Implications of food production and price shocks for household welfare in Ethiopia: a general equilibrium analysis

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January 2010

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for

Household Welfare in Ethiopia: A General Equilibrium Analysis

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January 2010

We gratefully acknowledge the financial support of the World Food Programme – Addis Ababa for this work. The views expressed in this paper are those of the authors and do not represent the official positions of their respective institutions or the World Food Programme.

Executive Summary

Although Ethiopia has made substantial progress in increasing food production, raising household incomes and establishing a safety net, tens of millions of people remain vulnerable to adverse shocks that have major implications for food supply, prices and household welfare. For example, Ethiopian farmers often suffer the adverse effects of insufficient or poorly timed rain. Drought-induced reductions in cereal supply and in some instances international price shocks also threaten food security of net food consumers.

Understanding the implications of large production and food price shocks on food security in Ethiopia requires an economy-wide perspective. This is because agriculture is such a large part of the economy and because food consumption accounts for over half of the value of total national consumption. Thus, the effects of large production shortfalls and food price increases ripple throughout the entire economy, having significant effects on household incomes and access to food through their impacts on the demand for labor, wage rates, the non-agricultural sector, and even the balance of payments and the real exchange rate.

This paper examines recent movements in cereal prices in light of world price movements and production trends, and then uses a Computable General Equilibrium (CGE) model to assess the effects of various types of shocks on prices, incomes and food consumption, particularly for poor households. The data basis for this analysis is the 2005/06 Ethiopia Social Accounting Matrix (SAM) developed by EDRI and researchers from the Institute of Development Studies and the International Food Policy Research Institute. This SAM provides a detailed set of consistent data on production by region, commodity supply and demand, factor income sources and payments to households and enterprises, household incomes and expenditures, and accounts for saving-investment, government and the rest of the world. The SAM-based CGE model employed in the core of this study distinguishes five agro-ecological zones, 46 production activities including 35 zone-specific agricultural production sectors, 22 commodity groups including 12 agro-food commodities, and 15 primary factors of production including zone-specific land and livestock capital. On the household side, the SAM-based model identifies 14 distinct household groups. Three sets

of simulations are conducted: drought- or disease- induced crop and livestock production shortfalls; increases in international prices of cereals; and variations in food aid.

Simulation results show that while production shocks in drought prone agro-ecological zones or for the enset crop have major effects on incomes of farmers who suffer losses in production, other farmers may benefit from the moderate price increases that result from the reduced supply. Moreover, the effects on national prices are generally small, since drought prone areas do not account for a very large share of national production. A major drought in the pastoralist arid lowland plains and in the drought-prone highlands of Ethiopia that reduces crop productivity by 20 percent and destroys 20 percent of livestock capital in these zones is associated with an aggregate real income loss on the order of 2.3 percent of Ethiopia's gross domestic product (GDP). Of course, a drought covering a wider area would have larger effects on national production, market prices and household incomes.

The simulations of international price increases show that to a large extent Ethiopia is insulated from international markets, since most of the major staples (teff, maize, sorghum and enset) are not internationally traded to a significant extent. Only wheat is traded on a large scale, and in recent years, the quantity of wheat imports has been constrained by foreign exchange restrictions for imports. Finally, the simulations of variations in food aid show that major increases in food aid can significantly reduce prices, benefitting all net purchasers of wheat (not merely the recipients of food aid), but adversely affecting net producers of wheat. The wheat price drop is associated with a decline in returns to land in the wheat-producing zones. Urban households gain noticeably more than rural households as they benefit from lower wheat and other crop prices without suffering from the adverse price and land rent effects on the production side.

Further analysis on the implications of drought over time (considering the effects of losses in the stocks of animals on future production) as well as analysis of the implications of country-wide droughts is needed. Refinement of model parameters and further sensitivity analysis is also called for.

One major policy implication arising from this analysis is the importance of careful monitoring of local markets and household access to food. The simulations indicate that severe production shocks that are isolated to relatively small areas of the country are not likely to be readily noticed in the major markets of Ethiopia, which are generally well-integrated. This is because these production shocks can represent a relatively small share of total supply. Thus, in addition to further work in understanding the economy-wide implications of production, external price and policy shocks, it remains crucial to complement this work with careful local monitoring of production, household incomes and prices.

Implications of Food Production and Price Shocks on Household Welfare in Ethiopia:

A General Equilibrium Analysis

Sherman Robinson, Dirk Willenbockel, Hashim Ahmed and Paul Dorosh

I. Introduction

Although Ethiopia has made substantial progress in increasing food production, raising household incomes and establishing a safety net, tens of millions of people remain vulnerable to major production shortfalls and external shocks. Fortunately, the country has not suffered through a major drought since 2002-03. Yet, regional droughts and crop shortfalls occur almost every year. Moreover, surges in world food prices, as occurred in 2007 and 2008, also adversely affect food security by raising the cost of wheat and other food imports.

Understanding the implications of large production and food price shocks on food security in Ethiopia requires an economy-wide perspective. This is because agriculture is such a large part of the economy, (accounting for 43 percent of GDP in 2005/06), and because food consumption accounts for over half of the value of total national consumption. Large production shortfalls and food price increases ripple throughout the entire economy, having significant effects on household incomes and access to food through their impacts on the demand for labor, wage rates, the non-agricultural sector, and even the balance of payments and the real exchange rate.

This paper provides a framework for such an economy-wide analysis of food security in Ethiopia. Utilizing a comprehensive, coherent data base on economic flows on production, incomes and consumption, the EDRI 2005-06 Social Accounting Matrix (SAM), and a computable general equilibrium (CGE) model, we provide a quantitative analysis of the implications of various shocks on household food security. Several basic scenarios are considered, including the implications of drought-induced livestock and crop production shortfalls in various regions of Ethiopia, world price increases and additional food aid inflows.

The plan of the paper is as follows. Section 2 provides a brief overview of recent developments in cereal price movements and trade policy in Ethiopia, highlighting the extent to which world price changes have affected the price of wheat, the country's major internationally traded cereal. Section 3 describes the structure of the Ethiopian economy as shown in the 2005-06 SAM, along with the structure of the CGE model used in the analysis. Simulation results are presented in Section 4. The final section summarizes the major findings and policy implications.

II. Cereal Prices and Trade[1]

Agricultural production shocks directly affect farm incomes, and thereby farm households' access to food. Likewise, macro-economic shocks and production shocks outside the agricultural sector affect household incomes by influencing demand and supply of goods, services and labor. Nonetheless, perhaps the most important pathway through which most households are affected by shocks in the domestic economy and international markets is through changes in domestic prices. Understanding the behavior of food markets, particularly price transmission between international and domestic markets and integration of domestic markets within the country is crucial for modeling and analyzing food security.

Cereal price movements in Ethiopia in the past several years have been puzzling. In spite of rapid increases in production (and net supply) of Ethiopia's four major cereals (teff, wheat, maize and sorghum), their nominal and real prices rose sharply between 2003/04 and 2007/08, with especially large price increases in 2007/08 (Tables 2.2 and 2.3; Figures 2.2 and 2.3). From 2003/04 to 2006/07, the average real price of the four major cereals (teff, wheat, maize and sorghum) [2] rose by 12 percent; including 2007/08, the real price increase was 45 percent. The average real price of the four cereals actually declined slightly (by 1 percent) in 2008/09, though.

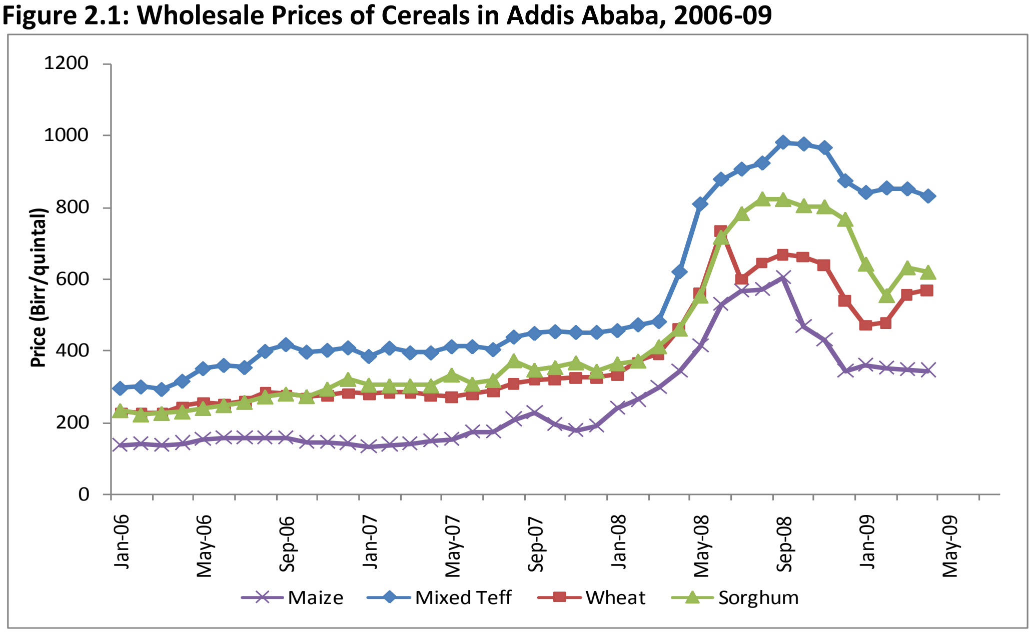
[1] This chapter is based on the analysis of cereal markets in Dorosh and Ahmed (2009), from which it draws heavily.
[2] The real price index reported here is a 2007-08 production-weighted average of the four major cereals.

Table 2.1: Nominal Wholesale Prices of Major Cereals in Addis Ababa (birr/quintal)

	Teff	Wheat	Maize	Sorghum
	Nominal Prices			
Oct97-Sept98	229.9	175.6	102.8	196.9
Oct98-Sept99	252.5	196.6	126.7	180.7
Oct99-Sept00	272.8	205.8	121.8	203.0
Oct00-Sept01	244.3	149.1	68.1	163.1
Oct01-Sept02	216.4	128.2	69.6	136.9
Oct02-Sept03	252.3	198.0	136.7	205.9
Oct03-Sept04	249.0	172.0	113.7	162.1
Oct04-Sept05	259.0	185.1	146.0	198.1
Oct05-Sept06	324.8	241.5	143.6	241.6
Oct06-Sept07	406.9	283.6	159.7	313.1
Oct07-Sept08	650.6	472.5	369.1	507.1
Oct08-Sept09	869.8	527.1	362.3	625.6
	Annual Change			
	Teff	**Wheat**	**Maize**	**Sorghum**
1997/98 - 1998/99	9.8%	11.9%	23.2%	-8.2%
1998/99 - 1999/00	8.0%	4.7%	-3.8%	12.3%
1999/00 - 2000/01	-10.4%	-27.6%	-44.1%	-19.7%
2000/01 - 2001/02	-11.4%	-14.0%	2.2%	-16.0%
2001/02 - 2002/03	16.6%	54.4%	96.3%	50.4%
2002/03 - 2003/04	-1.3%	-13.1%	-16.8%	-21.3%
2003/04 - 2004/05	4.0%	7.6%	28.4%	22.2%
2004/05 - 2005/06	25.4%	30.5%	-1.7%	22.0%
2005/06 - 2006/07	25.3%	17.4%	11.2%	29.6%
2006/07 - 2007/08	59.9%	66.6%	131.1%	62.0%
2007/08 - 2008/09	33.7%	11.5%	-1.9%	23.4%
2004/05 - 2008/09	**235.8%**	**184.8%**	**148.1%**	**215.8%**

Source: EGTE data.

Figure 2.1: Wholesale Prices of Cereals in Addis Ababa, 2006-09



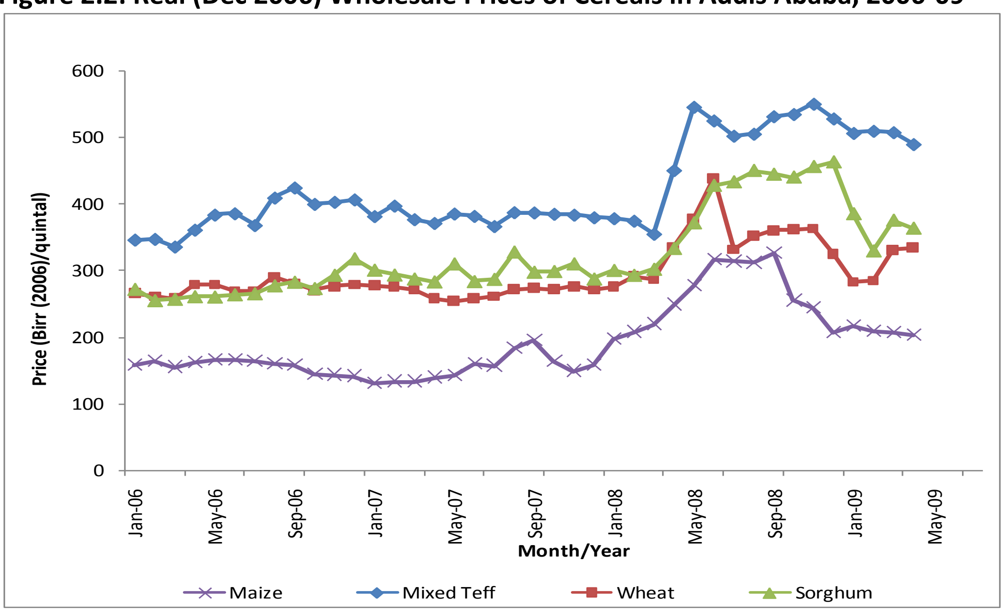
Source: EGTE data; Dorosh and Ahmed (2009).

Table 2.2: Real Wholesale Prices of Major Cereals in Addis Ababa (birr (2006)/quintal)

	Teff	Wheat	Maize	Sorghum
	Real Prices			
Oct97-Sept98	388.6	297.2	173.8	332.7
Oct98-Sept99	397.6	309.0	198.4	285.1
Oct99-Sept00	417.3	315.1	186.3	310.4
Oct00-Sept01	405.7	246.8	112.6	270.2
Oct01-Sept02	368.5	217.5	117.7	232.3
Oct02-Sept03	363.7	285.5	196.6	296.7
Oct03-Sept04	343.0	236.7	156.3	223.0
Oct04-Sept05	325.4	232.1	182.9	248.1
Oct05-Sept06	361.7	269.7	160.5	270.1
Oct06-Sept07	387.4	269.9	151.1	297.6
Oct07-Sept08	440.8	321.3	244.2	343.5
Oct08-Sept09	507.8	307.2	211.0	364.8
	Annual Change			
	Teff	**Wheat**	**Maize**	**Sorghum**
1997/98 - 1998/99	2.3%	4.0%	14.1%	-14.3%
1998/99 - 1999/00	5.0%	2.0%	-6.1%	8.9%
1999/00 - 2000/01	-2.8%	-21.7%	-39.5%	-13.0%
2000/01 - 2001/02	-9.2%	-11.9%	4.5%	-14.0%
2001/02 - 2002/03	-1.3%	31.2%	67.0%	27.7%
2002/03 - 2003/04	-5.7%	-17.1%	-20.5%	-24.8%
2003/04 - 2004/05	-5.1%	-1.9%	17.0%	11.2%
2004/05 - 2005/06	11.1%	16.2%	-12.3%	8.9%
2005/06 - 2006/07	7.1%	0.1%	-5.9%	10.2%
2006/07 - 2007/08	13.8%	19.1%	61.6%	15.4%
2007/08 - 2008/09	15.2%	-4.4%	-13.6%	6.2%
2004/05 - 2008/09	**56.0%**	**32.3%**	**15.4%**	**47.1%**

***** Real prices calculated using the national consumer price index as a deflator (December 2006=100).

Figure 2.2: Real (Dec 2006) Wholesale Prices of Cereals in Addis Ababa, 2006-09



Source: Calculated from EGTE data and CSA consumer price index; Dorosh and Ahmed (2009).

Increased demand for food because of rising per capita incomes, and (in especially for teff) urbanization, have been analyzed. However, even after taking these factors into account, the increase in real prices is not entirely explained, though these factors explain wheat prices reasonably well (Dorosh and Ahmed, 2009). The surge in real cereal prices in 2007/08 is especially puzzling, though it may have been due in part to expectations of a possible poor harvest or reduced levels of wheat imports (after the start of foreign exchange rationing in March 2008).

For the most part, prices of Ethiopia's major cereals are determined by domestic supply and demand, with little influence from international markets. There is very little external trade in teff, maize and sorghum, so net availability is essentially determined by domestic production less seed use and losses. For wheat, external trade is significant, particularly food aid imports which averaged 630 thousand tons per year over this period. Note, though, that food aid plus government commercial imports in 2007/08 (about 700 thousand tons) was not much different than in 2001/02 (630 thousand tons).

The links between international and domestic wheat prices are complex, however. From 2000 to 2009, wheat markets in Ethiopia have been governed by several different regimes of price determination (Box 1). From mid-2000 through 2004, domestic prices of wheat in Addis Ababa were generally below import parity levels but above export parity levels, thus providing little incentive for private imports or exports of ordinary wheat (Table 2.3 and Figure 2.3). Domestic prices were on average 24 percent below import parity levels in this period, in part because food aid inflows helped to depress prices to the benefit of net wheat consumers and the detriment of net wheat producers.[3]

Then, from early 2005 to early 2007, domestic prices of wheat (wholesale, Addis Ababa) tracked import parity prices, as private sector wheat imports constituted the marginal supply of wheat in Ethiopia, given levels of domestic production and food aid inflows. Thus, from 2004/05 through 2006/07, domestic prices of wheat were on average only 0.8 percent higher than import parity prices (Table 2.3). During this period, therefore, wholesale prices of wheat in Ethiopia were strongly linked to international prices.

[3] See Rashid, Assefa and Ayele (2008) for estimates of price distortions in Ethiopian agriculture.

Box 1: Wheat Market Regimes in Ethiopia, 2000 to 2009

Regime 1: January 2000-June 2005: Domestic wheat prices were generally between import and export parity

- Given levels of official imports (including food aid), there was little incentive for private sector imports of ordinary wheat
- Domestic prices were determined by domestic supply (including official imports) and demand

Regime 2: July 2005-March 2007: Domestic wheat prices were generally at import parity levels

- Private sector imports adjusted to equate total supply and domestic demand at the import parity price

Regime 3: April 2007- May 2008: Domestic wheat prices were again below import parity

- Given sharp increases in world prices, private sector imports were not profitable

Regime 4: June 2008 – May 2009: Domestic wheat prices were above import parity

- Restrictions on foreign exchange for imports prevented private imports from taking advantage of profitable import opportunities

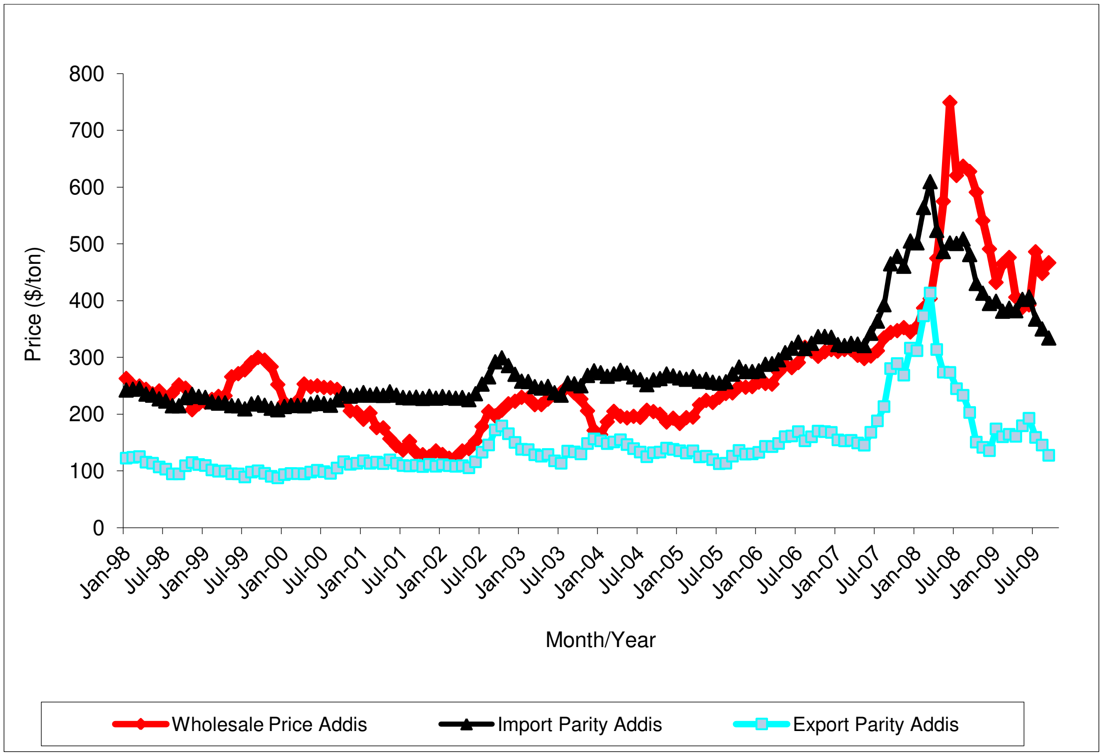
Table 2.3: Domestic and Import Parity Prices of Wheat in Ethiopia, 1998 – 2009

Crop Year (October-September)	White Wheat Wholesale Addis (Birr/kg)	Exchange Rate (Birr/$)	White Wheat Wholesale Addis ($/ton)	Wheat Import Parity Addis ($/ton)	Nominal Protection Coefficient (percent)
1998-99	1.97	7.87	248.9	221.8	12.7%
1999-00	2.06	8.30	248.0	215.9	15.0%
2000-01	1.49	8.52	175.4	233.5	-24.9%
2001-02	1.28	8.69	147.5	239.7	-38.9%
2002-03	1.98	8.72	227.1	257.7	-11.3%
2003-04	1.72	8.78	195.8	266.1	-25.8%
2004-05	1.85	8.83	209.6	262.4	-17.7%
2005-06	2.42	8.86	272.5	297.8	-3.6%
2006-07	2.84	9.06	313.1	348.7	-2.1%
2007-08	4.73	9.60	489.3	510.1	8.2%
2008-09	5.27	11.39	465.2	387.3	40.5%
Ave. 2000-01 - 04-05	1.66	8.71	191.1	251.9	-23.7%
Ave. 2005/06 - 07-08	3.33	9.17	358.3	385.5	0.8%

* Average of data from October 2008 through April 2009.

Source: Authors' calculations from Ethiopian Grain Trading Enterprise (EGTE) data.

Figure 2.3: Domestic, Import and Export Parity Prices of Wheat in Ethiopia, 1998 – 2009



Note: Import and export parity figures are calculated using U.S. Hard Red Winter Wheat Price (fob Gulf of Mexico) plus international shipping (estimated at US$30/ton for December 2008) and domestic handling and transport from Djibouti to Addis (estimated at approximately 1,350 Birr/ton in December 2008).
Source: Authors' calculations from Ethiopian Grain Trading Enterprise (EGTE) data.

Since mid-2007, however, domestic wheat prices have NOT been determined by international prices. World prices (import parity Addis Ababa) were higher than domestic prices from mid-2007 through March 2008. Thus, during this period, there were very little imports of ordinary wheat by the private sector as private imports of ordinary wheat were not profitable.

However, when poor rains in many parts of Ethiopia in early 2008 led to a failure of the *belg* season harvest and concerns about adequacy of rainfall for planting of the upcoming 2008 *meher* crops (harvested in October-December), domestic prices rose sharply.[4] Private imports of wheat were apparently again profitable, but restrictions on foreign exchange for imports of wheat (and other goods) were imposed in March 2008.

[4] The *belg* harvest accounts for about 15 percent of annual maize production, but less than 2 percent of annual teff, wheat and sorghum production.

As a result, import parity did not provide a ceiling on domestic prices of wheat. Instead, domestic wheat prices rose above world prices beginning in May 2008, reflecting the inability or unwillingness of private importers to take advantage of the profitable trade opportunity. Factors such as lack of access to foreign exchange, policy uncertainty related to government imports and domestic sales, and concern over possible seizure of private stocks all likely contributed to this lack of private sector import supply response.

In lieu of private sector imports, government policy in mid-2008 was to contract for its own imports of wheat and then sell the wheat at fixed prices in the domestic market (generally 300 Birr/quintal, only about half of the wholesale price of wheat in Addis Ababa market). Simple partial equilibrium wheat market analysis suggests that the announcement of the wheat imports and the subsequent government wheat sales accounted for the real price decline (see Dorosh and Ahmed, 2009, Table 8). Sales of government imported wheat reduced real wheat prices in domestic markets from July through October, but not by as much as initially expected, as market wheat demand ultimately proved to be quite price-elastic. Two factors likely accounted for the smaller than expected real price decline. First, wheat millers may not have milled all the wheat received or sold all the wheat flour produced by October 2008. Second, imported wheat is not a perfect substitute for locally produced wheat, so increases in imported wheat quantities would likely have smaller effects on prices of locally produced wheat than on prices of domestic sales of imported wheat.

Nonetheless, sales at below-market prices implied huge rents (excess profits) for traders and millers who were able to purchase wheat at 300 Birr/quintal and sizeable income transfer to poor households who were able to purchase government wheat directly.

Following the 2008 *meher* harvest, domestic wheat prices fell sharply, but nonetheless have still remained above import parity levels in spite of a 16 percent depreciation of the birr relative to the US dollar and a 27 percent reduction in the international price of wheat (fob US Gulf) from October 2008 to April 2009. Thus, the divergence between international and domestic prices remained.

III. Structure of the Ethiopian Economy: Production, Household Incomes and Consumption

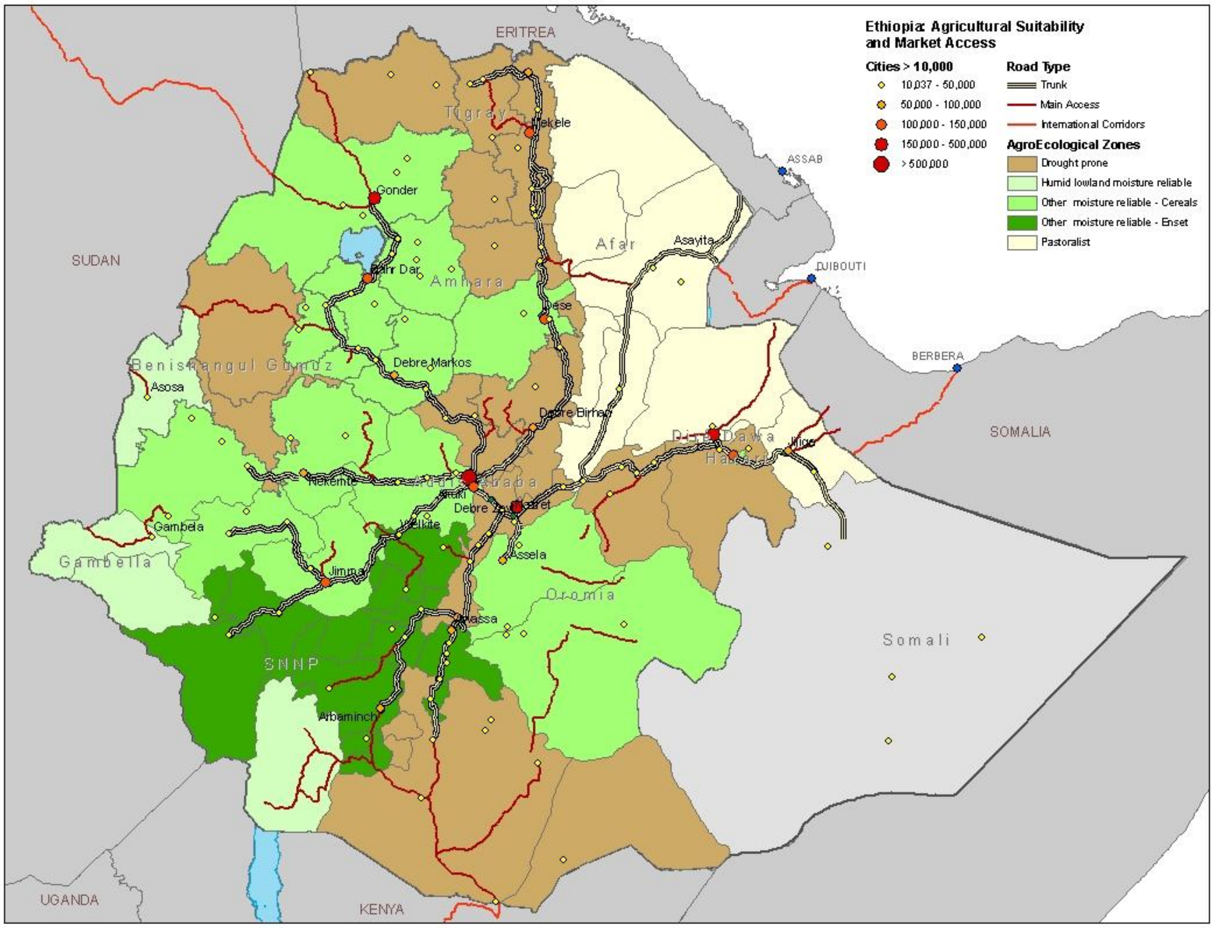
Linkages across production activities because of competition for factor inputs (land, labor and capita) or because of substitution or complementarity in demand affect domestic output and total income in the economy. Moreover, for each household (or household group), the structure of incomes by source (i.e. from various factors of production) and their initial consumption patterns and responsiveness to income and price changes determine changes in real incomes and consumption.

These economic flows are quantified in the social accounting matrix (SAM) for 2005/06 which forms the data base for the computable general equilibrium model of the Ethiopian economy employed for the simulation analysis in section 4. The SAM (EDRI, 2010) provides a detailed representation of the structure of production, demand, international trade and income distribution and contains a regional disaggregation of agricultural activities, household income and household consumption.

The five regions in the SAM are defined according to agro-ecological zones, where the boundaries of the zones are based on the boundaries of administrative zones (i.e. the level of government between region and woreda), (Figure 3.1 and Table 3.1).

The aggregation of the source SAM for purposes of the present study distinguishes 46 production activities including 35 zone-specific agricultural production sectors, 22 commodity groups including 12 agro-food commodities, and 15 primary factors of production (10 of which are zone-specific land and livestock) (Table 3.1). On the household side, the SAM-based model identifies 14 distinct household groups comprising poor and "non-poor" rural households residing in each of the five regional zones as well as poor and non-poor households distinguished by big and small urban settlements (Table 3.2). Poor household groups are defined as those households whose per capita expenditures place them in the poorest 40% of the national rural or urban per capita expenditure distribution, according to HICES 2004/05 data.

Figure 3.1: Agro-ecological Zones in the 2004/05 EDRI SAM



Source: EDRI (2010).

Table 3.1 Characterization of the Five Agro-Ecological Zones in the Ethiopia EDRI 2005/06 SAM

SAM Region	Temperature and Moisture Regime
Zone 1	Humid Lowlands Moisture Reliable
Zone 2	Moisture Sufficient Highlands – Cereals Based
Zone 3	Moisture Sufficient Highlands – Enset Based
Zone 4	Drought-Prone (Highlands)
Zone 5	Pastoralist (Arid Lowland Plains)

Table 3.2: Aggregation of Activities, Commodities and Households

Activities	in Zones	Commodities	
Atef	2 3 4	**Ctef**	Teff
Awhea	2 3 4	**Cwheat**	Wheat
Amaiz	1 2 3 4 5	**Cmaize**	Maize
abarsor	1 2 3 4 5	**Cbarsor**	Barley and sorghum
Aenset	1 2 3 4	**Cagex**	Export agriculture
Aagex	1 2 3 4 5	**Censet**	Enset
aothrag	1 2 3 4 5	**Cothrag**	Other agricultural products
Alivst	1 2 3 4 5	**Clivstk**	Livestock
		Chome1	Home-produced agricultural products
		Chome2	Home-produced processed food and services
Amilling		**Cmilling**	Flour and milling services
Afood		**Cfood**	Other processed food, beverages, tobacco
Achem		**Cchem**	Chemicals
Aelect		**Celect**	Electricity
Awater		**Cwater**	Water
		Cptrl	Petrol
Ai-mfg		**Ci-mfg**	Intermediate and investment goods
Af-mfg		**Cf-mfg**	Final consumer goods
Aconst		**Cconst**	Construction services
Atrd-trn		**Ctrd-trn**	Trade and transport services
Agov		**Cgov**	Public admin, education, health services
Aosvc		**Cosvc**	Other services

Table 3.2: Aggregation of Activities, Commodities and Households (cont.)

Factors

flab0	Agricultural labour
flab12	Administrative workers and professionals
flab3	Unskilled workers
flab4	Skilled workers
fland1	Land - Zone 1
fland2	Land - Zone 2
fland3	Land - Zone 3
fland4	Land - Zone 4
fland5	Land - Zone 5
flvstk1	Livestock capital - Zone 1
flvstk2	Livestock capital - Zone 2
flvstk3	Livestock capital - Zone 3
flvstk4	Livestock capital - Zone 4
flvstk5	Livestock capital - Zone 5
fkptl	Capital

Table 3.3 displays information on the commodity structure of domestic gross production, international trade and household consumption. Agriculture and food processing (AgFood) account for 42 percent of gross production value and generate around 50 percent of Ethiopia's GDP at factor cost in 2005/06. AgFood imports account only for 8.4 percent of Ethiopia' total import bill and the share of AgFood imports in domestic AgFood demand is also fairly low (5.3 percent). The only agricultural commodity with a large share of imports in domestic demand is wheat. Teff, maize, barley, sorghum and enset are all virtually non-traded goods. On the other hand, agriculture makes a significant contribution to Ethiopia's total export revenue. Cagex exports, which consist primarily of coffee and oilseeds, account for nearly 80 percent of agricultural exports. These basic facts need to be borne in mind when we turn to the world market food price shock simulation results in section 4. 63 percent of total household

consumption including non-marketed home production for own home consumption is AgFood consumption with a far higher share for rural poor households.

Table 3.3: Commodity Structure of Production, Trade and Consumption

	Share in Domestic Production	Share in Total Imports	Share in Total Exports	Share of Exports in Output	Share of Imports in Dom. Demand	Share in Household Consumption	Share in Rural Poor Consumption
Ctef	0.012	0.000	0.000	0.000	0.000	0.017	0.007
Cwheat	0.009	0.035	0.000	0.000	0.492	0.023	0.038
Cmaize	0.009	0.000	0.000	0.001	0.001	0.013	0.024
Cbarsor	0.010	0.000	0.000	0.002	0.000	0.014	0.022
Cagex	0.041	0.001	0.336	0.726	0.020	0.029	0.029
Censet	0.004	0.000	0.000	0.000	0.000	0.006	0.009
Cothrag	0.037	0.011	0.043	0.105	0.079	0.058	0.058
Clivstk	0.051	0.002	0.047	0.082	0.009	0.065	0.046
Chome1	0.121	0.000	0.000	0.000	0.000	0.197	0.289
Chome2	0.088	0.000	0.000	0.000	0.000	0.143	0.195
Cmilling	0.008	0.002	0.015	0.167	0.069	0.009	0.008
Cfood	0.031	0.033	0.033	0.096	0.230	0.056	0.043
Cchem	0.009	0.123	0.019	0.200	0.818	0.042	0.036
Celect	0.008	0.000	0.000	0.000	0.000	0.005	0.000
Cwater	0.006	0.000	0.003	0.051	0.001	0.003	0.001
Cptrl	0.000	0.122	0.000	-	1.000	0.010	0.006
Ci-mfg	0.021	0.092	0.034	0.148	0.568	0.012	0.007
Cf-mfg	0.031	0.336	0.068	0.201	0.776	0.122	0.069
Cconst	0.113	0.000	0.000	0.000	0.000	0.000	0.000
Ctrd-trn	0.184	0.173	0.295	0.144	0.216	0.025	0.010
Cgov	0.108	0.002	0.008	0.006	0.004	0.033	0.020
Cosvc	0.100	0.068	0.097	0.087	0.020	0.118	0.083
ToT (Avg)	1.000	1.000	1.000	0.090	0.133	1.000	1.000
AgFood	0.421	0.084	0.475	0.101	0.053	0.631	0.769

Tables 3.4 and 3.5 show the regional composition of agricultural production. Zone 2 produces nearly 50 percent of Ethiopia's total agricultural output and has the largest production share in all agricultural commodities except enset, while zone 1's contribution is marginal. 96 percent of Zone 5 agricultural output value is livestock production, and livestock accounts for 31 percent of Ethiopia's total agricultural gross production value. Table 3.5 shows the composition of household income by source for each household group and is the key to the explanation of the distributional impacts of the various shocks considered in section 4.

Table 3.4: Regional Shares in Domestic Agricultural Production

Percentage shares in gross output value

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total	*Total Value*
Teff	0.0	61.7	6.6	31.7	0.0	100.0	*5.155*
Wheat	0.0	66.9	7.4	25.6	0.0	100.0	*4.433*
Maize	1.0	58.2	16.1	23.4	1.2	100.0	*5.183*
Barley/Sorghum	0.7	57.9	4.8	35.9	0.6	100.0	*5.043*
Enset	1.0	18.8	48.1	32.1	0.0	100.0	*1.679*
Export crops	0.5	43.1	21.4	34.4	0.6	100.0	*9.490*
Other Ag	0.7	44.0	26.2	28.9	0.3	100.0	*9.316*
Livestock	1.1	42.4	9.8	24.7	22.1	100.0	*17.993*
TOTAL	0.7	48.4	15.1	28.7	7.1	100.0	*58.293*

Table 3.5 Activity Shares in Total Agricultural Output by Zone

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	All
Teff	0.00	0.11	0.04	0.10	0.00	0.09
Wheat	0.00	0.11	0.04	0.07	0.00	0.08
Maize	0.13	0.11	0.09	0.07	0.02	0.09
Barsor	0.09	0.10	0.03	0.11	0.01	0.09
Enset	0.04	0.01	0.09	0.03	0.00	0.03
Aagex	0.11	0.15	0.23	0.20	0.01	0.16
Aothrag	0.17	0.15	0.28	0.16	0.01	0.16
Livst	0.47	0.27	0.20	0.27	0.96	0.31
Sum	1.00	1.00	1.00	1.00	1.00	1.00
Zone Share	0.01	0.48	0.15	0.29	0.07	1.00

Table 3.6 Household Income by Source (Shares)

	Base	Lab0	Lab12	Lab3	Lab4	Land	Livstk	Cap	GovTr	RoWTr	Total
HH-Rural_EZ1P	*0.510*	0.77	0.00	0.00	0.00	0.04	0.05	0.11	0.03	0.00	1.00
HH-Rural_EZ2P	*9.857*	0.73	0.00	0.00	0.00	0.04	0.07	0.13	0.01	0.03	1.00
HH-Rural_EZ3P	*4.651*	0.68	0.02	0.00	0.00	0.04	0.04	0.14	0.02	0.06	1.00
HH-Rural_EZ4P	*8.423*	0.64	0.01	0.00	0.00	0.03	0.05	0.20	0.02	0.05	1.00
HH-Rural_EZ5P	*1.544*	0.12	0.00	0.00	0.00	0.02	0.33	0.45	0.01	0.08	1.00
HH-Rural_EZ1NP	*0.732*	0.46	0.01	0.00	0.00	0.04	0.04	0.43	0.00	0.01	1.00
HH-Rural_EZ2NP	*32.532*	0.41	0.02	0.00	0.00	0.11	0.05	0.39	0.00	0.02	1.00
HH-Rural_EZ3NP	*13.537*	0.39	0.03	0.00	0.00	0.12	0.03	0.41	0.01	0.02	1.00
HH-Rural_EZ4NP	*25.014*	0.35	0.01	0.00	0.00	0.10	0.04	0.45	0.01	0.05	1.00
HH-Rural_EZ5NP	*3.693*	0.07	0.00	0.00	0.00	0.01	0.19	0.66	0.01	0.07	1.00
HH-SmallurbanP	*2.819*	0.00	0.08	0.20	0.48	0.00	0.00	0.10	0.05	0.09	1.00
HH-LargeurbanP	*1.869*	0.00	0.14	0.06	0.33	0.00	0.00	0.10	0.03	0.33	1.00
HH-SmallurbanNP	*15.674*	0.00	0.10	0.06	0.25	0.00	0.00	0.49	0.02	0.07	1.00
HH-LargeurbanNP	*13.431*	0.00	0.09	0.03	0.25	0.00	0.00	0.28	0.03	0.33	1.00

Table 3.7 Agricultural Value Added by Agro-Ecological Zone

	bn birr (2005/06)			Shares		
	Zone 2	**Zone 3**	**Zone 4**	**Zone 2**	**Zone 3**	**Zone 4**
Teff	2.75	0.29	1.41	10.8%	3.7%	9.3%
Wheat	2.31	0.26	0.88	9.1%	3.2%	5.8%
Maize	2.71	0.75	1.09	10.7%	9.4%	7.2%
Bar/Sor	2.47	0.20	1.61	9.7%	2.6%	10.6%
Enset	0.25	0.66	0.44	1.0%	8.2%	2.9%
Exp Crops	3.78	2.01	3.08	14.9%	25.1%	20.3%
Oth Agric	3.64	2.09	2.35	14.3%	26.2%	15.5%
Livestock	7.47	1.72	4.34	29.4%	21.6%	28.6%
Total	25.38	7.97	15.19	100.0%	100.0%	100.0%

Notes:

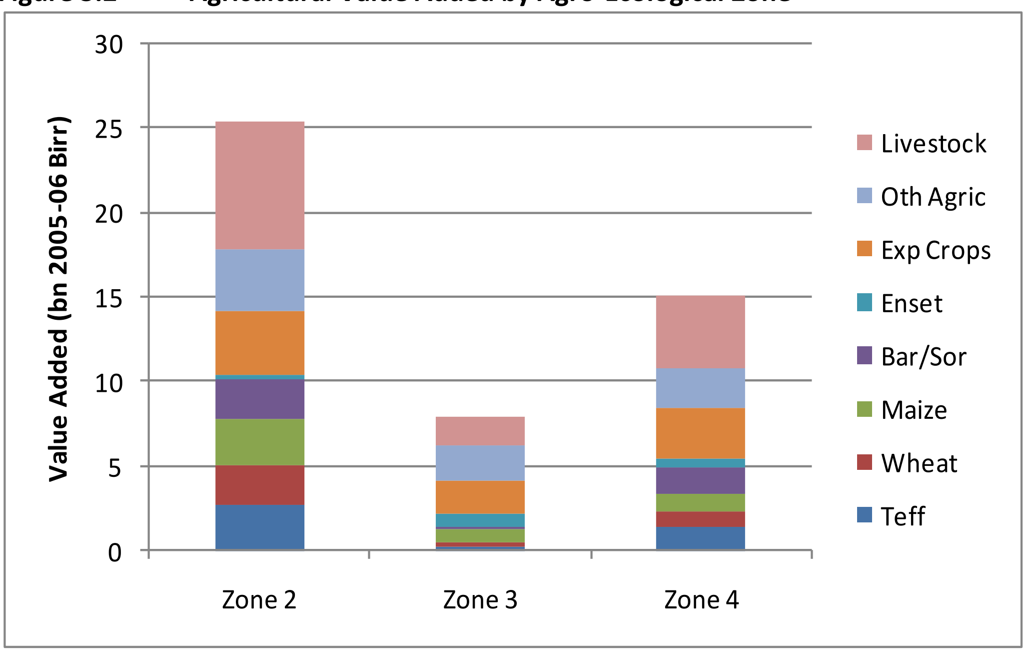
Zone 2: Rainfall sufficient highlands (cereal – based)

Zone 3: Rainfall sufficient highlands (enset – based) – most of SNNPR

Zone 4: Drought prone

Source: 2005/06 EDRI Social Accounting Matrix.

Figure 3.2 Agricultural Value Added by Agro-Ecological Zone



Notes:

Zone 2: Rainfall sufficient highlands (cereal – based)

Zone 3: Rainfall sufficient highlands (enset – based) – most of SNNPR

Zone 4: Drought prone

Source: 2005/06 EDRI Social Accounting Matrix.

The Structure of the CGE Model

The CGE model use in this analysis is a modified version of a SAM-based single-country CGE model in the tradition of Dervis, de Melo and Robinson (1982) and Lofgren et al. (2001) that incorporates agricultural production in multiple agro-ecological zones. Value added is modeled using constant elasticity of substitution (CES) production functions of factor inputs (land, livestock capital, various types of labor and non-agricultural capital). Intermediate inputs into production are determined as fixed shares of the quantity of output.

Payments from each factor of production are allocated to households and other institutions using fixed shares derived from the base SAM. Household consumption is modeled using a Linear Expenditure System (LES) specification.

Imported goods are assumed to be imperfect substitutes for domestically produced goods. Likewise, exported goods are imperfect substitutes for domestically produced and consumed goods. The domestic price of each commodity adjusts so that domestic supply equals domestic demand.

Capital stock (including livestock capital) is fixed in each sector and region. Land is fixed by region, but is allocated across crops so that the value of the marginal return to land is equal across each crop in a given region. In the labor markets, total supply of labor of each skill type is fixed (and fully employed). Real wages adjust so that demand for labor is equal to supply

In the external accounts, foreign savings (foreign capital inflows), are held fixed, (and since foreign transfers are fixed, the trade balance (and current account balance) are also fixed. The real exchange rate adjusts to achieve an export supply and import demand that yield the fixed trade balance.[5]

[5] Section 4.3 presents results for an alternative external market and factor market closures by exploring the implications of activity-specific land and capital and foreign exchange rationing. In the simulations with foreign exchange rationing presented in section 4.3, rents are modeled using an implicit tariff for all imports that adds to the cost of the foreign exchange. Rents are distributed to institutions in fixed shares.

The numeraire (i.e. reference price) of the model is the consumer price index (CPI). Thus, the model determines prices relative to this CPI.[6]

The simulations use a "balanced" macro closure in which aggregate investment, government demand, and consumption are fixed shares of total absorption. Thus, any macro adjustment burden is shared equally across these macro aggregates. The government deficit is endogenous. Savings rates adjust to achieve a savings-investment balance. Details of the equations of the model are given in Annex 1.

IV. Simulation Results

4.1 Overview

The set of stylized drought, food aid and price shock scenarios included in the simulation analysis is shown in Table 4.1. The first three simulation experiments consider the impact of a drought in the drought-prone highlands (zone 4) and the pastoralist arid lowland plains (zone 5). The scenarios are set up to allow a decomposition of the total drought impact into crop and livestock effects. The next two simulations serve to analyze the impacts of a drought in the enset-based moisture-sufficient highlands (zone 3) with a decomposition into enset and maize production effects. The *FOODAID* scenario simulates the general equilibrium implications of a large-scale inflow of wheat financed by the rest of the world. The remaining experiments analyze the consequences of world market price surges for wheat, other crops, processed food and fuels.

[6] It is crucial for a consistent interpretation of results reported below to bear in mind that the simulated changes in commodity prices, factor prices and the exchange rate always represent changes relative to the CPI.

Table 4.1 Simulation Scenarios

Scenario	Description
DROUGHTC	Drought in Zones 4 and 5: Crop Yield Loss Scenario -20% productivity shock to all zone 4/5 crops
DROUGHTL	Drought in Zones 4 and 5: Livestock Loss Scenario Loss of 20% of zone 4/5 livestock capital
DROUGHTA	Drought in Zones 4 and 5: Crop Yield and Livestock Loss Scenario DROUGHTC and DROUGHTL simultaneous
ENSETE	Drought in Zone 3: Enset Yield Loss Scenario -20% productivity shock to enset3
ENSETM	Drought in Zone 3: Maize Yield Loss Scenario -20% productivity shock to maiz3
FOODAID	Large-Scale Food Aid: Free Inflow of Wheat Sale of wheat stocks (equal to 50% of baseline wheat imports) financed by RoW
PWHEAT	World Market Price Surge for Wheat PWM and PWE Wheat +64%
PFOODM	World Market Price Surge for Food: Import Prices PWM Wheat +64%, Maize +28%, Agex +50%, Othrag +50%, Clivstk +30%, Food +50%
PFOODMX	World Market Price Surge for Food: Import and Export Prices PFOODM plus PWE Maize +28%, Agex +30%, Othrag +10%, Barsorg +26%, Livst +30%, Food +10%
PPETROL	World Market Price Surge for Fuel PWM Petrl +50%

PWM: World market price of imports. PWE: World market price of exports

4.2 Main Results

Simulation 1a: Drought-Induced Crop Production Losses (DROUGHTC)

To gain a clear perspective on the economy-wide impacts of a drought in zones 4 and 5, it is worth recalling that zone 4 produces about one third of Ethiopia's output of teff, enset, barley / sorghum and export crops and about a quarter of the country's wheat, maize and livestock output. Livestock value added accounts for 29 percent of total agricultural incomes in the region (Table 3.7). Zone 5's shares in national crop production are marginal, but its contribution to total livestock output is around 22 percent (Table3.4). The assumed drought-induced drop in crop productivity by 20 percent under the *DROUGHTC* scenario entails a decline in real GDP on the order of 1.8%.

Table 4.3 reports the equilibrium impacts on gross output by activity. Within zone 4, exports crops and other agriculture – the activities which generate the bulk of baseline agricultural export revenue - experience the strongest production decline and part of the labour and land previously used in these activities is reallocated to other crops, whose output correspondingly drops by less than 20 percent.

As shown in Table 4.7, cagex and cothrag exports decline significantly as the domestic market prices for these commodities rises substantially relative to the prices obtained in export markets (Table 4.6). At the same time, domestic demand for these traded commodities is squeezed by substitution effects towards imports in response to the domestic price increases relative to imports (Table 4.5). Note that the negative income effect of the drought shock reduces the demand for non-agricultural imports across the board. In the aggregate, this income effect dominates the increased demand for crop imports so that aggregate real import demand drops and the exchange rate appreciates (Table 4.2a).

Land rents in zone 4 take a massive hit, while the drought-free zones experience a rise in the returns to land (Table 4.8) owing to the fact that the drought raises domestic crop prices across the whole country. Relative to the consumer price index, the prices of all other primary factors decline.

Table 4.9 shows how these factor price effects feed through into real income by household group. Households in all zones suffer real income losses as a result of the drought-induced price increases for food of domestic origin. Rural non-poor households in zone 4 who receive 90 percent of zone 4 land rents take the largest real income blow in the DROUGHTC scenario followed by the rural poor and non-poor households located in zone 5. The fact that the real income losses for households in the drought zones are not dramatically higher than for households in zones 1 to 3 can be explained by the fairly low share of land rents in total household income, e.g. land rents in zone 4 account for 9.5 percent of non-poor and for 3.3 percent of poor household income. Urban households suffer larger income losses than poor households in the non-drought zones 1 to 3, since the latter benefit to some extent from the aforementioned increases in real land rents.

A more accurate assessment of the distribution of welfare effects by household group than real income effects based on a uniform country-wide CPI deflator are the equivalent variations reported in Table 4.11. The equivalent variation (EV) takes account of differences in consumer preference across households as revealed by observed spending patterns, and provides an exact money-metric measure of the change in utility due to the exogenous shock under consideration. In the present drought scenario, the EV for a household is the hypothetical change in money income in the absence of a drought that would generate the same welfare effect as the drought. Table 4.11 reports the equivalent variation as a percentage of baseline spending.

Simulation 1b: Drought-Induced Livestock Production Losses (DROUGHTL)

The DROUGHTL scenario simulates a loss of 20 percent of zone 4 and 5's livestock capital. The two zones account for nearly 47 percent of Ethiopia's baseline livestock capital stock. In the baseline, zone 4/5 livestock capital contributes 2.1% of Ehiopia's GDP, and hence the supply shock has a noticeable adverse impact on real income and absorption. In aggregate terms, the loss of productive capital raises the scarcity of domestically produced output in relation to imports, i.e. the real exchange rate appreciates while aggregate real imports and real exports drop.

The shock drives up the price of domestically produced livestock products and entails a strong rise in the rate of the return to livestock capital. Since livestock capital is sector-specific and immobile across regions, the return to surviving livestock capital rises by more than 50 percent in the drought zones directly hit by the shock, while in the other zones the livestock capital return is lifted up by around 17 percent. It is remarkable that in zone 5, where income from livestock capital accounts for a significant fraction of total rural household income (33 percent for poor and 19 percent for non-poor households), real income indeed rises on average for both household groups as a result of the shock.

However, this simulation result requires careful interpretation. In any actual life drought, the distribution of the drought impact will not be uniform across individual households within a zone-specific household group. For households that lost all their livestock in the drought, the increase in the returns to surviving livestock capital enjoyed by luckier households in the same zone, whose livestock assets escaped the drought shock, is of no avail with respect to their own primary income position. Moreover, the income and welfare change figures in Tables 4.9 and 10 do not take account of the capital loss itself, in other words, the figures do not capture the lost future income stream attributable to the destroyed livestock capital.

Simulation 1c: Drought-Induced Production Losses to Crops and Livestock (DROUGHTC)

The DROUGHTA scenario shows the combined simultaneous consequences of the zone 4/5 drought impacts on crop productivity and livestock capital in zones. Conversely, the DROUGHTC and scenarios provide a decomposition of the DROUGHTA scenario into effects due to crop and due to livestock impacts.

Simulations 2a and 2b: Drought-Induced Production Losses to Maize and Enset (ENSETE* and *ENSETM)

Zone 3 produces 48 percent of Ethiopia's national enset and 16 percent of national maize production, while domestic enset production accounts for 2.8 percent and maize for 8.9 percent of

Ethiopia's baseline agricultural production. Correspondingly, the economy-wide impacts of a drought affecting either enset or maize yields remain very moderate. Farmers in all regions including zone 3 respond to the drop in zone 3 enset yields and the resulting rise in the enset price by devoting more land to enset production. Enset is a non-traded good in the baseline and so the production shock is in this case not buffered by a reduction of exports and/or a rise in imports. The adverse real income and welfare effects for all household groups including rural zone 3 households remain on the order of 0.1 to 0.2 percent in both zone 3 drought scenarios.

Simulation 3: Increases in Food Aid Wheat (FOODAID)

Overseas food aid is modelled in the form of an exogenous release of composite wheat stocks for sale in the domestic market in combination with an increase in foreign savings of equal value. In baseline value terms, the exogenous increase in the supply of wheat is assumed to equal 50 percent of baseline wheat imports or 18 percent of domestic baseline wheat production. The additional wheat supply lowers the domestic supply price of domestically produced wheat by 4.2 percent relative to the CPI and leads to a drop in domestic wheat production in the two main wheat-growing regions by 8.5 percent (zone 2) and 6.6 percent (zone 4) respectively. The wheat price drop is associated with a 2 percent decline in returns to land in zone 2, which produces two-thirds of total domestic wheat production and by a 1 percent decline in the other two wheat-producing zones. Ordinary wheat imports – which do not include aid-in-kind wheat deliveries from overseas – drop by 30 percent.

The foreign exchange grant component of the aid scenario entails an appreciation of the real exchange rate by 0.8 percent and aggregate real exports decline by more than 2.5 percent while real imports rise by over 0.8 percent.[7]

[7] In an additional simulation not reported in the tables, we have decomposed the FOODAID scenario into its wheat-in-kind and foreign exchange grant components. Without the foreign exchange grant, the real exchange rate appreciates only marginally by 0.02 percent, exports decline by 0.16 percent and aggregate real absorption rises by 0.18 percent.

As shown in Table 4.10, welfare improves across all household groups. Urban households gain noticeably more than rural households in zones 1 to 4, as they benefit from lower wheat and other crop prices, as well as from lower import prices due to the exchange rate appreciation on the consumption, without suffering from the adverse price and land rent effects on the production side. Households living in the big urban settlements have a far larger share of foreign transfer income in total income (Table II.x) and hence they experience a far larger loss in the domestic purchasing power of these grants due to the exchange rate appreciation compared to both small urban and rural household. The fact that zone 5 households gain more than all other households group can be explained by two factors. First, no wheat and very little other crop production takes place in this zone and so adverse food aid impacts on returns to land are largely negligible in this zone. Second, livestock commodities, whose production is a major income source for zone 5 households, are "luxury goods" with an income elasticity of demand well above unity. As real disposable income rises due to the aid inflow, demand for livestock commodities rises in relation to demand for other agricultural commodities and drives up the relative price of clivst along with the returns to livestock capital.[8]

Simulations 3a and 3b: Increases in World Prices (PWHEAT* and *PFOODM)

The first two world market price shock scenarios consider the impacts of a substantial rise in the import prices of agricultural commodities and processed food in the absence of changes in the foreign currency price of Ethiopia's exports. The size orders for the assumed changes in the foreign currency prices of wheat, maize and animal products shown in Table 4.1 reflect observed price developments between mid-2007 and the peak of the recent global food price surge in mid-2008. For the more

[8] It should be noted that in the reported scenario, the cross-household distribution of the gains from aid are indirectly co-determined through the choice of macro closure. From a macro-accounting perspective, the proceeds from the sale of wheat aid and the foreign exchange grant relax the saving constraint. In the model, the saving-investment balance is re-established through an endogenous downward adaptation (in the form of an equal percentage-point decline) of the saving rates for all households in the model. Thus, the initial aid inflow is effectively broadly distributed across households in relation to initial income. Of course alternative more targeted distribution schemes are conceivable – e.g. in-kind distributions of wheat targeted at the poor. Such alternative distribution schemes would of course affect the real income gain figures in Tables 4.8 and 9, but the supply side and trade effects would remain broadly similar to the FOODAID scenario reported here.

heterogeneous other food commodity groups, for which world market price indices that match the within-group product composition of Ethiopian imports are not available and for which the share of imports in domestic demand is small, the *PFOODM* scenario assumes a hypothetical 50 percent increase. The *PWHEAT* scenario serves to decompose the *PFOODM* results into effects due to the price surge for Ethiopia's main import crop and effects due to all other price shocks.

In both scenarios, the deterioration of Ethiopia's terms of trade is necessarily associated with a real income loss and aggregate real absorption must fall in the absence of compensating changes in foreign transfer flows. Imports in the directly affected commodity groups respond elastically to the price hike and the negative income effect further reduces aggregate import demand. The aggregate import bill drops in foreign-currency terms and hence aggregate real exports decline as well in equilibrium as reported in Table 4.2a.

A closer look a the sectoral and regional changes underlying these aggregate effects shows that the volume of wheat imports declines by over 60 percent in both scenarios as demand switches to domestic sources. Domestic wheat production including non-marketed home production for home consumption rises by 30 percent while the domestic wheat supply price rises by over 10 percent relative to the CPI. In the PWHEAT scenario, land rents rise in zone 2 where the wheat share in total agricultural production is relatively high, while in the other wheat- growing zones the returns to land are actually falling relative to the numeraire, since here export agriculture is large in relation to wheat production and production of export crops shrinks, thereby releasing land for additional wheat production while exerting downward pressure on land rents. The real wage for unskilled agricultural labour rises in both scenarios, while livestock capital returns receive a significant blow since demand for livestock commodities is disproportionally affected by the negative income effect.

Due to the adverse impact of the import price surge on livestock capital returns, rural households in zone 5, where livestock production is the dominant activity, experience the strongest adverse welfare impacts. Urban households also suffer disproportionally compared to the rural population in zones 1 to 4 as they see their real wages and capital income drop without benefiting from the rise in the real returns to unskilled agricultural labour. Perhaps surprisingly, the equivalent variation results in Table 4.9 suggest that for rural poor households in zones 1 and 2 – these are the household groups with the highest shares of unskilled agricultural labour income in total income – the net welfare effect from the food import price surge could actually be slightly positive. To repeat, the economic mechanism underlying this simulation result is that the rise in agricultural world market prices induces a substitution effect from imports towards demand for domestic agricultural output that bids up domestic agricultural prices and the real wage of agricultural labour. Obviously, here the critical key assumption is that the border price changes of imports are actually transmitted to the rural poor.

Simulation 3c: Higher International Food Prices (FOODMX)

In contrast to the *PFOODM* scenario, this simulation assumes that the Ethiopian economy not only faces higher food prices on the import side, but is also able to realize higher foreign-currency prices in its export markets as detailed in Table 4.1.

The assumed world market price increase for cagex, the composite commodity that accounts for 89 percent of Ethiopia's baseline crop exports, is the export-share-weighted average of the observed world market price index changes for coffee (+18 percent) and oilseeds (+68 percent) between mid-2007 and mid-2008 (Sources: FAO and ICO). These two commodities account for 93 percent of Ethiopia's baseline cagex exports.

Interestingly, the model results suggest that in principle gains from higher export prices could in the aggregate fully compensate for the welfare losses from the import surge. The total equivalent variation is virtually zero while the gain in real absorption – which takes increases in real investment and government consumption into account – is significantly positive. However, the disaggregated welfare changes by household group in Table 4.9 show that significant gains for some households group coincide with heavy losses for others. Among the winners are primarily rural households resident in zones 1 to 3 while urban households and the rural population in zone 5 lose out. A glance at Tables 4.3 to 4.5 explains the reason. The export price surge drags agricultural labour and land from all other agricultural activities into the booming export agriculture sector, whose gross output expansion in zones 1 to 4 is of double-digit order, while real output of all other agricultural commodities declines. Land rents rise sharply and the real wage of agricultural labour also improves significantly. On the other hand, the real wage for other workers and returns to capital drop relative to the CPI. Households in big urban settlements experience a stronger welfare loss than under the *PFOODM* scenario as they experience the triple whammy of declining factor income, rising prices for domestic food and for imported food. The rural poor in zones 4 and 5 as well as non-poor households in zone 5 and the population in small urban areas are slightly better off than under PFOODM, but still experience significant welfare losses compared to the baseline.

Simulation 4: Higher International Petrol Prices (PPETROL)

The final world price shock scenario analyzes the impact of a 50 percent oil price increase. Oil imports do not directly compete with domestic production and are dominantly used as intermediate input in the production of non-agricultural commodities. Correspondingly, the price elasticity of petrol demand is very low. As a result, the price hike leads to a substantial increase in the foreign currency oil bill and necessitates a significant depreciation of the real exchange rate in order to restore external balance. Aggregate real exports must rise by over 6 percent while real imports decline by 3.6 percent. The terms of trade deterioration is associated with a marked decline in real income, absorption and aggregate household welfare as measured by the total equivalent variation in Table 4.9.

The activities with the highest baseline shares of petrol costs in total costs are construction, grain milling, investment good manufacturing and production of chemicals, all of which are forced to cut their output, as their supply price is driven up and demand drops. Correspondingly, the real factor rewards for industrial labour and capital primarily employed in these industries must fall.

The real depreciation provides an incentive to move resources from production for domestic markets to export production in sectors not directly hit by the rise in fuel cost, and hence agricultural exports expand across the board. In equilibrium, agex - the sector with the highest export/output ratio – expands by claiming a larger fraction of land from other crops, thereby raising the equilibrium real returns to land in zones 1 to 4. While all household groups suffer welfare losses due to the oil shock, these losses fall yet again disproportionally on urban households and rural households in zone 5.

4.3 Crop Specificity of Land and Foreign Exchange Rationing

All simulation results presented so far assume that land in each zone can be flexibly reallocated to different crops produced in the same zone. Here we briefly explore the sensitivity of results to variations in this particular assumption by treating land alternatively as crop-specific fixed factor, i.e we now rule out crop-switching. The results can be interpreted as a short-run analysis, where the short-run is delineated by the minimum time interval required to switch between crops on the same plot. In line with the short-run horizon, capital is likewise treated as sector-specific.

A comparison of the macro results in Table 4.2a with Table 4.2b reveals that this alternative factor market closure makes no difference for the direction and surprisingly little difference for the magnitude of the macroeconomic impacts. The disaggregated welfare impacts by household reported in Table 4.9b are likewise remarkably close to the main results reported in the previous section. Correspondingly, we do not reproduce the full set of disaggregated results for this alternative.

Beginning in March 2008, access to foreign exchange for imports has been restricted in Ethiopia to avoid excessive drawdown of foreign exchange reserves (Dorosh, Robinson and Ahmed, 2009). Import rationing entails an overvaluation of the real exchange rate.

In order to explore the implications of the presence of an import rationing scheme for the impacts of the drought shocks considered here, we first construct a synthetic new baseline with a binding constraint on the foreign exchange value of imports. In this new baseline equilibrium, the trade balance deficit is fixed at 20 percent below its initial value while the real exchange rate is fixed and the model solves endogenously for the import value constraint (QMTOTVAL) and the rent rate or parallel foreign exchange market premium (DTM, i.e. the wedge between the price agents are prepared to pay for the rationed foreign exchange value at the margin and the fixed official rate) consistent with lower foreign savings at a fixed exchange rate. Rent income arising from the black market premium is assumed to flow to the big urban non-poor households. This new import-constrained equilibrium serves now as benchmark for comparison for the impacts of drought and world food price shocks.

Since, as seen in the previous section, all but the PPETROL shock generate appreciation pressure for the real exchange rate, the DTM premium drops in most of the scenarios, i.e. the distortionary wedge between the equilibrium real exchange rate and the official fixed exchange rate is reduced. Despite some obvious differences in the magnitudes of the aggregate real export and import effects, the real absorption effects are all very close to the case without import rationing and exchange rate rigidity. The sectoral production effects not reported here are also very similar, e.g. the correlation coefficient between the sectoral gross output effects under the two external closures in the DROUGHTA scenario equals 0.9963.

The fact that the real absorption losses in Table 4.2c are slightly lower than those in Table 4.2a above should not be misinterpreted to indicate that the foreign exchange constraints or exchange rate rigidity make the economy somehow more resilient to the exogenous shocks under consideration. The opposite is the case. As shown in Table 4.2d, when the domestic economy is initially subject to import rationing with an overvalued exchange rate as before, but responds to the shock with an elimination of the import quota and a switch to exchange rate flexibility, the economy ends up better off than under the foreign exchange constraints, although the differences are not dramatic in the present case.

Table 4.2a: Macroeconomic Impacts – No Import Rationing – RER Flexibility

Percentage changes (except BASE)

	BASE *bill. Birr*	**DROUGHTC**	**DROUGHTL**	**DROUGHTA**	**ENSETE**	**ENSETM**	**FOODAID**	**PWHEAT**	**PFOODM**	**PFOODMX**	**PPETROL**
ABSORPTION	*162.558*	-1.50	-0.39	-1.88	-0.09	-0.11	0.59	-0.39	-1.00	1.79	-1.87
EXPORTS	*16.774*	-4.14	-0.18	-4.39	-0.23	-0.15	-2.56	-3.41	-5.19	7.93	6.26
IMPORTS	*47.009*	-1.48	-0.07	-1.57	-0.08	-0.05	0.84	-2.07	-4.07	8.95	-3.63
GDP	*122.223*	-1.79	-0.46	-2.25	-0.11	-0.13	0.00	0.00	-0.01	-0.04	0.00
EXR	*1.000*	-0.84	-0.92	-1.68	-0.10	-0.16	-0.82	-1.52	-3.33	-10.65	2.24

Table 4.3: Real Gross Output

Percentage Changes (except BASE)

	BASE	**DROUGHTC**	**DROUGHTL**	**DROUGHTA**	**ENSETE**	**ENSETM**	**FOODAID**	**PWHEAT**	**PFOODM**	**PFOODMX**	**PPETROL**
atef2	*3.181*	3.6	0.3	3.9	-0.2	-0.2	1.2	-1.8	-3.2	-3.8	-1.6
atef3	*0.340*	6.4	0.3	6.6	-0.2	-0.3	1.0	-0.9	-2.5	-4.3	-1.7
atef4	*1.633*	-21.2	0.2	-20.9	-0.1	-0.1	1.0	-1.3	-2.8	-4.0	-1.7
awhea2	*2.967*	-1.2	1.0	-0.2	-0.2	-0.3	-8.5	31.6	29.4	-13.0	0.3
awhea3	*0.330*	-2.4	0.5	-1.8	-0.2	-0.2	-0.8	3.3	1.9	-4.0	-1.0
awhea4	*1.135*	-17.7	0.9	-17.0	-0.1	-0.2	-6.6	24.3	22.3	-10.3	0.1
amaiz1	*0.052*	0.3	0.4	0.7	0.0	1.3	0.3	-0.3	-0.9	-0.7	-0.4
amaiz2	*3.018*	-0.3	0.3	0.0	-0.1	1.5	0.7	-1.2	-1.8	-2.2	-0.8
amaiz3	*0.835*	-1.8	0.4	-1.4	-0.2	-14.9	0.8	-0.8	-1.9	-2.7	-1.1
amaiz4	*1.214*	-12.7	0.4	-12.3	-0.2	0.1	0.9	-1.2	-2.3	-2.6	-1.1
amaiz5	*0.063*	-24.2	0.5	-23.8	0.1	1.5	0.1	-0.5	-1.2	2.6	0.1
abarsor1	*0.035*	1.4	0.5	1.8	0.0	-0.2	0.3	-0.4	-1.2	-1.5	-0.3
abarsor2	*2.920*	1.3	0.3	1.5	-0.1	-0.1	0.7	-1.1	-1.8	-2.0	-0.8

	BASE	DROUGHTC	DROUGHTL	DROUGHTA	ENSETE	ENSETM	FOODAID	PWHEAT	PFOODM	PFOODMX	PPETROL
abarsor3	*0.244*	0.9	0.4	1.3	-0.1	-0.2	0.4	-0.1	-1.0	-2.0	-0.8
abarsor4	*1.812*	-14.1	0.4	-13.7	-0.1	-0.2	0.8	-1.1	-2.2	-2.7	-0.9
abarsor5	*0.031*	-15.5	0.5	-15.0	-0.1	-0.3	0.6	-1.2	-2.3	-1.0	-0.5
aenset1	*0.016*	-1.7	0.1	-1.6	0.7	-0.2	0.7	-0.5	-1.2	-3.7	-1.2
aenset2	*0.316*	8.3	-0.3	7.9	17.3	0.0	0.9	-2.5	-2.3	-1.8	-0.6
aenset3	*0.808*	-0.7	0.0	-0.6	-17.0	-0.3	0.7	0.1	-0.7	-4.6	-1.5
aenset4	*0.539*	-14.3	0.0	-14.2	4.6	0.0	0.6	-0.4	-1.0	-3.2	-1.1
aagex1	*0.043*	1.4	1.0	2.3	0.0	-0.4	-0.9	-1.7	-2.3	15.2	3.0
aagex2	*4.094*	0.4	1.2	1.5	-0.6	-0.3	0.0	-6.7	-7.3	22.2	4.0
aagex3	*2.031*	0.4	0.8	1.2	-0.8	-0.7	-1.0	-1.1	-1.9	12.8	2.8
aagex4	*3.262*	-27.1	0.9	-26.4	-0.3	0.0	-0.4	-3.0	-3.5	14.3	2.7
aagex5	*0.061*	-16.3	0.4	-16.0	0.0	-0.4	0.3	-1.4	-2.2	3.2	0.3
aothrag1	*0.068*	-0.6	0.5	-0.1	-0.1	-0.2	0.8	-1.2	-1.8	-2.9	-0.9
aothrag2	*4.094*	1.4	0.5	1.9	-0.2	-0.2	1.3	-2.2	-1.8	-6.7	-1.2
aothrag3	*2.441*	3.6	0.6	4.2	-0.2	-0.3	0.9	-1.0	0.1	-5.4	-1.2
aothrag4	*2.688*	-24.4	0.6	-23.9	-0.1	-0.1	1.0	-1.5	-0.8	-5.2	-0.9
aothrag5	*0.023*	-46.2	1.2	-45.5	0.3	-0.4	0.4	-2.1	1.0	-4.8	1.0
alivst1	*0.191*	-0.7	3.0	2.3	0.0	-0.1	0.4	-0.9	-1.8	-0.4	-0.2
alivst2	*7.635*	-0.7	3.2	2.5	0.0	-0.1	0.4	-0.9	-1.8	-0.4	-0.2
alivst3	*1.762*	-0.7	3.1	2.4	0.0	-0.1	0.4	-0.9	-1.8	-0.4	-0.2
alivst4	*4.438*	-0.7	-13.9	-14.3	0.0	-0.1	0.4	-0.9	-1.8	-0.4	-0.2
alivst5	*3.968*	-0.7	-13.9	-14.4	0.0	-0.1	0.4	-0.9	-1.8	-0.4	-0.2
Amilling	*1.542*	0.3	0.2	0.5	0.0	0.0	-0.3	-4.2	-3.1	-3.9	-0.9
Afood	*12.550*	0.6	0.7	1.3	0.0	-0.1	-0.2	-0.9	7.2	-1.2	1.1
Achem	*1.603*	2.3	0.2	2.5	0.1	0.0	-2.8	1.2	-0.3	-14.3	-3.4
Aelect	*1.666*	0.0	0.1	0.1	0.0	0.0	0.3	-0.4	-0.6	-1.2	-1.1
Awater	*1.588*	-0.3	0.2	-0.1	0.0	0.0	0.6	0.0	-0.3	0.9	-0.8
Ai-mfg	*3.909*	0.1	0.0	0.1	0.0	0.0	2.4	0.5	0.5	3.2	-4.5

	BASE	DROUGHTC	DROUGHTL	DROUGHTA	ENSETE	ENSETM	FOODAID	PWHEAT	PFOODM	PFOODMX	PPETROL
Af-mfg	*5.675*	-0.1	-0.6	-0.7	0.0	0.0	1.3	0.1	-0.2	1.7	-1.9
Aconst	*21.240*	-0.4	0.1	-0.3	0.0	0.0	3.7	0.7	0.8	7.0	-5.0
Atrd-trn	*36.081*	-0.1	0.1	0.0	0.0	0.0	-1.1	-0.3	-0.6	-3.0	0.5
Agov	*17.080*	0.2	0.3	0.5	0.0	0.0	0.1	0.7	0.9	3.3	-0.8
Aosvc	*25.993*	-0.2	-0.2	-0.4	0.0	0.0	-0.1	-0.3	-1.8	-1.5	1.6

Table 4.4 Supply Price of Domestic Output

Percentage change relative to CPI

	DROUGHTC	DROUGHTL	DROUGHTA	ENSETE	ENSETM	FOODAID	PWHEAT	PFOODM	PFOODMX	PPETROL
Ctef	6.9	-2.0	4.8	0.0	0.0	-0.4	0.7	0.7	8.5	-0.3
Cwheat	2.1	-1.6	0.5	0.0	-0.1	-4.2	11.1	10.9	2.4	0.5
Cmaize	1.1	-2.0	-0.8	0.0	1.5	-0.6	1.1	1.4	9.5	-0.1
Cbarsor	2.2	-2.0	0.3	0.0	0.0	-0.6	1.1	1.3	9.9	-0.1
Cagex	7.2	-1.5	5.7	0.3	0.0	-0.1	1.8	2.5	5.6	-1.5
Censet	3.6	-1.1	2.5	5.1	0.0	-0.8	0.3	-0.4	15.2	1.0
Cothrag	2.9	-2.0	0.9	-0.1	0.0	-0.2	0.7	1.2	7.1	-0.7
Clivstk	-2.7	8.5	5.5	-0.2	-0.2	0.5	-0.4	-1.0	3.6	-1.9
Chome1	4.6	-0.3	4.2	0.5	0.6	-0.1	0.3	0.1	8.9	-0.5
Chome2	-2.2	2.2	-0.1	-0.2	-0.2	0.5	-0.5	-1.4	1.3	-1.9
Cmilling	-1.9	-1.1	-2.9	-0.2	-0.2	-0.1	6.0	4.7	-2.7	3.6
Cfood	-1.3	-1.8	-3.0	-0.1	-0.1	0.1	0.1	2.2	0.1	-1.1
Cchem	-2.1	-1.0	-3.0	-0.2	-0.2	0.3	-1.7	-3.0	-5.4	3.3
Celect	-2.5	-1.0	-3.4	-0.2	-0.2	0.5	-1.8	-3.5	-4.0	-0.6
Cwater	-2.6	-1.0	-3.5	-0.2	-0.2	0.9	-1.8	-3.4	-3.2	-2.5
Ci-mfg	-2.4	-1.0	-3.3	-0.2	-0.2	0.5	-1.7	-3.3	-4.3	3.5
Cf-mfg	-2.0	-0.1	-2.1	-0.2	-0.2	0.5	-1.5	-2.7	-2.9	-0.7
Cconst	-1.8	-1.0	-2.7	-0.1	-0.2	0.2	-1.6	-3.0	-5.3	5.5
Ctrd-trn	-2.8	-1.0	-3.7	-0.2	-0.2	0.8	-1.8	-3.4	-2.6	0.2
Cgov	-2.5	-0.9	-3.3	-0.2	-0.2	0.6	-1.6	-2.8	-2.9	-1.3
Cosvc	-2.5	-0.8	-3.3	-0.2	-0.2	0.8	-1.4	-1.9	-2.0	-2.6

Table 4.5 Real Factor Prices

Percentage changes relative to CPI

	DROUGHTC	DROUGHTL	DROUGHTA	ENSETE	ENSETM	FOODAID	PWHEAT	PFOODM	PFOODMX	PPETROL
flab0	-1.4	-2.7	-3.9	-0.2	0.0	-0.3	1.3	2.2	5.6	-1.2
flab12	-2.7	-0.8	-3.5	-0.2	-0.2	1.0	-1.4	-3.0	-0.2	-4.2
flab3	-2.9	-1.0	-3.8	-0.2	-0.2	1.5	-1.7	-3.3	-1.3	-4.3
flab4	-2.8	-1.0	-3.8	-0.2	-0.2	0.9	-1.8	-3.1	-2.1	-4.0
fland1	0.8	0.7	1.5	0.1	0.0	-0.1	-2.9	-5.8	27.8	1.5
fland2	4.4	1.1	5.5	0.8	-0.1	-2.1	1.1	-1.7	35.7	3.6
fland3	4.2	0.8	5.0	0.8	0.2	-1.0	-3.1	-5.2	35.5	3.4
fland4	-16.1	0.9	-15.3	0.5	-0.4	-1.1	-1.5	-4.3	32.8	2.8
fland5	-5.7	0.3	-5.4	-0.1	0.3	0.3	-1.5	-3.8	15.7	0.0
flvstk1	-5.4	17.1	10.8	-0.3	-0.5	1.9	-4.0	-8.1	3.3	-2.6
flvstk2	-5.3	18.2	11.9	-0.3	-0.5	1.9	-4.1	-8.3	3.4	-2.6
flvstk3	-5.3	17.7	11.4	-0.3	-0.5	1.9	-4.1	-8.2	3.3	-2.6
flvstk4	-5.4	56.6	48.8	-0.3	-0.5	1.9	-4.1	-8.2	3.3	-2.6
flvstk5	-5.3	55.7	48.0	-0.3	-0.5	1.9	-4.1	-8.2	3.4	-2.6
fkptl	-2.9	-1.0	-3.8	-0.2	-0.2	0.8	-1.9	-3.6	-2.4	-3.8

Table 4.6 Real Imports

Percentage Changes (except BASE)

	BASE	DROUGHTC	DROUGHTL	DROUGHTA	ENSETE	ENSETM	FOODAID	PWHEAT	PFOODM	PFOODMX	PPETROL
Cwheat	*1.643*	3.6	-1.0	2.6	0.0	0.1	-30.0	-62.0	-60.4	25.5	-4.2
Cmaize	*0.002*	1.3	-1.2	0.1	0.0	1.6	0.5	2.6	-21.7	26.1	-3.1
Cagex	*0.051*	13.7	-0.6	12.9	0.6	0.3	1.7	5.3	-48.5	39.6	-7.4
Cothrag	*0.533*	4.4	-1.7	2.6	0.0	0.1	2.1	3.1	-48.9	35.6	-6.3
Clivstk	*0.079*	-4.2	13.5	8.5	-0.3	-0.1	3.1	1.2	-37.1	28.8	-8.1
Cmilling	*0.095*	-2.5	-0.2	-2.8	-0.2	-0.1	1.8	16.4	19.7	20.2	2.7
Cfood	*1.863*	-0.8	-1.4	-2.1	-0.1	0.1	1.4	2.0	-41.0	16.0	-4.2
Cchem	*6.989*	-1.6	0.1	-1.5	-0.1	-0.1	0.4	0.7	0.6	1.5	-0.5
Cwater	*0.001*	-5.2	-0.3	-5.5	-0.2	-0.2	6.0	-0.9	-0.9	25.9	-13.8
Cptrl	*8.278*	-0.3	0.1	-0.2	0.0	0.0	1.3	0.1	0.1	2.3	-3.8
Ci-mfg	*5.427*	-0.6	0.0	-0.6	0.0	0.0	3.0	0.4	0.5	6.2	-4.0
Cf-mfg	*20.340*	-1.0	0.0	-1.0	0.0	0.0	2.0	0.0	-0.1	5.5	-3.4
Ctrd-trn	*8.137*	-4.4	0.0	-4.5	-0.2	-0.2	2.5	-1.0	-0.8	16.8	-3.7
Cgov	*0.079*	-3.0	0.2	-2.8	-0.1	-0.1	2.9	0.3	1.4	20.4	-6.8
Cosvc	*3.178*	-3.6	-0.1	-3.7	-0.2	-0.1	3.2	-0.2	1.3	17.7	-8.3

Table 4.7 Real Exports

Percentage Changes (except BASE)

	BASE	DROUGHTC	DROUGHTL	DROUGHTA	ENSETE	ENSETM	FOODAID	PWHEAT	PFOODM	PFOODMX	PPETROL
Cwheat	*0.000*	-12.1	3.2	-9.1	-0.2	-0.5	-14.7	310.1	26.1	71.2	6.4
Cmaize	*0.002*	-4.5	2.3	-2.3	-0.2	-3.5	-0.3	-5.6	-9.5	11.8	4.7
Cbarsor	*0.003*	-6.3	2.3	-4.1	-0.2	-0.3	-0.7	-5.6	-9.6	11.7	5.3
Cagex	*3.622*	-16.6	1.8	-15.1	-1.0	-0.5	-2.2	-8.1	-11.3	45.8	9.4
Cothrag	*0.464*	-8.0	2.4	-5.7	-0.1	-0.3	-1.8	-5.0	-6.4	-15.8	6.9
Clivstk	*0.718*	3.3	-20.1	-17.1	0.3	-0.1	-2.3	-3.3	-6.5	26.9	8.0
Cmilling	*0.239*	2.3	0.5	2.8	0.1	0.0	-1.7	-15.6	-15.6	-17.7	-2.9
Cfood	*0.341*	2.9	2.3	5.3	0.2	-0.1	-3.9	-3.9	2.8	-5.7	10.9
Cchem	*0.233*	5.6	0.3	6.0	0.2	0.1	-5.4	1.6	-0.9	-25.9	-4.2
Cwater	*0.053*	3.3	0.2	3.6	0.2	0.1	-2.4	0.5	-0.3	-14.2	8.0
Ci-mfg	*0.344*	1.3	0.1	1.3	0.1	0.1	1.4	0.7	0.5	-2.2	-4.5
Cf-mfg	*0.965*	0.3	-0.8	-0.5	0.0	0.0	0.6	0.0	-0.8	-3.1	-0.6
Ctrd-trn	*4.955*	3.4	0.2	3.6	0.2	0.1	-3.9	0.1	-0.6	-16.6	4.3
Cgov	*0.127*	3.5	0.2	3.7	0.2	0.1	-2.8	0.7	-0.7	-13.0	7.1
Cosvc	*1.629*	3.1	-0.6	2.6	0.2	0.1	-3.0	-0.6	-4.2	-17.9	10.6

Table 4.8 Real Income by Household Group

Percentage Changes (except BASE)

	BASE	DROUGHTC	DROUGHTL	DROUGHTA	ENSETE	ENSETM	FOODAID	PWHEAT	PFOODM	PFOODMX	PPETROL
HH-Rural_EZ1P	*0.510*	-1.6	-1.2	-2.8	-0.2	0.0	0.0	0.5	0.6	5.2	-1.4
HH-Rural_EZ2P	*9.857*	-1.6	-0.8	-2.4	-0.2	-0.1	-0.1	0.4	0.4	5.1	-1.3
HH-Rural_EZ3P	*4.651*	-1.5	-1.3	-2.8	-0.2	-0.1	-0.1	0.2	0.2	4.3	-1.3
HH-Rural_EZ4P	*8.423*	-2.3	-0.6	-2.9	-0.2	-0.1	0.0	0.1	-0.1	3.8	-1.5
HH-Rural_EZ5P	*1.544*	-3.3	7.2	3.6	-0.2	-0.3	0.9	-2.2	-4.4	0.0	-2.5
HH-Rural_EZ1NP	*0.732*	-2.1	-0.9	-3.0	-0.2	-0.1	0.3	-0.5	-1.2	2.6	-2.2
HH-Rural_EZ2NP	*32.532*	-1.5	-0.5	-2.0	-0.1	-0.1	0.1	-0.3	-1.2	5.2	-1.7
HH-Rural_EZ3NP	*13.537*	-1.5	-0.9	-2.3	-0.1	-0.1	0.2	-0.8	-1.6	5.2	-1.7
HH-Rural_EZ4NP	*25.014*	-3.6	-0.4	-4.0	-0.1	-0.2	0.2	-0.8	-1.8	3.5	-1.8
HH-Rural_EZ5NP	*3.693*	-3.1	3.8	0.6	-0.2	-0.3	0.8	-2.0	-4.0	-1.3	-2.9
HH-smallurbanP	*2.819*	-2.5	-0.9	-3.4	-0.2	-0.2	0.8	-1.7	-3.1	-2.5	-3.3
HH-BigurbanP	*1.869*	-2.1	-0.9	-2.9	-0.2	-0.2	0.4	-1.6	-3.1	-4.6	-1.8
HH-smallurbanNP	*15.674*	-2.6	-1.0	-3.5	-0.2	-0.2	0.8	-1.7	-3.3	-2.7	-3.4
HH-BigurbanNP	*13.431*	-2.1	-0.9	-3.0	-0.2	-0.2	0.3	-1.6	-3.2	-4.7	-1.8

Table 4.9a Welfare: Hicksian Equivalent Variation

In percent of baseline consumption expenditure

	DROUGHTC	DROUGHTL	DROUGHTA	ENSETE	ENSETM	FOODAID	PWHEAT	PFOODM	PFOODMX	PPETROL
HH-Rural_EZ1P	-1.9	-1.5	-3.3	-0.3	-0.2	0.4	0.4	0.5	0.8	-0.2
HH-Rural_EZ2P	-2.1	-1.0	-3.1	-0.2	-0.2	0.4	0.1	0.1	0.7	-0.3
HH-Rural_EZ3P	-1.7	-1.7	-3.3	-0.3	-0.1	0.4	0.0	-0.2	0.2	-0.2
HH-Rural_EZ4P	-2.8	-0.8	-3.5	-0.3	-0.2	0.5	-1.0	-1.2	-0.4	-0.5
HH-Rural_EZ5P	-4.2	7.3	2.8	-0.3	-0.4	1.6	-4.1	-6.6	-3.6	-2.1
HH-Rural_EZ1NP	-1.7	-1.2	-2.9	-0.2	-0.1	0.7	-0.2	-0.9	0.0	-1.0
HH-Rural_EZ2NP	-1.6	-0.7	-2.3	-0.1	-0.2	0.4	-0.3	-1.1	1.9	-0.8
HH-Rural_EZ3NP	-1.1	-1.3	-2.3	-0.1	-0.1	0.6	-0.5	-1.2	2.8	-0.8
HH-Rural_EZ4NP	-3.8	-0.6	-4.3	-0.2	-0.2	0.6	-1.1	-2.0	0.3	-1.1
HH-Rural_EZ5NP	-3.7	4.0	0.1	-0.3	-0.3	1.5	-3.5	-5.7	-4.0	-2.6
HH-smallurbanP	-2.2	-1.0	-3.1	-0.1	-0.1	1.3	-2.3	-4.4	-4.1	-2.6
HH-BigurbanP	-1.5	-0.9	-2.3	0.0	-0.1	0.7	-1.7	-4.1	-5.1	-2.1
HH-smallurbanNP	-1.5	-1.0	-2.5	-0.1	-0.1	1.1	-1.4	-3.1	-2.0	-2.9
HH-BigurbanNP	-0.7	-0.8	-1.5	0.0	0.0	0.7	-0.9	-2.3	-2.9	-2.2
Total	-2.1	-0.7	-2.7	-0.1	-0.2	0.6	-0.9	-1.8	0.0	-1.3

Table 4.2b: Macroeconomic Impacts – No Import Rationing – RER Flexibility – Sector-Specific Land and Capital

Percentage changes (except BASE)

	BASE *bill. Birr*	**DROUGHTC**	**DROUGHTL**	**DROUGHTA**	**ENSETE**	**ENSETM**	**FOODAID**	**PWHEAT**	**PFOODM**	**PFOODMX**	**PPETROL**
ABSORPTION	*162.558*	-1.50	-0.39	-1.88	-0.09	-0.11	0.58	-0.44	-1.04	1.61	-1.89
EXPORTS	*16.774*	-3.55	-0.34	-3.92	-0.03	-0.05	-2.72	-1.02	-2.86	3.69	5.84
IMPORTS	*47.009*	-1.27	-0.12	-1.40	-0.01	-0.02	0.78	-1.53	-3.58	6.65	-3.80
GDP	*122.223*	-1.79	-0.46	-2.25	-0.11	-0.13	-0.01	-0.03	-0.04	-0.05	-0.01
EXR	*1.000*	-1.28	-0.82	-2.03	-0.27	-0.23	-1.35	-1.76	-3.82	-8.92	3.02

Table 4.2c: Macroeconomic Impacts – Import Rationing – Fixed RER

Percentage changes (except BASE, QMTOTVAL, TMRENT)

	BASE *bill. Birr*	**DROUGHTC**	**DROUGHTL**	**DROUGHTA**	**ENSETE**	**ENSETM**	**FOODAID**	**PWHEAT**	**PPETROL**
ABSORPTION	*160.459*	-1.49	-0.36	-1.85	-0.09	-0.10	0.63	-0.35	-2.00
EXPORTS	*17.161*	-2.65	1.72	-1.18	-0.04	0.19	-0.76	-0.34	1.64
IMPORTS	*44.782*	-1.02	0.66	-0.45	-0.01	0.07	1.54	-0.90	-5.41
GDP	*119.790*	-1.75	-0.46	-2.21	-0.11	-0.13	0.00	0.00	0.00
EXR	*1.000*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QMTOTVAL	*44.782*	*44.327*	*45.077*	*44.580*	*44.776*	*44.814*	*45.473*	*44.723*	*45.064*
DTM in%	*6.9*	5.0	4.4	2.8	6.7	6.5	4.7	2.9	13.7
TMRENT	*3.110*	*2.232*	*2.003*	*1.231*	*2.999*	*2.916*	*2.151*	*1.291*	*6.183*

Table 4.2d: Macroeconomic Impacts – Import Rationing – Fixed RER in Base -

No Rationing – Flex RER in Post-Shock Equilibrium

Percentage changes (except BASE, QMTOTVAL, TMRENT)

	BASE *bill. Birr*	**DROUGHTC**	**DROUGHTL**	**DROUGHTA**	**ENSETE**	**ENSETM**	**FOODAID**	**PWHEAT**	**PPETROL**
ABSORPTION	*160.459*	-1.47	-0.34	-1.84	-0.06	-0.07	0.65	-0.35	-1.91
EXPORTS	*17.161*	1.23	5.25	0.98	5.21	5.29	2.88	1.97	11.82
IMPORTS	*44.782*	0.47	2.01	0.38	2.00	2.03	2.94	-0.07	-1.58
GDP	*119.790*	-1.76	-0.45	-2.21	-0.11	-0.13	0.00	0.00	0.00
EXR	*1.000*	1.83	1.61	1.00	2.43	2.36	1.71	1.05	4.73
QMTOTVAL	*44.782*	-	-	-	-	-	-	-	-
DTM in%	*6.9*	-	-	-	-	-	-	-	-
TMRENT	*3.110*	-	-	-	-	-	-	-	-

Table 4.9b Welfare: Hicksian Equivalent Variation - No Import Rationing – RER Flexibility –Sector-Specific Land and Capital

In percent of baseline consumption expenditure

	DROUGHTC	DROUGHTL	DROUGHTA	ENSETE	ENSETM	FOODAID	PWHEAT	PFOODM	PFOODMX	PPETROL
HH-Rural_EZ1P	-2.1	-1.5	-3.5	-0.5	-0.2	0.5	-0.2	0.1	2.0	-0.2
HH-Rural_EZ2P	-2.4	-1.0	-3.3	-0.3	-0.2	0.4	-0.3	-0.1	1.8	-0.3
HH-Rural_EZ3P	-1.9	-1.7	-3.5	-0.4	-0.2	0.4	-0.6	-0.5	1.4	-0.2
HH-Rural_EZ4P	-2.8	-0.8	-3.5	-0.3	-0.3	0.6	-1.8	-1.8	0.9	-0.5
HH-Rural_EZ5P	-4.5	7.4	2.5	-0.4	-0.5	1.7	-4.7	-7.5	-1.6	-2.1
HH-Rural_EZ1NP	-1.9	-1.2	-3.0	-0.3	-0.1	0.8	-0.4	-1.1	0.8	-1.3
HH-Rural_EZ2NP	-1.8	-0.7	-2.5	-0.2	-0.2	0.5	0.1	-0.7	1.7	-1.1
HH-Rural_EZ3NP	-1.2	-1.3	-2.4	0.0	0.0	0.8	-0.8	-1.4	2.9	-1.1
HH-Rural_EZ4NP	-3.5	-0.5	-4.0	-0.2	-0.3	0.8	-1.2	-2.2	0.9	-1.3
HH-Rural_EZ5NP	-3.9	4.1	-0.1	-0.3	-0.4	1.7	-4.0	-6.5	-2.5	-2.8
HH-smallurbanP	-2.4	-0.9	-3.3	-0.1	-0.1	2.0	-2.3	-4.6	-1.9	-3.3
HH-BigurbanP	-1.7	-0.9	-2.5	0.0	-0.1	1.0	-1.6	-4.2	-3.3	-2.2
HH-smallurbanNP	-1.6	-1.0	-2.6	0.0	-0.1	1.6	-1.3	-3.0	-0.8	-3.5
HH-BigurbanNP	-0.8	-0.8	-1.6	0.0	0.0	0.9	-0.7	-2.2	-1.8	-2.4
Total	-2.2	-0.6	-2.8	-0.2	-0.2	0.8	-0.9	-1.9	0.7	-1.5

V. Policy Implications and Concluding Observations

The simulations illustrate the extent to which production and price shocks spread throughout the economy. Drought reduces farmer crop incomes in the affected regions. Reduced supply affects national prices since markets are generally integrated at the wholesale level. Farmers outside drought regions actually benefit, but net consumers everywhere lose.

Production shocks can have devastating effects on households directly affected, but can leave the national economy largely unaffected. Effects on the national economy are limited even though the simulations assume integrated commodity markets (i.e. the domestic price of each commodity changes by the same amount throughout the country). The effects of production shocks would be even more limited nationwide if commodity price transmission were less perfect, (but would be more severe in the area experiencing the production shock).

Thus, isolated production shocks can pose severe threats to household welfare at the local level, but be essentially unnoticed at the national level because of the small size of the shocks relative to the entire economy and the diversity of food products (not all of which are directly affected by the shock). Localized monitoring of production and market conditions is essential. The simulations of international price increases show that to a large extent Ethiopia is insulated from international markets, since most of the major staples (teff, maize, sorghum and enset) are not internationally traded to a significant extent. Only wheat is traded on a large scale, and in recent years, the quantity of wheat imports has been constrained by foreign exchange restrictions for imports. The third set of simulations, on variations in food aid, show that major increases in food aid can significantly reduce prices, benefitting all net purchasers of wheat (not merely the recipients of food aid), but adversely affecting net producers of wheat.

Further work is needed to refine model parameters and specifications and to better understand dynamic effects of droughts and price shocks. Sensitivity analysis regarding key assumptions and parameters is required. In order to better model droughts, further analysis is needed regarding the multi-period effects of losses of livestock capital on livestock investment and output. Additional analysis of implications of foreign exchange rationing (as is currently in place) is also needed. Finally, one major policy implication arising from this analysis is the importance of careful monitoring of local markets and household access to food. The simulations indicate that severe production shocks that are isolated to relatively small areas of the country are not likely to be readily noticed in the major markets of Ethiopia, which are generally well-integrated. This is because these production shocks can represent a relatively small share of total supply. Thus, in addition to further work in understanding the economy-wide implications of production, external price and policy shocks, it remains crucial to complement this work with careful local monitoring of production, household incomes and prices.

Annex: Model Description

In the following technical description of the CGE model, variables are capitalized while lower-case notation is used for taste, technology and policy parameters as well as other exogenous constants. Variable and parameter descriptions (except for the share and shift parameters in the various CES aggregators) are provided under the equation block in which they first appear.

The calibrated model distinguishes 46 production activities (index set *a*), 22 commodity groups (index set *c*), 14 household groups (index set *h*) and 15 primary factors (index set *f*) as listed in Table II.2.

Trade and Commodity Prices

Domestic-currency price of exports to region r:

$$PER_{c,r} = PWER_{c,r}\left(1 - ter_{c,r}\right)ER \quad (1)$$

Determination of export price index dual to QE_c:

$$PE2_c QE_c = \sum_r PER_{c,r} QER_{c,r} \quad (2)$$

Domestic producer price of composite exports (net of domestic transport margins):

$$PE_c = PE2_c - \sum_{ct} PQ_{ct} ice_{ct,c} \quad (3)$$

Determination of producer price index dual to commodity output QX_c:

$$PX_c QX_c = PDS_c QD_c + PE_c QE_c \quad (4)$$

Domestic-currency price of imports from region r:

$$PMR_{c,r} = PWMR_{c,r}\left(1 + tmr_{c,r}\right)ER \quad (5)$$

Determination of import price index dual to QM_c:

$$PM2_c QM_c = \sum_r PMR_{c,r} QMR_{c,r} \quad (6)$$

Import price index inclusive of domestic transport margins:

$$PM_c = PM2_c + \sum_{ct} PQ_{ct} icm_{ct,c} \quad (7)$$

Determination of price index dual to Armington composite QQ_c:

$$PQ_c(1 - tq_c)QQ_c = PDD_c QD_c + PM_c QM_c \quad (8)$$

Consumer price of domestic output for domestic market:

$$PDD_c = PDS_c + \sum_{ct} PQ_{ct} icd_{ct,c} \tag{9}$$

Allocation of commodity output between composite export supply and domestic supply:

$$QX_c = \alpha t_c [\delta T_c QE_c^{\rho T_c} + (1 - \delta T_c) QD_c^{\rho T_c}]^{1/\rho T_c} \tag{10}$$

$$\frac{QE_c}{QD_c} = \left[\frac{PE_c}{PDS_c} \frac{1-\delta T_c}{\delta T_c}\right]^{\frac{1}{pT_c - 1}} \tag{11}$$

Allocation of composite exports by region of destination:

$$\frac{QER_{c,r}}{QE_c} = \left[\frac{PER_{c,r}}{PE2_c \delta E_{c,r} \alpha E_c^{\rho E_c}}\right]^{\frac{1}{pE_c - 1}} \tag{12}$$

Allocation of demand between aggregate imports and domestic commodities:

$$QQ_c = \alpha Q_c [\delta Q_c QM_c^{-\rho Q_c} + (1 - \delta Q_c) QD_c^{-\rho Q_c}]^{-1/\rho Q_c} \tag{13}$$

$$\frac{QM_c}{QD_c} = \left[\frac{PDD_c}{PM_c} \frac{\delta Q_c}{1-\delta Q_c}\right]^{\frac{1}{1+pQ_c}} \tag{14}$$

Allocation of aggregate import demand across regions of origin:

$$\frac{QMR_{c,r}}{QM_c} = \left[\frac{PMR_{c,r}}{PM2_c} \frac{\alpha M_c{}^{\rho M_c}}{\delta M_{c,r}}\right]^{\frac{-1}{1+pM_c}} \tag{15}$$

Demand for trade / transport service inputs

$$QT_c = \sum_{cp} icm_{c,cp} QM_{cp} + ice_{c,cp} QE_{cp} + icd_{c,cp} QD_{cp} \tag{16}$$

$PER_{c,r}$	Domestic price of exports of commodity c by region r
$PWER_{c,r}$	World market price of exports of commodity c by region r
PE_c	Price of composite export good QE_c excluding transport costs
$PE2_c$	Price of composite export good QE_c c at border including transport costs
$PMR_{c,r}$	Domestic price of imports of commodity c to region r
$PWMR_{c,r}$	World market price of imports of commodity c to region r
PM_c	Domestic price of composite import QM_c including transport costs

PQ_c Price of Armington composite commodity QQ_c

PDD_c Consumer price of domestically produced commodity c for the home market including transport costs

PDS_c Producer price of domestically produced commodity c for the home market excluding transport costs

PX_c Producer price dual to composite domestic output QX_c

ER Exchange rate (domestic unit of account per "$")

QX_c Domestic production of composite commodity c

QD_c Domestic production of commodity c for domestic demand

QE_c Exports of commodity c

QER_c Exports of commodity c to region r

QM_c Imports of commodity c

$QMR_{c,r}$ Imports of commodity c from region r

QQ_c Armington composite commodity c

QT Trade and transport margin demand

$1/(\rho T_c - 1)$ Elasticity of transformation between export and domestic market production

$1/(\rho E_c - 1)$ Elasticity of transformation between exports to different destination regions

$1/(1 + \rho Q_c)$ Elasticity of substitution between imports and domestic commodity c

$1/(1 + \rho A_c)$ Elasticity of substitution between imports from different regions

$tmr_{c,r}$ Tariff rate on imports of origin r

tq_c Domestic sales tax rate

$ter_{c,r}$ Tax rate on exports to destination r

$icd_{ct,c}$ Transport service ct per unit of commodity c produced and sold domestically

$icm_{ct,c}$ Transport service ct per unit of commodity c imported and sold domestically $ice_{ct,c}$ Transport service ct per unit of commodity c exported

Import Rationing

$$TMRENT = \sum_c \sum_r DTM\ pwmr_{c,r} QMR_{c,r} EXR \quad (17)$$

$$qmtotval = \sum_c \sum_r pwmr_{c,r} QMR_{c,r} \quad (18)$$

TMRENT	Rent due to import rationing
DTM	Import rationing rental rate (zero in the absence of a binding rationing constraint)
qmtotval	Foreign currency value of total imports allowed under rationing

Technology, Factor Demand and Activity-Commodity Mapping

Value added production function:

$$QVA_a = \alpha va_a \left[\sum_f \phi_{f,a} QF_{f,a}{}^{-\rho va_a}\right]^{-1/\rho va_a} \quad (19)$$

Leontief top level production function for activity output

$$QA_a = \begin{cases} QVA_a / iva_a \\ QINTA_a / inta_a \end{cases} \quad (20/21)$$

Intermediate input demand for commodity c by activity a:

$$QINT_{c,a} = ica_{c,a} QINTA_a \quad (22)$$

Inverse factor demand:

$$W_f WDIST_{f,a} = \phi_{f,a} FD_{f,a}^{-(1+\rho va_a)} (ava_a)^{-\rho va_a} QVA_a^{1+\rho va_a} PVA_a \quad (23)$$

Aggregator for commodities produced by multiple activities: (24)

$$QX_c = \alpha ac_c \left[\sum_a \psi_{a,c} QXAC_{a,c}{}^{-\rho ac_c}\right]^{-1/\rho ac_c} \quad (25)$$

$$\frac{PXAC_{a,c}}{PX_c} = \psi_{a,c} \alpha ac_c{}^{-\rho ac_c} \left[\frac{QX_c}{QXAC_{a,c}}\right]^{1+\rho ac_c} \quad (26)$$

$$QXAC_{a,c} = \theta_{a,c} \left[QA_a - \sum_h QHA_{a,h}\right] \quad (27)$$

$$PA_a = \sum_c \theta_{a,c} PXAC_{a,c} \tag{28}$$

QA_a	Output of activity a
$QF_{f,a}$	Cost-minimizing demand for factor f by activity a
QVA_a	Real value added in activity a
$QXAC_{a,c}$	Output of commodity c by activity a (make matrix)
$QINTA_a$	Aggregate intermediate input quantity used by activity a
$QUINT_{c,a}$	Input quantity of commodity c used by activity a
PA_a	Price of activity output
$PXAC_{a,c}$	Price of commodity c from activity a
$WF_f WDIST_{f,a}$	Price of factor f in activity a (WDIST=1 for non-specific factors)
iva_a	Real value added per unit of activity a output
$inta_a$	Aggregate intermediate input quantity per unit of activity a output
$ica_{c,a}$	Input of commodity c per unit of activity a's aggregate intermediate input
$\theta_{a,c}$	Share of commodity c in activity a output
αva_a	total factor productivity(TFP) parameter for activity a

Income and Final Domestic Demand

Factor income:

$$YF_f = \sum_a W_f WDIST_{f,a} QF_{f,a} \tag{29}$$

Income of household h from factor f:

$$YIF_{h,f} = \sum_f hfsh_{h,f}(YF_f - \sum_r nfi_{r,f} ER) \tag{30}$$

Total income of household h:

$$YI_h = \sum_f YIF_{h,f} + trnsfr_{h,gov} * CPI + \sum_r trnsfr_{h,r}\, EXR + shrent_h TMRENT \tag{31}$$

Household expenditure:

$$HEXP_h = YH_h(1 - tyh_h)(1 - S_h) \tag{32}$$

Optimal household consumption demand for marketed commodities:

$$PQ_cQH_{c,h} = PQ_{c,}\gamma m_{c,h} + \beta m_{c,h}(HEXP_h - \sum_c PQ_c\,\gamma m_{c,h} - \sum_a PA_a\gamma h_{a,h}) \tag{33}$$

Optimal household demand for home-produced output:

$$PA_aQHA_{a,h} = PA_{a,}\gamma h_{a,h} + \beta h_{a,h}(HEXP_h - \sum_c PQ_c\,\gamma m_{c,h} - \sum_a PA_a\gamma h_{a,h}) \tag{34}$$

Government expenditure:

$$EG = \sum_c PQ_cQG_c + trnsfr_{h,gov} * CPI \tag{35}$$

Government income:

$$\begin{aligned} YG = \sum\nolimits_h tyh_h(1 - S_h)YH_h \\ + (\sum\nolimits_c \sum\nolimits_r tmr_{c,r}pwmr_{c,r}QMR_{c,r} + ter_{c,r}pwer_{c,r}QER_{c,r})EXR + \sum\nolimits_c tq_cPQ_cQQ_c \\ + \sum\nolimits_r trnsfr_{gov,r} \end{aligned} \tag{36}$$

Government budget constraint:

$$GSAV = YG - EG \tag{37}$$

Government consumption by commodity:

$$QG_c = gstr_cGADJ \tag{38}$$

Investment demand by commodity:

$$QINV_c = IADJ\ invstr_c \tag{39}$$

YF_f	Total income for factor f including factor income from RoW
$nfi_{f,r}$	net factor income to region r
$hfsh_{h,f}$	household h’s share of factor f income
$trnsfr_{h,r}$	Transfers from region r to household h
$trnsfr_{gov,r}$	Net transfers from region r to government

$trnsfr_{h,r}$ Net transfers from region r to household h

$trnsfr_{h,gov}$ Government transfers to household h

$HEXP_h$ Total consumption expenditure by household h

S_h Saving rate of household h (adjusts endogenously to maintain S-I balance)

tyh_h Income tax rate of household h

tq_c Domestic sales tax on commodity c

$shrent_h$ Share of household h in rent arising from import rationing

$QH_{c,h}$ Consumer demand for market commodity c by household h

$\gamma m_{c,h}$ LES subsistence consumption parameter for marketed commodity h

$\gamma h_{a,h}$ Subsistence consumption parameter for home consumption of activity a

$\beta m_{c,h}$ Marginal household h budget share for marketed commodity c

$\beta h_{a,h}$ Marginal household h budget share for home consumption of activity a

EG Government expenditure

GSAV Government saving

YG Government income

QG_c Government consumption demand for commodity c

GADJ Scaling factor for vector of real government consumption

$gstr_c$ Commodity structure parameter for real government consumption

$QINV_c$ Investment demand for commodity c

$invstr_c$ Commodity structure parameter for real investment demand

IADJ Scaling factor for vector of real investment demand

Market equilibrium conditions

Factor market clearing:

$$FS_f = \sum_a FD_{f,a} \tag{40}$$

Domestic commodity market clearing

$$QQ_c = \sum_a QINT_{c,a} + \sum_h QH_{c,h,t} + QG_{c,t} + QINV_{c,t} + qdst_c + QT_c \tag{41}$$

Balance of payments:

$$FSAV = \sum_c \sum_r (pwmr_{c,r} QMR_{c,r} - pwer_{c,r} QER_{c,r}) + \sum_r (\sum_f nfi_{f,r} - \sum_h trnsfr_{h,r} - trnsfr_{gov,r} \tag{42}$$

FS$_f$ Total supply of factor f

FSAV Foreign savings (balance of payments deficit)

Macro Closure

Total saving:

$$TOTSAV_t = \sum_h S_{h,t} YH_{h,t}(1 - tyh_h) + GSAV + FSAV\ EXR \tag{43}$$

Final absorption:

$$ABSO = \sum_c PQ_c(QG_c + QINV_c + qdst_c + \sum_h QH_{c,h}) + \sum_a PA_a QHA_{a,h} \tag{44}$$

Investment and government consumption shares in final absorption:

$$\sum_c PQ_c(QINV_c + qdst_c) = invsh\ ABSO \tag{45}$$

$$\sum_c PQ_c QG_c = govsh\ ABSO \tag{46}$$

TOTSAV Total savings

ABSO Nominal absorption

invsh	Fixed investment share of absorption
govsh	Fixed government share of absorption

Under this macro closure the share of consumer expenditure in absorption is fixed via (45) and (46) and the household saving rates adjust endogenously. GADJ in (38) adjusts endogenously to enforce (37) and IADJ in (39) adjusts endogenously to establish TOTSAV = invsh ABSO.

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