Chapter 10

EXPANDING TEFF PRODUCTION: ECONOMYWIDE ANALYSIS OF GROWTH AND POVERTY IMPACTS

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The sufficient consumption of cereals is central to the well-being of virtually all Ethiopian households. Almost two-thirds of all calories consumed come from cereal grain, while more than 40 percent of the value of the average household food basket in Ethiopia consists of cereals (Table 10.1). The diverse cropping systems of the country provide a range of cereals, with teff, wheat, maize, barley, and sorghum each having local importance in specific areas for food security. Nationally, teff, wheat, and maize, in particular, lie at the center of the increasingly vibrant agricultural output markets of Ethiopia (Minten, Stifel, and Tamru 2014). The level of annual production of these cereals is central to Ethiopia's national food security.

Given the centrality of teff, wheat, and maize to the food economy of Ethiopia, increased domestic production of the cereals can be expected to benefit both their producers and consumers and lead to positive wider economic effects. Higher productivity potentially will provide higher incomes for farmers and consequently improve the welfare of their households and enable them to further accumulate assets. Increased supply of grain will lower prices for cereal consumers and raise their overall consumption, thereby allowing them to productively reallocate economic resources that might previously have been devoted to food. More generally, increased productivity should result in greater capital investment in agriculture or in other sectors of the Ethiopian economy, propelling broader economic growth.

This chapter analyzes the economywide effects of significantly increasing the production of teff, wheat, and maize, both separately and jointly. Although our particular focus is on teff, maize and wheat are also considered closely in order to contrast the characteristics of teff and the other two cereals within the Ethiopian economy and for Ethiopian households. A detailed Computable General Equilibrium (CGE) model of the Ethiopian economy is used for this analysis. The CGE model is linked to a household survey–based

TABLE 10.1 Cereals in Ethiopia, 2004/2005—share of total calories consumed and household food expenditures (%)

	National		Rural		Urban	
Food item	Calories	Food expenditures	Calories	Food expenditures	Calories	Food expenditures
All cereals	64	41	64	43	64	27
Teff	11	9	8	8	30	17
Wheat	13	9	13	10	10	5
Maize	17	9	18	10	5	2
Other cereals	24	14	24	15	18	3
Other foods	36	59	36	57	37	73
Total	**100**	**100**	**100**	**100**	**100**	**100**

Source: Berhane et al. (2012).

microsimulation module. This enables estimation of the impact on household poverty and calorie intake of the various production scenarios run through the model. The production increases simulated in the analysis are consistent with the targets set by the Ethiopian Agricultural Transformation Agency (ATA) through their Teff, Wheat, and Maize Initiatives that began in 2012 and 2013. Accordingly, the simulation results provide additional evidence for evaluating Ethiopia's cereals investment plan and the design of broader agricultural development strategy.

Trends in Cereal Productivity and Related Economic Growth in Ethiopia

Agriculture is the major economic sector in Ethiopia, accounting for 46 percent of total gross domestic product (GDP) in 2001/2002. Within agriculture, cereal crops dominate. As shown in Table 10.2, cereal crops generated 35 percent of agricultural GDP. Over time, agriculture, and cereal crops in particular, have proven to be important sources of national economic growth. For example, the per capita GDP in Ethiopia rose from US$210 in 2001/2002 to US$438 in 2012/2013 (measured in 2010/2011 prices). Cereal crops alone accounted for more than 11 percent of this increase. Furthermore, a third of the contribution from cereal crops was due to rising teff production. Although there was equally rapid growth in maize and wheat production, these sectors are smaller than teff, so they each accounted for only a quarter of the increase in GDP per capita from rising cereals production.

TABLE 10.2 Sectoral decomposition of GDP growth in Ethiopia, 2001/2002–2012/2013 (%)

		Contribution to change in GDP, 2001/2002–2012/2013			
	Share of total GDP in 2001/2002	All sources	Overall increase in cropland	Increase in crop yields	Reallocation of cropland
Total GDP	100.0	100.0	n.a.	n.a.	n.a.
Agricultural crops	29.0	23.0	8.9	11.8	2.3
Cereals	17.0	11.4	5.2	7.2	–1.1
Teff	5.3	3.7	1.6	2.4	–0.3
Maize	3.5	2.2	1.1	1.2	–0.1
Wheat	3.3	2.3	1.0	1.3	0.0
Other cereals	4.9	3.8	2.0	2.3	–0.5
Other crops	12.0	11.6	3.7	4.5	3.4
Livestock, forestry, fishing	19.9	5.5	n.a.	n.a.	n.a.
Nonagricultural sectors	51.1	71.5	n.a.	n.a.	n.a.

Source: Diao and Thurlow (2014).
Note: n.a. = not applicable.

Table 10.2 decomposes the sources of GDP growth for crops from 2001/2002 through 2012/2013. The supply of land used for crop production in Ethiopia has grown rapidly at 4.2 percent per year. Controlling for changes in cropping patterns and yields, this land expansion was responsible for 8.9 percent of the increase in GDP per capita and about two-fifths of total crop GDP growth. During this period, there was also a significant increase in the yields of most crops. Together, rising crop yields accounted for 11.8 percent of the increase in total GDP and more than half of the increase in crop GDP. Finally, there were slight changes in the overall allocation of cropland, with a general departure from lower-value cereals toward higher-value vegetables and permanent crops, such as coffee. This land reallocation led to higher average productivity per hectare, although the contribution was somewhat marginal—that is, it generated only 2.3 percent of total GDP growth over the decade.

Crop-specific information on sources of recent production growth in Table 10.2 show that yield gains accounted for almost two-thirds of the increase in teff GDP from 2001/2002 through 2012/2013. However, the expansion of land used for cultivating teff grew more slowly than the overall supply of land. This implies that, relatively speaking, there was a general shift in cropping patterns away from growing teff, in that the share of teff land in total cropland declined slightly. Increases in maize and wheat production were

from similar sources, although the relative yield gains for these two crops were somewhat smaller than for teff. Overall, it is clear that teff, maize, and wheat are central to the Ethiopian economy, both as sources of income and for economic growth. Whether these crops can continue to increase their productivity levels over the next decade is therefore of significant importance for ongoing economic development in Ethiopia.

Cereal Productivity Interventions of the Ethiopian Agricultural Transformation Agency

The government of Ethiopia, through its Agricultural Growth Program—a key element of the agricultural sector program of the country's Growth and Transformation Plans—aims to build and sustain rapid growth in crop production and productivity. It aims to do this by encouraging farmers to use the best agronomic practices and raise the availability and adoption of improved inputs, particularly seed and fertilizer. Cereals are at the center of most of these efforts. To promote increased agricultural production and catalyze agricultural transformation in the country, in 2010 the Ethiopian government established the ATA. In 2012 and 2013 the agency instituted crop-specific initiatives for teff, wheat, and maize. Under each initiative, the ATA, working through the regional Bureaus of Agriculture, makes available to farmers in the woredas (districts) targeted by the initiatives improved access to inputs, agricultural advisory services, output markets, and, in some cases, agricultural financing. These packages of improved inputs and services are expected to lead to significant sustained increases for each cereal produced in the target woredas. When the program rollout is complete, the Teff Initiative, if implemented as designed, will operate in 209 woredas, the Wheat Initiative in 95 woredas, and the Maize Initiative in 132 woredas. These target woredas are located in high-potential areas in Tigray, Amhara, Oromia, and Southern Nations, Nationalities, and Peoples' (SNNP) region.

The ATA cereal initiatives are not just about agricultural development but are designed also to advance Ethiopia further along the pathway of economic and broad social development laid out in the Growth and Transformation Plan, the country's master development framework. This is because there are strong interlinkages across agricultural subsectors, and the links between agriculture and the rest of the Ethiopian economy are strengthening, particularly between net producers and net consumers. Increasing cereal production is therefore expected to benefit not only rural farmers but also urban consumers and the overall economy.

Given this broader objective, we use an economywide CGE model to examine the likely economic impacts of successfully implementing the ATA's cereal initiatives. The model is based on a detailed social accounting matrix (SAM) for the Ethiopian economy that contains highly disaggregated information on both farm and nonfarm sectors across different agroecological regions within the country. As such, the model provides an ideal tool for evaluating economic links and how agricultural growth can contribute to broader development goals, including national economic growth and poverty reduction.

The Economywide Model for Ethiopia

To assess the economic growth, price, consumption, and distributional impacts of increased teff, wheat, and maize productivity, an economywide model is used that differentiates agricultural production in different regions of Ethiopia and a microsimulation module that captures the heterogeneity of Ethiopian households' incomes and expenditures (Diao and Thurlow 2012). The model is designed to capture trade-offs and synergies from accelerating growth in different agricultural subsectors, the economic interlinkages between agriculture and the rest of the economy, and the effects of different sources of growth on household incomes and poverty. The model is recursive dynamic and is run using annual time-steps over the 10-year period from 2006 to 2015. The model is solved as a series of equilibriums with economic actors optimizing their behavior within each time-step period—that is, there is no intertemporal or long-run optimization. Between periods the model is updated to reflect changes in population, labor supply, and exogenous technical change. Importantly, previous period investment determines the annual rate of capital accumulation, such that increases in incomes and savings will increase the subsequent supply of new capital stock.

The model identifies 69 subsectors, 24 of which are in agriculture (Table 10.3). Agricultural crops fall into five broad groups, including cereals. The cereals group is separated further into teff, barley, wheat, maize, sorghum, and millet. Most of the agricultural commodities captured by the model are not only consumed by households or exported but are also used as inputs into various processing activities in the manufacturing sector. Similarly, the agricultural subsectors in the model also use inputs from nonagricultural sectors. The model is constructed to incorporate these links between agriculture and other segments of the wider economy.

The model captures regional heterogeneity within the agricultural sector of Ethiopia's economy. Farm production is disaggregated across four rural zones,

TABLE 10.3 Subsectors in the Computable General Equilibrium model of the Ethiopian economy

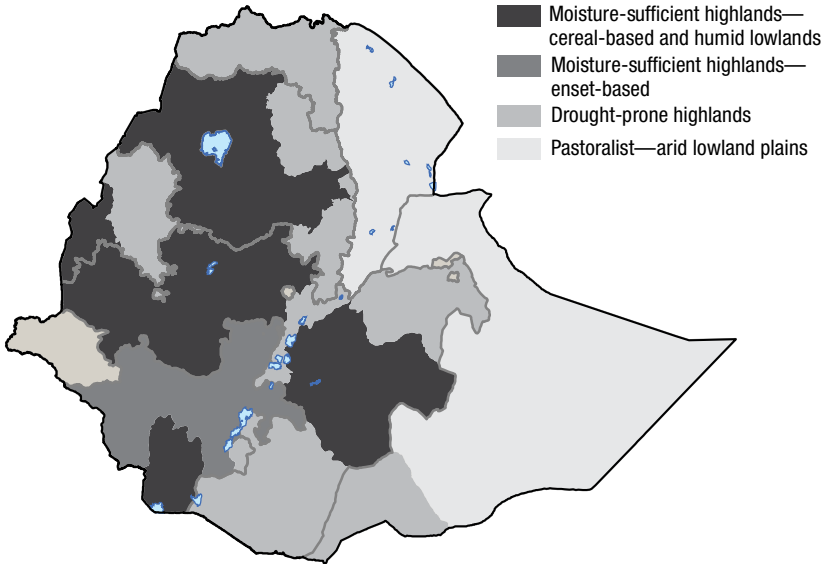
Sectors or groups within sectors	Subsectors
Cereals	Teff, wheat, maize, barley, sorghum, millet
Pulses and oilseeds	Pulses, oilseeds
Horticulture	Vegetables, fruits, enset
Export crops	Cotton, sugarcane, tea, tobacco, coffee, cut flowers
Other crops	*Chat*, other crops
Livestock	Cattle, milk, poultry, animal products
Other agriculture	Fisheries, forestry
Agroprocessing	Meat, dairy, vegetable products, grain milling, milling services, sugar refining, tea processing, other food processing, beverages, tobacco processing
Other manufacturing	Textiles, yarn, fibers, lint, clothing, leather products, wood products, paper and publishing, petroleum, fertilizer, chemicals, nonmetallic minerals, metals, metal products, machinery, vehicles and transport equipment, electronic equipment, other manufacturing
Other industry	Coal, natural gas, other mining, electricity, water, construction
Services	Wholesale and retail trade, hotels and catering, transport, communications, financial services, business services, real estate, other private services, public administration, education, health

Source: Dorosh and Thurlow 2012.

as shown in Figure 10.1. These zones reflect different agroecological and climatic conditions across the country. The model is calibrated to observed cropping patterns in each of the four zones in the 2005/2006 cropping season. Representative farmers in each zone respond to changes in production technology, 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 nonfarm activities, including livestock and fishing, wage employment, and diversification into nonagricultural sectors, such as transport, trade, and construction. By capturing production information across subnational regions, the model is useful for capturing the growth links and income and price effects resulting from changes in productivity for teff as well as for wheat and maize.

The model endogenously estimates the impact of exogenous changes in cereal productivity on the value of household consumption, poverty, and per capita calorie consumption. There are 12 representative household groups in the model, disaggregated by the four rural zones and small or large urban centers, and by their poor or nonpoor status. In this case, "the poor" are defined

FIGURE 10.1 Rural zones in the Computable General Equilibrium model of the Ethiopian economy



Source: Adapted from Dorosh and Thurlow (2012).

to include all households falling into the bottom two consumption quintiles (that is, the poorest 40 percent of the population).

The Ethiopia CGE model has a microsimulation component whereby each sample household in the nationally representative 2004/2005 Household Income, Consumption, and Expenditure Survey (HICES) is assigned to a corresponding representative household in the model (Arndt et al. 2012). When a model simulation is run, relative changes in *real* consumption expenditure for each of the 12 representative households in the model are passed down to their corresponding households in the household survey. The value of total real expenditures for each sample household, as captured in the survey data, is then recalculated using the modeled changes in real consumption expenditures. This new level of per capita expenditure for each survey household is compared to the separate poverty lines for rural and urban areas (in base-year prices), and standard poverty measures are recalculated. Similarly, changes in food quantity consumption patterns of survey sample households can be computed to determine changes in daily per capita calorie consumption associated with various scenarios run in the CGE model.

The model makes a number of assumptions about how the economy maintains macroeconomic balance. For the current account a flexible exchange rate maintains a fixed level of foreign savings. This means that the government cannot increase foreign debt to pay for new investments and that export earnings are needed to pay for any additional imports. For the government account, tax rates are fixed, and recurrent expenditure grows at a fixed rate. The fiscal deficit therefore adjusts to ensure that public expenditures equal receipts—any new or expanded government program will require additional revenue to finance. Investment and private consumption also are fixed shares of absorption, with private savings adjusting to ensure that savings equals investment in equilibrium.

The core dataset used to create the CGE model is the 2005/2006 social accounting matrix (SAM), which captures the economic structure of the Ethiopian economy. The SAM provides a balanced accounting of all economic transactions that take place within the economy, drawing on data from household surveys, national accounts, and a broad range of other data on production and consumption in Ethiopia. The Ethiopian Development Research Institute (EDRI) originally developed this SAM (Tebekew et al. 2009). The SAM disaggregates information on the agricultural sector by the four rural zones and includes a detailed disaggregation of household groups by those zones. Zonal-level agricultural production and area data taken from the 2005/2006 Agricultural Sample Survey were used to disaggregate production in the SAM to the subnational rural zones shown in Figure 10.1. The CGE model for Ethiopia therefore is consistent with recent agricultural production levels and yields at the level of these zones.

While most of the parameters in the CGE model are derived from the SAM, there are a number of behavioral elasticities that govern how changes in relative prices affect domestic production, foreign trade, and household consumption patterns. Household income elasticities determine how households choose to spend any additional incomes. Income elasticities used in the model were derived from econometric estimates computed from the 2004/2005 HICES (Diao et al. 2012, 137). Trade elasticities determine how readily producers respond to relative price changes in supplying domestic or export markets. Similarly, they determine the willingness and ease with which consumers switch between consuming domestically produced or imported commodities. In the absence of Ethiopia-specific estimates of trade elasticities, we use the global cross-country elasticities reported in Dimaranan (2006).

Baseline Performance of the Economywide Model for Ethiopia

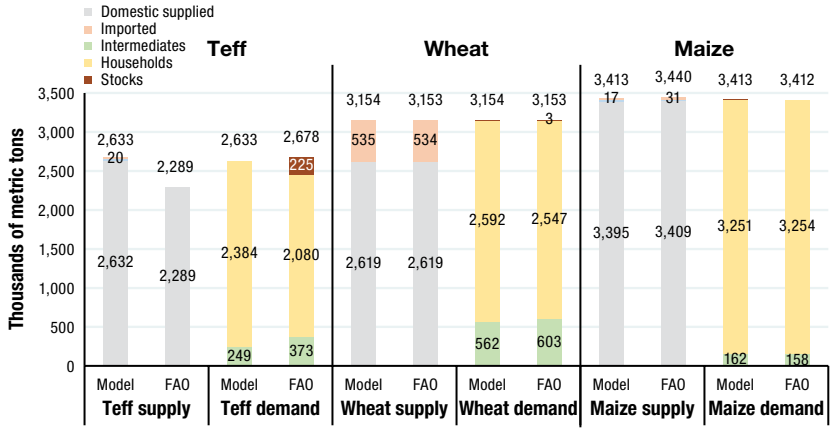
The cereal production and cereal-related policy and program scenarios that were run through the CGE model involve altering parameters in the model so that it no longer reflects the production levels and economic relationships in the economy of Ethiopia as described by the 2005/2006 SAM, but reflects changes in those levels and relationships that are defined by the scenarios of interest. As the model is run over time, changes in productivity result in changes in supply, which lead to changes in product prices and, hence, demand. Movements in relative prices also cause changes in the demand for imports and supply of exports. These initial effects then prompt a range of further changes in other sectors of the economy via reallocations of land and labor from less to more economically rewarding crops. In turn, this leads to changes in noncereal crop production levels; reallocation of labor across both farm and nonfarm activities as economic actors seek to maximize returns to their labor; and changes in household expenditures and food consumption.

The supply of and demand for teff, wheat, and maize in Ethiopia in 2006, both modeled and observed, is presented in Figure 10.2. The base year for the model is 2006.[1] We see that the model reflects quite closely the observed national supply and demand conditions for these three cereals as reported in the Food Balance Sheet for Ethiopia for 2006 computed by the Food and Agriculture Organization of the United Nations (FAO 2014). The only significant difference is for teff supply, where the model estimates a supply approximately 15 percent higher than what was observed. This deviation is due to unequal supply and demand for teff in the Food Balance Sheets.

The first stage in creating the CGE model is to establish a baseline scenario for the period 2006 to 2015 that excludes the additional expansion of teff, wheat, and maize production as envisaged by the ATA under its three cereal initiatives. The supply of teff, wheat, and maize in the baseline is as shown in Figure 10.3. The purpose of the baseline scenario is not to track recent production changes or predict future growth, but rather to provide a counterfactual scenario against which the incremental benefits or losses associated with the ATA initiatives can be compared. By design, the baseline scenario is calibrated so that the year-on-year increase in the supplies of the cereal

1 When we refer to the CGE model's base year, we are referring to the information contained in the 2005/2006 SAM (which was built using official data but closely matches what appears in the FAO Food Balance Sheets).

FIGURE 10.2 Baseline teff, wheat, and maize supply and demand conditions of the Ethiopia CGE model compared to FAO crop supply and demand estimates, 2006



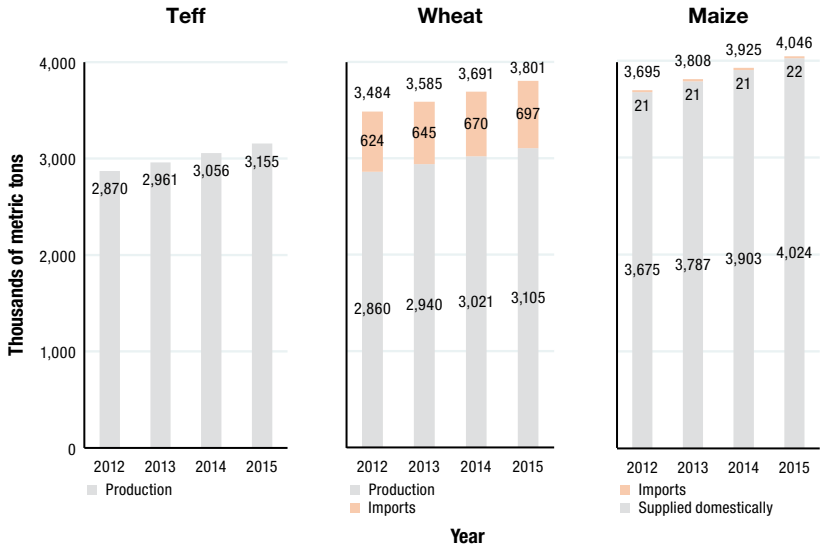
Source: Ethiopia CGE model and FAOSTAT Food Balance Sheet data (FAO 2014).
Note: CGE = computable general equilibrium; FAO = Food and Agriculture Organization of the United Nations.

crops is fairly uniform and reflects a growth rate that is slower than what has been observed in recent years. Slower growth is assumed because the ATA initiatives to be modeled are expected to contribute to maintaining recent rapid production growth in these cereals, rather than only accelerating it. As such, the annual growth in supply in the baseline scenario for teff is about 3.2 percent; for wheat, about 3.0 percent; and for maize, about 3.1 percent.

The increase in the supply of teff in the baseline is wholly from production, as there is virtually no international trade in this cereal. That of wheat is made up of both domestic production and imports, with imports making up about 18 percent of total wheat supply.[2] The supply of maize is made up primarily of domestic production, but the model does impose some small quantities of maize imports and exports—the "supplied domestically" category is the net of domestic production minus the exports imposed in the model. The total domestic maize production in 2015 predicted by the model is 4.042 million

2 For all the model scenarios that involve wheat, it is assumed that there is no difference in quality between domestic and imported wheat that would lead to differentiation between the two types of wheat in Ethiopian markets or among Ethiopian consumers. This is not likely to be the case, as imported wheat may well be better or less suited for commercial bakeries and other industrial processing than domestic wheat, or may have taste and other consumption characteristics that may make it either more or less preferred for home processing and consumption. However, the CGE model for Ethiopia does not take into account any such differences.

FIGURE 10.3 Baseline scenario between 2012 and 2015 for the national supply of teff, wheat, and maize without the ATA initiatives for each cereal, Ethiopia CGE model results



Source: Ethiopia CGE model.
Note: ATA = Ethiopian Agricultural Transformation Agency; CGE = computable general equilibrium.

metric tons, with 22,000 metric tons of maize imports and 18,000 metric tons of maize exports.

Although not presented here, similar baseline conditions are estimated by the CGE model for a range of output indicators that will be used to assess the economic effects of the productivity scenarios. These include economic growth rates, price and consumption changes, and poverty and calorie intake measures. The baseline conditions for 2015 for these variables, as predicted by the model, are the values against which the economic effects of the ATA production scenarios will be assessed.

Teff, Wheat, and Maize Production Increases

The ATA established the initiatives for teff, wheat, and maize to bring about a sharp increase in the production of the three cereals. As was noted earlier, the ATA aims to improve farmers' access to improved inputs, agricultural advisory services, output markets, and, in some cases, agricultural financing. Particularly for teff, the ATA Initiative also involved introducing farmers to promising new production techniques. These packages of inputs and services

are expected to raise cereal productivity in the targeted woredas and subsequently result in the diffusion of the new technologies to other areas of the country where the cereals are produced.

The Teff Initiative began in 2012 in 158 woredas, with expansions to the initiative planned in 2013 and 2014 to reach 209 target woredas. The Wheat Initiative began in 2013 in 40 woredas and aimed to be completed in 2014 with an additional 55 woredas. The Maize Initiative was only to be launched in the 2014 season with a three-year rollout to reach 132 target woredas by the final year. Although these initiatives were introduced in a staggered fashion, the three are simulated in the analysis as if they were rolled out in parallel, starting in 2013 and with full implementation by 2015. In the design of the three initiatives, the ATA did not establish specific production increase targets in each of the target woredas. For these analyses, a relatively ambitious production increase of 25 percent in the target woredas for each initiative is used.

Simulated Production Increases

To determine the economywide effects of the ATA Teff, Wheat, and Maize Initiatives, it was first necessary to determine what a 25 percent production increase for each of the three cereals in each set of target woredas would correspond to in terms of zonal and overall national production increases. These increases were specified for each cereal across each of the four rural zones of the CGE model. To do this, woreda-level teff, wheat, and maize production data was used from the last nationally representative woreda-level agricultural production survey, the Ethiopian Agricultural Sample Enumeration (EASE) implemented by Ethiopia's Central Statistical Agency (CSA) between February 2001 and February 2002. This dataset was used to determine what share of the production of each cereal in each of the administrative zones for the EASE survey year came from the target woredas for the ATA Initiatives. These shares of administrative zone production were then applied to the most recent crop production information estimated at administrative zone level, the Agricultural Sample Survey of 2010/2011. Through this method the proportion of recent production of the cereals in those administrative zones that was accounted for by production in the target woredas of the three initiatives was determined (Ethiopia, CSA 2011). These results were then aggregated to determine changes in teff, wheat, and maize production for the country as a whole and for each of the four CGE rural zones (although the pastoralist zone has no target woredas for the ATA Initiatives) that would be attributable to 25 percent production increases for those crops in the target woredas of the three ATA Initiatives.

TABLE 10.4 Estimated national production increase for grain associated with a 25% production increase under ATA Cereals Initiatives, relative to 2010/2011 production levels

	Teff		Wheat		Maize	
25% increase in production in target woredas of the ATA Cereals Initiatives	Year-on-year national production increase (%)	Target woredas (number)	Year-on-year national production increase (%)	Target woredas (number)	Year-on-year national production increase (%)	Target woredas (number)
Year 1 (2012/2013)	15.4	158	6.6	40	8.9	69
Year 2 (2013/2014)	1.9	31	5.1	55	3.1	40
Year 3 (2014/2015)	0.8	20	n.a.	n.a.	1.5	23
Total	**18.1**	**209**	**11.7**	**95**	**13.5**	**132**

Source: Authors' calculations using Ethiopia, CSA 2006; and Ethiopia, CSA 2011.
Note: n.a. = not applicable.

As shown in Table 10.4, the 25 percent increases in teff production in the Teff Initiative target woredas should result in an estimated increase of 18.1 percent in national teff production after the initiative is fully implemented. For wheat, the corresponding figure is 11.7 percent, while for maize it is 13.5 percent. Given the dynamic nature of the Ethiopian CGE model, to define the scenario modeled for each cereal, the year-on-year production increases presented in Table 10.4, disaggregated by rural zone, were used over two (wheat) or three (teff and maize) model years as the shocks imposed on the model. This was achieved by increasing in the CGE model the productivity levels of the three cereals sectors in each of the subnational rural regions. The initial production shocks were applied in the 2013 model year. Note that the production increases are in addition to the year-on-year cereal production increases that already occur in the baseline scenario.

The scale of the Teff Initiative, with 209 target woredas, is considerably larger than that of the Wheat and Maize Initiatives, with 95 and 132 target woredas, respectively. However, given the lower yields of teff relative to wheat and maize, the impact in terms of the total increase in cereal produced under each initiative is not so different—between 430,000 and 490,000 metric tons additional cereal output is produced under each initiative. This can be seen in the results presented in Table 10.5. Ethiopia, CSA (2011) reports that the national average on-farm yields are 1,260 kilograms per hectare for teff, 1,840 kilograms per hectare for wheat, and 2,540 kilograms per hectare for maize.

Results for the Cereal Production Scenarios

The model was run for each of the three cereal production increases individually and jointly. While the production shocks are applied each year in the model, the various economic effects of the three initiatives are considered only at the end of the 2015 model year once all of the initiatives have been fully implemented. Given this staggered introduction of the initiatives, the model results reflect some second-round reallocation of land, labor, and capital due to the first-round economic effects arising from the cereal production increases. As such, the results presented here do not reflect only the immediate economic effects of increases in production of the three cereals, but they also reflect how actors in the Ethiopian economy will seek to exploit new economic opportunities that arise in consequence of those production increases and the changes in supply, demand, and prices that the increases generate.

The modeled changes in national production of the three cereals and in wheat imports due to the 25 percent increase in production in the target woredas of the ATA Initiatives are presented in Table 10.5. With the second-round economic effects of the production increases, the increases for teff and maize, when considered individually, are somewhat lower after three years of the implementation of the programs than was envisioned. For example, teff production nationally is up by 14.0 percent, rather than the 18.1 percent that was estimated from a 25 percent increase in production in the target woredas (Table 10.4). The increase in cereal productivity allows farmers to diversify into other higher-value crops—a transition that is also encouraged by declining real prices for cereals relative to other crops (Figure 10.4). The case of wheat is more complicated, because increased production displaces significant imports. Overall, domestic wheat production increases by 14.0 percent, but the total wheat available increases by only 7.2 percent, since imports drop by 22.8 percent in response to domestic wheat becoming relatively cheaper than imported wheat.

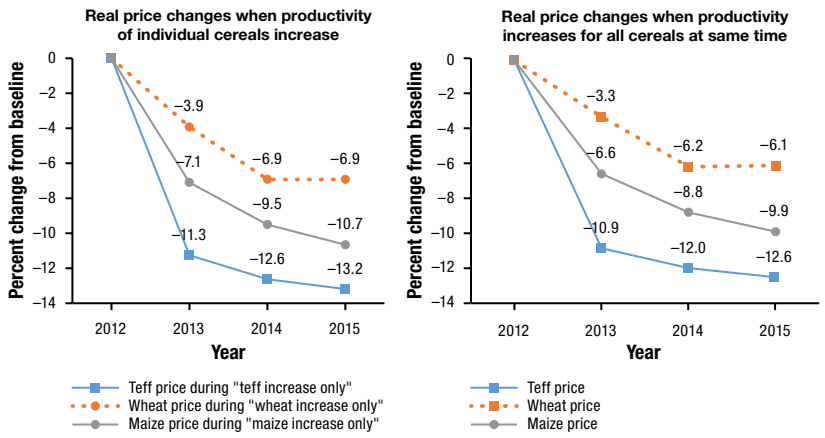
When the joint implementation of the three initiatives is modeled, cereal production overall increases by 13.5 percent nationally. Under the joint-implementation scenario, wheat imports decline relative to baseline conditions by slightly more than under the individual Wheat Initiative scenario, reflecting additional displacement of those imports from the increased production of the other cereals, which are partial substitutes for wheat. Note that the absolute increases in grain production across the three cereals are quite similar—between 430,000 metric tons and 495,000 metric tons—even though the Teff Initiative is significantly larger in scale than the other two.

TABLE 10.5 Modeled changes due to ATA Cereal Initiatives in national production and imports of grain, from the baseline scenario for 2015, in thousands of metric tons

		Change in cereal production and imports relative to baseline by 2015			
	Baseline	Teff increase only	Wheat increase only	Maize increase only	All cereal increases together
Production, all	10,302	466 (4.5%)	436 (4.2%)	488 (4.7%)	1,394 (13.5%)
Teff	3,155	440 (14.0%)	1 (0.0%)	5 (0.2%)	447 (14.2%)
Wheat	3,105	14 (0.4%)	434 (14.0%)	7 (0.2%)	456 (14.7%)
Wheat imports	697	–5 (–0.8%)	–159 (–22.8%)	–2 (–0.3%)	–165 (–23.6%)
Maize	4,042	12 (0.3%)	1 (0.0%)	476 (11.8%)	491 (12.1%)

Source: Ethiopia computable general equilibrium model.
Note: ATA = Ethiopian Agricultural Transformation Agency.

FIGURE 10.4 Modeled changes in real prices for teff, wheat, and maize, from the baseline scenario for 2015 (%)



Source: Ethiopia computable general equilibrium model.

Figure 10.4 shows how the real price of the three cereals changes over the three years of implementation of the Teff and Maize Initiatives and the two years of implementation of the Wheat Initiative. The price shifts are somewhat larger when the initiatives are considered in isolation (left panel) compared to when the initiatives are considered jointly (right panel). This is partly accounted for by the higher crop incomes for producers, which arise from the broad increases in cereal production generating additional demand. This additional demand reduces the declines in prices of the cereals associated with their increased supply.[3]

The impacts of rising cereal productivity on the size of the Ethiopian economy are shown in Table 10.6. Several patterns are observed. Jointly, the increase in cereal production leads to a 1.36 percent increase in GDP for Ethiopia and a 3.07 percent increase in the size of the economy's agricultural sector. However, there is virtually no net growth in the nonagricultural sectors of the economy because of these increases in cereal productivity. This is partly a result of there being relatively little grain processing linked to domestic production that is classified as "manufacturing" in Ethiopia's national accounts. This implies that most of the milling that does take place—mainly within households—is subsumed within agricultural GDP. Moreover, increases in agricultural productivity encourage farmers to allocate more of their labor to farm rather than nonfarm activities, such that any increase in downstream processing is offset by falling nonfarm labor supplies.

Across the rural zones modeled, greatest growth is seen in the cereal-based highlands, as would be expected. However, increases in teff production also provide particular benefit to the drought-prone highlands. Maize production increases are not only important for economic growth in the cereal-based highlands, but also are the most significant contributor, from among the three cereals, to economic growth in the enset-based highlands, an area agroecologically better suited for maize production than for wheat and teff. The pastoralist zone, although no increase in cereal production was modeled in this zone,

3 The decision of consumers to source cereals from either domestic or foreign markets is an endogenous outcome in the CGE model and is based on changes in relative real cereal prices. We model the increase in production resulting from the ATA through an increase in the TFP (shift) parameter in the CES production function (this approach is consistent with the ATA's focus on raising cereal productivity). Consumers respond by sourcing a larger share of their demand from domestic producers rather than imports. This outcome from the model is what is expected following a sizable increase in cereal production, so there is no need for us to manually impose contrary consumer behavior on the model's CES Armington aggregation functions. It should be noted that imported cereal, primarily wheat, makes up a very small share of total cereal consumption in Ethiopia, so the import functions in the CGE models turn out to be much less important than domestic production and household consumption functions.

TABLE 10.6 Modeled changes in annual economic growth due to production increases in teff, wheat, and maize, from the 2015 baseline scenario (%)

		Change in GDP relative to baseline by 2015			
	Share of baseline GDP in 2015	Teff increase only	Wheat increase only	Maize increase only	All cereal increases together
Overall	**100.0**	**0.58**	**0.31**	**0.46**	**1.36**
Agriculture sector	44.5	1.31	0.70	1.05	3.07
Cereal-based highlands and humid lowlands	19.4	1.83	1.10	1.43	4.37
Enset-based highlands	5.9	0.72	0.35	1.25	2.32
Drought-prone highlands	11.4	1.59	0.69	0.96	3.25
Pastoralist–arid lowlands	3.0	0.20	–0.03	0.24	0.42
Nonagriculture	55.5	–0.01	0.01	–0.01	–0.01

Source: Ethiopia computable general equilibrium model.
Note: GDP = gross domestic product.

benefits from increased teff and maize production, likely through increased consumption made possible through reduction in the real prices of these cereals. However, production increases in wheat do not generate these positive economic effects in the pastoralist zone.

Comparing the cereals, their individual impact on economic growth primarily will be due to the production increases achieved for each and the value of that production. Although teff yields per unit area are significantly lower than are those for wheat and maize, the Teff Initiative is the largest in scale of the three initiatives. Moreover, the per unit value of teff is significantly higher than for the other two crops—the average ratio of their prices in the Addis Ababa market between 2001 and 2011 was 2.47 for teff-to-maize and 1.47 for teff-to-wheat (Minten, Stifel, and Tamru 2012). In consequence, the Teff Initiative has the largest impact on economic growth, even though the overall production increases due to each initiative are quite similar (Table 10.5).

The impact of the three cereal initiatives on household welfare and poverty are considered in Table 10.7 and Table 10.8. Household welfare is measured using the per capita real value of consumption in the CGE model. Under the ATA Initiatives, consumption increases for all households. The joint effect of the three initiatives shows that poor households in urban areas see the largest increase in their welfare, benefitting from lower cereal prices in the urban markets. Poor households in rural areas see the second highest welfare benefits, which flow both from higher incomes for cereal producers whose production levels increase and, for net rural cereal consumers, from lower prices for

TABLE 10.7 Modeled changes in household welfare (per capita real consumption) due to grain production increases, from the 2015 baseline scenario (%)

	Teff increase only	Wheat increase only	Maize increase only	All cereal increases together
All households	**0.57**	**0.21**	**0.35**	**1.13**
Rural poor	0.64	0.28	0.53	1.45
Rural nonpoor	0.46	0.22	0.37	1.05
Urban poor	1.25	0.18	0.19	1.63
Urban nonpoor	0.62	0.10	0.07	0.79

Source: Ethiopia CGE model.

TABLE 10.8 Modeled changes in poverty due to production increases in teff, wheat, and maize, from the 2015 baseline scenario

	Teff increase only	Wheat increase only	Maize increase only	All cereal increases together
Poverty headcount, % change:				
All households	–0.77	–0.50	–0.84	–2.00
Rural	–0.78	–0.53	–0.97	–2.22
Urban	–0.73	–0.31	–0.23	–0.93
Number of poor individuals	–646,000	–418,000	–708,000	–1,687,000
Depth of poverty, % change:				
All households	–0.29	–0.15	–0.28	–0.70
Rural	–0.26	–0.16	–0.31	–0.71
Urban	–0.42	-0.10	–0.12	–0.64

Source: Ethiopia CGE model with microsimulation module.

the cereals that they consume. The urban nonpoor see the lowest welfare benefits in relative terms.

When the three cereal initiatives are considered separately, the increases in teff production provide the greatest relative welfare benefits to urban households and maize production increases generate the greatest benefits to rural households, while wheat production increases deliver similar but lower levels of relative welfare benefits to households in both rural and urban areas.

By linking the results of the CGE model to information on the characteristics of sample households of the 2004/2005 HICES, the microsimulation module of the Ethiopian CGE model is used to estimate changes in the poverty measures for the Ethiopian population. Using a poverty line that

is initially set at the fortieth percentile of per capita consumption of households in the 2004/2005 HICES, Table 10.8 provides insights as to what the cereal production increases will mean for the poverty status of households in Ethiopia. The poverty headcount measure—that is, the share of the population whose consumption is below the poverty line—drops under all scenarios where cereal production increases. The cereal initiatives improve the consumption of some households sufficiently such that their new level of consumption is above the poverty line. Across the three cereals, increased maize production has the greatest impact on the incidence of poverty in rural areas, while in urban areas, teff is the most important cereal in this regard.

Changes in the depth of poverty measure give insight into how the cereal initiatives affect the welfare of all of the poor, as the measure reflects the mean consumption shortfall relative to the poverty line across the whole population. The three initiatives are shown to reduce the depth of poverty in Ethiopia. However, when comparing the respective impact of the production increases of the different cereals, production increases of teff seem not to be as efficacious in reducing the depth of poverty in rural areas as they are for reducing the rural poverty headcount. This may reflect specific elements in the patterns of both teff production and teff consumption across the distribution of consumption in the rural population of Ethiopia—the poorest rural households may neither produce nor consume much teff. For maize, production increases of the cereal do not reduce the depth of poverty in urban areas to the same degree as in rural areas. However, in contrast to the relatively high impact of increased teff production on the rural poverty headcount, maize production increases lead to only a limited change in the poverty headcount in urban areas. The relative impact of wheat production increases on poverty measures in rural and urban areas is consistent across the two areas, although lower than that of the other two cereals.

The impact of the three cereal initiatives on household cereal consumption is considered in Table 10.9. The impact of the Wheat Initiative on consumption is significantly lower than for the Teff and Maize Initiatives. However, as the production increases achieved by the three initiatives are comparable (Table 10.5), the reason for the lower impact of the Wheat Initiative on overall household consumption is that much of the increased production of wheat serves to displace wheat imports.

Considering the impact of each initiative on cereal consumption, on a percentage basis the Teff Initiative increases consumption in urban centers by considerably more than it does in rural areas. For maize, as observed earlier, the opposite is the case, with a greater impact on the consumption of rural

TABLE 10.9 Modeled changes in household cereal consumption due to production increases in teff, wheat, and maize, from the 2015 baseline scenario, in thousands of metric tons

	Baseline	Teff increase only	Wheat increase only	Maize increase only	All cereal increases together
All households	9,757	423 (4.3%)	220 (2.3%)	444 (4.5%)	1,090 (11.2%)
Poor (all)	3,775	166 (4.4%)	86 (2.3%)	180 (4.8%)	434 (11.5%)
Nonpoor (all)	5,981	256 (4.3%)	134 (2.2%)	264 (4.4%)	656 (11.0%)
Rural (all)	8,534	313 (3.7%)	200 (2.3%)	428 (5.0%)	945 (11.1%)
Rural poor	3,277	123 (3.7%)	77 (2.3%)	171 (5.2%)	372 (11.4%)
Rural nonpoor	5,257	190 (3.6%)	123 (2.3%)	257 (4.9%)	572 (10.9%)
Urban (all)	1,223	110 (9.0%)	20 (1.6%)	15 (1.3%)	146 (11.9%)
Urban poor	499	44 (8.8%)	9 (1.8%)	9 (1.8%)	62 (12.5%)
Urban nonpoor	724	66 (9.1%)	11 (1.5%)	6 (0.9%)	83 (11.5%)

Source: Ethiopia CGE model.

households. For wheat, a more balanced impact on consumption is seen across the rural/urban and poor/nonpoor groups. Although the differential impacts are not large, the urban nonpoor display the greatest relative increase in overall cereal consumption with higher production of teff, while higher production of maize results in the rural poor displaying the largest percentage increase in such consumption. The modeled increase of the Maize Initiative on the cereal consumption of the poor nationwide is greater than that of the Teff Initiative, suggesting that efforts to increase national teff production are somewhat less "pro-poor" than similar efforts to increase maize production.

When the initiatives are considered jointly, it is the urban poor group that shows the largest percentage increase in cereal consumption, followed by the urban nonpoor and rural poor groups. The rural nonpoor group shows the lowest relative increase in cereal consumption under the joint initiatives scenario. Note, however, that these differences are not large.

Using the microsimulation module of the Ethiopian CGE model, changes in per capita calorie consumption of Ethiopian households resulting from the

TABLE 10.10 Modeled changes in per capita daily calorie consumption due to production increases in teff, wheat, and maize, from the 2015 baseline scenario (%)

	Calorie consumption (baseline)	Teff increase only	Wheat increase only	Maize increase only	All cereal increases together
All households	2,163	1.89	0.86	2.42	5.18
Rural (all)	2,192	1.54	0.88	2.69	5.13
Rural poor	1,374	1.64	0.79	2.97	5.42
Rural nonpoor	2,353	1.53	0.89	2.65	5.10
Urban (all)	2,021	3.79	0.70	0.94	5.45
Urban poor	1,293	3.80	0.81	1.53	6.17
Urban nonpoor	2,140	3.79	0.69	0.87	5.38

Source: Ethiopia CGE model with microsimulation module.

ATA Cereal Initiatives can be estimated, as presented in Table 10.10. These changes do not simply reflect the impact of the increased calories made available through an increase in cereal production but also changes in the composition of household food consumption baskets because of relative food price shifts that these production increases cause. Again, the Teff Initiative is seen as relatively the most important for the urban population, while the Maize Initiative is the most important for the rural population. When the initiatives are considered jointly, the relative impact on calorie consumption across the rural/urban and poor/nonpoor groups is similar to that seen in Table 10.9 on changes in cereal consumption levels—the greatest increase in calorie consumption is found among the urban poor and the lowest increase is among the rural nonpoor.

Broader Implications for Cereal Policy in Ethiopia

This analysis suggests that the impact of the cereal production increases envisioned by the Teff, Wheat, and Maize Initiatives of the ATA on the size of Ethiopia's economy are important, if not significantly transformative. If each initiative prompts a 25 percent increase in production of the cereals in question in the target woredas in which the initiatives are being implemented, this will result in a national expansion in the production of each cereal of between 430,000 metric tons and 495,000 metric tons. The increased production for each cereal alone will lead to somewhere between a 0.3 percent and 0.6 percent increase in the size of the country's economy relative to the

baseline, while the increased joint production of the three cereals increases the size of total GDP by 1.4 percent (Table 10.6). While it is difficult to assign a monetary value to this expansion, it is possible to provide a broad estimate of the overall economic gain. For example, the total value of the Ethiopian economy was US$41.7 billion in 2012. As such, the 1.4 percent expansion in total GDP in the joint cereal production scenario adds about US$580 million to the Ethiopian economy. This suggests that there is a substantial economic benefit from successfully implementing the ATA cereal initiatives. However, this analysis did not consider the cost of achieving the ATA objectives. These costs, if internalized, will offset some of the economic gains (for example, raising taxes to pay for the Cereal Initiatives could reduce growth in other sectors).

It is important to note, however, that the cereal production increases simulated in the CGE model do not bring about much change in the structure of Ethiopia's economy. The change due to the ATA Cereals Initiatives in the size of the nonagriculture sectors of the economy in aggregate is virtually nil (see Table 10.6). Almost all of the economic growth associated with the production increases comes from the agricultural sector of the economy. Two factors explain this. First, as the economic returns in agriculture become more attractive due to higher productivity levels, there is likely to be a flow in factors of production out of manufacturing and services into agriculture. This will constrain continued growth in the nonagriculture sectors. Second, in compiling the national accounts for Ethiopia, most of the activities in the value chains of these cereals are defined as being within the agricultural sector. For example, teff flour is treated as an agricultural product rather than a manufactured one. As such, the value-added from processing teff is included within agricultural rather than manufacturing GDP. The only exceptions to this are the trade and transport margins associated with moving teff from farm to market—the value-added of which is assigned to the services sector.

In summary, the apparent weak links between agriculture and nonagriculture principally reflects how cereal processing is defined within Ethiopia's national accounts and competition over scarce land and labor resources between agricultural and nonagricultural activities. This suggests that if the ATA Initiatives are going to contribute to structural transformation as defined in Ethiopia's Growth and Transformation Plan, it will be necessary to extend value chains beyond the agricultural sector. For example, as the value chain of teff becomes more complex and more of the processing of teff occurs outside of the household, it is more likely that teff consumption will be reclassified as a source of manufacturing growth. Given existing value chains and

prevailing definitions in national accounts, the successful implementation of the ATA Initiatives for teff, wheat, and maize will not bring about much change in the structure of the Ethiopian economy.

Concerning their impact on consumption and welfare, the simulation analysis shows that the ATA Cereal Initiatives are expected to have quite different impacts across rural and urban households and poor and nonpoor households. The insights gained from the modeling exercise are that significant increases in teff production will provide greatest benefits for urban consumers, particularly poor urban households, while the economic benefits of increases in maize production will principally flow to rural households, both poor maize consumers and maize producers. The benefits gained from increases in wheat production are distributed more evenly across all households. The reasons for this variation in the impact of the production increases of the three cereals across household groups are found in differences in the food baskets of the various groups, in relative cereal prices, and in the price elasticities of supply and demand for the cereals. Cultural factors also explain some of these patterns: teff is viewed as a superior commodity, its consumption associated among many Ethiopians with a better quality of life. Table 10.1 shows that, while urban households proportionally consume very little maize, their teff consumption is much higher than is seen in rural households. Rural and urban households, in contrast, consume wheat in almost equal proportions.

While all three cereals have their role in Ethiopia's economy and in the food baskets of Ethiopian households, one important question is from which cereal does society derive the greatest return? Using the CGE model and the data at hand, we cannot answer this question confidently and completely. However, the analysis here provides some insights into the merits of public investments in the three cereals relative to each other. It was noted that the average ratio of the prices of the cereals in the Addis Ababa market between 2001 and 2011 was 2.47 for teff-to-maize and 1.47 for teff-to-wheat (Minten, Stifel, and Tamru 2012). Similarly, the national average on-farm yields of teff are 1,260 kilograms per hectare, 1,840 kilograms per hectare for wheat, and 2,540 kilograms per hectare for maize (Ethiopia, CSA 2011)—using the average maize yield as the denominator, these correspond to ratios of the yields of the cereals nationally as 0.497 for teff-to-maize and 0.724 for teff-to-wheat. The relative market value of production per hectare for teff and wheat relative to maize can be calculated as the product of these two ratios. For teff, this is 1.23, while for wheat, it is 1.06. These results indicate that farmers who can choose between maize and the other two cereals and achieve the national average yield levels, would do better to produce teff or wheat, rather than maize,

assuming the market value of that production is the principal criterion guiding their decision. Moreover, if recent increases in the average yields of teff and wheat can be sustained and exceed any increases in maize yields, these cereals will become even more financially attractive for farmers relative to maize.

However, the decision is more complicated than this analysis would suggest both at farm and at national policy levels. The significantly higher land productivity of maize will make maize a more reasonable production choice than wheat or teff for smallholders on small plots, particularly if production for own consumption is important. At a policy level the fact that maize provides more production on less land means that investments in increasing maize productivity will be strategic. The significance of this is that some of the economic objectives of Ethiopia, such as food security, can be achieved on a smaller land base with maize than would be the case with other crops, making available more land to other economic uses. Given the agroecological diversity of Ethiopia, a mix of cereals makes sense for agronomic reasons alone. However, there are also good economic reasons for maintaining a mix in cereals, both high value (like teff) and lower value (like maize).

In summary, the cereal subsector of Ethiopia's agricultural economy offers considerable scope for contributing to the economic transformation of the country. ATA's Teff, Wheat, and Maize Initiatives provide an appropriate approach to realizing some of the potential the sector has to contribute to such a transformation. Current cereal productivity levels in Ethiopia are below potential—the average wheat yields of 1,840 kilograms per hectare are only 57.9 percent of average wheat yields (3,175 kilograms per hectare) in the United States for 2013, while the average maize yield of 2,540 kilograms per hectare is only 25.5 percent of average maize yields (9,970 kilograms per hectare) of US farmers (USDA 2014). While this comparison is not wholly fair, it does demonstrate that the agronomic productivity potential of these two cereals is far from realized in Ethiopia. While judging the on-farm productivity potential for teff is more difficult than it is for the better researched maize and wheat, likely a similar story applies to teff. Ethiopian farmers can become much more productive, bringing benefits to their own households and the country as a whole.

However, policy makers should be sensitive to the possibility that there might be alternative public investments, whether in the agricultural sector or in other sectors, that would provide similar levels of economic growth, poverty reduction, and increased household consumption more efficiently at less cost. The analyses here provide no insights on this possibility. While keeping this caveat in mind, nonetheless it would appear that increasing public investments

to improve productivity levels and increase overall production of cereals has considerable potential for bringing about strong economic growth in the country, particularly in the agricultural sector and across the rural economy. While the results of the modeling here do not provide any evidence of structural transformation of the economy with the level of production increases examined, it should be expected that as the agricultural sector grows through increased productivity, gradually more positive spillovers into the other sectors of the economy and strengthened links between those sectors and the agricultural sector will be observed. As such, as Ethiopia seeks sustained strong economic growth and broad poverty reduction, continued investment in raising production of cereals should be one of the principal strategies it uses to attain these objectives.

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