WELFARE AND PRODUCTION EFFECTS OF TECHNICAL CHANGE, MARKET INCENTIVES AND RURAL INCOMES: A CGE ANALYSIS OF UGANDA'S AGRICULTURE

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A Contribution to the Strategic Criteria for Rural Investments in Productivity (SCRIP) Program of the USAID Uganda Mission

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Strategic Criteria for Rural Investments in Productivity (SCRIP) is a USAID-funded program in Uganda implemented by the International Food Policy Research Institute (IFPRI) in collaboration with Makerere University Faculty of Agriculture and Institute for Environment and Natural Resources. The key objective is to provide spatially-explicit strategic assessments of sustainable rural livelihood and land use options for Uganda, taking account of geographical and household factors such as asset endowments, human capacity, institutions, infrastructure, technology, markets & trade, and natural resources (ecosystem goods and services). It is the hope that this information will help improve the quality of policies and investment programs for the sustainable development of rural areas in Uganda. SCRIP builds in part on the IFPRI project *Policies for Improved Land Management in Uganda (1999-2002).* SCRIP started in March 2001 and is scheduled to run until 2006.

The origin of SCRIP lies in a challenge that the USAID Uganda Mission set itself in designing a new strategic objective (SO) targeted at increasing rural incomes. The *Expanded Sustainable Economic Opportunities for Rural Sector Growth* strategic objective will be implemented over the period 2002-2007. This new SO is a combination of previously separate strategies and country programs on enhancing agricultural productivity, market and trade development, and improved environmental management.

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ABSTRACT

In Uganda, as in much of sub-Saharan Africa, poverty is concentrated in rural areas. Rural farm households comprise two-thirds of the population, but have per capita incomes equal to only about one-third those of the urban population. Because agriculture accounts for a large share of incomes for these households, policies and external shocks that affect agriculture, including shifts in agricultural terms of trade, increased agricultural productivity, and reductions in marketing costs, may have significant effects on rural poverty. Constraints to agricultural development vary sharply across regions, however, because of marked differences in agro-ecologies, infrastructure, and cropping patterns.

This report presents an initial attempt to quantify some of these key linkages and the implications of various external shocks and investments using a Computable General Equilibrium (CGE) model of the Ugandan economy, explicitly focused on regional variations in agricultural production and household incomes. The base data for the model is contained in a Social Accounting Matrix (SAM) constructed for this analysis, that quantifies economic flows involving production activities, commodity supply and demand, household incomes and expenditures, government accounts, investment and external trade for Uganda in 1999.

Simulation results suggest that agricultural growth has the potential to significantly raise rural incomes in Uganda provided that markets perform well and producer incentives are maintained. A five percent increase in agricultural productivity could raise consumption by 1.2 to 2.1 percent among rural households. Price effects are important, as food prices fall by 3.3 to 3.6 percent, benefiting urban households whose total consumption increases by 2.4 to 2.7 percent. Reducing agricultural marketing margins by 30 percent leads to increases of 2.3 to 4.1 percent in real consumption of farmer households, as producer prices of agricultural commodities rise in real terms.

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1. INTRODUCTION

In Uganda, as in much of sub-Saharan Africa, poverty is concentrated in rural areas. 86 percent of the population lives in rural areas, and farm households comprise two-thirds of the population. Average monthly per capita household expenditures of these farm households was only 20 thousand Ugandan shillings (about $14) according to the 1999 Uganda Household Survey, about one-third the per capita household incomes of the urban population. Given the large share of agriculture in rural incomes, policies and external shocks that affect agriculture, including shifts in agricultural terms of trade, increased agricultural productivity, and reductions in marketing costs, may have significant effects on rural poverty.

Constraints to agricultural development vary sharply across regions because of marked differences in agro-ecologies, infrastructure, and cropping patterns (Pender et. al, 2001). Thus, external shocks such as changes in world prices or weather, investments in marketing infrastructure, and technical change in agriculture, can potentially have much different effects in, for example, the high-potential, bimodal, rainfall areas of southern Uganda than in the medium and low-potential, unimodal, rainfall regions of northern Uganda. Moreover, because agriculture is such a large sector in the Ugandan economy and farm households comprise a large share of total incomes and consumption, there are important linkages between agriculture, other sectors and the macro-economy. As a result, changes in the agricultural sector can have significant effects on the urban economy as well.

This report presents an initial attempt to quantify some of these key linkages and the implications of various external shocks and investments using a Computable General Equilibrium (CGE) model of the Ugandan economy, explicitly focused on regional variations in agricultural production and household incomes. Chapter 2 presents the data base constructed for this analysis, a Social Accounting Matrix (SAM) that describes the

economic flows involving production activities, household incomes, and consumption in a consistent framework. Chapter 3 describes the structure and equations of the computable general equilibrium model for Uganda developed from the IFPRI standard CGE model (Lofgren et al., 2001). The model explicitly takes into account key features of the Ugandan economy, including a high degree of own consumption of agricultural production and differences in cropping patterns across regions. Results from policy simulations involving increased capital inflows, changes in the world price of coffee, technical change in the agricultural sector and reductions in marketing costs are presented in Chapter 4. Concluding observations are given in Chapter 5.

2. A SOCIAL ACCOUNTING MATRIX FOR UGANDA, 1999

A SAM is a consistent set of accounts that quantifies the economic flows involving production, incomes and expenditures during a fixed period of time. Five major types of accounts are described in the 1999 Uganda SAM: activities, commodities, factors of production, institutions (including the Rest of World) and capital (savings and investment).

The production accounts describe the values of commodity (goods and services) inputs into each production activity, along with payments to factors of production, (land, labor and capital) and indirect taxes. Commodity accounts tabulate the value of total supply (the sum of the values of domestic production, imports, indirect taxes and marketing margins) and total demand (deriving from input use, final consumption, investment demand, government consumption and exports). Factor accounts describe the sources of factor income (value added in each production activity) and how these factor payments are distributed to the various institutions in the economy (households of different types, enterprises, government and the Rest of World). Accounts for institutions include all income and expenditures of institutions, including transfers between institutions. Finally, the savings-investment account includes savings of the various institutions and how they are spent on investment commodities.

1999 was chosen as the base year for the Uganda SAM since the last national household expenditure survey was conducted in that year. Unfortunately, the most recent full set of national accounts for Uganda, a core building block for construction of a SAM, was constructed for 1991. (More recent estimates of the GDP are based largely on the input-output structure of that year and information on the level of production, trade and demand in subsequent years.) Thus, as described below, in constructing the 1999 Uganda SAM, information on the 1991 input-output table and national accounts was supplemented by sectoral value added, trade and macro-economic aggregates from various government sources and the IMF, and the 1999 Uganda Household Expenditure

survey. The procedure involved two steps. First, a "proto-SAM" constructed using the above mentioned data sources (and sometimes choosing among contradictory pieces of information). Given that data come from different years and different sources, the resulting "proto-SAM was, as expected, not balanced. Hence, in the second step, the SAM was balanced, using a "maximum-entropy" estimation procedure (discussed below). We will first describe the structure of the SAM and how it was constructed. After that we will outline the estimation procedure that was used for balancing the SAM.

2.1. STRUCTURE OF THE SAM

Table 2.1 lists the accounts of the 1999 Uganda SAM. A total of 25 production activities are specified, each producing a single unique commodity. Given the objective of examining the impact of various agricultural investments and policies on production, incomes, prices and consumption, the SAM has a more detailed treatment of agriculture. Given the objective of examining the impact of various agricultural investments and policies on production, incomes, prices and consumption, the SAM has a more detailed treatment of agriculture. It includes twelve agricultural activities (coffee, other cash crops[1], maize, sorghum/millet, cassava, sweet potatoes, matooke (cooking bananas), horticulture, other agriculture, livestock, forestry, and fishing). Each of these agricultural activities is split into separate accounts for production in each of the six rural zones of the country. Seven industrial activities are included: meat and dairy processing, coffee processing, grain milling, other beverages, textiles and leather, manufacturing, and petroleum and chemicals). The service sector activities are utilities, construction, transport, private services, and public services. A 26th commodity, Agricultural Chemicals, is also included in the SAM, for which there is no domestic production activity; (commodity supply derives solely from imports).

The SAM includes nine factors of production: capital, skilled and unskilled labor, and six types of land, corresponding to the agro-climatic zones listed at the bottom of

[1] Other cash crops include tea, cotton, sugar and tobacco.

Table 2.1 as defined in Pender et. al. (2001), p. 16, (See Map 2.1).[2] Households are disaggregated into nine household groups. Urban households are split into poor and non-poor according to their 1999/2000 per capita household expenditures, with poor households defined as the poorest 30 percent, approximately equal to the estimated percentage of poor households out of total urban households (28 percent) using data from the 1992 Integrated Household Survey (Appleton et. al., 1999). Rural farm households, (classified according to occupation of the head of household) are split according to the six agro-climatic zones listed above. Non-farm rural households form the last household group, accounting for 19.8 percent of total population.[3]

[2] Zone 6 comprises two zones from Pender et. al. (2001): the medium-potential, unimodal, rainfall region at moderate elevation and the low-potential, unimodal, rainfall region at moderate elevation.

[3] Non-farm rural households are defined as rural households for which the main occupation of the head of household is not crop or cattle farming (according to the Uganda Household Expenditure Survey).

Table 2.1. Accounts in the Uganda 1999 SAM

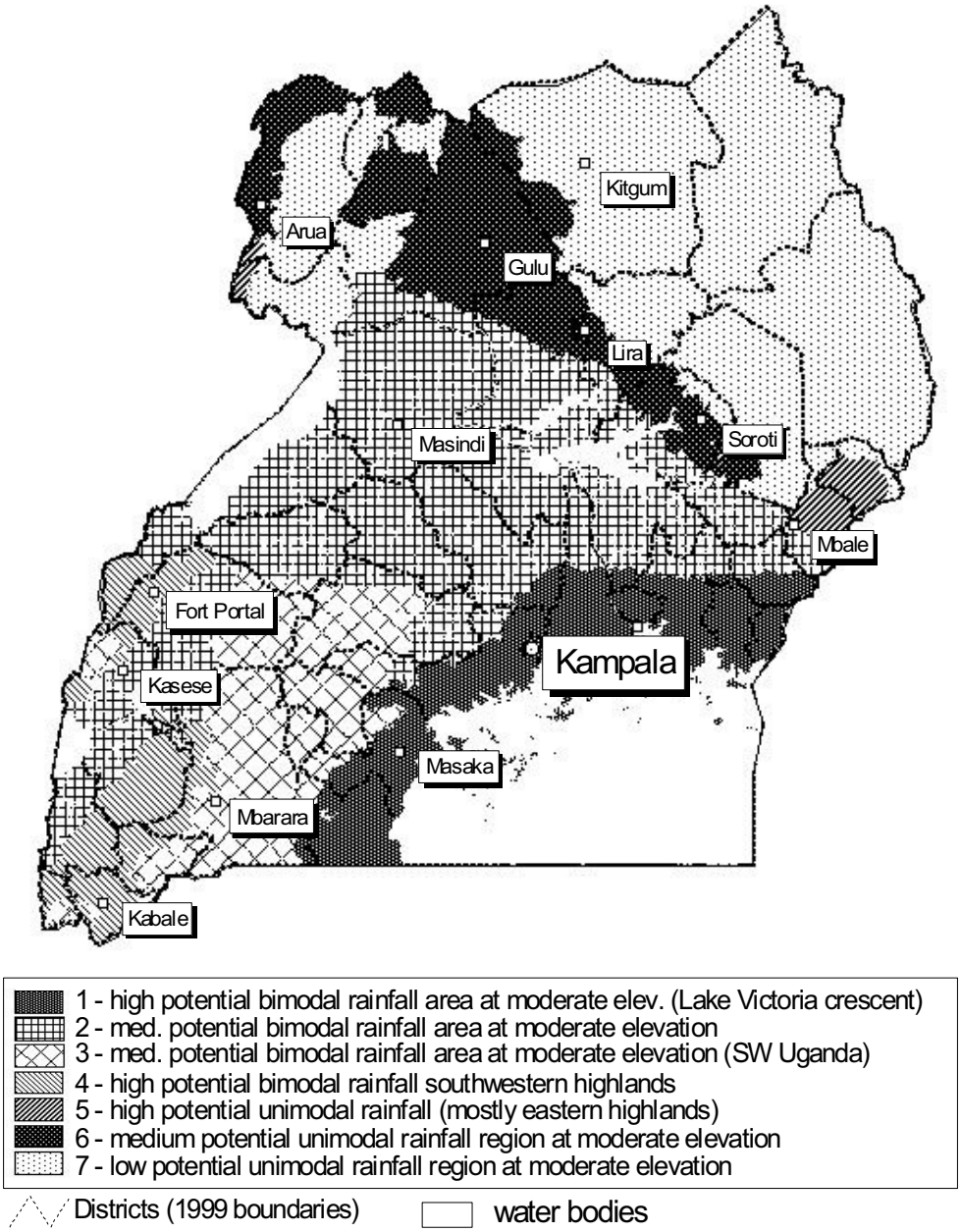
Activities (25)		
Agriculture (12)	**Industry (7)**	**Services (6)**
Coffee	Meat and dairy processing	Utilities
Other Cash Crops	Coffee processing	Construction
Maize	Grain milling	Commerce
Sorghum/Millet	Other beverages	Transport
Cassava	Textiles and leather	Private services
Sweet Potatoes	Manufacturing	Public services
Matooke	Petroleum and chemicals	
Horticulture		
Other agriculture		
Livestock		
Forestry		
Fishing		
Commodities (26): Same as activities, plus Agricultural Chemicals		
Factors of production (9)		
Unskilled labor	Skilled labor	Capital
Land [zones 1-6]*		
Households (9)		
Urban poor	Urban non-poor	Farmers [zones 1-6]*
Non-farm rural		
Other institutions (2)		
Government	Rest of the world	

Note: all agricultural activities are disaggregated by zone with the exception of Fishing where it covers Zones 1, 2, and 6

*Zones (from Pender et. al. 2001, pp.16-17; Rucker et. al., 2002)

Zone 1: Lake Victoria Crescent (high potential, bimodal rainfall, moderate elevation)
Zone 2: Medium Potential (bimodal rainfall, moderate elevation)
Zone 3: Low Potential Southwest (bimodal rainfall, moderate elevation)
Zone 4: Southwest Highlands (high potential, bimodal rainfall)
Zone 5: Eastern Highlands (high potential, uni-modal rainfall)
Zone 6: North (low and medium potential, uni-modal rainfall, moderate elevation)

Map 2.1. Zones of Agro-Climatic Potential



Note: In the Uganda SAM and model, Zone 6 comprises two zones from Pender et. al. (2001) shown in this map: Zone 6 (the medium-potential, unimodal, rainfall region at moderate elevation) and Zone 7 (the low-potential, unimodal, rainfall region at moderate elevation).
Source: Pender et. al. (2001).

Macro-economic data

Table 2.2 shows an aggregate version of the 1999 Uganda SAM. Note that in the SAM all indirect taxes are shown as taxes on commodities and that consumption out of own production by households (totaling 985.5 billion Ugandan shillings, about 11 percent of total household expenditures), is shown as household consumption of the output of activities. The payment from commodities to commodities represents marketing margins.

Production Activities

The starting point for construction of the production activities accounts was data on value added in 1999 by activity from Government of Uganda (2000), page A4. Intermediate consumption was calculated using the input-output coefficients from the 1991 national accounts. All intermediate consumption of chemicals by agricultural sector activities was classified as agricultural chemical consumption; intermediate consumption of chemicals by other sectors was classified as petroleum and other chemicals. Housing services, which are not included in the 1991 national accounts, but are included in the 1999 value added estimates are not included in the SAM. Shares of each activity's production and value added in national production and value added are reported in Table 2.3.

Data on value added by crop are taken from unpublished Uganda Bureau of Statistics for 1999. Agricultural value added is split between land and labor, assuming a 0.7 share of land in value added for coffee and other export crops, and a 0.4 share of land in value added for food and other crops.

Returns to land were split between regions using shares for production of farmers (not including non-farm households) from the 1999 household expenditure survey. Returns to capital in livestock and forestry were allocated to farmers using population

Table 2.2 Uganda Macro SAM, 1999 (billion Ugandan shillings)

	Activity	Commodity	Factors	Households	Government	Rest of the World	Saving-Investment	Institution tax	Import tax	Commodity tax	Total
Activity		11,780.48		985.50							12,765.98
Commodity	4,427.07	1,404.43		7,038.39	1,025.77	1,064.16	1,562.01				16,521.82
Factors	8,338.91										8,338.91
Households			8,338.91		39.04	619.54					8,997.50
Government						505.32		227.81	464.37	278.82	1,476.32
Rest of the World		2,593.72									2,593.72
Saving-Investment				745.80	411.51	404.70					1,562.01
Institution tax				227.81							227.81
Import tax		464.37									464.37
Commodity tax		278.82									278.82
	12,765.98	16,521.82	8,338.91	8,997.50	1,476.32	2,593.72	1,562.01	227.81	464.37	278.82	

Source: Uganda 1999 SAM.

Table 2.3. Structure of the Economy, Uganda 1999

Sector	Output (X)	Value added (VA)	Exports (E)	Imports (M)	Export/ Output (E/X)	Import/ final demand (M/Q)	Elasticity CET	Elasticity Armington
Agriculture				(%)				
Coffee	2.56	3.06	–	–	–	–	–	–
Other Cash Crops	1.28	1.30	–	–	–	0.02	–	–
Maize	1.94	2.86	0.87	–	3.55	–	3.0	–
Sorghum/millet	2.36	3.48	–	–	–	–	–	–
Cassava	1.81	2.67	–	–	–	–	–	–
Sweet Potatoes	1.73	2.55	–	–	–	–	–	–
Matooke	4.35	6.41	–	–	–	–	–	–
Horticulture	4.68	6.89	1.21	–	1.72	–	3.0	–
Other agriculture	3.75	5.52	2.09	0.84	5.90	6.52	3.0	3.0
Livestock	5.03	7.34	–	0.13	–	0.54	–	3.0
Forestry	1.35	1.51	–	0.02	–	0.36	–	3.0
Fishing	1.73	2.20	4.11	0.01	15.87	0.22	3.0	3.0
Total	32.56	45.79	8.27	1.00				
Industry								
Meat and dairy	0.93	0.42	–	2.24	–	33.99	–	1.5
Coffee processing	3.13	0.33	41.92	–	98.43	1.89	2.5	–
Grain milling	0.59	0.26	–	0.67	–	19.60	–	1.5
Other beverages	8.38	4.73	8.36	1.85	6.86	4.86	2.5	1.5
Textiles and leather	0.94	0.59	0.46	9.22	3.33	68.47	2.5	1.5
Manufacturing	4.75	3.22	15.75	48.39	23.36	75.28	2.5	1.5
Agric. chemicals	–	–	–	1.37	–	100.00	–	1.5
Petroleum and	1.00	0.44	–	20.07	–	84.61	–	1.5
Total	19.73	9.98	66.48	83.82				
Services								
Utility	1.05	1.31	1.81	0.18	14.46	4.21	2.5	1.5
Construction	10.52	8.00	–	0.17	–	0.34	–	1.5
Trade	10.60	12.24	–	0.69	–	1.39	–	1.5
Transportation	7.56	4.95	8.31	6.73	9.16	17.50	2.5	1.5
Private services	12.32	13.94	15.12	7.41	10.23	12.67	2.5	1.5
Public services	5.66	3.79	–	–	–	–	–	–
Total	47.71	44.23	25.24	15.18				
Total	100.0	100.0	100.0	100.0				
Agriculture	33.65	44.44	6.87	1.01				
Non-agriculture	66.35	55.56	93.13	98.99				

Source: Uganda 1999 SAM.

weights from the 1999 household expenditure survey. Non-labor value added derived from fishing is allocated between rural capital (land) in zones 1, 2, and 6, based on fish production data by region.

Table 2.4 shows the payments to factors in the agricultural sector as a share of the total factor payment in agriculture. Thus, for example, coffee accounts for 15.4 percent of total value added attributed to land in Zone 1 (the Lake Victoria Crescent area).

Commodity Accounts

As noted above, each activity produces a unique commodity. Imports are estimated using the 1991 import shares by commodity and the 1999 estimates of total imports derived from IMF estimates of total imports of goods and non-factor services in the aggregate national accounts for 1998/99 (IMF, 1999). Likewise, VAT on imports and domestic indirect taxes are allocated across commodities using shares of tax revenues from the 1991 detailed national accounts, except for petroleum taxes and "other duties" which are allocated to petroleum and manufacturing imports, respectively.

Investment demand by commodity was calculated using shares of total investment demand from the 1991 detailed national accounts. Government demand for public services was calculated as the residual between total supply of public services and total intermediate demand for public services. The remainder of government demand was allocated to private services.

Export demand for major export commodities is derived from data on value of exports in dollars (Uganda Bureau of Statistics, 2000; p. 138) and an average exchange rate of 1459 Ugandan Shillings/U.S. dollar. Exports of commerce, transport and other private services are calculated using the share of these exports in total exports in 1991. Exports of manufactured goods are calculated as the residual between estimated total

Table 2.4 Uganda: Factor Shares of Agricultural Value Added, 1999

	Coffee	Other Cash Crops	Maize	Sorghum	Cassava	Sweet Potatoes	Matooke	Horti-culture	Other Crops	Livestock	Forestry	Fishing	Total
Unskilled Labor	4.0	1.7	7.4	9.0	6.9	6.6	16.6	17.7	14.3	9.5	2.0	4.5	100.0
Skilled Labor													
Capital													
Land Zone 1	15.4	6.8	6.7	2.3	2.3	5.8	7.8	20.0	7.2	11.4	3.7	10.6	100.0
Land Zone 2	8.0	3.2	6.0	7.4	9.2	5.9	8.6	10.5	11.7	19.3	5.4	4.8	100.0
Land Zone 3	8.6	3.4	2.5	5.9	2.5	2.2	24.6	11.3	11.2	24.2	3.7	0.0	100.0
Land Zone 4	6.6	2.6	2.1	15.5	1.5	5.7	21.3	8.7	14.2	16.4	5.3	0.0	100.0
Land Zone 5	11.2	4.4	11.9	1.8	0.6	1.8	18.5	14.8	13.1	17.3	4.7	0.0	100.0
Land Zone 6	0.2	0.1	2.0	9.0	8.8	1.5	0.4	0.2	7.2	64.0	6.7	0.0	100.0
Total Value Added	6.7	2.8	6.3	7.6	5.8	5.6	14.0	15.1	12.1	16.1	3.3	4.6	100.0

Source: Uganda 1999 SAM.

Zone 1: High potential, bimodal rainfall, moderate elevation (Lake Victoria crescent)
Zone 2: Medium potential, bimodal rainfall, moderate elevation
Zone 3: Low potential, bimodal rainfall, moderate elevation (southwest Uganda)
Zone 4: High potential, bimodal rainfall, southwestern highlands
Zone 5: High Potential, unimodal rainfall, (mostly eastern highlands)
Zone 6: Low and medium potential, unimodal rainfall, moderate elevation (northern Uganda)

exports and non-factor services (from the macro-economic aggregates) and the sum of estimated exports of all other commodities and non-factor services.

Household Income

No complete data on sources of household income by factor of production is available. Initial estimates of factor payments to households were made mainly on the basis on data on agricultural production by region and population data from the 1999/2000 household expenditure survey. All payments to skilled labor were allocated to urban non-poor households. Payments to unskilled labor were allocated according to the household's share in total active labor force, assuming that only half of the labor force of urban non-poor households is unskilled labor. 81 percent of returns to land in each zone were allocated to farmers in that zone, with the remaining 19 percent of land incomes in each zone allocated to urban poor (1 percent), urban non-poor (5 percent) and rural non-farm (13 percent), based on the shares of these latter three groups in total value of agricultural production from the 1999/2000 household expenditure survey. 70, 20 and 2 percent of returns to capital are allocated to urban non-poor, rural non-farm, and urban poor households, respectively, with the remaining returns to capital allocated according to population shares of the other household groups.

The matrix of factor payments to household groups is given in Table 2.5. Per capita incomes of farmer household groups range from 218.0 shillings/year for farm households in zone 6 (low and medium potential, uni-modal rainfall, moderate elevation) to 374.8 thousand shillings/year for farmers in zone 3 (low potential bimodal rainfall in the sowthwest). Per capita incomes of the urban non-poor (933.7 thousand shillings/year) are 4.3 times higher than those of the poorest farmer household group (Zone 6).

Table 2.5 Uganda 1999 SAM: Household Incomes by Source (billion Ugandan shillings)

	Urban Poor	Urban Non-Poor	Farmers Zone 1	Farmers Zone 2	Farmers Zone 3	Farmers Zone 4	Farmers Zone 5	Farmers Zone 6	Non-farm Rural	Total
Unskilled Labor	98.4	235.9	813.7	867.3	384.3	334.9	141.5	350.2	838.9	4,065.21
Skilled Labor		417.3								417.28
Capital	38.1	1454.0	38.9	43.6	18.6	15.9	7.3	27.5	329.1	1,972.95
Land 1 (Lake Victoria crescent)	2.4	11.5	498.5						95.9	608.37
Land 2 (medium potential, bimodal)	1.9	9.1		387.8					76.1	474.91
Land 3 (low potential, southwest)	1.2	5.6			239.7				46.2	292.63
Land 4 (southwest highlands)	0.7	3.3				142.3			27.5	173.87
Land 5 (eastern highlands)	0.4	1.7					72.5		14.0	88.56
Land 6 (northern Uganda)	1.0	4.8						188.8	50.6	245.14
Transfer Income	11.0	223.7	94.8	85.7	46.7	34.3	15.7	35.8	110.8	658.58
Total	155.04	2,366.81	1,445.97	1,384.50	689.31	527.46	236.97	602.23	1,589.19	8,997.50
Population	429	2535	3890	4395	1839	1577	717	2763	4318	22463
Per Capita Income (thousand U.Sh.)	361.0	933.7	371.7	315.0	374.8	334.6	330.5	218.0	368.0	400.55
Per Capita Expenditures (Survey)	293.4	823.7	285.0	229.1	292.9	250.4	251.1	150.8	300.1	318.56
Ratio: Income/Expenditures	1.23	1.13	1.30	1.38	1.28	1.34	1.32	1.45	1.23	1.26
Share of Total Population (%)	1.91	11.28	17.32	19.56	8.19	7.02	3.19	12.30	19.22	100.00
Share of Total Income (%)	1.72	26.31	16.07	15.39	7.66	5.86	2.63	6.69	17.66	100.00

Source: Uganda 1999 SAM; Uganda National Household Survey 1999.

Household Consumption

Data from the 1999/2000 household expenditure survey show aggregate national consumption of 7152 billion Ugandan shillings (26,530 U.Sh./person/month times 22.46 million people), 90 percent of the 7911 billion Ugandan shillings consumption figure from the national account estimates. In the Uganda SAM, initial estimates of total household commodity consumption, disaggregated by commodity, were calculated as the residual between total supply and non-consumption demand as described above for each commodity. Household consumption of non-processed coffee, other export crops, and agricultural chemicals, however, was assumed to be zero.[4]

For food commodities, this total consumption was allocated across household using the share of each household group's consumption in total consumption of each commodity from the national expenditure survey. In the absence of accurate data on expenditures on horticulture, livestock, forestry, fishing and coffee processing, consumption of these items was calculated using the share of each household in total expenditures of all commodities. (The implicit assumption is that the budget share of these commodities is roughly constant across household groups.) For all other commodities, each household's share of total consumption of non-food / non-clothing items was used. Savings were allocated across households according to their shares in total national household expenditures. The final consumption and savings shares in the SAM (derived after the cross entropy balancing) are reported in Table 2.6.

2.2. BALANCING THE SAM: THE CROSS ENTROPY (CE) METHOD

The structure of a SAM, with row totals equal to column totals for each account, requires that inconsistencies in data from various sources be removed. In constructing the

[4] Note that there was a large imbalance in the initial calculations for the processed coffee commodity accounts, with total uses of processed coffee substantially higher than total availability (by roughly 25 billion Ugandan shillings, about 6 percent of total reported processed coffee exports). This imbalance was adjusted through the cross entropy method described below.

Table 2.6 Household Expenditure Shares

	Urban Poor	Urban Non-Poor	Farmers Zone 1	Farmers Zone 2	Farmers Zone 3	Farmers Zone 4	Farmers Zone 5	Farmers Zone 6	Non-farm Rural	Total
Own Consumption										
Maize	0.14	0.04	0.63	0.57	0.66	0.55	1.48	0.15	0.43	0.41
Sorghum/Millet	0.19	0.15	0.83	3.93	4.04	8.49	0.76	4.75	2.11	2.30
Cassava	0.49	0.09	1.53	4.20	1.47	0.86	0.28	6.55	1.84	1.86
Sweet Potatoes	0.83	0.27	3.75	3.09	1.33	3.16	1.13	0.99	2.09	1.91
Matooke	0.78	0.71	3.79	2.41	9.04	7.36	7.61	0.16	1.97	2.86
Horticulture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Agriculture	0.58	0.16	2.07	1.71	3.45	5.22	2.95	1.21	1.30	1.61
Subtotal	**3.01**	**1.42**	**12.61**	**15.92**	**19.98**	**25.63**	**14.20**	**13.81**	**9.74**	**10.95**
Purchased										
Maize	1.68	0.70	0.89	0.54	1.87	0.96	1.94	0.63	1.13	0.93
Sorghum Millet	1.38	0.71	0.28	1.08	0.67	1.61	0.14	5.29	1.65	1.22
Cassava	1.77	0.47	0.60	1.02	0.51	0.25	0.38	2.97	0.81	0.81
Sweet Potatoes	1.29	0.58	0.30	0.20	1.60	1.43	0.27	0.21	0.60	0.59
Matooke	2.42	2.27	0.70	0.40	0.49	0.54	0.74	0.11	1.13	1.11
Horticulture	8.06	7.52	7.82	7.62	7.82	7.52	7.57	7.24	8.27	7.73
Other Agriculture	6.80	3.13	3.54	5.13	3.89	4.25	3.46	7.43	4.71	4.27
Livestock	8.06	7.55	7.83	7.63	7.82	7.52	7.57	7.24	8.28	7.74
Forestry	1.35	1.43	1.28	1.22	1.30	1.24	1.26	1.16	1.35	1.31
Fish	2.34	2.43	2.22	2.13	2.26	2.16	2.19	2.02	2.36	2.27
Meat	1.51	1.58	1.41	1.86	1.41	1.04	1.50	2.14	1.77	1.62
Processed Coffee	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Milled Grain	1.33	1.21	0.54	0.52	0.19	0.21	0.74	0.31	0.81	0.72
Beverages	20.51	9.82	19.06	17.70	12.44	9.40	21.83	13.74	17.09	14.74
Textiles	3.18	4.20	3.26	2.99	3.29	2.93	2.72	2.98	3.77	3.50
Manufactured Goods	4.47	4.65	4.36	4.19	4.35	4.17	4.20	3.94	4.63	4.42
Agric. Chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum Products	6.35	6.38	6.22	6.02	6.19	5.93	5.96	5.67	6.61	6.24
Utilities	0.75	0.81	0.71	0.68	0.73	0.70	0.70	0.65	0.76	0.74
Construction	2.37	2.59	2.30	2.20	2.30	2.20	2.22	2.06	2.46	2.36
Trade	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport	5.59	5.56	5.41	5.23	5.42	5.20	5.24	4.95	5.73	5.43
Private Services	10.75	9.86	10.68	10.48	10.52	10.11	10.12	9.86	11.30	10.43
Public Services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Savings	4.99	15.47	7.93	5.22	4.91	4.98	5.00	5.58	5.00	8.29
Direct Taxes	0.00	9.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.53
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Uganda 1999 SAM.

SAM, various adjustments to the data were made to produce a "proto-SAM" which was not fully balanced. Final balancing of the SAM was achieved using the CE.[5]

The CE technique is a method of solving underdetermined estimation problems. The problem is underdetermined because, for an n x n matrix, we are seeking to identify n^2 unknown, non-negative parameters, i.e. the cells of the SAM. However, there are only $2n-1$ independent row and column adding-up restrictions. In other words, restrictions must be imposed on the estimation problem so that we have enough information to obtain a unique solution and to provide enough degrees of freedom. The underlying philosophy of CE estimation is to use *all* and *only* the information available for the problem at hand: the estimation procedure should not ignore any available information nor should it add any false information. [6]

In the case of SAM estimation, 'information' may be the knowledge that there is measurement error concerning the variables, and that some parts of the SAM are known with more certainty than others. There may be a prior in the form a SAM from a previous year, whereby the entropy problem is to estimate a new set of coefficients 'close' to the prior using new information to update it. Furthermore, 'information' could consist of moment constraints on row and column sums, e.g. the average of the column sums. In addition to the row and column sums, 'information' may also consist of certain economic aggregates such as total value-added, aggregate consumption, investment, government consumption, exports and imports. Such information may be incorporated as linear adding-up restrictions on the relevant elements of the SAM. In addition to equality constraints such as these, information may also be incorporated in the form of inequality

[5] The CE method is an approach which originates from information theory (see e.g. Kapur and Kesavan 1992, and Golan et al. 1996) and has been applied to social accounting matrix estimation in e.g. Robinson et al. (2001), Robinson and El-Said (2000), and Noland, Robinson and Wang (2000). Only a concise presentation of the technique will be given here, and the reader is referred to the afore-mentioned references for further detail.

[6] See Shannon (1948) and Theil (1967) for a discussion of the concept of 'information'.

constraints placing bounds the mentioned macro aggregates. Finally, one may want to restrict cells that are zero in the prior to remain so also after the CE balancing procedure.[7]

[7] In constructing the Uganda SAM, a standard deviation of 8 percent was used for the prior error distribution of the average of each row and corresponding column sum. Similarly, standard deviations for the prior error distributions for the values of major economic aggregates (GDP at factor cost, government consumption, investment, total exports and total imports) were fixed at 1 percent. Finally, the standard deviation for the prior error distribution for each cell in the activity columns was fixed at 5 percent. For each cell in the matrix of factor payments to households and household consumption, the standard deviation of the prior error distribution was fixed at 10 percent. For all remaining cells in the SAM, the standard deviation of the prior error distribution was fixed at 8 percent.

3. OVERVIEW OF THE UGANDA CGE MODEL[8]

The Uganda CGE model used in this study is based on IFPRI's Standard CGE Model (Lofgren, et al 2001). A CGE model describes how all the payments (economic flows) that are recorded in a SAM change as a consequence of an external shock (a change in an exogenous variable or parameter). As a consequence, the model follows the SAM disaggregation of factors, activities, commodities, and institutions. It is written as a set of simultaneous equations, many of which are non-linear. There is no objective function. The equations define the behavior of the different actors. In part, this behavior follows simple rules captured by fixed coefficients (for example, *ad valorem* tax rates). For production and consumption decisions, behavior is captured by non-linear, first-order optimality conditions. The equations also include a set of constraints that have to be satisfied by the system as a whole but which are not necessarily considered by any individual actor. These constraints cover markets (for factors and commodities) and macroeconomic aggregates (balances for savings-investment, the government, and the current-account of the rest of the world).

This section first describes the basic CGE model. Special features of the Uganda CGE model and values of some key model parameters are presented at the end.

3.1. ACTIVITIES, PRODUCTION, AND FACTOR MARKETS

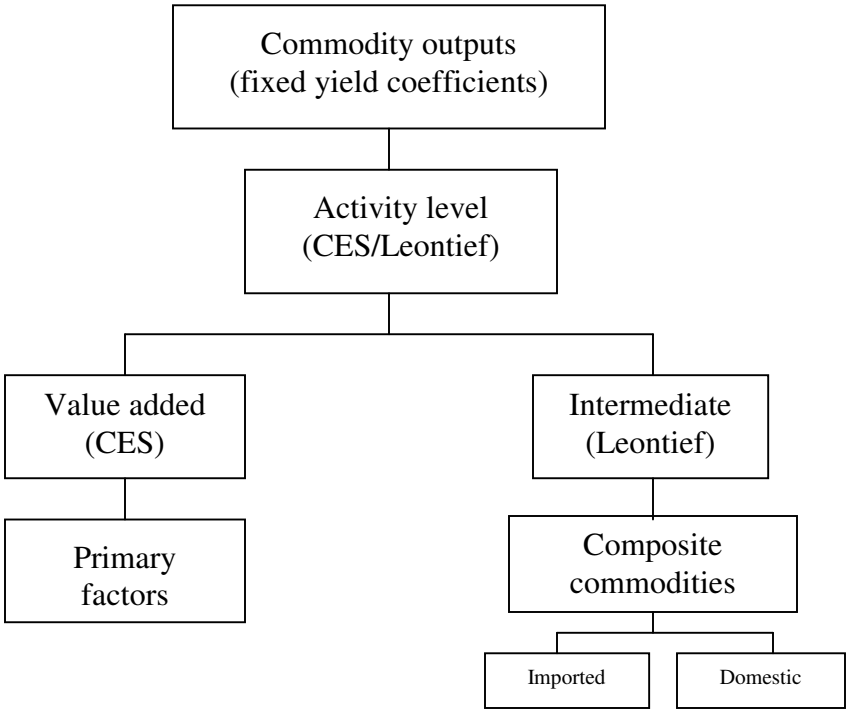
Each producer (represented by an activity) is assumed to maximize profits, defined as the difference between revenue earned and the cost of factors and intermediate inputs. Profits are maximized subject to a production technology, the structure of which is shown in Figure 3.1. At the top level, the technology is specified by a CES (constant elasticity of substitution) or, alternatively, a Leontief function of the quantities of value-

[8] This section draws heavily on Lofgren, et al. (2001). The reader is referred to this source for more details, including a mathematical statement.

added and aggregate intermediate input. The Leontief alternative is the default. The CES alternative may be preferable in particular sectors if empirical evidence suggests that available techniques permit the aggregate mix between value-added and intermediate inputs to vary. Value-added is itself a CES function of primary factors whereas the aggregate intermediate input is a Leontief function of disaggregated intermediate inputs.

Each activity produces one or more commodities according to fixed yield coefficients. (As noted, any commodity may be produced by more than one activity.) The

Figure 3.1. Production technology



revenue of the activity is defined by the level of the activity, yields, and commodity prices at the producer level.

As part of its profit-maximizing decision, each activity uses a set of factors up to the point where the marginal revenue product of each factor is equal to its wage (also called factor price or rent). Factor wages may differ across activities, not only when the

market is segmented but also for mobile factors. In the latter case, the model incorporates discrepancies that stem from exogenous causes (for example wage differences across activities due to considerations such as status, comfort, or health risks).

The user can choose between alternative factor market closures (mechanisms for equilibrating supplies and demands in factor markets). According to the default closure, the quantity supplied of each factor is fixed at the observed level. An economy-wide wage variable is free to vary to assure that the sum of demands from all activities equal the quantity supplied. Each activity pays an activity-specific wage that is the product of the economy-wide wage and an activity-specific wage (distortion) term. For the default closure, the latter terms are fixed.

Alternatively, it is possible to assume that a factor is unemployed and the real wage is fixed. This assumption may, for example, be appropriate in settings where there is considerable unemployment for a given labor category. Compared to the default closure, the only change is that the economy-wide wage variable is fixed (or exogenized) while the supply variable is "flexed" (or endogenized). Each activity is free to hire any desired quantity at its fixed, activity-specific wage (which, implicitly, is indexed to the model numéraire). In this setting, the supply variable is superfluous; it merely records the total quantity demanded.

Under a third closure, the factor market is segmented and each activity is forced to hire the observed, base-year quantity–the factor is activity-specific. This closure may be preferred in short-run analysis and/or when there are significant quality differences between the units of a factor that are used in different activities, for example units of non-agricultural capital used in different industrial and service activities. For this case, the quantities of activity-specific factor demands and the economy-wide wage are fixed while the activity-specific wage terms and the supply variables are flexible.

3.2. INSTITUTIONS

In the model, households, enterprises, the government, and the rest of the world represent institutions. The households (disaggregated as in the SAM) receive income from the factors of production (directly or indirectly, via the enterprises), and transfers from other institutions. Transfers from the rest of the world to households are fixed in foreign currency. (All transfers between the rest of the world and domestic institutions and factors are fixed in foreign currency.) The households use their income to pay direct taxes, save, consume, and make transfers to other institutions. In the basic model version, direct taxes and transfers to other domestic institutions are defined as fixed shares of household income. The treatment of direct tax and savings shares is related to the choice of closure rule for the government and savings-investment balances. (This topic is discussed below in Section 3.4). The income that remains (after taxes, savings, and transfers to other institutions) is spent on consumption.

Household consumption covers marketed commodities, purchased at *market prices* that include commodity taxes and transactions costs, and home commodities, which are valued at activity-specific *producer prices*.[9] Household consumption is allocated across different commodities (both market and home commodities) according to Linear Expenditure System (LES) demand functions.

Instead of being paid directly to the households, factor incomes may be paid to one or more enterprises. Enterprises may also receive transfers from other institutions. Enterprise incomes are allocated to direct taxes, savings, and transfers to other institutions. Enterprises do not consume. Apart from this, the payments to and from enterprises are modeled in the same way as the same payments to and from households.

The government collects taxes and receives transfers from other institutions. In the basic model version, all taxes are at fixed *ad valorem* rates. The government uses this

[9] Note that these producer prices are the same for each household in the Uganda model.

income to purchase commodities for its consumption and for CPI-indexed transfers to other institutions. In the basic model version, government consumption is fixed in real (quantity) terms whereas government transfers to domestic institutions (households and enterprises) are CPI-indexed. Government savings (the difference between government income and spending) is a flexible residual.

The rest of the world is the only remaining institution. As noted, transfer payments from the rest of the world and domestic institutions and factors are all fixed in foreign currency. Commodity trade with the rest of the world is discussed in the following section. Foreign savings (or the current account deficit) is the difference between foreign currency spending and receipts.

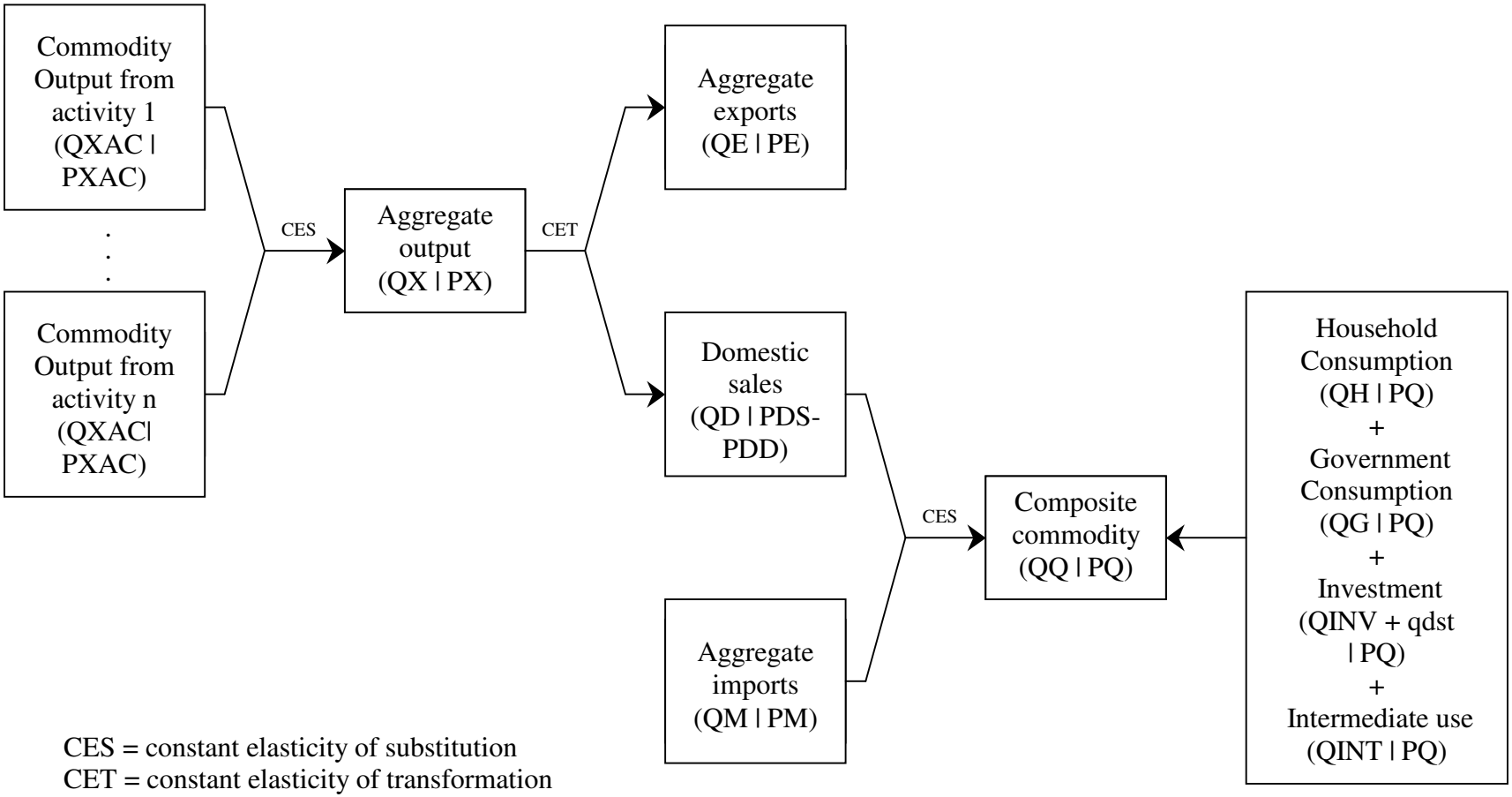
Section 3.4 discusses the rules for clearing the macroeconomic balances (the macro closures), *i.e.*, how equilibrium is achieved in the balances for the government, the rest of the world, and the savings-investment account (where institutional savings are aggregated and allocated to domestic investment).

3.3. COMMODITY MARKETS

With the exception of home-consumed output, all commodities (domestic output and imports) enter markets. Figure 3.2 shows the physical flows for marketed commodities and associated quantity and price variables as defined in the model equations discussed in Lofgren, et al. (2001).

Domestic output may be sold in the market or consumed at home. For marketed output, the first stage in the chain consists of generating aggregated domestic output from the output of different activities of a given commodity. These outputs are imperfectly substitutable, for example as a result of differences in timing, quality, and location

Figure 3.2. Flows of marketed commodities



CES = constant elasticity of substitution
CET = constant elasticity of transformation

between different activities. A Constant-Elasticity-of-Substitution (CES) function is used as aggregation function. The demand for the output of each activity is derived from the problem of minimizing the cost of supplying a given quantity of aggregated output subject to this CES function. Activity-specific commodity prices serve the role of clearing the implicit market for each disaggregated commodity.

At the next stage, aggregated domestic output is allocated between exports and domestic sales on the assumption that suppliers maximize sales revenue for any given aggregate output level, subject to imperfect transformability between exports and domestic sales, expressed by a Constant-Elasticity-of-Transformation (CET) function. In the international markets, export demands are infinitely elastic at given world prices. The price received by domestic suppliers for exports is expressed in domestic currency and adjusted for the transactions cost (to the border) and export taxes (if any). The supply price for domestic sales is equal to the price paid by domestic demanders minus the transactions cost of domestic marketing (from the supplier to the demander) per unit of domestic sales.[10] If the commodity is not exported, total output is passed to the domestic market.

Domestic demand is made up of the sum of demands for household consumption, government consumption, investment (the determination of which is discussed below), intermediate inputs, and transactions (trade and transportation) inputs.

To the extent that a commodity is imported, all domestic market demands are for a composite commodity made up of imports and domestic output, the demands for which are derived on the assumption that domestic demanders minimize cost subject to imperfect substitutability. This is also captured by a CES aggregation function.[11] Total market demand is directed to imports for commodities that lack domestic production and to domestic output for non-imported commodities.

[10] In the current version of the model, transactions costs do not vary by region.
[11] This function is also referred to as an Armington function, named after Paul Armington who introduced imperfect substitutability between imports and domestic commodities in economic models (Armington 1969).

The derived demands for imported commodities are met by international supplies that are infinitely elastic at given world prices. The import prices paid by domestic demanders also include import tariffs (at fixed *ad valorem* rates) and the cost of a fixed quantity of transaction services per import unit (which cover the cost of moving the commodity from the border to the demander).[12] Similarly, the derived demand for domestic output is met by domestic suppliers. The prices paid by the demanders include the cost of transaction services (in this case reflecting that the commodity was moved from the domestic supplier to the domestic demander). The prices received by domestic suppliers are net of this transactions cost. Flexible prices equilibrate demands and supplies of domestically marketed domestic output.

The assumptions of imperfect transformability (between exports and domestic sales of domestic output) and imperfect substitutability (between imports and domestically sold domestic output) permit the model to better reflect the empirical realities of most countries (in comparison with the alternative assumptions of perfect substitutability and transformability). The assumptions that are used give the domestic price system a degree of independence from international prices and avoid unrealistic export and import responses to economic shocks. At the disaggregated commodity level, these assumptions allow for a continuum of tradability and two-way trade, which commonly is observed even at very fine levels of disaggregation.

3.4. MACROECONOMIC BALANCES

The model includes three macroeconomic balances: the (current) government balance, savings-investment balance, and the external balance (the current account of the

[12] Note that these transactions costs are not *ad valorem* – the rates (the ratio between the margin and the price without the margin) change when there are changes in the prices of transactions services and/or the commodities that are marketed. Thus, for example, a simulated negative productivity shock that causes a significant increase in the producer (activity) price will in general lead to a smaller percentage increase in the price of domestic sales of that commodity.

balance of payments, which includes the trade balance). Alternative macro-closures rules for these balances can be specified.[13]

In the simulations presented in chapter 4, government expenditures are fixed (exogenous).[14] Thus, government savings (the difference between total government revenues and total government expenditures) is endogenous. Likewise, investment is also fixed -- implicitly assumed to be constrained by factors other than total available savings. The marginal propensities to save of households change in order to bring about an equilibrium between savings and investment. (Several alternatives to this closure are also possible, including savings -driven closures, in which the value of investment adjusts according to various specified rules.)

For the external balance (which is expressed in foreign currency), foreign savings (foreign capital inflows) are fixed and the (real) exchange rate adjusts to achieve equilibrium in the current account.[15] The consumer price index is the numeraire, fixed at its base level. If, *ceteris paribus*, foreign savings (the difference between the value of imports and other current account payments and the value of exports and other current account receipts) are below the exogenous level, a depreciation of the real exchange rate would correct this situation by simultaneously (i) reducing spending on imports (a fall in import quantities at fixed world prices); and (ii) increasing earnings from exports (an increase in export quantities at fixed world prices).

The appropriate choice between the different macro closures depends on the context of the analysis. Given that this is a single-period model, a closure combining fixed foreign savings, fixed real investment, and fixed real government consumption may be preferable for simulations that explore the equilibrium welfare changes of alternative policies. Such a closure avoids the misleading welfare effects that appear when foreign

[13] Macro closures of CGE models is a contentious topic with a large literature. For summaries, see Robinson (1989), Rattsø (1982), and Taylor (1990).
[14] Although government expenditure varies over time in Uganda, we hold government expenditure constant in these simulations, so as to isolate the direct impacts of the external shocks and policy changes modeled.
[15] With the consumer price index fixed as the model numeraire, changes in the nominal exchange rate are equivalent to changes in the real exchange (here operationally defined as the nominal exchange rate deflated by the consumer price index).

savings and real investment change in simulations with a single-period model – *ceteris paribus*, for the simulated period, increases in foreign savings and decreases in investment raise household welfare (and vice versa for decreases in foreign savings and increases in investment). This result is misleading since the analysis does not capture welfare losses in later periods that arise from a larger foreign debt and a smaller capital stock.

In addition, it is often informative to explore the impact of any experiment under a set of alternative macro closures. The results often provide important insights into the real-world trade-offs that are associated with alternative macroeconomic adjustment patterns.

3.5. MODEL PARAMETERS AND FACTOR MARKET CLOSURE

The simulations model total labor supply as fixed, given the shortage of skilled labor in Uganda, and tight constraints on unskilled labor supply, particularly in agriculture during periods of high labor demand for planting, weeding and harvesting. Thus, real wage rates adjust in response to changes in labor demand. Land (and agricultural capital) are fixed in coffee, export crops, livestock, forestry and fishing, simulating short-run (within one year) rigidities in land and capital allocation. Likewise, total land in each region is fixed; land planted to the other crops adjusts given these constraints, according to producer incentives.

Production and consumption parameters in the Uganda model are calibrated so that both supply and demand are inelastic with respect to price, i.e. so that domestic supply (demand) of each product would increase (decrease) by less than 1 percent when its price increases by one percent, holding other factors constant.[16] For the agricultural

[16] Note that in the general equilibrium model simulations, other factors are not held constant, so that quantity changes are in general not equal to those implied by the changes in price of the products and their own-price elasticities of demand.

sectors, the elasticity of substitution between land and labor is set so that the own-price elasticity of supply for most sectors is equal to 0.3.[17]

Household consumption demand is modeled using the linear expenditure system equations described above. The Frisch parameter is set equal to –1.6 for the urban non-poor households, and - 4.0 for all other households (Dervis, de Melo and Robinson, 1982; Lluch, Powell and Williams, 1977). Income elasticities of demand are set equal to one. Given these parameters, the resulting own-price elasticities for the urban non-poor households are approximately equal to - 0.6. For all other household groups, the own-price elasticities of demand are approximately equal to - 0.3 (Table 3.2).

[17] Coffee and other cash crops are exceptions. For these sectors, the elasticity of substitution between land and labor is set so that the own-price elasticity of supply is equal to 0.1 and 0.2, respectively.

Table 3.1. Own Price Elasticity of Demand

	Urban Poor	Urban Non-Poor	Farmers Zone 1	Farmers Zone 2	Farmers Zone 3	Farmers Zone 4	Farmers Zone 5	Farmers Zone 6	Non-farm Rural
Maize	-0.26	-0.63	-0.26	-0.25	-0.26	-0.26	-0.27	-0.26	-0.26
Sorghum, Millet	-0.26	-0.63	-0.25	-0.26	-0.26	-0.26	-0.25	-0.29	-0.26
Cassava	-0.26	-0.63	-0.25	-0.26	-0.25	-0.25	-0.25	-0.27	-0.26
Sweet potatoes	-0.26	-0.63	-0.25	-0.25	-0.26	-0.26	-0.25	-0.25	-0.25
Matooke	-0.27	-0.64	-0.26	-0.25	-0.25	-0.25	-0.26	-0.25	-0.26
Horticulture	-0.31	-0.66	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.32
Other Agriculture	-0.30	-0.64	-0.28	-0.29	-0.28	-0.28	-0.28	-0.31	-0.29
Livestock	-0.31	-0.66	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.32
Forestry	-0.26	-0.63	-0.26	-0.26	-0.26	-0.26	-0.26	-0.26	-0.26
Fish	-0.27	-0.64	-0.27	-0.27	-0.27	-0.27	-0.27	-0.27	-0.27
Meat	-0.26	-0.63	-0.26	-0.26	-0.26	-0.26	-0.26	-0.27	-0.26
Processed Coffee	-0.25	-0.63	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25
Milled Grain	-0.26	-0.63	-0.25	-0.25	-0.25	-0.25	-0.26	-0.25	-0.26
Beverages	-0.41	-0.67	-0.41	-0.39	-0.35	-0.32	-0.42	-0.36	-0.38
Textiles	-0.28	-0.65	-0.28	-0.27	-0.28	-0.27	-0.27	-0.27	-0.28
Manufactured Goods	-0.29	-0.65	-0.29	-0.28	-0.28	-0.28	-0.28	-0.28	-0.29
Petroleum Products	-0.30	-0.66	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30
Utilities	-0.26	-0.63	-0.26	-0.26	-0.26	-0.26	-0.26	-0.26	-0.26
Construction	-0.27	-0.64	-0.27	-0.27	-0.27	-0.27	-0.27	-0.27	-0.27
Transport	-0.29	-0.65	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.30
Private Services	-0.33	-0.67	-0.34	-0.33	-0.33	-0.33	-0.33	-0.33	-0.34

Source: Authors' calculations from Uganda SAM.

4. MODEL SIMULATIONS

This chapter presents the results of policy simulations of the impacts of changes in foreign capital inflows, world coffee prices, agricultural productivity shocks and reductions in marketing costs on the macro-economy, the agricultural sector and household incomes. We begin with a simulation of a 20 percent increase in foreign savings to highlight the linkages between foreign exchange earnings, the real exchange rate, investment and income distribution. Simulations 2 – 6 then explore the implications of various scenarios involving coffee production and exports, a major source of foreign exchange earnings. Simulations 7-9 examine the implications of increases in total factor productivity in various agricultural sectors. Finally, simulation 10 models the impacts of an exogenous decrease in agricultural marketing margins. Sensitivity analysis, using alternative assumptions regarding model parameters and labor market behavior, is presented in Appendix 1.

4.1. SIMULATION 1: 20 PERCENT INCREASE IN FOREIGN SAVINGS

Net foreign capital inflows, whether in the form of foreign aid or private commercial flows, have the potential to fund productive investments in the public and private sector and raise real incomes in the long run. Net foreign capital inflows (financing the current account deficit), which ranged from $221.4 to $236.5 million from 1994/95 through 1996/97, more than doubled by 1998/99 to $478.5 billion. In Simulation 1, we model a further twenty percent increase in foreign savings relative to the base 1999 level (an increase of 54 million dollars that is equal to 7.4 percent of base 1999 exports).

In the simulation, with total investment fixed in real terms, household savings decline and household consumption spending rises.[18] The increase in household consumption raises demand for both non-traded goods (domestic output sold at home)

[18] Implicitly, this can happen because the increased savings makes credit more available and households are able to borrow for their investment needs and/or households respond to higher prices by reducing savings rather than consumption expenditures.

and imports. The prices of non-traded goods increase while import prices decline due to the exchange rate appreciation.[19] For the same reason, the prices received by domestic producers for their exports decline. In response, domestic producers allocate a larger share of their output to the domestic market. The final, combined effects of these developments are an increase in domestic sales of domestic output, an increase in imports (in dollar terms by 1.6 percent), a decline in exports (in dollar terms by 3.7 percent), and an appreciation of the real exchange rate of 3.0 percent (Table 4.1).

Real producer prices for coffee fall by 3.8 percent in this scenario, a major cause of the 0.5 percent decline in value added from coffee production (Table 4.2). Coffee exports decline by 0.5 percent in dollar terms. Other sectors that produce substantial amounts of tradable goods also decline: particularly other beverages and textiles (falling by 10.1 and 8.7 percent, respectively). Production of non-traded agricultural crops generally rises slightly as increases in their real prices (by about 1.2 percent, Table 4.3) encourage domestic production and consumption. Production of maize and horticultural products, which are also exported in relatively small quantities, is essentially unchanged. Returns to land increase and tend to increase more in the areas where little coffee is grown, i.e. the northern Uganda region (6), and least in regions where coffee is a major share of returns to land, i.e. zone 1 (the Lake Victoria crescent region), (Table 4.4). Increases in farmer incomes mirror these differences in returns to land: real incomes of farmers in zones 5 and 6 increase by 0.7 and 1.0 percent: real incomes of farmers in zone 1 (the Lake Victoria crescent) increase by only 0.5 percent. All households enjoy some increase in real incomes (except urban non-poor) and consumption, however, as the increased flow of resources (foreign savings) permits a total increase in consumption of 1.1 percent.

[19] Throughout the simulations, all nominal price and income change take place in the context of a fixed CPI (i.e., in a setting where, on average, consumer prices do not change).

Table 4.1. Selected Results for Model Simulations 1-6

	Base*	-1- 20% increase in foreign savings	-2- 60% decrease in coffee export prices	-3- 100% increase in coffee land, 10% decrease in coffee export prices	-4- 100% increase in Arabica land	-5- 20% increase in Robusta factor productivity	-6- 20% increase in Arabica productivity
		Percent change from base					
Household consumption**							
UrbanPoor	361.0	1.0	-2.1	3.2	0.3	0.6	0.1
Urban Non-Poor	933.7	0.4	2.2	-0.1	-0.1	-0.2	0.0
Farmers Zone 1	371.7	1.2	-7.9	0.2	0.1	1.4	0.0
Farmers Zone 2	315.0	1.4	-5.0	1.5	0.3	0.9	0.1
Farmers Zone 3	374.8	1.4	-5.7	0.7	0.1	1.0	0.0
Farmers Zone 4	334.6	1.3	-4.4	1.6	0.2	0.8	0.0
Farmers Zone 5	330.5	1.3	-6.1	0.8	1.7	0.4	0.7
Farmers Zone 6	218.0	1.6	-2.9	1.9	0.2	0.6	0.1
Rural Non-Farm	368.0	1.2	-3.7	1.8	0.2	0.8	0.1
Total household consumption	400.6	1.1	-3.5	1.0	0.2	0.7	0.1
Real Absorption***	10,611.7	0.8	-2.6	0.7	0.1	0.5	0.0
Exports (dollar value)	1,064.2	-3.7	7.3	23.4	1.5	4.5	0.4
Coffee processing	446.0	-0.5	-68.2	66.9	6.7	19.7	1.6
Agriculture	88.1	-3.7	-12.7	15.6	1.5	4.5	0.3
Imports (dollar value)	2,593.7	1.6	-5.2	6.4	0.6	1.9	0.1
Value added	8,338.9	0.0	-0.3	1.9	0.2	0.6	0.0
Agriculture	3,818.1	0.2	-1.5	4.5	0.4	1.2	0.1
Coffee	254.8	-0.5	-20.0	84.9	7.1	19.6	1.6
Maize	238.3	-0.2	2.0	-2.4	-0.2	-0.5	0.0
Exchange rate	100.0	-3.0	11.3	-10.3	-1.1	-3.0	-0.2

Source: Model Simulations

* In the base column, aggregate real indicators are measured at base-year (1999) values.

** The figures for household consumption in the base column show per capita income in thousand Ugandan shillings.

***Among the components of absorption, only household consumption (75% of base-year absorption) changes. Government consumption and investment (10% and 15% of base-year absorption, respectively) are fixed in real terms as part of the macro closure rule.

Note: Zone 1: Lake Victoria crescent; Zone 2: Medium potential, bimodal rainfall; Zone 3: Low potential, southwest Uganda; Zone 4: Southwestern highlands; Zone 5: Eastern highlands; Zone 6: Northern Uganda.

Table 4.2 Value Added by Activity: Simulations 1-6

	BASE	-1- 20% increase in foreign savings	-2- 60% decrease in coffee export prices	-3- 100% increase in coffee land, 10% decrease in coffee export prices	-4- 100% increase in Arabica land	-5- 20% increase in Robusta factor productivity	-6- 20% increase in Arabica productivity
		Percent change from base					
Coffee	254.83	-0.5	-20.0	84.9	7.1	19.6	1.6
Other Cash Crops	108.55	-0.2	1.8	-3.1	-0.3	-0.6	0.0
Maize	238.32	-0.2	2.0	-2.4	-0.2	-0.5	0.0
Sorghum/Millet	290.51	1.0	-3.1	0.5	0.1	0.5	0.0
Cassava	222.47	1.0	-3.4	0.5	0.1	0.5	0.0
Sweet Potatoes	212.68	0.8	-3.9	0.1	0.1	0.6	0.0
Matooke	534.41	0.4	-1.4	-1.3	0.0	0.1	0.0
Horticulture	574.28	0.4	-0.5	-1.1	-0.1	0.0	0.0
Other Crops	460.63	0.0	0.6	-2.0	-0.2	-0.3	0.0
Livestock	612.21	0.3	-1.2	-0.4	0.0	0.1	0.0
Forestry	126.10	0.2	-0.7	-0.6	0.0	0.0	0.0
Fishing	173.95	-2.1	14.6	-7.1	-0.9	-2.3	-0.2
Meat	34.71	-0.9	3.6	-5.0	-0.5	-1.2	-0.1
Coffee Products	27.84	-0.5	-20.0	84.9	6.7	19.6	1.5
Milling	21.52	-0.4	2.6	-4.2	-0.4	-0.9	-0.1
Beverages	394.17	0.0	1.3	-3.1	-0.3	-0.5	0.0
Textiles	49.35	-1.4	5.2	-3.2	-0.3	-0.8	-0.1
Manufacturing	268.40	-0.8	2.7	-3.2	-0.3	-0.8	-0.1
Petroleum	36.57	-0.5	1.9	-2.8	-0.2	-0.6	0.0
Utilities	108.83	0.2	-0.5	0.4	0.0	0.2	0.0
Construction	667.47	0.2	-0.5	0.1	0.0	0.1	0.0
Trade	1,021.04	0.1	-0.4	2.4	0.2	0.7	0.1
Transport	412.37	-0.3	1.2	-1.0	-0.1	-0.1	0.0
Private Services	1,162.32	-0.4	2.0	-3.1	-0.3	-0.6	0.0
Public Services	316.18	0.0	0.0	0.0	0.0	0.0	0.0
Total	8,329.73	0.0	-0.3	1.9	0.2	0.6	0.0

Source: Model Simulations

Table 4.3 Consumer Commodity Prices: Simulation Results

	BASE	-1- 20% increase in foreign savings	-2- 60% decrease in coffee export prices	-3- 100% increase in coffee land, 10% decrease in coffee export prices	-4- 100% increase in Arabica land	-5- 20% increase in Robusta factor productivity	-6- 20% increase in Arabica productivity
		Percent change from base					
Coffee	1.01	-4.0	-74.0	-34.7	-2.0	-5.8	-0.4
Other Cash Crops	1.23	0.6	-1.0	-0.1	0.0	0.2	0.0
Maize	1.23	1.3	-4.7	4.3	0.4	1.3	0.1
Sorghum/Millet	1.20	1.2	-4.1	3.9	0.4	1.1	0.1
Cassava	1.21	1.2	-4.1	3.9	0.4	1.1	0.1
Sweet Potatoes	1.15	1.3	-4.0	3.7	0.4	1.1	0.1
Matooke	1.18	1.3	-4.2	3.8	0.4	1.1	0.1
Horticulture	1.20	1.3	-4.4	3.9	0.4	1.2	0.1
Other Crops	1.16	0.6	-2.2	0.7	0.1	0.4	0.0
Livestock	1.20	1.6	-4.3	1.8	0.3	1.0	0.1
Forestry	1.19	1.1	-2.6	0.8	0.1	0.6	0.0
Fishing	1.19	1.6	-6.3	3.8	0.4	1.4	0.1
Meat	1.18	-0.5	1.6	-1.6	-0.2	-0.5	0.0
Coffee Products	1.00	-2.9	-55.6	-29.5	-2.5	-6.7	-0.6
Milling	1.23	-0.1	0.1	0.6	0.0	0.0	0.0
Beverages	1.34	0.5	-2.3	2.7	0.3	0.7	0.1
Textiles	1.18	-1.9	6.7	-5.3	-0.6	-1.7	-0.1
Manufacturing	1.16	-2.5	9.3	-8.0	-0.8	-2.4	-0.2
Fertilizers	1.00	-2.4	8.8	-7.3	-0.8	-2.3	-0.2
Petroleum	1.27	-2.3	8.7	-7.3	-0.8	-2.2	-0.2
Utilities	1.04	-1.3	5.1	-5.4	-0.5	-1.3	-0.1
Construction	1.01	-0.6	1.7	0.1	0.0	-0.3	0.0
Trade	1.02	0.3	-2.2	6.1	0.5	1.2	0.1
Transport	1.02	-1.2	3.7	-2.1	-0.2	-0.8	-0.1
Private Services	1.01	-0.4	0.8	-0.3	0.0	-0.2	0.0
Public Services	1.00	-1.0	3.7	-3.2	-0.3	-1.0	-0.1

Source: Model Simulations

Table 4.4. Decomposition of Changes in Household Incomes

	Simulation 1 – 20 Percent Increase in Foreign Savings									
	Urban Poor	**Urban Non-Poor**	**Farmers Zone 1**	**Farmers Zone 2**	**Farmers Zone 3**	**Farmers Zone 4**	**Farmers Zone 5**	**Farmers Zone 6**	**Rural Non-Farm**	**All Households**
	Percent change from base									
Unskilled Labor	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4
Skilled Labor		-0.3								-0.1
Capital	-0.1	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Land 1	0.0	0.0	0.3						0.1	0.1
Land 2	0.0	0.0		0.5					0.1	0.1
Land 3	0.0	0.0			0.5				0.0	0.0
Land 4	0.0	0.0				0.6			0.0	0.0
Land 5	0.0	0.0					0.3		0.0	0.0
Land 6	0.0	0.0						0.6	0.0	0.0
Transfers	-0.2	-0.3	-0.2	-0.2	-0.2	-0.3	-0.2	0.0	-0.2	-0.2
Total Income	0.3	-0.7	0.5	0.8	0.8	0.8	0.7	1.0	0.4	0.3
Consumption	1.0	0.4	1.2	1.4	1.4	1.3	1.3	1.6	1.2	1.1

Source: Model Simulations

Note: Zone 1: Lake Victoria crescent; Zone 2: Medium potential, bimodal rainfall;
Zone 3: Low potential, southwest Uganda; Zone 4: Southwestern highlands;
Zone 5: Eastern highlands; Zone 6: Northern Uganda

4.2. SIMULATION 2: 60 PERCENT DECREASE IN EXPORT PRICE OF COFFEE

Uganda's coffee export revenues have declined steeply in recent years, as world coffee prices have plummeted (Table 4.5 and Figure 4.1). The average price of Uganda's robusta coffee exports, (which accounted for 74 percent of coffee exports in 1998/99) fell by 60.8 percent from 1998/99 to 2000/01. Similarly, the price of arabica coffee, fell by 44.6 percent. Nonetheless, programs to increase the volume and quality of coffee exports of robusta coffee cultivated in southern Uganda (zones 1-4) and arabica coffee (cultivated only in zone 2 (medium potential, bimodal rainfall) and zone 5 (eastern highlands)) are a major thrust of Uganda's rural development strategy.[20]

In simulation 2, we model the effects of a 60 percent decline in the world price of coffee (both robusta and arabica), along with a 20 percent decline in coffee production, (approximating the actual robusta export price and quantity change in from 1998/99 to 2000/01.)[21] Coffee exports fall by 68.2 percent in dollar terms, reducing real incomes and consumption demand, and leading to an decrease in the price of non-traded goods (most agricultural crops) relative to traded goods (industrial products). The real exchange rate depreciates by 11.3 percent, reducing import demand, but increasing incentives for non-coffee exports. Real producer prices of most crops rise by about 0.9 percent. Among agricultural crops, value added of maize, horticulture, and other agriculture (relatively more tradable agricultural sectors) increase; value added of other crop sectors fall.

Real incomes of farmers fall in all agricultural zones, with the largest declines in major coffee producing zones (8.7 percent in zone 1: the Lake Victoria crescent), but with a –4.1 percent decline in the northern zone, as well, because of the fall in prices of

[20] Essentially all the coffee grown in zone 1 (Lake Victoria crescent), zone 3 (low potential southwest Uganda) and zone 4 (southwest highlands) is robusta coffee. An estimated 92 percent of the value of coffee production in zone 2 (medium potential bi-modal) is also robusta. All of the coffee grown in zone 5 (eastern highlands) is arabica. (Calculations based on Uganda Coffee Development Authority unpublished data.)

[21] In this simulation, we reduce coffee production in each zone by 20 percent, allowing the rates of return to labor in coffee production in each region to vary from the average rates of return to labor by endogenizing the *wdist* parameter.

Table 4.5 Uganda Coffee Production, Prices and Exports

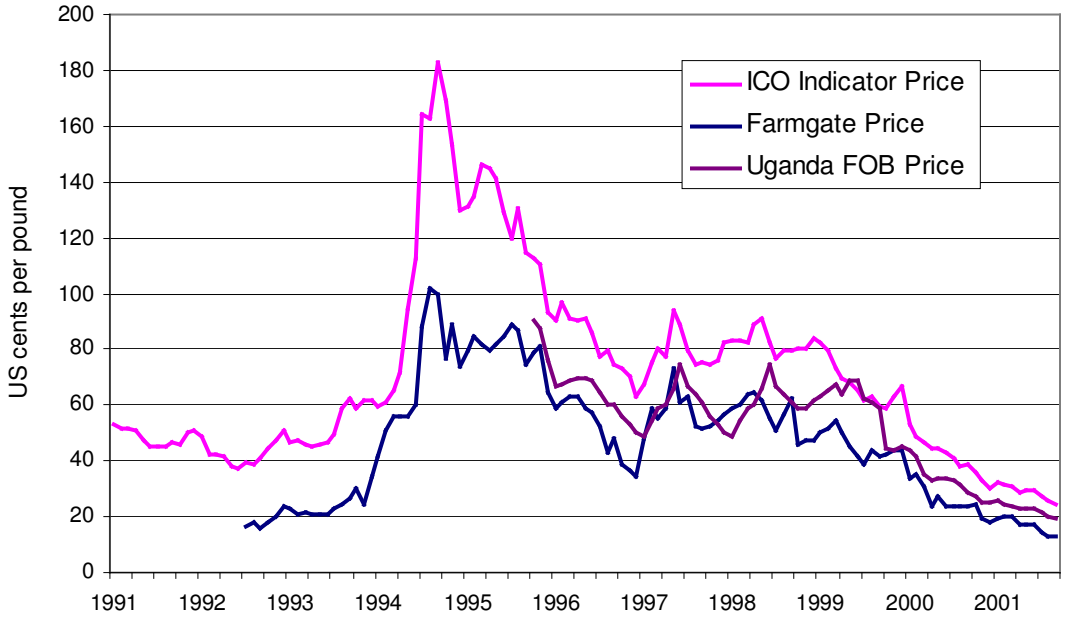
	1991-95 Average	1996/97	1997/98	1998/99	1999/2000	2000/01
Production (thousand tons) *	156	288	220	205	236	248
Robusta						201
Arabica						47
Exports (thousand tons) **	145	254	182	218	175	
Robusta		227	162	197	143	
Arabica		27	20	21	32	
Exports (million US dollars) **	209	396	309	296	288	
Robusta		289	227	248	122	
Arabica		66	49	35	43	
Average Price (US dollars/kg) **	1.44	1.56	1.70	1.36	1.65	
Robusta		1.27	1.40	1.26	0.85	
Arabica		2.44	2.45	1.67	1.34	

* Production data are given for calendar years, e.g. data shown for 1996/97 indicates data for 1996. Data for 2000/01 production, however, are for October 2000 to September 2001.

** Trade data are given for marketing years, e.g. data shown for 1996/97 indicates data from October 1996 to September 1997. Data for 1991-95, however, are for calendar years 1991 to 1995

Source: Uganda Coffee Development Authority; Bolwig et. al. (2002).

Figure 4.1 Robusta Coffee Prices in International Markets and Uganda



Source: Bolwig et. al. (2002).

Table 4.6 Decomposition of Changes in Household Incomes

	Simulation 2 – 60 Percent decrease in Price of Coffee Exports									
	Urban Poor	**Urban Non-Poor**	**Farmers Zone 1**	**Farmers Zone 2**	**Farmers Zone 3**	**Farmers Zone 4**	**Farmers Zone 5**	**Farmers Zone 6**	**Rural Non-Farm**	**All Households**
	Percent change from base									
Unskilled Labor	-3.2	-0.6	-2.9	-3.0	-2.9	-3.0	-3.4	-3.5	-2.9	-2.3
Skilled Labor		1.2								0.3
Capital	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
Land 1	-0.4	-0.1	-6.5						-1.5	-1.7
Land 2	-0.2	-0.1		-4.0					-0.6	-0.7
Land 3	-0.1	0.0			-4.5				-0.4	-0.4
Land 4	0.0	0.0				-3.9			-0.1	-0.1
Land 5	0.0	0.0					-3.6		-0.1	-0.1
Land 6	0.0	0.0						-1.3	-0.1	-0.1
Transfers	0.7	1.0	0.7	1.0	0.7	1.1	-0.1	0.6	1.1	0.9
Total Income	-2.9	2.0	-8.7	-6.0	-6.8	-5.7	-7.1	-4.1	-4.4	-4.0
Consumption	-2.1	2.2	-7.9	-5.0	-5.7	-4.4	-6.1	-2.9	-3.7	-3.5

Source: Model Simulations
Note: Zone 1: Lake Victoria crescent; Zone 2: Medium potential, bimodal rainfall;
Zone 3: Low potential, southwest Uganda; Zone 4: Southwestern highlands;
Zone 5: Eastern highlands; Zone 6: Northern Uganda

non-traded food crops. Real consumption of the urban non-poor actually increases, however, as the real exchange rate depreciation tends to raise the producer prices and output of textiles and manufactured goods, leading to increased returns to capital and to skilled labor (Table 4.6).

4.3. SIMULATIONS 3-6: INCREASED AREA PLANTED AND PRODUCTIVITY OF COFFEE

Simulations 3 – 6 show the implications of various scenarios involving area planted and total factor productivity of coffee. Simulation 3 models a doubling of area planted to coffee, a development goal of the Ugandan government, holding total area planted to other crops constant. Since Uganda is a major exporter of robusta coffee (with about 10 percent of the world market), we also model a decline in the world price of coffee (of 11 percent).[22] Simulation 4 isolates the effects of a doubling of area planted to arabica coffee alone, with no change in world prices (given Uganda's very small share of world arabica coffee exports). Simulations 5 and 6 model 20 percent increases in total factor productivity of robusta and arabica coffee, respectively.

Although area cultivated doubles in simulation 3, coffee exports (in dollar terms) and production increase by only 66.9 and 84.9 percent, respectively, because the export increase leads to a real appreciation of the Ugandan shilling by 10.3 percent that exacerbates the effect of the 11 percent world price decline for coffee producers. In spite of the large gain in production, real incomes of farmers increase by only 1.2 to 2.9 percent, as tradable agricultural products suffer from the real exchange rate appreciation of lower prices, while production of non-tradable crops rise by only 0.5 to 0.6 percent. Urban non-poor income shows the smallest increase as total returns to skilled labor and capital fall along with the output of industrial sectors (Table 4.7).

[22] This decline in world prices is based on a price elasticity of world robusta coffee import demand of –1.0, following You and Bolwig (2002).

Table 4.7 Decomposition of Changes in Household Incomes

Simulation 3 – 100 Percent Increase in Coffee Land and 10 percent decrease in Price of Coffee Exports

	Urban Poor	Urban Non-Poor	Farmers Zone 1	Farmers Zone 2	Farmers Zone 3	Farmers Zone 4	Farmers Zone 5	Farmers Zone 6	Rural Non-Farm	All Households
	Percent change from base									
Unskilled Labor	4.3	0.8	3.9	4.0	3.9	3.9	4.6	4.7	3.9	3.1
Skilled Labor		-1.2								-0.3
Capital	0.7	1.6	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.6
Land 1	-0.1	0.0	-2.2						-0.5	-0.6
Land 2	-0.1	0.0		-1.4					-0.2	-0.2
Land 3	0.0	0.0			-1.4				-0.1	-0.1
Land 4	0.0	0.0				-1.2			0.0	0.0
Land 5	0.0	0.0					-1.2		0.0	0.0
Land 6	0.0	0.0						-0.3	0.0	0.0
Transfers	-0.6	-0.9	-0.7	-0.1	-0.8	0.0	-1.5	-1.3	-0.8	-0.7
Total Income	4.1	0.2	1.2	2.6	1.8	2.9	2.0	3.1	2.7	1.6
Consumption	3.2	-0.1	0.2	1.5	0.7	1.6	0.8	1.9	1.8	1.0

Source: Model Simulations

Note: Zone 1: Lake Victoria crescent; Zone 2: Medium potential, bimodal rainfall; Zone 3: Low potential, southwest Uganda; Zone 4: Southwestern highlands; Zone 5: Eastern highlands; Zone 6: Northern Uganda

The effects of a doubling of area planted to arabica coffee alone (simulation 4) are much smaller than the effects of a doubling in area planted to robusta coffee. In this simulation, no change in world prices is modeled because Uganda's share of world arabica coffee exports is negligible. Value added in total coffee production increases by only 7.1 percent (compared with 84.9 percent in simulation 3). Similarly, the appreciation of the real exchange is only 1.1 percent (less than $1/10^{th}$ of the magnitude in simulation 3). Farmers in zone 5 (Eastern Highlands) enjoy the biggest gains in real incomes and consumption (1.7 percent, Table 4.1) as this region accounts for 41 percent of national arabica coffee production, and returns to land in arabica coffee account for 4.5 percent of real incomes for zone 5 farmers in the 1999/2000 SAM.

Increases in total factor productivity in robusta (simulation 5) and arabica coffee (simulation 6) have similar effects on coffee production and exports as increases in area planted. A 20 percent increase in total factor productivity of robusta coffee (with no change in world prices) raises coffee production and exports by 19.6 and 19.7 percent, respectively, leading to a 3.0 percent real exchange rate appreciation. Returns to land rise in this scenario, accounting for 0.6 to 1.0 percent of the 1.1 to 1.6 percent increase in real incomes of farmers in robusta coffee regions (zones 1-4). In contrast, returns to land fall when area planted to coffee is increased and world coffee prices fall (simulation 3, Table 4.7). Likewise, a 20 percent increase in total factor productivity of arabica coffee results in a 1.6 percent increase in both total coffee value added and total coffee exports, increasing farmer incomes in arabica coffee production regions, especially the zone 5 (Eastern Highlands).

4.4. SIMULATIONS 7-9: PRODUCTIVITY INCREASES IN CROP AGRICULTURE

Agricultural research and extension offer the potential to increase total factor productivity in agriculture through improved use of new seed technologies and other improved agronomic practices. Simulations 7-9 model the effects of exogenous increases

in total factor productivity (i.e. increases in productivity apart from increases in land, labor or intermediate inputs) without any improvements in agricultural marketing institutions or infrastructure. In simulation 7, total factor productivity of crop agriculture is increased by 5 percent; simulations 8 and 9 model 20 percent increases in maize and matooke, respectively.

In simulation 7, (5 percent increase in total factor productivity of all crop agriculture), production of most commodities increases by less than 5 percent, as increased supply leads to declines in market prices (Tables 4.8 and 4.9). Market prices of maize, sorghum/millet, cassava, sweet potatoes and matooke and horticultural products all fall by about 3.2 to 3.8 percent, so that production increases are limited to 2.1 to 3.3 percent for these crops (Table 4.10). Coffee production increases by 5.2 percent, however, as coffee prices, closely linked to world prices, fall by only 0.1 percent. (Compared to the base simulation, coffee production thus becomes relatively more profitable relative to the other crops and draws more labor resources for production.)

Real consumption among farmers rises by 1.2 to 2.1 percent; consumption of urban groups rises even more (2.4 to 2.7 percent) as these households benefit not only from reduced real prices of agricultural products, but also higher returns to capital (Table 4.11). Returns to capital rise because increases in demand for non-agricultural commodities boost their prices by 1 to 3 percent. Thus, the gains in agricultural productivity have significant benefits for households throughout the economy.

Gains in total factor productivity of a single crop have much smaller impacts on incomes and consumption. Increasing total factor productivity of maize by 20 percent only results in an increase in maize production by about 1.3 percent, but other commodities are affected only slightly (simulation 8). Given the inelastic supply and demand for maize, consumers reap most of the benefits of the productivity gain as maize consumer prices decline by 4.0 percent (and producer prices fall by 4.7 percent). The largest gains in total consumption are by farm households in zone 3 (low potential,

Table 4.8 Selected Results for Model Simulations 7-10

	Base*	-7- 5% increase in agriculture factor productivity	-8- 20% increase in maize factor productivity	-9- 20% increase in matooke factor productivity	-10- 30% decrease in agriculture marketing margins
		Percent change from base			
Household consumption**					
UrbanPoor	361.0	2.4	0.2	1.6	0.0
Urban Non-Poor	933.7	2.7	0.3	2.4	-0.9
Farmers Zone 1	371.7	1.2	0.1	0.8	4.1
Farmers Zone 2	315.0	1.6	0.1	0.6	3.1
Farmers Zone 3	374.8	1.5	0.1	1.3	3.8
Farmers Zone 4	334.6	2.1	0.1	1.3	2.3
Farmers Zone 5	330.5	1.3	0.1	1.5	3.5
Farmers Zone 6	218.0	1.7	0.1	0.0	3.8
Rural Non-Farm	368.0	1.9	0.2	1.1	1.8
Total household consumption	400.6	1.9	0.2	1.2	2.1
Real Absorption***	10,611.7	1.4	0.1	0.9	1.6
Exports (dollar value)	1,064.2	2.7	0.2	1.3	1.9
Coffee processing	446.0	5.2	0.0	0.0	0.2
Agriculture	88.1	2.7	2.2	1.3	9.1
Imports (dollar value)	2,593.7	1.1	0.1	0.5	0.8
Value added	8,338.9	1.7	0.1	1.1	-0.1
Agriculture	3,818.1	2.8	0.2	1.6	1.9
Coffee	254.8	5.2	0.0	0.0	0.2
Maize	238.3	2.1	1.3	0.9	1.8
Exchange rate	100.0	0.8	0.1	1.3	0.6

Source: Model Simulations

* In the base column, aggregate real indicators are measured at base-year (1999) values.

** The figures for household consumption in the base column show per capita income in thousand Ugandan shillings.

***Among the components of absorption, only household consumption (75% of base-year absorption) changes. Government consumption and investment (10% and 15% of base-year absorption, respectively) are fixed in real terms as part of the macro closure rule.

Note: Zone 1: Lake Victoria crescent; Zone 2: Medium potential, bimodal rainfall; Zone 3: Low potential, southwest Uganda; Zone 4: Southwestern highlands; Zone 5: Eastern highlands; Zone 6: Northern Uganda.

Table 4.9 Value Added by Activity: Simulations 7-10

	BASE	-7- 5% increase in agriculture factor productivity	-8- 20% increase in maize factor productivity	-9- 20% increase in matooke factor productivity	-10- 30% decrease in agriculture marketing margins
		Percent change from base			
Coffee	254.83	5.2	0.0	0.0	0.2
Other Cash Crops	108.55	1.4	0.1	2.2	2.9
Maize	238.32	2.1	1.3	0.9	1.8
Sorghum/Millet	290.51	2.8	0.1	0.9	2.0
Cassava	222.47	2.7	0.1	0.7	2.1
Sweet Potatoes	212.68	2.8	0.1	1.0	1.7
Matooke	534.41	2.5	0.1	5.4	2.0
Horticulture	574.28	3.3	0.2	1.3	2.7
Other Crops	460.63	4.4	0.0	0.2	1.8
Livestock	612.21	1.8	0.2	1.5	1.3
Forestry	126.10	1.2	0.1	1.1	1.4
Fishing	173.95	1.8	0.3	2.2	4.1
Meat	34.71	1.0	0.1	1.2	1.5
Coffee Products	27.84	5.2	0.0	0.0	0.2
Milling	21.52	1.9	0.9	1.4	2.2
Beverages	394.17	1.4	0.1	2.3	3.0
Textiles	49.35	1.1	0.1	0.9	2.3
Manufacturing	268.40	-0.4	0.0	-0.1	0.3
Petroleum	36.57	0.1	0.0	0.2	0.9
Utilities	108.83	0.2	0.0	0.2	0.2
Construction	667.47	0.2	0.0	0.1	0.3
Trade	1,021.04	1.7	0.1	1.1	-10.4
Transport	412.37	0.7	0.1	0.6	-0.1
Private Services	1,162.32	0.4	0.1	0.4	0.7
Public Services	316.18	0.0	0.0	0.0	0.0
Total	8,329.73	1.7	0.1	1.1	-0.1

Source: Model Simulations

Table 4.10 Consumer Commodity Prices: Simulations 7-10

	BASE	-7- 5% increase in agriculture factor productivity	-8- 20% increase in maize factor productivity	-9- 20% increase in matooke factor productivity	-10- 30% decrease in agriculture marketing margins
		Percent change from base			
Coffee	1.01	-0.1	0.1	1.2	1.9
Other Cash Crops	1.23	-2.4	-0.1	-0.3	-0.7
Maize	1.23	-3.3	-4.0	-0.2	-1.7
Sorghum/Millet	1.20	-3.2	0.0	-0.2	-1.1
Cassava	1.21	-3.2	0.0	-0.1	-1.2
Sweet Potatoes	1.15	-3.6	0.0	-0.2	0.4
Matooke	1.18	-3.5	0.0	-14.1	-0.3
Horticulture	1.20	-3.4	0.0	-0.2	-1.0
Other Crops	1.16	-3.6	0.2	1.8	0.5
Livestock	1.20	-0.3	-0.1	-1.0	2.4
Forestry	1.19	-0.1	-0.1	-0.7	0.9
Fishing	1.19	0.3	-0.1	-0.3	-0.9
Meat	1.18	1.2	0.1	0.8	-0.1
Coffee Products	1.00	-0.2	0.1	1.4	1.8
Milling	1.23	0.3	-1.1	1.1	-1.2
Beverages	1.34	0.7	0.1	-1.5	-0.5
Textiles	1.18	1.2	0.1	1.3	-0.5
Manufacturing	1.16	1.1	0.1	1.4	-0.2
Fertilizers	1.00	1.2	0.1	1.4	-0.8
Petroleum	1.27	1.2	0.1	1.4	-0.5
Utilities	1.04	2.7	0.3	2.4	2.6
Construction	1.01	1.6	0.1	1.2	0.0
Trade	1.02	2.9	0.2	1.8	-6.8
Transport	1.02	1.7	0.2	1.4	-0.1
Private Services	1.01	1.8	0.1	1.4	0.7
Public Services	1.00	1.2	-0.2	1.3	0.8

Source: Model Simulations

Table 4.11 Decomposition of Changes in Household Incomes

	Simulation 7 – 5 Percent Increase in Total Factor Productivity in Agriculture									
	Urban Poor	**Urban Non-Poor**	**Farmers Zone 1**	**Farmers Zone 2**	**Farmers Zone 3**	**Farmers Zone 4**	**Farmers Zone 5**	**Farmers Zone 6**	**Rural Non-Farm**	**All Households**
	Percent change from base									
Unskilled Labor	1.2	0.2	1.1	1.1	1.1	1.1	1.2	1.3	1.1	0.8
Skilled Labor		0.3								0.1
Capital	0.9	2.0	0.1	0.1	0.1	0.1	0.2	0.2	0.6	0.7
Land 1	0.0	0.0	-0.5						-0.1	-0.1
Land 2	0.0	0.0		-0.6					-0.1	-0.1
Land 3	0.0	0.0			-0.7				-0.1	-0.1
Land 4	0.0	0.0				-0.8			0.0	0.0
Land 5	0.0	0.0					-0.5		0.0	0.0
Land 6	0.0	0.0						-0.4	0.0	0.0
Transfers	0.0	0.1	0.0	0.2	0.0	0.3	-0.2	-0.3	0.0	0.1
Total Income	2.0	2.6	0.7	0.8	0.5	0.7	0.7	0.7	1.4	1.4
Consumption	2.4	2.7	1.2	1.6	1.5	2.1	1.3	1.7	1.9	1.9

Source: Model Simulations

Note: Zone 1: Lake Victoria crescent; Zone 2: Medium potential, bimodal rainfall;
Zone 3: Low potential, southwest Uganda; Zone 4: Southwestern highlands;
Zone 5: Eastern highlands; Zone 6: Northern Uganda

southwest Uganda) and zone 4 (southwestern highlands), (0.13 percent in each zone) and by the urban poor (0.24 percent) and urban non-poor (0.29 percent).

A 20 percent increase in total factor productivity of matooke production, likewise, leads to a reduction in market prices (simulation 9). Value added in matooke production increases by only 5.4 percent as consumer prices fall by 14.1 percent in real terms. Returns to land fall in each region, preventing a significant increase in real incomes. However, the fall in prices of matooke enables increased consumption of matooke and other products. The real value of total consumption consumption rises by 0.6 to 1.5 percent for all rural households except farmers in zone 6 (Northern Uganda) who consume little matooke. Total consumption of the urban poor and urban non-poor increase by 1.6 and 2.4 percent, respectively.

4.5. SIMULATION 10: 30 PERCENT REDUCTION IN ALL AGRICULTURAL MARKETING MARGINS

As shown in simulations 5-9, agricultural productivity gains in the absence of improvements in marketing result in only small gains for producers since the resulting fall in market prices limits their income gains. One option to improve rural incomes and consumption is to reduce marketing costs for agricultural products, thereby raising producer prices (in real terms) and expanding markets.

Simulation 10 models a 30 percent reduction in all agricultural marketing margins (for both exports and domestic sales), implicitly brought about through investments in marketing infrastructure (roads, communications networks, storage facilities, etc.) or marketing institutions (e.g. trader associations and market information systems). The producer prices and consumer prices of all agricultural commodities rise in real terms. Consumer prices of agricultural commodities rise (in real terms) because higher agricultural incomes spur demand for these commodities, and because labor and capital

released from the commerce sector are employed in other non-agricultural activities, raising their production and lowering their relative price.

Production rises in all sectors except commerce (which falls by 10.4 percent), and transport. Production of major food crops (maize, sorghum/millet, cassava, sweet potatoes, matooke) rises between 1.65 and 2.13 percent. Value added in the fishing sub-sector, increases by 4.08 as its large marketing margins are reduced.

In this simulation, rural households gain while urban households lose. This is mainly because overall returns to land (including agricultural capital) contribute to income gains of 3.5 to 4.8 percent for farmers in zones 1 through 4, and income gains of 4.3 to 4.5 percent for farmers in zones 5 and 6 (Table 4.12). Returns to capital and labor actually fall slightly in this scenario because of the large decline in value added in the commerce sector. Nonetheless, real consumption rises for all rural households, with the largest gains for farm households in zones 1, 3, 5, and 6, (3.5 to 4.1 percent). For the urban poor and non-poor, the consumption declines are by 0.1 and 0.9 percent, respectively. Given lower initial per-capital incomes and consumption in rural areas, over-all inequality declines in this scenario.

Table 4.12 Decomposition of Changes in Household Incomes

	Simulation 10 – 30 Percent Reduction in Agricultural Marketing Margins									
	Urban Poor	**Urban Non-Poor**	**Farmers Zone 1**	**Farmers Zone 2**	**Farmers Zone 3**	**Farmers Zone 4**	**Farmers Zone 5**	**Farmers Zone 6**	**Rural Non-Farm**	**All Households**
	Percent change from base									
Unskilled Labor	-0.1	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
Skilled Labor		0.4								0.1
Capital	-0.7	-1.6	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.5	-0.6
Land 1	0.3	0.1	4.8						1.1	1.3
Land 2	0.2	0.1		4.8					0.8	0.9
Land 3	0.1	0.0			4.9				0.4	0.4
Land 4	0.0	0.0				4.9			0.1	0.2
Land 5	0.0	0.0					3.3		0.1	0.1
Land 6	0.0	0.0						3.4	0.2	0.2
Transfers	0.1	0.0	0.1	-0.7	0.2	-0.9	1.1	1.3	0.2	0.0
Total Income	0.0	-1.0	4.8	4.0	4.9	3.8	4.3	4.5	2.2	2.5
Consumption	0.0	-0.9	4.1	3.1	3.8	2.3	3.5	3.8	1.8	2.1

Source: Model Simulations

Note: Zone 1: Lake Victoria crescent; Zone 2: Medium potential, bimodal rainfall;
Zone 3: Low potential, southwest Uganda; Zone 4: Southwestern highlands;
Zone 5: Eastern highlands; Zone 6: Northern Uganda

5. CONCLUDING OBSERVATIONS

The model simulations presented in this report highlight important linkages between the macro-economy, sectoral output, and household incomes and consumption in Uganda. Appreciation of the real exchange rate, brought about by increases in capital inflows, can have significant negative effects on tradable agriculture, including coffee and maize, and lead to increased production of non-traded food crops. The sharp decline in the world price of coffee has had wide-ranging effects, leading to a real exchange rate depreciation, discouraging production of non-tradable agriculture, but spurring production of industrial tradables (textiles and manufactured goods). Even with world coffee prices at their 1999 levels, however, a doubling of production would have relatively limited income effects, increasing average farm household incomes by less than 2.0 percent.

The model simulations also show the potential for increases in agricultural productivity and reductions in marketing costs to raise rural incomes in Uganda. A five percent increase in agricultural productivity could raise consumption by 1.2 to 2.1 percent among rural households. Price effects are important, as food prices fall by 3.2 to 3.6 percent, benefiting urban households whose total consumption increases by 2.4 to 2.7 percent. The simulations of maize productivity increases further highlight the role of price effects and the importance of market outlets for crops. In this simulation, a 20 percent increase in productivity leads to only a 1.3 increase in production, as producer prices fall by 4.7 percent fall. Total consumption by farmer household groups rises by 0.1 percent or less. Major reductions in marketing costs, however, can significantly benefit rural producers and consumers. Reducing agricultural marketing margins by 30 percent leads to increases of 2.3 to 4.1 percent in real consumption of farmer households, as producer prices of agricultural commodities rise in real terms.

The results presented should be treated as only indicative of the effects of these policy and external shocks. Further work is needed involving sensitivity analysis using alternative parameters and different closures in the labor markets. Nonetheless, the broad

observations outlined above – the importance of linkages between the macro-economy, sectoral, and household outcomes, the positive benefits of technical change in agriculture and the serious problems of maintaining producer incentives, and the widespread benefits of reducing marketing costs, remain. Agricultural growth has potential to significantly raise rural incomes in Uganda provided that markets perform well and producer incentives are maintained.

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APPENDIX 1: SENSITIVITY ANALYSIS

Table A.1 presents sensitivity analysis of the model simulations using alternative assumptions regarding labor market closure and price responsiveness of supply of agricultural sectors (including crops, livestock and fisheries).

The model simulations presented in the main text assume a "neo-classical" labor market closure for unskilled labor: unskilled labor is free to move across all activities while its economywide wage rate adjusts to bring about equilibrium between supply and demand. Here, we model a segmented labor market. For unskilled labor in agricultural sectors, we assume full employment and a market-clearing wage. For unskilled labor in non-agricultural sectors, however, we impose a fixed wage with a flexible supply, in effect assuming that the market clears via changes in unemployment or underemployment.

We also make agricultural sectors more supply responsive by raising the elasticity of substitution between factors of production sufficiently to generate implicit partial equilibrium own-price elasticities of supply equal to 0.5 for all agricultural sectors, instead of 0.1 to 0.3 as in the main simulations in the paper.

In simulation 1 (20 percent increase in foreign savings),[23] with a more elastic supply response in agriculture and a segmented labor market, a slightly smaller real exchange rate appreciation (by 2.8 percent instead of 3.0 percent) is needed to induce the decline in exports and increase in imports that bring about a new equilibrium in the current account balance. In particular, the higher degree of price responsiveness permits a stronger decline in coffee production and exports.

For simulation 2 (60 percent decrease in coffee export prices), changing the supply responsiveness of agriculture or closure in the labor market makes little difference

[23] In the base simulation, a 20 percent increase in foreign savings amounts to a dollar value of 54 million, about 7.4 percent of base 1999 exports market prices.

to coffee prices or output. In the non-agricultural part of the economy, more unskilled labor is employed, with a positive impact on the urban poor and on their demand for agricultural outputs. Overall household consumption does not fall as much (-3.2 instead of -3.5 percent).

In simulation 3 (100 percent increase in coffee land and 10 percent decrease in coffee export prices), coffee value added rises less (65.7 percent as compared to 84.9 percent) since, under our alternative assumptions, lower coffee prices generate a stronger reallocation of resources to other agricultural activities. With a smaller increase in coffee export earnings, the real exchange rate appreciation is also smaller (7.2 versus 10.3 percent). Farmer incomes and consumption rise substantially more in the supply-responsive model (by 0.5 to 2.6 percent for consumption), since a more flexible resource allocation permits higher agricultural factor earnings. A stronger increase in farmer incomes boosts demand for the outputs of non-agricultural activities and unskilled employment within these activities.

In simulations 7 and 8, increased productivity of agricultural sectors results in larger gains in agricultural value added and farmer incomes with segmented unskilled labor markets, because in this case, unskilled agricultural labor is constrained to remain in the agricultural sectors rather than being released to non-agricultural sectors. The productivity gain in agriculture has a positive impact on profitability in non-agricultural sectors, boosting production and unskilled labor employment in the non-agricultural economy. This effect is particularly strong for simulation 4.

In simulation 10, (30 percent decrease in marketing margins), if labor supply in agriculture cannot rise as in the main model simulation), there is essentially no increase in agricultural value added (compared to a 1.9 percent increase with the non-segmented labor closure). With less labor employed in agriculture, however, the agricultural wage rate is higher, and thus returns to land increase by less than in the main simulation. The net effect is lower real incomes for rural households and a decline in real household consumption in rural areas (by 1.4 to 2.0 percent). Lower consumption by rural

households further weakens demand for non-agricultural commodities, reducing returns to capital, and real incomes of the urban non-poor.

Thus, changes in labor market closure and model parameters generally result in only small changes in the magnitudes of simulated relative prices, quantities and incomes. Choices of labor market closure appear to be relatively more important to the results, suggesting that additional analysis of employment and wage rates is warranted.

Table A.1. Selected Results for Model Simulation

		-1- 20% increase in FSAV			-2- 60% decrease in coffee export prices			-3- 100% increase in coffee land and 10% decrease in coffee export prices		
	Base*	Base Model	Supply Responsive Model	Change	Base Model	Supply Responsive Model	Change	Base Model	Supply Responsive Model	Change
		Percent change from base								
Household consumption**										
UrbanPoor	361.0	1.0	1.0	0.0	-2.1	-1.9	0.3	3.2	2.1	-1.1
Urban Non-Poor	933.7	0.4	0.3	-0.1	2.2	3.5	1.2	-0.1	0.1	0.2
Farmers Zone 1	371.7	1.2	1.3	0.1	-7.9	-8.2	-0.3	0.2	2.8	2.6
Farmers Zone 2	315.0	1.4	1.4	0.0	-5.0	-5.0	0.0	1.5	2.5	1.0
Farmers Zone 3	374.8	1.4	1.3	0.0	-5.7	-5.6	0.1	0.7	2.4	1.7
Farmers Zone 4	334.6	1.3	1.2	-0.1	-4.4	-3.9	0.5	1.6	2.1	0.5
Farmers Zone 5	330.5	1.3	1.3	0.0	-6.1	-6.3	-0.2	0.8	2.5	1.7
Farmers Zone 6	218.0	1.6	1.6	-0.1	-2.9	-2.8	0.1	1.9	2.3	0.5
Rural Non-Farm	368.0	1.2	1.1	0.0	-3.7	-3.4	0.2	1.8	2.2	0.4
Total household consumption	400.6	1.1	1.1	0.0	-3.5	-3.2	0.3	1.0	1.9	0.9
Real Absorption***	10,611.7	0.8	0.8	0.0	-2.6	-2.4	0.2	0.7	1.4	0.7
Exports (dollar value)	1,064.2	-3.7	-4.0	-0.3	7.3	7.7	0.4	23.4	19.9	-3.5
Coffee processing	446.0	-0.5	-2.3	-1.8	-68.2	-68.3	0.0	66.9	49.6	-17.4
Agriculture	88.1	-3.7	-4.0	-0.3	-12.7	-12.3	0.4	15.6	12.9	-2.7
Imports (dollar value)	2,593.7	1.6	1.5	-0.1	-5.2	-5.1	0.2	6.4	5.3	-1.1
Value added	8,338.9	0.0	0.0	0.0	-0.3	0.0	0.3	1.9	2.5	0.7
Agriculture	3,818.1	0.2	0.0	-0.2	-1.5	-0.3	1.2	4.5	4.2	-0.3
Coffee	254.8	-0.5	-2.2	-1.8	-20.0	-20.0	0.0	84.9	65.7	-19.2
Maize	238.3	-0.2	-0.2	0.0	2.0	3.1	1.2	-2.4	-0.9	1.6
Exchange rate	100.0	-3.0	-2.8	0.2	11.3	11.6	0.3	-10.3	-7.2	3.2

Source: Model Simulations

* In the base column, aggregate real indicators are measured at base-year (1999) values.

** The figures for household consumption in the base column show per capita income in thousand Ugandan shillings.

***Among the components of absorption, only household consumption (75% of base-year absorption) changes. Government consumption and investment (10% and 15% of base-year absorption, respectively) are fixed in real terms as part of the macro closure rule.

Table A.1. Selected Results for Model Simulation

		-7- 5% increase in agriculture factor productivity			-8- 20% increase in maize factor productivity			-10- 30% decrease in agriculture marketing margins		
	Base*	Base Model	Supply Responsive Model	Change	Base Model	Supply Responsive Model	Change	Base Model	Supply Responsive Model	Change
		Percent change from base								
Household consumption**										
UrbanPoor	361.0	2.4	2.7	0.4	0.2	0.3	0.0	0.0	-0.1	-0.1
Urban Non-Poor	933.7	2.7	3.3	0.6	0.3	0.4	0.1	-0.9	-2.5	-1.5
Farmers Zone 1	371.7	1.2	2.4	1.2	0.1	0.2	0.1	4.1	2.4	-1.7
Farmers Zone 2	315.0	1.6	2.6	1.0	0.1	0.2	0.1	3.1	1.8	-1.4
Farmers Zone 3	374.8	1.5	2.7	1.2	0.1	0.2	0.1	3.8	1.8	-2.0
Farmers Zone 4	334.6	2.1	3.0	0.9	0.1	0.2	0.1	2.3	0.7	-1.6
Farmers Zone 5	330.5	1.3	2.4	1.1	0.1	0.2	0.1	3.5	2.1	-1.5
Farmers Zone 6	218.0	1.7	2.8	1.1	0.1	0.2	0.1	3.8	2.2	-1.6
Rural Non-Farm	368.0	1.9	2.7	0.8	0.2	0.2	0.1	1.8	0.6	-1.2
Total household consumption	400.6	1.9	2.8	0.9	0.2	0.2	0.1	2.1	0.7	-1.5
Real Absorption***	10,611.7	1.4	2.1	0.7	0.1	0.2	0.1	1.6	0.5	-1.1
Exports (dollar value)	1,064.2	2.7	4.2	1.5	0.2	0.3	0.1	1.9	-0.2	-2.1
Coffee processing	446.0	5.2	7.0	1.8	0.0	0.1	0.1	0.2	-2.2	-2.5
Agriculture	88.1	2.7	4.2	1.5	2.2	2.5	0.3	9.1	-0.3	-9.5
Imports (dollar value)	2,593.7	1.1	1.7	0.6	0.1	0.1	0.1	0.8	-0.1	-0.8
Value added	8,338.9	1.7	2.5	0.8	0.1	0.2	0.1	-0.1	-1.4	-1.3
Agriculture	3,818.1	2.8	3.8	0.9	0.2	0.3	0.1	1.9	0.0	-1.9
Coffee	254.8	5.2	7.0	1.8	0.0	0.1	0.1	0.2	-2.2	-2.5
Maize	238.3	2.1	2.9	0.8	1.3	1.4	0.1	1.8	0.1	-1.7
Exchange rate	100.0	0.8	0.9	0.2	0.1	0.1	0.0	0.6	-0.1	-0.7

Source: Model Simulations

* In the base column, aggregate real indicators are measured at base-year (1999) values.

** The figures for household consumption in the base column show per capita income in thousand Ugandan shillings.

***Among the components of absorption, only household consumption (75% of base-year absorption) changes. Government consumption and investment (10% and 15% of base-year absorption, respectively) are fixed in real terms as part of the macro closure rule.