
19 Cattle	53 Coal
20 Milk	54 Natural gas
21 Poultry	55 Other mining
22 Animal products	56 Electricity
23 Fisheries	57 Water
24 Forestry	58 Construction
<u>Agricultural processing</u>	59 Wholesale and retail trade
25 Meat	60 Hotels and catering
26 Dairy	61 Transport
27 Vegetable products	62 Communications
28 Grain milling	63 Financial services
29 Milling services	64 Business services
30 Sugar refining	65 Real estate
31 Tea processing	66 Other private services
32 Other foods processing	67 Public administration
33 Beverages	68 Education
34 Tobacco processing	69 Health

Source: Dynamic Regional Economywide Model of Ethiopia (DREME).

DREME captures cropping patterns in each of the four zones. The representative farmer in each zone responds to changes in production technology and commodity demand and prices by reallocating their land across different crops in order to maximize incomes. These farmers also reallocate their labor and capital between farm and non-farm activities, including livestock and fishing, wage employment, and diversification into non-agricultural sectors, such as transport, trade and construction. Thus, by capturing production information across sub-national regions, DREME combines the national or macroeconomic consistency of an economywide model with zonal-level production models. DREME is thus an ideal tool for capturing the growth linkages and income-and price-effects resulting from accelerating growth in different agricultural sectors.

Figure 1: Zones in the DREME model



Finally, DREME endogenously estimates the impact of growth on household incomes and poverty. There are 12 representative household groups in the model, disaggregated by rural zones, small and large urban centers, and poor/non-poor status. ‘Poor’ is defined here as including all households falling into the lowest two per capita expenditure quintiles (i.e., the poorest 40 percent of the population).³ Household income elasticities are based on estimates from the 2004/05 household income and expenditure survey (HICES, 2005) (see Table 2). Each household questioned in HICES 2004/05 is linked directly to the corresponding representative household in the model. This is the micro-simulation component of DREME. In this formulation of the model, changes in representative households’ consumption and prices in the CGE model component are passed down to their corresponding households in the survey, where total consumption expenditures are recalculated. This new level of per capita expenditure for each

³ Given this definition of poverty, we then use the cutoff level of per capita expenditures that defines the poor and non-poor households (separately for the rural and urban areas) as the poverty lines in the subsequent simulations.

survey household is compared to the separate poverty lines for rural and urban areas, and standard poverty measures are recalculated. Thus, poverty is measured in exactly the same way as standard poverty estimates, and changes in poverty draws on the consumption patterns, income distribution and poverty rates captured in the latest household income and expenditure survey.

Table 2: Selected income elasticities in the DREME model

	Rural	Urban		Rural	Urban
Maize	0.70	0.50	Cattle meat	0.80	0.80
Wheat	1.00	0.66	Poultry	0.75	1.15
Teff	1.10	0.70	Milk	0.75	0.75
Other cereals	0.70	0.50	Other meats	0.50	0.50
Root crops	0.50	0.70	Fish	0.70	0.70
Pulses	0.75	0.60	Processed foods	0.80	0.90
Oilseeds	0.80	0.50	Beverages	0.50	0.80
Enset	0.70	0.50	Textiles	1.20	1.00
Vegetables	0.50	0.75	Other manufactures	1.20	1.00
Fruits	0.50	0.75	Construction	0.90	0.50
Sugarcane	0.75	0.60	Utilities	1.00	0.80
Chat	0.70	0.50	Trade and transport	1.00	0.80
Coffee	0.60	0.60	Restaurants	0.80	0.50
Tobacco	0.70	0.50	Other private services	1.10	1.10
			Public services	1.20	0.90

Source: Authors' estimates based on data from the 2004/05 Household Income, Consumption and Expenditure Survey (HICES).

Data sources for the model

The core dataset capturing the economic structure of the Ethiopian economy is the 2005/06 social accounting matrix (SAM) developed by the Economic Development Research Institute (EDRI).⁴ This SAM includes four agro-ecological zones and a detailed regional disaggregation of household groups. Zonal-level agricultural production and area data were taken from the 2005/06 agricultural sample survey were used to identify the four zones and to disaggregate production in the SAM. DREME is therefore consistent with recent agricultural production levels and yields at the zonal level.

⁴ Ahmed et al., (2009).

POVERTY REDUCTION UNDER ETHIOPIA'S CURRENT GROWTH PATH

We use DREME to examine the impact of Ethiopia's current growth path on poverty reduction. This 'business-as-usual' scenario draws on production trends for various agricultural and non-agricultural sub-sectors. Ethiopia experienced rapid growth from 1998 to 2007, with national GDP growing at almost eight percent per year. During this period the agricultural sector did not grow as rapidly, with an average growth rate of six percent per year. However, much of this rapid economic growth has occurred in the last few years, and it is uncertain whether in today's global economic recession, such rapid growth can still be achieved over the near-term. Accordingly, the baseline scenario takes a more cautionary position and assumes average annual agricultural growth of 3.8 percent per year during 2009-2015 (see Table 3).⁵ Although this is below the recent spike in agricultural GDP growth rates, it still assumes a fairly strong performance by the agricultural sector over the coming decade.⁶

More than half of agriculture's strong growth performance during 1998-2007 was driven by land expansion, with the rest resulting from changes in cropping patterns and improvements in yields. For example, land area under maize cultivation expanded by 2.2 percent per year during this period, while yields improved each year by 1.5 percent. Similar patterns were observed for other cereals, with the only exception being wheat, where land area expanded extremely fast at 5.5 percent per year, compared to yield growth of 2.7 percent. Long-term agricultural growth has thus been driven more by expanded cultivated land than by improvements in cropping technologies. The Baseline scenario is calibrated to production trends from 1998-2007 and so it assumes that land expansion will continue along its long-term path, with about two-thirds of production increases driven by area expansion. This is equivalent to an increase in total harvested land by 2.6 percent per year during 2009-2015, which is slightly below to the rural population growth rate of 3.0 percent. According to production trends, land area expansion varies across zones. Cultivated land growth is 2.2 percent per year in Zones 1a and 1b (humid regions), 3.2 percent in Zone 2 (drought-prone region), and 3.7 percent in Zone 3 (pastoralist region). As shown in Table 4, the non-agricultural sectors are expected to maintain their strong performance over the coming decade, with manufacturing and services growing more rapidly than agriculture at 8.2 percent per year.

The 3.8 percent agricultural growth rate in the Baseline scenario is based on more detailed production trends for different agricultural sub-sectors.

⁵ Simulations are run beginning with the base year of 2005/06. Productivity shocks are modeled only from 2008/09 onwards, however (i.e. all scenarios are the same until 2008/09), so simulation results are shown from this year onwards only.

⁶ As discussed in more detail in section 4, five different scenarios were designed for this analysis. Scenarios 1-3 target specific groups of crops or agricultural sub-sectors, including cereals (Simulation 1); export-oriented crops (Simulation 2); and livestock (Simulation 3). The 'all agriculture' scenario (Simulation 4) includes additional growth from the fisheries and forestry sub-sectors. Simulation 5 includes accelerated productivity growth in the 'non-agriculture' sector, as well.

Table 3: Sector growth results from model scenarios

	GDP share, 2009 (%)	Average annual GDP growth rate, 2009-2015 (%)					
		Baseline	Cereals	Export-crops	Livestock	All agric.	Non-agric.
		(1)	(2)	(3)	(4)	(5)	(6)
<u>Total GDP</u>	<u>100.00</u>	<u>5.95</u>	<u>6.26</u>	<u>6.39</u>	<u>6.81</u>	<u>6.88</u>	<u>8.50</u>
<u>Agriculture</u>	<u>44.90</u>	<u>3.81</u>	<u>4.57</u>	<u>4.87</u>	<u>5.81</u>	<u>5.98</u>	<u>6.08</u>
<u>Cereals</u>	<u>13.49</u>	<u>5.18</u>	<u>7.25</u>	<u>7.30</u>	<u>7.51</u>	<u>7.53</u>	<u>7.79</u>
Teff	3.55	5.52	6.49	6.61	6.91	6.90	7.03
Barley	1.56	4.84	6.26	6.38	6.64	6.67	7.08
Wheat	2.95	6.44	10.96	10.87	11.05	11.08	11.41
Maize	3.56	4.08	5.67	5.76	5.93	5.95	6.21
Sorghum	1.87	4.77	5.77	5.83	5.98	5.99	6.22
<u>Pulses & oilseeds</u>	<u>3.83</u>	<u>3.34</u>	<u>3.54</u>	<u>3.60</u>	<u>3.75</u>	<u>3.77</u>	<u>3.73</u>
Pulses	2.78	3.51	3.77	3.77	3.97	4.00	3.94
Oilseeds	1.05	2.90	2.90	3.17	3.17	3.17	3.17
<u>Horticulture</u>	<u>2.45</u>	<u>3.84</u>	<u>3.96</u>	<u>4.01</u>	<u>4.08</u>	<u>4.26</u>	<u>4.32</u>
Vegetables	1.21	3.38	3.38	3.38	3.38	3.59	3.59
Fruits	0.19	3.89	3.89	3.89	3.89	4.09	4.09
Enset	1.05	4.33	4.62	4.72	4.88	5.03	5.16
<u>Export crops</u>	<u>4.50</u>	<u>4.54</u>	<u>4.54</u>	<u>7.20</u>	<u>7.20</u>	<u>7.20</u>	<u>7.20</u>
Cotton	0.45	4.61	4.61	6.91	6.91	6.91	6.91
Sugarcane	0.27	4.92	4.92	5.60	5.60	5.60	5.60
Tobacco	0.01	-1.34	-1.34	0.59	0.59	0.59	0.59
Coffee	3.66	4.54	4.54	7.43	7.43	7.43	7.43
Cut flowers	0.09	3.02	3.02	4.35	4.35	4.35	4.35
<u>Other crops</u>	<u>3.66</u>	<u>3.79</u>	<u>4.07</u>	<u>3.94</u>	<u>3.96</u>	<u>3.97</u>	<u>3.78</u>
Chat	1.45	3.05	3.05	3.05	3.05	3.05	3.05
Other crops	2.21	4.27	4.71	4.50	4.54	4.55	4.25
<u>Livestock</u>	<u>12.94</u>	<u>2.88</u>	<u>2.91</u>	<u>2.93</u>	<u>6.02</u>	<u>6.02</u>	<u>6.14</u>
Cattle	4.84	2.54	2.59	2.64	5.62	5.63	5.32
Milk	5.89	2.93	2.99	3.07	5.74	5.75	5.83
Poultry	0.36	3.23	3.30	3.37	6.86	6.83	6.23
Animal products	1.85	3.51	3.40	3.12	7.67	7.68	8.99
<u>Other agriculture</u>	<u>4.04</u>	<u>1.51</u>	<u>1.52</u>	<u>1.52</u>	<u>1.52</u>	<u>3.52</u>	<u>3.53</u>
Fisheries	0.03	1.41	1.41	1.40	1.39	3.46	3.44
Forestry	4.02	1.51	1.52	1.52	1.52	3.52	3.54
<u>Industry</u>	<u>12.47</u>	<u>7.27</u>	<u>7.27</u>	<u>7.28</u>	<u>7.36</u>	<u>7.36</u>	<u>10.43</u>
<u>Manufacturing</u>	<u>5.24</u>	<u>8.15</u>	<u>8.18</u>	<u>8.17</u>	<u>8.42</u>	<u>8.40</u>	<u>11.35</u>
<u>Agro-processing</u>	<u>2.41</u>	<u>6.08</u>	<u>6.51</u>	<u>6.69</u>	<u>6.83</u>	<u>6.82</u>	<u>8.20</u>
Meat processing	0.03	3.15	3.20	3.29	5.64	5.65	5.65
Dairy	0.00	6.16	6.31	6.55	6.82	6.78	7.67
Grain milling	0.42	6.53	7.18	7.26	7.31	7.27	9.04
Sugar refining	0.03	6.44	6.60	7.23	7.38	7.38	8.69
Other foods	0.70	5.37	5.43	5.44	5.67	5.69	6.85
Beverages	0.10	6.52	6.47	7.03	6.95	6.90	9.67
Tobacco processing	1.03	6.71	6.44	6.96	8.66	8.62	10.94
<u>Other industry</u>	<u>1.89</u>	<u>6.93</u>	<u>6.99</u>	<u>7.05</u>	<u>7.18</u>	<u>7.16</u>	<u>8.93</u>
<u>Services</u>	<u>33.47</u>	<u>8.19</u>	<u>8.20</u>	<u>8.20</u>	<u>8.23</u>	<u>8.25</u>	<u>11.32</u>
Private	11.76	6.80	6.91	7.03	7.16	7.20	9.58
Public	4.88	5.69	5.69	5.69	5.69	5.69	5.71

Source: Results from the Dynamic Regional Economywide Model of Ethiopia (DREME).

Note: The simulations are cumulative, such that the *Export-Crop* scenario includes the productivity gains from the *Cereals* scenario (1) plus additional productivity gains for export crops. Similarly, the *Livestock* scenario (3) includes the productivity gains for both cereals and export crops (i.e., from the previous two scenarios).

Table 4: Production targets for baseline and agricultural growth scenarios

	Crop yields					Crop production					Crop land area	
	Levels (mt/ha)		Target 2015	Growth rates (%)		Levels (1000 mt)			Growth rates (%)		Growth rates (%)	
	Initial 2005	Baseline 2015		Baseline 2005-15	Target 2005-15	Initial 2005	Baseline 2015	Target 2015	Baseline 2005-15	Target 2005-15	Baseline 2005-15	Target 2005-15
Cereals												
Teff	0.76	1.01	1.11	2.86	3.82	2,191	3,660	4,010	5.26	6.23	2.33	2.32
Barley	1.00	1.30	1.51	2.63	4.15	1,271	2,009	2,264	4.68	5.94	2.00	1.73
Wheat	1.20	1.67	2.18	3.40	6.18	2,230	4,105	5,567	6.29	9.58	2.80	3.20
Maize	1.72	1.99	2.32	1.46	3.03	3,647	5,424	6,095	4.05	5.27	2.55	2.17
Sorghum	1.12	1.44	1.56	2.48	3.30	2,608	4,226	4,564	4.94	5.76	2.40	2.37
Pulses & oils												
Pulses	0.92	1.03	1.04	1.08	1.20	1,110	1,632	1,699	3.93	4.35	2.82	3.11
Oilseeds	0.77	0.76	0.78	-0.10	0.08	778	1,035	1,054	2.90	3.08	3.00	3.00
Horticulture												
Enset	7.52	8.74	8.92	1.51	1.72	211	321	336	4.25	4.74	2.70	2.97
Vegetables	4.17	4.54	4.60	0.86	1.00	954	1,321	1,340	3.31	3.45	2.42	2.42
Fruits	13.73	15.78	15.99	1.40	1.54	436	630	639	3.74	3.88	2.31	2.31
Export crops												
Sugarcane	33.69	36.79	38.67	0.88	1.39	1,617	2,614	2,747	4.92	5.44	4.00	4.00
Tea	0.96	1.04	1.08	0.76	1.16	5	9	10	6.81	7.23	6.00	6.00
Cotton	1.01	1.07	1.25	0.58	2.13	86	135	157	4.61	6.21	4.00	4.00
Tobacco	0.67	0.64	0.74	-0.34	1.02	3	3	3	-1.33	0.01	-1.00	-1.00
Coffee	0.66	0.66	0.81	0.04	2.12	157	244	300	4.54	6.72	4.50	4.50
Flowers	1.00	1.10	1.21	1.00	1.91	10	13	15	3.02	3.95	2.00	2.00
Other crops												
Chat	0.77	0.79	0.79	0.19	0.19	120	165	165	3.24	3.24	3.05	3.05
Other staple	4.89	5.26	5.30	0.73	0.80	1,576	2,537	2,586	4.87	5.07	4.12	4.24
All crops											2.62	2.62

Source: Crop targets drawn from consultations with CAADP stocktaking team and representatives from the Ministry of Agriculture; final sector targets are based on results from the Dynamic Regional Economywide Model of Ethiopia (DREME).

Notes: Growth rates shown are national averages. Baseline 2015 denotes levels in the baseline scenario for 2015. Baseline 2005-15 denotes the growth rate in the baseline scenario from 2005 to 2015.

Table 4 shows the assumptions made about each sub-sector's yield growth. We initially adopt the teff yield of 0.76 tons per hectare that was observed in 2005/06 and then assume that teff yields grow at 2.86 percent per year such that Ethiopia achieves a sustained national average teff yield of 1.01 tons per hectare by 2015). Land area under teff cultivation also grows at 2.33 percent each year under the Baseline scenario, such that overall production expands by 5.26 percent. This is consistent with observed production patterns for 1998-2007. Moreover, yield and area expansions vary at the zonal-level based on actual production trends. The Baseline thus reflects expected improvements in the performance of the teff sector over the next decade with the rate of growth of investments continuing as before. Similarly, for wheat, we assume that initial yields continue to grow rapidly at 3.40 per year, and that yields rise to 1.67 tons per hectare by 2015. National and regional production of each of the five cereals crops in DREME is thus calibrated to closely reproduce long-term production trends.

National production trends were used to calibrate the Baseline growth rates for non-cereals crops. Particularly rapid production growth was observed for the horticultural crops, including fruits, vegetables and enset. However, unlike cereals, these high growth rates were driven more by land expansion than by improvements in crop yields. For example, during 1998-2007, enset yields remained largely unchanged, but cultivated land area grew extremely fast. This is reflected in the Baseline scenario, where the production growth rate is driven mainly by a faster expansion of enset land area. Similar biases towards land expansion over yield improvements were observed for pulses, oilseeds, and other staples, such as root crops.

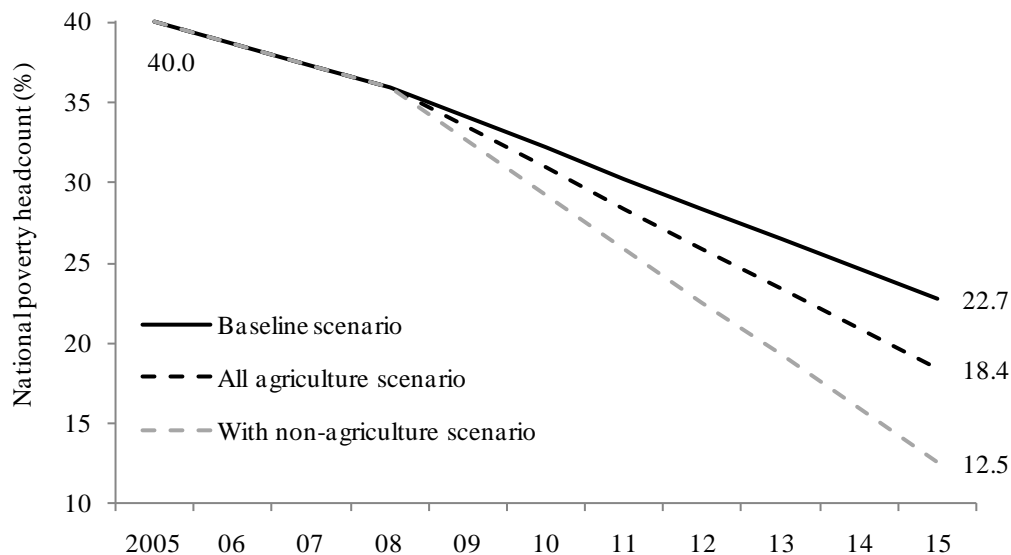
Industrial and export crops performed quite well during 1998-2007, with the exception of tobacco, whose production levels declined slightly. This is reflected in the Baseline scenario. For example, coffee and cotton production rises by 4.54 and 4.61 percent per year respectively during 2009-2015. This is driven by a fairly rapid expansion of land area under export crop cultivation. The Baseline scenario therefore assumes that the export-oriented continue to grow rapidly, albeit slower than the major staple crops. Only tobacco production is expected to decline based on long-term trends.

Livestock is a key agricultural sub-sector generating a significant share of agricultural GDP, and with strong upstream linkages to meat processing in the manufacturing sector (see Table 3). The Baseline scenario assumes that livestock GDP will expand at a rate of 2.9 percent per year. This is below the rapid growth of the crop sectors, but is entirely consistent with livestock GDP growth rates reported in national accounts for 1998-2007. The Baseline scenario does reflect more rapid growth in the milk and poultry sub-sectors. Fisheries and forestry are also agricultural sub-sectors in DREME, with the latter generating 4.04 percent of total agricultural GDP in 2005/06. Based on national accounting for the period 1998-2007, the Baseline scenario assumes that fisheries GDP remains virtually unchanged during 2009-2015. For the forestry

sub-sector, the Baseline scenario assumes that value-added in this sub-sector will grow at 4.02 percent per year.

Drawing on the above trends, DREME simulation results indicate that, with four percent growth in the agricultural sector and more rapid growth in the non-agricultural sectors, overall national GDP will grow at an average rate of 5.95 percent during 2009-2015. This is equal to the average GDP growth rate of six percent observed for 1998-2007, thus assuming that Ethiopia's economy will maintain its long-term growth rate over the coming decade. With population growth at three percent per year, this means that per capita GDP also grows rapidly at about three percent. With rising per capita incomes and growth across all sectors, DREME estimates that poverty will decline from 40 percent to 23 percent during 2005-2015 (see Figure 2). The faster expansion of the non-agricultural sectors means that national income growth favors urban households and areas more than rural ones. For example, poverty falls in small urban centers from 34 to 9 percent by 2015, while rural poverty declines from 41 to 25 percent. Given overall rapid poverty reduction, and despite an expanding population, the absolute number of poor people in Ethiopia would decline from 25.8 million people in 2005 to 19.6 million by 2015. While this is a significant reduction in the number of poor people living in Ethiopia, it reveals the persistent burden of poverty in the country and emphasizes the need for reinforcing pro-poor sources of economic growth.

Figure 2: National poverty results from model scenarios.



Source: Results from the Dynamic Regional Economywide Model of Ethiopia (DREME).
 Note: The 'poverty headcount' is the percentage share of the population living below the poverty line. We assign the poverty line so that 40 percent of the population is classified as 'poor' (i.e., the bottom two expenditure quintiles).
 As noted in footnote 5 above, all simulations are the same from 2005 to 2008. Productivity shocks are modeled from 2009 onwards.

ACCELERATING AGRICULTURAL GROWTH AND POVERTY REDUCTION

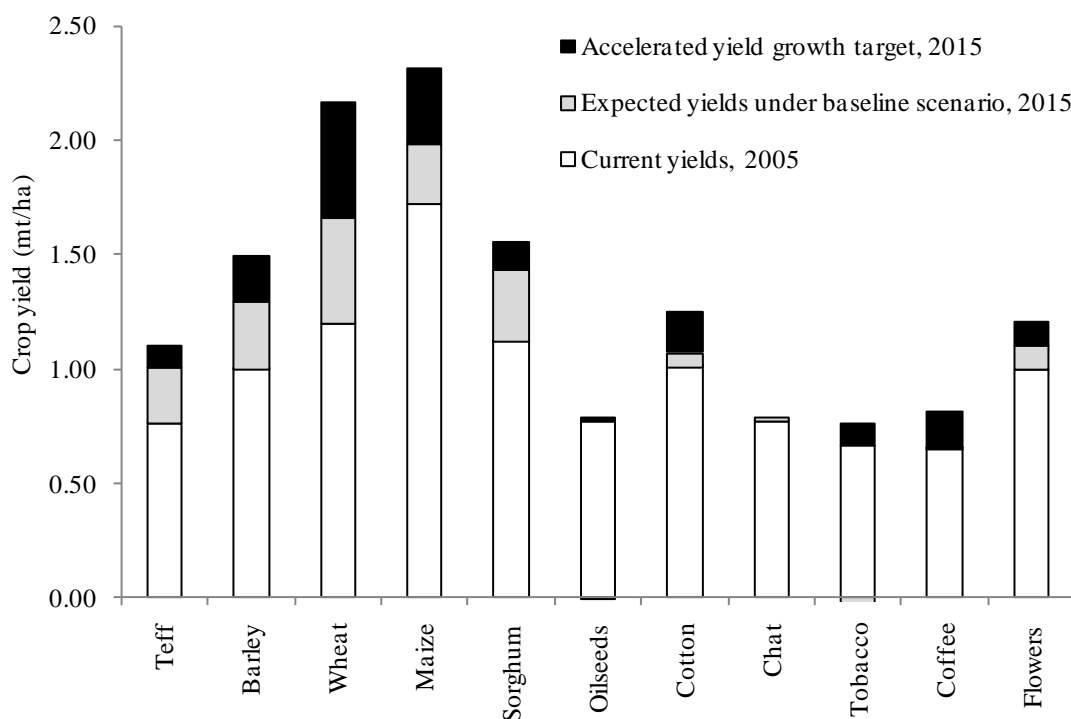
In the previous section we described the results of the Baseline scenario, which estimated the impact of Ethiopia's current growth path on poverty reduction. We found that while economic growth over the coming decade is expected to remain robust and will halve the national poverty rate by 2015, it will reduce the number of poor people by less than one-third. Therefore, in this section we examine whether a medium-term six percent agricultural growth target identified by CAADP is achievable, based on reasonable sub-sector growth potentials. We also estimate the potential contribution of different agricultural sub-sectors in helping Ethiopia substantially reduce poverty throughout the country.

A sustained six percent agricultural growth rate is achievable

Accelerated crop production is modeled by increasing yields in order to achieve yield targets identified for 2015. Taking teff as an example, under the Baseline scenario we assumed that average yields would rise from 0.76 to 1.01 tons per hectare during 2006-2015 (see Table 4). In this section we model more ambitious teff yield improvements, with the annual yield growth rate for teff rising from its current 2.86 percent per year to 3.82 percent per year. This implies that national average teff yields will rise consistently over the next decade to reach 1.11 tons per hectare by 2015. This national target yield was identified together with the CAADP stocktaking team and in consultation with the Ministry of Agriculture and Rural Development (MOARD). The yields of other crops were also increased in a similar manner but to differing degrees based on long-term trends and potential yields (see Figure 3). Production growth targets were also identified for the livestock and fisheries subsectors.

Five different scenarios were designed for this analysis (Table 3). In Scenarios 1-3 we target specific groups of crops or agricultural sub-sectors, including cereals (Simulation 1); export-oriented crops (Simulation 2); and livestock (Simulation 3). For instance, in the 'cereals-led growth' scenario we increase total factor productivity (TFP) for all cereals crops so as to achieve the crop-specific yield target shown in Table 4. In the non-crop scenarios, such as 'livestock-led growth', we also increase total factor productivity (TFP) to achieve targeted GDP growth rates. The results of each simulation are cumulative, so that Simulation 2 includes the effects of Simulation 1, Simulation 3 includes the effects of Simulation 2, and so on. In the 'all agriculture' scenario (Simulation 4), we include additional growth from the fisheries and forestry sub-sectors. This is equivalent a 'CAADP' scenario, since it captures all possible sources of additional agricultural growth. Finally, in the 'non-agriculture' scenario (Simulation 5), we accelerate economic growth in not just the agricultural sector, but in non-agriculture as well. The results of these scenarios are discussed below.

Figure 3: Current, expected and targeted crop yields



Source: Crop targets drawn from consultations with CAADP stocktaking team and representatives from the Ministry of Agriculture; final sector targets are based on results from the Dynamic Regional Economywide Model of Ethiopia (DREME).

Under the 'All Agriculture' scenario, agricultural growth accelerates to six percent per year for the period 2009-2015 (see Table 3). This is driven by a strong expansion in cereals production. For example, wheat production increases from about four million tons under the Baseline scenario to over six million tons under the 'All Agriculture' scenario (see Table 4). Similarly large expansions of coffee production are also achieved under this accelerated scenario. Thus, even though the additional growth required for other crops is less pronounced, the achievement of the six percent agricultural growth target remains ambitious. Livestock growth would also have to double from an annual average growth rate of 2.88 percent per year under the Baseline scenario to 6.02 percent under the 'All Agriculture' scenario. However, despite these challenges, the results from DREME indicate that if the crop yield and livestock productivity targets can be achieved by 2015 then Ethiopia will be able to achieve and sustain the six percent agricultural growth target set forth by CAADP.

Since agriculture is more than a third of the Ethiopian economy, the acceleration of agricultural growth increases the national GDP growth rate from its current 5.95 percent per year to 6.88 percent per year. Faster agricultural growth also stimulates additional growth in the non-

agricultural sectors, by raising final demand for non-agricultural goods and by lowering input prices and fostering upstream processing. For instance, under the 'All Agriculture' scenario, the GDP growth rate of agriculture-processing in the manufacturing sector increases from 6.08 percent under the Baseline scenario to 6.82 percent per year. Achieving the six percent agricultural growth target therefore has economywide growth-linkage effects for non-agriculture.

Finally, we examine the impact of accelerating economic growth outside of agriculture. In the 'Non-agriculture' scenario we increase the productivity growth rates of the nonagricultural subsectors by an additional two percentage points per year during 2009-2015. As shown in Table 4, this causes the national GDP growth rate to increase from 6.88 percent under the 'All Agriculture' scenario to 8.50 percent. Faster nonagricultural growth also stimulates additional demand for agriculture, thus helping raise agriculture's GDP growth above the six percent target. The increase in demand for agricultural products is larger for cereals and livestock, which form a larger share of urban households' and nonagricultural workers' consumption baskets, and whose incomes are rising as a result of faster nonagricultural growth. Thus, accelerating agricultural growth has positive economywide effects, which can be further strengthened by an expanded nonagricultural sector.

Agricultural growth greatly reduces poverty

The acceleration of agricultural growth to around six percent per year under the 'All Agriculture' scenario and its spillover effects into non-agriculture causes poverty to decline by a further 4.3 percentage points. This is shown in Figure 2, where the share of Ethiopia's population under the poverty line falls to 18.36 percent by 2015 under the 'All Agriculture' scenario compared to 22.67 percent under the Baseline scenario. Thus, taking population growth into account, achieving the six percent growth target lifts an additional 3.7 million people above the poverty line by 2015. This is sufficient to almost halve the number of poor people in Ethiopia today (i.e., from 25.8 to 15.9 million).

Faster agricultural growth benefits a majority of households. However, not all households in all agro-ecological zones benefit equally from achieving the higher crop yields and faster sub-sector growth rates targeted under the 'All Agriculture' growth scenario. Table 5 shows how poverty rates change under the various scenarios. Poverty declines amongst both rural and urban households, although the declines are more than twice as large in rural areas. Moreover, there are large declines in rural poverty rates in the two zones where poverty is initially highest: humid enset region (Zone 1b) and drought-prone region (Zone 2). Within urban areas, households in both small and large urban centers benefit from faster agricultural growth. This is because urban households usually spend a significant share of their incomes on food and agricultural products. They thus benefit from faster agricultural growth and lower food prices.

Table 5: Household poverty results from model scenarios

	Initial poverty headcount (%)		Final year poverty headcount, 2015 (%)					
			Baseline	Cereals	Export-crops	Live-stock	All agric.	Non-agric.
	2005	2008	(1)	(2)	(3)	(4)	(5)	(6)
National	40.02	35.88	22.67	20.28	19.36	18.38	18.36	12.46
Rural regions	41.33	37.28	25.49	22.80	21.80	20.82	20.77	13.72
Humid cereals (1a)	38.19	33.91	20.71	18.48	17.65	17.35	17.35	12.12
Humid enset (1b)	44.98	41.05	30.15	27.66	26.26	24.83	24.41	15.05
Drought-prone (2)	47.97	44.14	33.13	29.43	28.31	26.92	27.08	17.77
Pastoralist (3)	27.70	24.11	16.10	13.45	12.91	10.19	10.19	6.12
Small urban centers	33.95	28.94	8.57	7.55	7.10	6.20	6.41	5.18
Large urban centers	32.95	29.16	9.30	8.48	7.84	6.75	6.77	8.16

Source: Results from the Dynamic Regional Economywide Model of Ethiopia (DREME).

Note: The 'poverty headcount' is the percentage share of the population living below the poverty line. We assign the poverty line so that 40 percent of the population is classified as 'poor' (i.e., the bottom two expenditure quintiles).

The impact of agricultural growth on households' incomes and poverty depends on a number of factors. One key factor is the geographic distribution of agricultural production. As indicated in Table 6, higher-value export-oriented crops are grown more intensively in certain zones.⁷ Coffee, for example, is concentrated in the humid cereals region (Zone 1a). However, it forms a large share of agricultural GDP in the humid enset (Zone 1b). Similarly, while cereals form a large share of agricultural GDP in the humid cereals region (Zone 1a), it also contributes a large share to the poorer drought-prone region's agricultural GDP (i.e., it is 41.8 percent in Zone 1a and 34.1 percent in Zone 2). Finally, livestock is a key sector in all regions, contributing between one-quarter to one-third to agricultural GDP in Zones 1a, 1b and 2. However, it is especially important in the pastoralist region, where it accounts for most of agricultural GDP, with the remaining agricultural incomes dominated by cereals. These concentrations of particular crops and sub-sectors will influence how agricultural growth driven by certain sectors affects household incomes in different parts of the country.

The sources of additional incomes also vary across representative households within zones. Not surprisingly, households that already depend more on cereals tend to benefit more from cereals-led growth. However, there are two forces driving changes in production following sub-sector-specific yield improvements. First, increasing cereals yields directly effects farm incomes since it increases the quantity of output that a farm produces using the same quantity of factor inputs. But since supply of the agricultural product increases faster than demand (unless incomes are rising rapidly from other sources), prices typically fall following yield increases. In response to these price changes, farmers may reallocate some of their land to other crops.

⁷ Note that agricultural GDP in Table 5 excludes fisheries and forestry (i.e., only includes crops and livestock).

Thus it is important to note that, while we model cereals-led growth by increasing cereals yields, some of the gains under this scenario are derived from diversification into other higher-value crops facing better demand conditions. DREME captures both direct and indirect effects in its assessment of the effects of improved yields in different sub-sectors.

Real income and poverty impacts are also determined by household consumption demand. For example, households that spend a significant share of their incomes on cereals will benefit from lower prices when cereals production rises. Household consumption patterns are based on the 2004/05 household income and expenditure survey, as captured in the 2005/06 EDRI social accounting matrix. The average budget shares for different household groups are shown in Table 7. Even though relatively little agricultural GDP in the Pastoralist region (Zone 3) is derived from cereals production, households in this region spend 16 percent of their disposable income on cereals. Thus, while a national expansion of cereals production may not directly benefit households in the Pastoralist region, it will indirectly benefit them through lower food prices. This is also the case for urban households, who derive relatively little income from agriculture directly, but spend at least a third of their incomes on agricultural goods and processed foods. Together with regional production patterns, these average budget shares and the income elasticities in Table 2 will determine the impact of agricultural growth on poverty.

Figure 4 shows the importance of taking demand constraints and relative price changes into account. Wheat, for example, faces domestic demand constraints and has weaker linkages to upstream food processing and foreign markets. As such, when wheat production increases substantially under the 'All Agriculture' scenario, its prices decline by seven percent in real terms (or relative to the overall consumer price index). Milk and cattle product prices decline in more sharply (by more than 15 percent), highlighting the crucial importance of improved marketing in these sub-sectors. By contrast, some agricultural subsectors do not experience yield improvements under the 'All Agriculture' scenario, such as pulses and horticulture, and so increased household incomes causes real prices for these crops to rise. Finally, some crops may also have stronger linkages to upstream processing and foreign markets, such as coffee, which means that their prices are quite stable, even in the 'All Agriculture' scenario.

In summary, DREME results indicate that it is possible for Ethiopia to reach the CAADP target of six percent agricultural growth. It will, however, require substantial improvements in crop yields and livestock productivity over a relatively short period of time (i.e., seven years). If these crop- and sub-sector-level targets can be achieved then the resulting broader-based agricultural growth is likely to benefit households in both rural and urban areas. However, the higher growth potential of certain export crops and better market conditions in certain parts of the country may cause uneven income growth and poverty reduction. The livestock sub-sectors also contribute to agricultural growth and poverty reduction throughout the country. Finally, accelerating nonagricultural growth can reduce some of the demand constraints on agricultural growth

Table 6: Regional growth results under model scenarios

	Initial agric. GDP share (%)	Average annual GDP growth rate, 2009-2015 (%)					
		Baseline	Cereals	Export- crops	Livestock	All agric.	Non-agric.
		(1)	(2)	(3)	(4)	(5)	(6)
<u>National (all zones)</u>							
Agriculture	100.00	4.02	4.84	5.17	6.18	6.20	6.32
Cereals	33.01	5.18	7.25	7.30	7.51	7.53	7.79
Pulses & oils	9.37	3.34	3.54	3.60	3.75	3.77	3.73
Horticulture	5.99	3.84	3.96	4.01	4.08	4.26	4.32
Export crops	11.00	4.54	4.54	7.20	7.20	7.20	7.20
Other staples	8.96	3.79	4.07	3.94	3.96	3.97	3.78
Livestock	31.67	2.88	2.91	2.93	6.02	6.02	6.14
<u>Humid cereals (1a)</u>							
Agriculture	100.00	4.05	5.15	5.50	6.31	6.33	6.46
Cereals	41.77	5.19	7.54	7.58	7.79	7.81	8.06
Pulses & oils	12.17	2.90	2.96	3.03	3.17	3.19	3.09
Horticulture	4.18	2.94	2.85	2.86	2.89	3.08	3.06
Export crops	9.88	4.55	4.55	7.55	7.55	7.55	7.55
Other staples	3.60	2.97	3.07	3.11	3.17	3.18	3.24
Livestock	28.39	2.88	2.92	2.93	5.63	5.64	5.75
<u>Humid enset (1b)</u>							
Agriculture	100.00	3.70	4.16	4.85	5.45	5.48	5.52
Cereals	17.57	2.75	4.77	4.88	5.08	5.10	5.39
Pulses & oils	4.81	4.49	4.95	4.96	5.18	5.21	5.26
Horticulture	13.46	4.15	4.35	4.43	4.54	4.71	4.83
Export crops	22.43	4.52	4.52	7.37	7.37	7.37	7.37
Other staples	21.12	3.89	4.13	3.93	3.97	3.97	3.71
Livestock	20.61	2.87	2.91	2.92	5.64	5.65	5.76
<u>Drought-prone (2)</u>							
Agriculture	100.00	4.42	5.13	5.33	6.09	6.11	6.22
Cereals	34.07	5.79	7.36	7.41	7.63	7.64	7.92
Pulses & oils	9.41	3.95	4.35	4.43	4.57	4.59	4.64
Horticulture	6.51	4.41	4.68	4.73	4.80	4.98	5.04
Export crops	9.69	4.53	4.53	6.40	6.40	6.40	6.40
Other staples	13.50	4.07	4.45	4.31	4.30	4.31	4.08
Livestock	26.81	2.87	2.91	2.92	5.61	5.62	5.74
<u>Pastoralist (3)</u>							
Agriculture	100.00	2.91	2.93	2.95	7.17	7.18	7.30
Cereals	2.37	3.31	2.54	2.61	2.77	2.78	3.00
Pulses & oils	0.06	5.77	7.12	7.07	7.23	7.24	7.19
Horticulture	0.56	4.25	4.25	4.25	4.25	4.46	4.46
Export crops	0.14	4.67	4.67	4.67	4.67	4.67	4.67
Other staples	1.38	3.86	3.86	3.86	3.86	3.86	3.86
Livestock	95.49	2.88	2.91	2.93	7.33	7.33	7.45

Source: Results from the Dynamic Regional Economywide Model of Ethiopia (DREME).

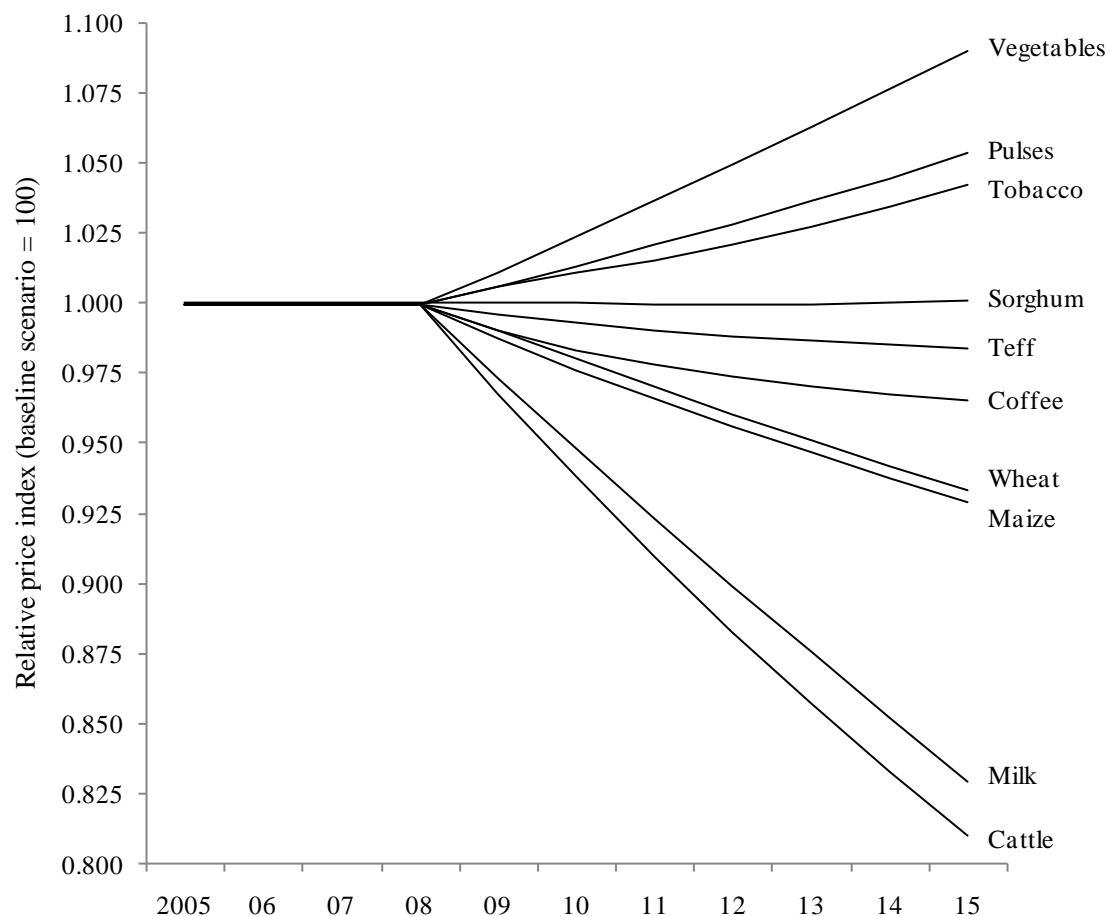
Note: Agricultural GDP in this table excludes fisheries and forestry, since these two sectors are not regionalized in DREME. The national agricultural growth rate is therefore slightly higher in this table.

Table 7: Household average consumption shares

	Rural households							Urban households				
	All	Zone 1a	Zone 1b	Zone 2	Zone 3	Poor	Non-poor	All	Small centers	Large centers	Poor	Non-poor
<u>All goods and services</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
<u>Agriculture</u>	<u>53.7</u>	<u>53.4</u>	<u>47.1</u>	<u>57.1</u>	<u>56.8</u>	<u>59.3</u>	<u>51.1</u>	<u>26.9</u>	<u>31.1</u>	<u>21.8</u>	<u>42.4</u>	<u>22.6</u>
Cereals	20.5	23.1	13.1	21.8	15.8	24.6	18.6	8.6	10.1	6.9	16.3	6.5
Pulses & oilseeds	4.2	5.0	2.7	4.5	1.4	4.8	4.0	1.6	1.8	1.3	2.9	1.2
Horticulture	3.6	2.5	7.5	3.5	0.5	3.9	3.5	1.3	1.5	1.0	2.2	1.0
Export crops	2.6	2.8	3.7	1.9	1.3	2.9	2.5	1.2	1.5	0.8	2.0	1.0
Other crops	5.8	4.8	5.4	7.4	5.8	5.9	5.8	3.3	3.9	2.6	5.2	2.8
Livestock	10.6	9.1	6.8	11.6	28.3	11.6	10.1	8.6	9.0	8.1	10.4	8.1
Other agriculture	6.3	6.0	7.8	6.4	3.6	5.6	6.7	2.4	3.4	1.1	3.3	2.1
<u>Industry</u>	<u>25.7</u>	<u>24.1</u>	<u>30.9</u>	<u>24.3</u>	<u>29.4</u>	<u>21.7</u>	<u>27.6</u>	<u>44.7</u>	<u>41.4</u>	<u>48.8</u>	<u>36.2</u>	<u>47.1</u>
<u>Manufacturing</u>	<u>24.9</u>	<u>23.4</u>	<u>30.3</u>	<u>23.3</u>	<u>28.6</u>	<u>20.8</u>	<u>26.8</u>	<u>41.2</u>	<u>39.0</u>	<u>43.8</u>	<u>33.5</u>	<u>43.3</u>
Agro-processing	12.2	11.7	14.2	11.3	15.2	11.2	12.7	16.1	16.7	15.4	19.1	15.3
<u>Other industry</u>	<u>0.8</u>	<u>0.7</u>	<u>0.6</u>	<u>1.0</u>	<u>0.8</u>	<u>0.8</u>	<u>0.8</u>	<u>3.5</u>	<u>2.4</u>	<u>4.9</u>	<u>2.8</u>	<u>3.8</u>
<u>Services</u>	<u>20.6</u>	<u>22.5</u>	<u>21.9</u>	<u>18.6</u>	<u>13.8</u>	<u>19.0</u>	<u>21.4</u>	<u>28.4</u>	<u>27.5</u>	<u>29.4</u>	<u>21.4</u>	<u>30.3</u>

Source: EDRI social accounting matrix (Ahmed et al., 2009).

Figure 4: Changes in real market prices from baseline values under 'All Agriculture' scenario.



Source: Results from the Dynamic Regional Economywide Model of Ethiopia (DREME).

Note: These are real prices changes for selected products relative the prices achieved under the baseline scenario (adjusted for changes in the overall consumer price index). They therefore show how additional production places downward pressure on some commodities' prices, but rising incomes and demand allow some commodities' prices to rise when growth is accelerated.

Comparing sub-sector growth in terms of growth and poverty reduction

The previous section highlighted the potential contributions of different crops and sub-sectors in increasing agricultural growth and poverty reduction. However, the different sizes of these sub-sectors made it difficult to compare the effectiveness of sector growth in reducing poverty. Understanding how growth-poverty linkages vary at the sub-sector and household level is important for designing pro-poor growth strategies in different parts of the country. In this section we calculate poverty-growth elasticities that allow us to compare the 'pro-poorness' of growth in alternative sub-sectors. These elasticities are endogenous outcomes from the model results. Growth affects individual households differently due to heterogeneity across household

groups. The above analysis has shown how, with differences in household and farm characteristics, changes in income and consumption across households can differ considerably from average changes at the national level. Thus, to capture growth-poverty linkages, changes in the distribution of incomes, which are primarily determined by a country's initial conditions, need to be understood. In the previous section we saw how households in certain regions have better opportunities to produce export-oriented crops, and are thus better positioned to benefit from export-crop-led agricultural growth. However, export-crop-producing households are typically less poor than other rural households. Thus, agricultural growth driven by export crops may have less of an impact on poverty, especially amongst the poorest households. By contrast, cereals tend to be a more important source of agricultural incomes for poorer households. Thus, growth in cereals may be more effective at reducing poverty than similar growth in export crops.

The 'poverty-growth elasticity' measures the responsiveness of the poverty rate to changes in per capita agricultural GDP growth. More specifically, the elasticity measures the percentage change in the poverty rate caused by one percent increase in agricultural GDP per capita. Table 8 shows the calculated poverty-growth elasticities under the different growth scenarios. The results indicate that agricultural growth driven by cereals is particularly effective at reducing poverty in the drought-prone region (Zones 2 and 3), where households are generally poorer and depend more heavily on incomes from cereals production. Poverty in the Pastoralist region (Zone 3) is also greatly affected by cereals-led growth due to these crops importance in poorer households' consumption baskets (see Table 7). For a similar reason, cereals-led growth is also effective at reducing poverty in smaller urban centers, where households are poorer than in larger centers and thus spend a larger share of their incomes on purchasing cereals and milled grains.

Table 8: Poverty-growth elasticities from model scenarios

	Percentage change in poverty headcount rate from a one percent increase in national agricultural GDP led by the following sectors...		
	Cereals-led	Export-crops-led	Livestock-led
National	-1.17	-1.08	-0.36
Rural regions	-1.27	-1.13	-0.35
Humid cereals (1a)	-1.16	-1.03	-0.12
Humid enset (1b)	-1.06	-1.44	-0.46
Drought-prone (2)	-1.48	-1.06	-0.42
Pastoralist (3)	-1.94	-0.93	-1.50
Small urban centers	-0.62	-0.65	-0.42
Large urban centers	-0.50	-0.92	-0.50

Source: Results from the Dynamic Regional Economywide Model of Ethiopia (DREME).
Note: The 'poverty headcount' is the percentage share of the population living below the poverty line. We assign the poverty line so that 40 percent of the population is classified as 'poor' (i.e., the bottom two expenditure quintiles).

In contrast, expanding export crops is most effective at reducing poverty in the humid enset region (Zone 1b) and amongst households in larger urban centers, who are better endowed with capital and other assets needed to produce export crops. Finally, livestock production is especially effective at reducing poverty in urban areas and amongst rural households in the pastoralist region (Zone 3). Urban consumers spend a larger share of their incomes on meat and dairy and so benefit more when production in this sector expands (see Table 7). Overall, however, it is cereals that is most effective at reducing national poverty, since a larger share of poor household depend on cereals for their incomes, and since more poor consumers (in rural and urban areas) spend a greater share of their income on cereals and milled grains.

The previous section concluded that to increase agricultural growth and reach the six percent growth target, it will be necessary to encourage growth in a number of agricultural sub-sectors. The poverty-growth elasticities suggest that cereals should be afforded a high priority in any strategy aimed at substantially reducing poverty. Moreover, cereals already form a large part of the agricultural sector and have high enough growth potential to substantially raise agricultural and national GDP. Cereals are therefore a priority sector for increasing investments.

SUMMARY OF MAJOR FINDINGS

A new economywide modeling framework was developed and used to examine the contribution of accelerating growth in alternative agricultural crops and sub-sectors and to assess how Ethiopia can achieve the CAADP target of six percent agricultural growth. The impact of agricultural growth at the macro- and microeconomic levels, as well as on poverty, was estimated. The three major conclusions of this paper are summarized below.

Six percent agricultural growth is ambitious but achievable

The CGE model results indicated that if Ethiopia can meet its targets for crop yields and livestock productivity, then it should be possible to reach and sustain the six percent agricultural growth target during 2006-2015. Even though these yield targets are below the maximum potential yields identified by agricultural field trials, they are still ambitious given the short timeframe of the CAADP initiative (i.e., seven years). However, by focusing additional growth in agriculture, agricultural growth at six percent per year would increase overall GDP growth by one percentage point per year. This higher growth rate would reduce national poverty to 18.36 percent by 2015, which is lower than the 22.67 percent poverty rate that would have been achieved without additional agricultural growth. This means that the higher growth under the accelerated agricultural growth scenario would lift an additional 3.7 million people above the poverty line by 2015.

Not everyone will benefit equally under the CAADP growth scenario

Most households are expected to benefit from faster agricultural growth. However, some agro-ecological zones that grow higher-value cereals and export-oriented crops and which are better situated to larger urban markets (e.g., the rain sufficient highlands) stand to gain more than other parts of the country. Furthermore, poverty amongst households in some zones will remain high, despite faster agricultural growth. Finally, both rural and urban households benefit from faster agricultural growth, although rural households benefit more. This is because, agricultural incomes are most important for rural households, but food commodities are an important part of the consumption baskets of both urban and rural households.

The composition of agricultural growth matters

Comparing the effectiveness of growth driven by different sub-sectors in reducing poverty and encouraging broader-based growth, additional growth driven by cereals have larger impacts on poverty reduction, especially in rural areas. This is because these crops are already large and so can contribute substantially to achieving broad-based agricultural growth. Yield improvements in these crops not only benefit households directly, by increasing incomes from agricultural production, but also by allowing farmers to diversify their land allocation towards other higher-value crops. Cereals are also effective at raising rural real incomes and reducing poverty, especially amongst the poorest households. Thus, high priority should be afforded to improving cereals yields and opening market opportunities for upstream processing to reduce demand constraints.

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APPENDIX 1: SPECIFICATION OF THE CGE AND MICRO-SIMULATION MODEL

A computable general equilibrium (CGE) model was developed to assess sector-specific growth options and their poverty impacts. The model is calibrated to the Economic Development Research Institute's 2005/06 social accounting matrix (SAM) that provides information on demand and production for 69 detailed sectors (see Table 1).⁸ The model further disaggregates agricultural activities across agro-ecological regions using data from the 2005 agricultural sample survey. Based on the SAM, the production technologies across all sectors are calibrated to their current situation, including each sector's use of primary inputs, such as land, labor and capital, and intermediate inputs. To capture existing differences in labor markets, the model classifies employed labor into different sub-categories, including skilled, semi-skilled and unskilled workers based on occupational categories. Information on employment and wages by sector and region is taken from the 2004/05 household income and expenditure survey (HICES, 2005).

Most workers in the model can migrate between regions and sectors. These workers are disaggregated according to occupational categories (i.e., administrators; professional; skilled; and unskilled). Agricultural family labor is region-specific but mobile across agricultural subsectors. Both agricultural and nonagricultural capital investments move freely across regions and within the broad non-agriculture sector. The 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. Once invested, capital becomes sector-specific and can only be adjusted through exogenously-determined depreciation and the attraction of new investments. Incomes from employment accrue to households according to employment and wage data from the household survey. This detailed specification of production and factor markets in the model allows it to capture the changing scale and technology of production across sectors and sub-national regions, and therefore, how changes in the economic structure of growth influences its distribution of incomes.

The growth-poverty relationship is examined by combining a CGE and microsimulation model. An important factor determining the contribution of agriculture to overall economic growth is its linkages with the rest of the economy. Agriculture's proponents argue that agriculture has strong growth-linkages. The model captures production linkages by explicitly defining a set of nested constant elasticity of substitution (CES) production functions allowing producers to generate demand for both factors and intermediates. The CGE model also captures forward and backward production linkages between sectors. Import competition and export opportunities are modeled by allowing producers and consumers to shift between domestic and foreign markets depending on changes in the relative prices of imports, exports and domestic goods. More

⁸ The model is a variant of the basic neo-classical CGE model developed by Dervis, de Melo and Robinson (1982) and Lofgren, Harris and Robinson (2001), and closely follows that of Thurlow (2005).

specifically, the decision of producers to supply domestic or foreign markets is governed by a constant elasticity of transformation (CET) function, while substitution possibilities exist between imports and domestically supplied goods under a CES Armington specification. In this way the model captures how import-competition and the changing export opportunities of agriculture and industry can strengthen or weaken the linkages between growth and poverty.

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

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

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

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

For the simulations of agricultural productivity gains presented in this paper, total factor productivity growth in specified crop, livestock or industrial sectors is exogenously increased, according to the structure of each particular simulation. The productivity shock simulations are cumulative, with each successive simulation including the productivity shocks from the earlier simulations. Thus, for example, the Export-Crop scenario (simulation 2) includes the productivity gains from the Cereals scenario (simulation 1) plus additional productivity gains for export crops. Similarly, the Livestock scenario (simulation 3) includes the productivity gains for both cereals and export crops (simulation 2) plus additional productivity gains in the livestock sector. As noted in footnote 5 above, all simulations use the same productivity growth rates for all sectors from 2005 to 2008. The productivity shocks differ across simulations only from 2009 onwards.

Table A1. CGE model sets, parameters, and variables

Symbol	Explanation	Symbol	Explanation
Sets			
$a \in A$	Activities	$c \in CMN(\subset C)$	Commodities not in CM
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CT(\subset C)$	Transaction service commodities
$c \in C$	Commodities	$c \in CX(\subset C)$	Commodities with domestic production
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$f \in F$	Factors
$c \in CDN(\subset C)$	Commodities not in CD	$i \in INS$	Institutions (domestic and rest of world)
$c \in CE(\subset C)$	Exported commodities	$i \in INSD(\subset INS)$	Domestic institutions
$c \in CEN(\subset C)$	Commodities not in CE	$i \in INSDNG(\subset INSD)$	Domestic non-government institutions
$c \in CM(\subset C)$	Aggregate imported commodities	$h \in H(\subset INSDNG)$	Households
Parameters			
$cwts_c$	Weight of commodity c in the CPI	$qdst_c$	Quantity of stock change
$dwts_c$	Weight of commodity c in the producer price index	\overline{qg}_c	Base-year quantity of government demand
ica_{ca}	Quantity of c as intermediate input per unit of activity a	\overline{qinv}_c	Base-year quantity of private investment demand
$icd_{cc'}$	Quantity of commodity c as trade input per unit of c' produced and sold domestically	$shif_{if}$	Share for domestic institution i in income of factor f
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	$shii_{ii'}$	Share of net income of i' to i ($i' \in INSDNG$; $i \in INSDNG$)
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	ta_a	Tax rate for activity a
$inta_a$	Quantity of aggregate intermediate input per activity unit	\overline{tins}_i	Exogenous direct tax rate for domestic institution i
iva_a	Quantity of aggregate intermediate input per activity unit	$tinsOI_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
\overline{mps}_i	Base savings rate for domestic institution i	tm_c	Import tariff rate
$mpsOI_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tq_c	Rate of sales tax
pwe_c	Export price (foreign currency)	$trnsfr_{if}$	Transfer from factor f to institution i
pwm_c	Import price (foreign currency)		

Table A1 continued. CGE model sets, parameters, and variables

Symbol	Explanation	Symbol	Explanation
Greek Symbols			
α_a^a	Efficiency parameter in the CES activity function	δ_{cr}^t	CET function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor f in activity a
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity c for household h
α_c^q	Armington function shift parameter	θ_{ac}	Yield of output c per unit of activity a
α_c^t	CET function shift parameter	ρ_a^a	CES production function exponent
β^a	Capital sectoral mobility factor	ρ_a^{va}	CES value-added function exponent
β_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	ρ_c^{ac}	Domestic commodity aggregation function exponent
δ_a^a	CES activity function share parameter	ρ_c^q	Armington function exponent
δ_{ac}^{ac}	Share parameter for domestic commodity aggregation function	ρ_c^t	CET function exponent
δ_{cr}^q	Armington function share parameter	η_{fat}^a	Sector share of new capital
ν_f	Capital depreciation rate	QF_{fa}	Quantity demanded of factor f
Exogenous Variables			
\overline{CPI}	Consumer price index	\overline{MPSADJ}	Savings rate scaling factor (= 0 for base)
\overline{DTINS}	Change in domestic institution tax share (= 0 for base; exogenous variable)	\overline{QFS}_f	Quantity supplied of factor
\overline{FSAV}	Foreign savings (FCU)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
\overline{GADJ}	Government consumption adjustment	\overline{WFDIST}_{fa}	Wage distortion factor for factor f in activity a
\overline{IADJ}	Investment adjustment factor		
Endogenous Variables			
AWF_{ft}^a	Average capital rental rate in time period t	QG_c	Government consumption demand for commodity
$DMPS$	Change in domestic institution savings rates (= 0 for base; exogenous variable)	QH_{ch}	Quantity consumed of commodity c by household h
DPI	Producer price index for domestically marketed output	QHA_{ach}	Quantity of household home consumption of commodity c from activity a for household h
EG	Government expenditures	$QINTA_a$	Quantity of aggregate intermediate input
EH_h	Consumption spending for household	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
EXR	Exchange rate (LCU per unit of FCU)	$QINV_c$	Quantity of investment demand for commodity
$GSAV$	Government savings	QM_{cr}	Quantity of imports of commodity c

Table A1 continued. CGE model sets, parameters, and variables

Symbol	Explanation	Symbol	Explanation
Endogenous Variables Continued			
MPS_i	Marginal propensity to save for domestic non-government institution (exogenous variable)	QQ_c	Quantity of goods supplied to domestic market (composite supply)
PA_a	Activity price (unit gross revenue)	QT_c	Quantity of commodity demanded as trade input
PDD_c	Demand price for commodity produced and sold domestically	QVA_a	Quantity of (aggregate) value-added
PDS_c	Supply price for commodity produced and sold domestically	QX_c	Aggregated quantity of domestic output of commodity
PE_{cr}	Export price (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity c from activity a
$PINTA_a$	Aggregate intermediate input price for activity a	RWF_f	Real average factor price
PK_{ft}	Unit price of capital in time period t	$TABS$	Total nominal absorption
PM_{cr}	Import price (domestic currency)	$TINS_i$	Direct tax rate for institution i ($i \in INSDNG$)
PQ_c	Composite commodity price	$TRII_{ii'}$	Transfers from institution i' to i (both in the set INSDNG)
PVA_a	Value-added price (factor income per unit of activity)	WF_f	Average price of factor
PX_c	Aggregate producer price for commodity	YF_f	Income of factor f
$PXAC_{ac}$	Producer price of commodity c for activity a	YG	Government revenue
QA_a	Quantity (level) of activity	YI_i	Income of domestic non-government institution
QD_c	Quantity sold domestically of domestic output	YIF_{if}	Income to domestic institution i from factor f
QE_{cr}	Quantity of exports	ΔK_{fat}^a	Quantity of new capital by activity a for time period t

Table A2. CGE model equations

Production and Price Equations

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

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

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

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

$$QF_{fa} = \alpha_{fa}^{van} \cdot \left(\sum_{f' \in F} \delta_{ff'a}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}} \right)^{\frac{1}{\rho_{fa}^{van}}} \quad (5)$$

$$W_{f'} \cdot WFDIST_{f'a} = W_f \cdot WFDIST_{fa} \cdot QF_{fa} \cdot \left(\sum_{f'' \in F} \delta_{ff''a}^{van} \cdot QF_{f''a}^{-\rho_{fa}^{van}} \right)^{-1} \cdot \delta_{ff'a}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}-1} \quad (6)$$

$$QVA_a = iva_a \cdot QA_a \quad (7)$$

$$QINTA_a = inta_a \cdot QA_a \quad (8)$$

$$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a \quad (9)$$

$$QXAC_{ac} = \theta_{ac} \cdot QA_a \quad (10)$$

$$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac} \quad (11)$$

$$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{\frac{1}{\rho_c^{ac}-1}} \quad (12)$$

$$PXAC_{ac} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1} \quad (13)$$

$$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_{c'} \cdot ice_{c'c} \quad (14)$$

$$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \quad (15)$$

$$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PDS_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t-1}} \quad (16)$$

Table A3. CGE model equations (continued)

$$QX_c = QD_c + \sum_r QE_{cr} \quad (17)$$

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr} \quad (18)$$

$$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c} \quad (19)$$

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

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

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

$$QQ_c = QD_c + \sum_r QM_{cr} \quad (23)$$

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

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

$$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c \quad (26)$$

$$\overline{DPI} = \sum_{c \in C} PDS_c \cdot dwts_c \quad (27)$$

Institutional Incomes and Domestic Demand Equations

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

$$YIF_{if} = shif_{if} \cdot \left[YF_f - transfr_{rowf} \cdot EXR \right] \quad (29)$$

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG} TRII_{ii'} + transfr_{i gov} \cdot \overline{CPI} + transfr_{i row} \cdot EXR \quad (30)$$

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

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

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

$$QINV_c = IADJ \cdot \overline{qinv}_c \quad (34)$$

$$QG_c = \overline{GADJ} \cdot \overline{qg}_c \quad (35)$$

Table A3. CGE Model Equations (continued)

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} \overline{trnsfr}_{i \text{ gov}} \cdot \overline{CPI} \quad (36)$$

System Constraints and Macroeconomic Closures

$$YG = \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{\text{gov } f} + \overline{trnsfr}_{\text{gov row}} \cdot EXR \quad (37)$$

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

$$\sum_{a \in A} QF_{fa} = QFS_f \quad (39)$$

$$YG = EG + GSAV \quad (40)$$

$$\sum_{r \in CMNR} pwm_{cr} \cdot QM_{cr} + \sum_{f \in F} \overline{trnsfr}_{\text{row } f} = \sum_{r \in CENR} pwe_{cr} \cdot QE_{cr} + \sum_{i \in INSD} \overline{trnsfr}_{i \text{ row}} + FSAV \quad (41)$$

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

$$\overline{MPS}_i = \overline{mps}_i \cdot 1 + \overline{MPSADJ} \quad (43)$$

Capital Accumulation and Allocation Equations

$$AWF_{ft}^a = \sum_a \left[\left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot WF_{ft} \cdot WFDIST_{fat} \right] \quad (44)$$

$$\eta_{fat}^a = \left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{ft} \cdot WFDIST_{fat}}{AWF_{ft}^a} - 1 \right) + 1 \right) \quad (45)$$

$$\Delta K_{fat}^a = \eta_{fat}^a \cdot \left(\frac{\sum_c PQ_{ct} \cdot QINV_{ct}}{PK_{ft}} \right) \quad (46)$$

$$PK_{ft} = \sum_c PQ_{ct} \cdot \frac{QINV_{ct}}{\sum_{c'} QINV_{c't}} \quad (47)$$

$$QF_{fat+1} = QF_{fat} \cdot \left(1 + \frac{\Delta K_{fat}^a}{QF_{fat}} - \nu_f \right) \quad (48)$$

$$QFS_{ft+1} = QFS_{ft} \cdot \left(1 + \frac{\sum_a \Delta K_{fat}^a}{QFS_{ft}} - \nu_f \right) \quad (49)$$