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Increasing World Food Prices: Blessing or Curse?

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ABSTRACT

This study evaluates the potential impact of the recent rise in world food prices on the Ugandan economy and possible policy options to respond to it. Uganda is largely a net exporter of some cereals whose prices increased considerably especially maize. Using a recursive dynamic CGE model, we attempt to answer questions on who are the beneficiaries and losers after the surge in food prices. The rural producers of maize tend to benefit considerably with their poverty levels reducing. On the other hand, the urban purchasers of cereals are affected owing to the higher prices of food. This therefore suggests that the Ugandan government should take advantage of the increasing food prices by stimulating and undertaking policies that would enhance productivity especially for crops where the country has a comparative advantage. To circumvent the negative effects on the urban population, the government could design targeted programs for the urban poor.

A. INTRODUCTION

Increasing world food prices has been a major concern for many countries. This has raised concerns on the food security of countries and the nutrition situation of people who are net buyers of food. In addition, increasing food prices have had other macroeconomic consequences including rising inflation which was partly exacerbated by the rising world oil prices. The prices of maize and wheat have more than doubled although of recent they have subsided. Likewise, the price of rice almost doubled in the first four months of 2008. For a net producer of these products this could be a welcome development. Uganda is a net exporter of maize while at the same time it imports the bulk of its wheat. For rice, the country has continued to design programs to increase rice production, and this has resulted into higher production and reduction in the import bill of rice. The changes in world food prices also could have other indirect effects on other sectors particularly agro-processing. The effects also depends on whether the commodity in question is being produced abundantly to the extent that part of it is exported, or the country has to rely on importing to satisfy its local demand. At a household level, it also depends on whether the household in question is a net buyer of the commodity or net producer.

To understand all these intricate details, we apply a recursive dynamic computable general equilibrium (DCGE) model based on the newly constructed social accounting matrix (SAM) for Uganda. The model is used to analyze the impacts of rising food prices and the possible impact of the consumption and production behavior of households. The model attempts to differentiate households depending on whether they are involved in agricultural activities or not. Also households are classified according to whether they are rural or urban.

Based on this disaggregation of the model, we find that the net producers of maize tend to be beneficiaries of the recent price surge. Being that rice and wheat are mainly imported, the welfare of households would be negatively

affected as result of a price increase. Consumption of households that are not actively involved in agricultural activities would be reduced owing to the increase in food prices. These are mainly urban households that would need to be protected due to the higher inflation of food commodities. While the raw materials for agro-processing industries also increase, the demand for the value added products increases which benefits the sectors involved.

There is a caveat to these results. It's been found that in Uganda about 61 percent of rural households are significant net buyers of food. A more detailed analysis would require disaggregating households within the SAM into those that are net buyers and those that are net sellers of food. For now the results are restricted by the assumption that households in urban areas not involved in farming activities are net buyers, while farmers in rural areas involved in farming activities are net sellers of food items.

From a policy perspective, Uganda is blessed by having a comparative advantage in agriculture. Therefore, with increasing food prices, the government should invest more in the sector to improve the productivity of the sector. This can be done by providing for example extension services to workers, fertilizers and modified seeds that can improve the yields of these crops. In addition, the government should improve on the available infrastructure so that farmers can be able to benefit from the higher prices by getting their harvest to the right markets. On the other hand, for households that are negatively affected especially the urban poor, the government can design targeted programs so that the increase in food prices does not result into worsening of poverty and nutrition levels for some individuals.

The rest of the paper is organized as follows: in Section B we provide the background and recent developments of food prices. Section C provides some literature review. Section D gives the framework through which food prices affect producers, consumers and government. Section E presents the results from the

dynamic CGE model. Lastly, we provide the conclusion and policy implications in section F.

B. Background

Since the early 2000s, global food prices have been rising, especially so in the last 12-24 months with the FAO global food price index rising by 57% in this period (Wiggins and Levy, 2008). Whereas the effect of poor harvests have been responsible, the persistent and unusual price hikes signify serious structural changes in supply and demand that may take some time to stabilize. The most mentioned supply side cause has been the rising cost of oil that not only raises the cost of nitrogen fertilizers used in agricultural production but also increases the cost of machinery and transport of food to market. Demand side causes include the growing incomes of consumers in the emerging economies especially of meat that is mainly produced by feeding grain to livestock. The other is the global concern for the high oil prices and oil security that has made the biofuels industry an attractive alternative to fossil oil and has diverted grains, sugar and palm oil into production of ethanol and biodiesel.

In Uganda's case, although the causes of the high food prices do not differ significantly from those of the other countries, the sluggish production of the main food crops may as well explain the high food prices. Uganda has one of the most fertile soils in the continent but agricultural production has not been increasing at the rate of the population increase (one of the highest in the world at 3.2%), a situation that has distorted the food balance. This has been mainly the result of an incoherent agricultural extension policy and small budgetary allocation to agriculture that has resulted into low technology adoption.

The result has been that except for root crops (which have recently also been trending downwards), there has been a low and sometimes a decline in the production of the main food crops in the country (Figure 1a and 1b).

Fig.1:

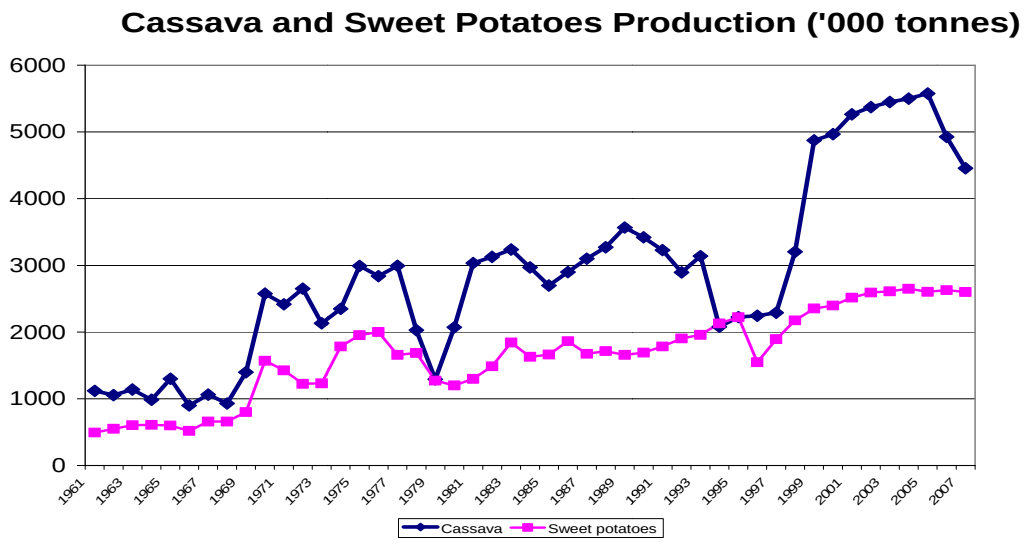
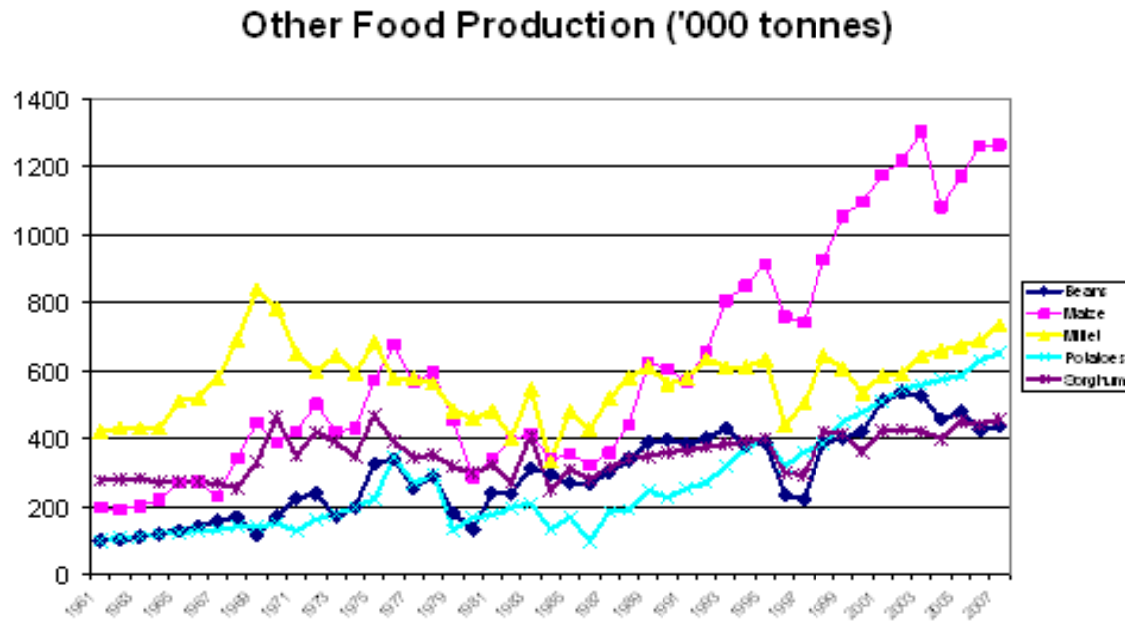


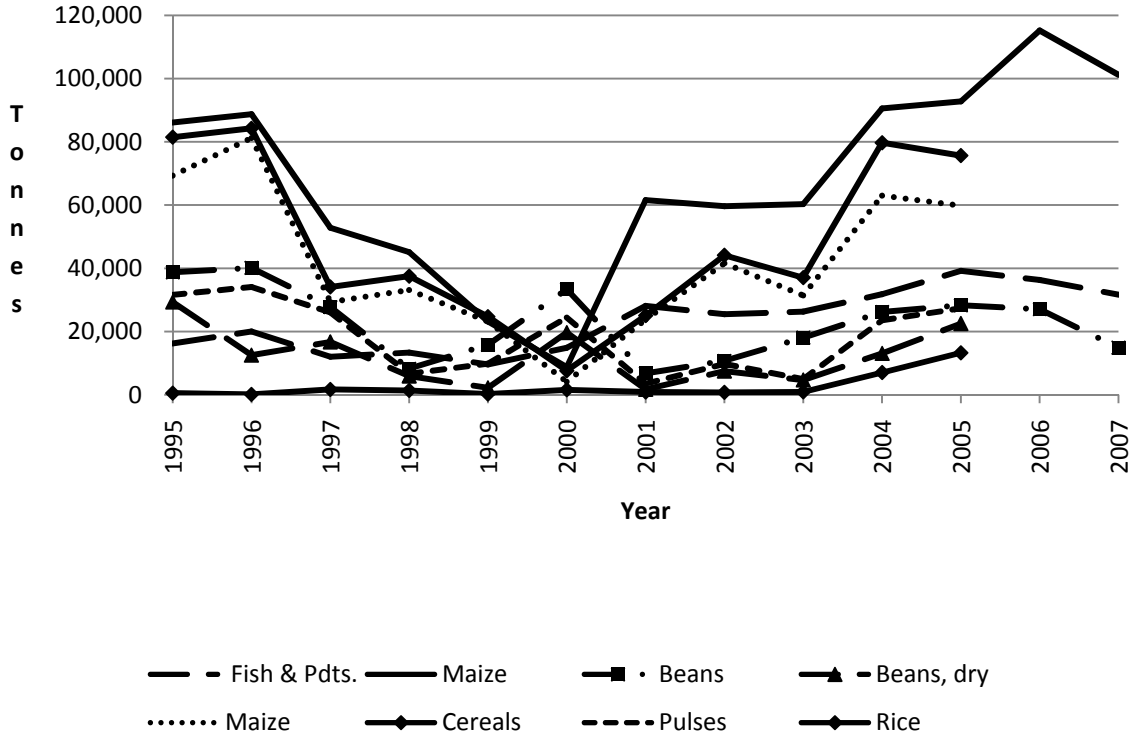
Fig. 1b:



Source: FOASTAT

This is in spite of the fact that in addition to increased domestic demand (arising from increase in urbanization and in the population), food exports especially to the region has recently been trending upwards after sharp drops in the late 1990's (Figure 2).

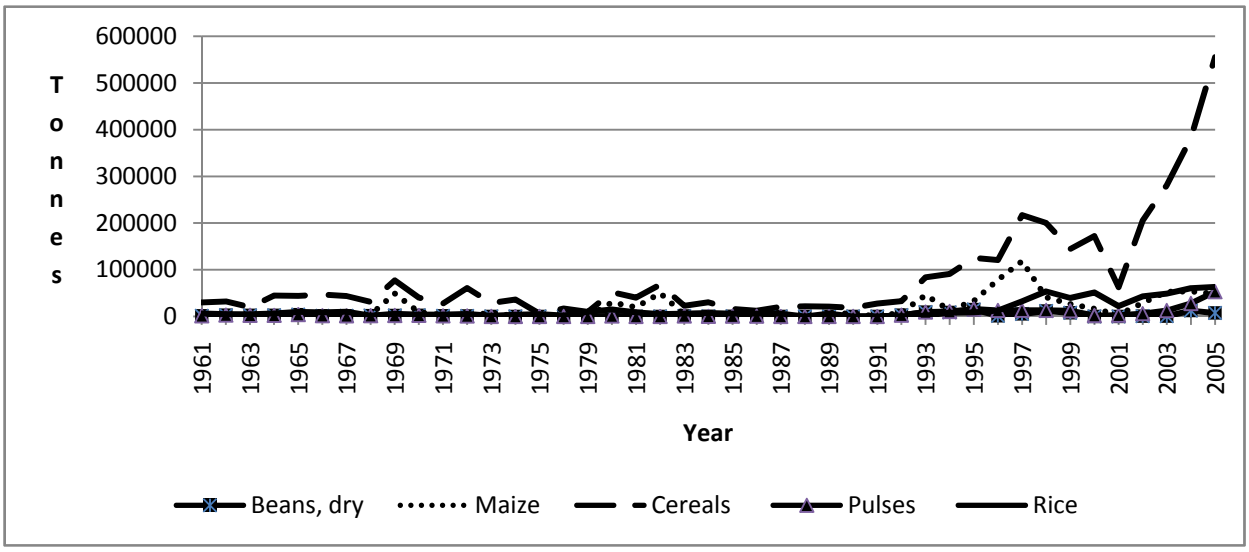
Fig. 2: Uganda's Annual Food Crop Exports for Selected groups of Crops, 1990-2005, and Individual Crops, 1995-2007



Source: FOASTAT

In addition, the increased in food demand and increased exports have not been covered by food imports, which though have been trending upwards recently especially cereals, have not positively impacted the food balance (Figure 3).

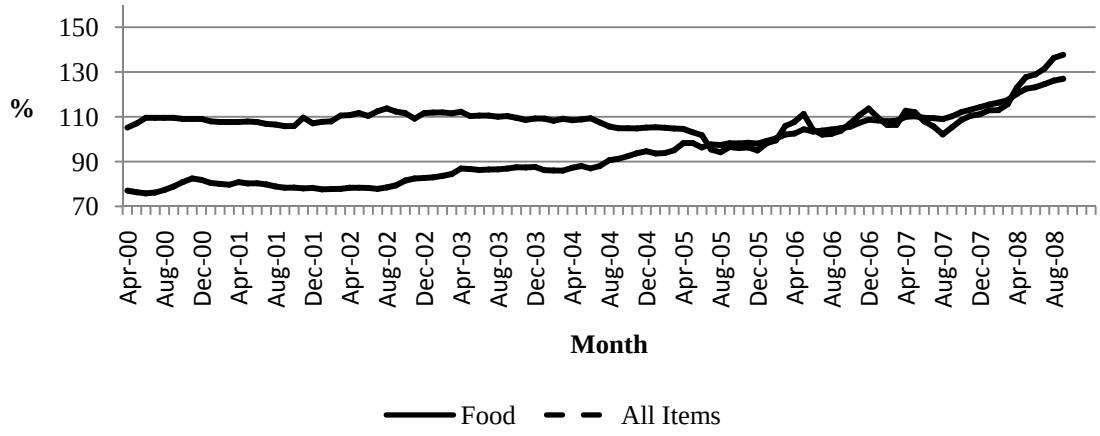
Fig. 3: Uganda Food Imports for Selected Groups and Individual Food Crops, 1994-2006



Source: FAOSTAT

This negative change in food balance together with other supply side causes like the cost of transport has led to high food prices. For example, the Uganda Food Index has increased sharply that together with high fuel prices has led to increase in the overall CPI and inflation rate (Figures 4).

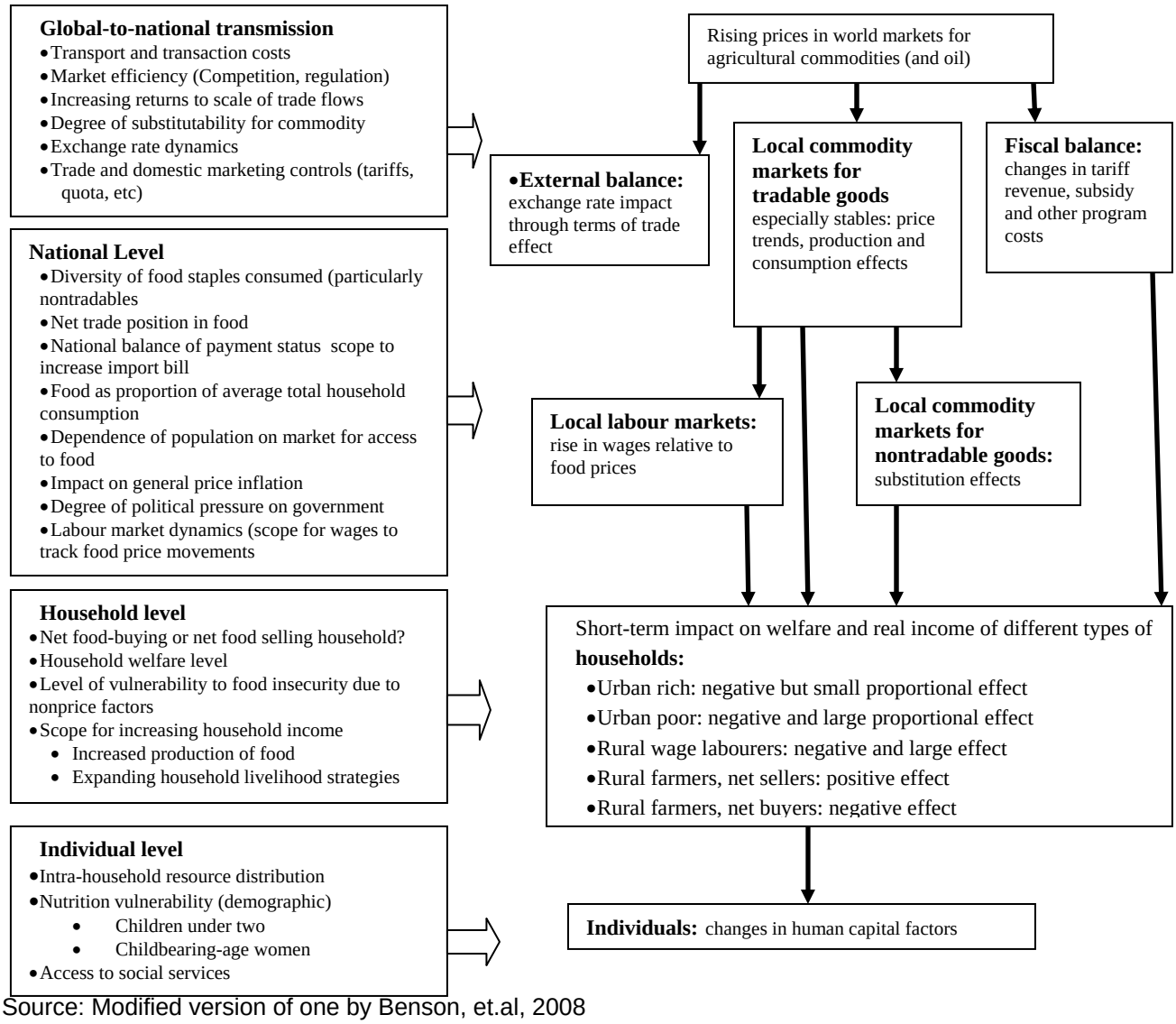
Fig. 4: Uganda Monthly CPI Changes for Food and for the Composite Item, 2000-2008



Source: UBOS

This increase in inflation has had a negative impact on the economy and on the welfare of Ugandans, but the distributional effects in the country have not been fully analyzed. It is not clear who are the main losers and beneficiaries of these price increases. Whereas it seems clear that high food prices should impact negatively the households, the agrarian nature of the Ugandan economy makes it difficult to ascertain with confidence these impacts without deeper analysis. For agricultural countries like Uganda, it is possible that high food prices may instead of leading to loss of welfare actually do the opposite to some categories of households especially those involved in food production. Therefore the framework under which high food prices may affect the economy and the welfare of households is likely to be different from that of those countries that are net food importers. But the framework for Uganda may not differ much from the general one presented by Benson, et.al, 2008 and may look like the one presented in Figure 5.

Fig.5: Framework of the Expected Impact of High Food Prices on the Ugandan Economy



Source: Modified version of one by Benson, et.al, 2008

C. Literature Review

There has been considerable work done on the phenomenon of high food prices and its impact on peoples' welfare, especially of the poor. But there is paucity of general equilibrium analyses on African countries and apparently none on Uganda. However, because of the possible impact of high food prices on the macroeconomic stability and financial health of low income countries, the World Bank and IMF have taken keen interest in this subject and have consequently been undertaking a lot of research on the subject. Most of these studies use the hypothesis that, in many poor countries, the recent increases in prices of staple foods raise the real incomes of those selling food, many of whom are relatively poor, while hurting net food consumers, many of whom are also relatively poor, with the expectations that the average impact on poverty would depend upon the balance between these two effects. The World Bank's Ivanic and Martin, 2008 in the study about the implications of higher global food prices for poverty in nine low-income countries, using a simple approach of calculating the first-order welfare changes of households covered in ten detailed surveys, found that the short-run impacts of higher staple food prices on poverty differ considerably by commodity and by country, but, that poverty increases are much more frequent, and larger, than poverty reductions. The study found out that whereas many rural households, who are generally food producers, gain from higher food prices, the overall impact on poverty remains negative, the most hurt being the urban poor. The loss as a simple average of the estimated effects on national poverty rates (US$1/day) in this nine-country sample, they found, was an increase of 4.5 percentage points which when applied to all low-income countries, translates into an increase in the poverty headcount of 105 million people (out of the low-income population of 2.3 billion) representing a loss of almost seven years of poverty reduction.

Nouve and Wodon, 2008 using a Dynamic CGE Model to analyze the impact of rising rice prices in Mali found a similar impact, with the average price of rice increase of about 20 percent to 25 percent in the year ending 2007, without

policy responses expected to have increased the share of the population in poverty by 0.7 percentage point with the increase expected to have been even larger if the FCFA had not been appreciating versus the US dollar.

Wodon, et.al, 2008a, using a set of recent and comprehensive household surveys to assess the potential impact of higher food prices on the poor in a dozen Western and Central African countries found out that the rising food prices for rice, wheat, maize, and other cereals as well as for milk, sugar and vegetable oils could lead to a substantial increase in poverty in many of the countries. The contributing factor they cite for this is the fact that a substantial share of food consumption in these countries is imported, so that the negative impact for consumers is larger than the positive impact for net sellers of locally produced foods. They however, could not establish the magnitude of the impact but surmised that a large share of the increase in poverty will consist of deeper levels of poverty among households who are already poor, even if there will also be a larger number of poor households in the various countries. They found that with a 50 percent increase in prices for selected food items, the average increase in the share of the population in poverty would be between 2.5 and 4.4 percentage points, the impact being between 3.7 and 5.2 percentage points in urban areas, and between 2.2 and 4.1 points in rural areas. Such numbers they contend, applied to a typical sub-Saharan country, the food price crisis could lead to close to 30 million additional persons falling into poverty in the region.

Coulombe and Wodon, 2008, using Guinea census and survey data to estimate the geographic impact of higher food prices in Guinea also show that the impact of the price rises may not necessarily hit all the regions equally. They found that in the case of a rice price increase if the potential positive impact of higher food prices on rice producers is taken into account, the poorest areas of the country will not be the hardest hit, in which case poverty may decline in some of these areas even if for the country as a whole poverty will increase significantly due to the large share of rice in the household consumption budget.

It is also possible that the impact of the food price rise may vary with the type of commodity in question depending on whether the food item is produced locally or is imported. For example, Wodon, et.al, 2008b using simple statistics and non-parametric methods to assess the potential impact on poverty of rising cereals prices in Ghana, found that the impact of a change in the price of rice is unambiguously negative because a large share of the rice consumed is imported, so that the negative impact for consumers is much larger than the positive impact for producers, while for maize the impact is ambiguous since much of the consumption is locally produced. The impact of the maize price increase may be poverty reducing, as long as the higher price paid by consumers translates into a higher price received by producers. But the paper finds that, overall an increase in the price of the various cereals of 25 percent would lead to an increase in poverty though very small, at below one percentage point.

The negative impact of the high food prices highlighted in a number of countries has presented enormous challenges to policy makers that calls for swift but well targeted responses to address potential disastrous welfare deterioration of especially the poor. A number of policy prescriptions have been proposed by development organizations including the World Bank, IMF, International Food Policy Research Institute (IFPRI), Overseas Development Institute (ODI) and independent researchers to help limit the impact of the high food prices. ODI's Wiggins and Levy, 2008 proposed use of transfers to the poor in the form of cash payments or vouchers, though they recommend direct food transfers in times of rapid price increase. Other policy options they recommended were reduction of tariffs on imported grains, and limiting or taxing exports of grains, and for IMF to release resources under the Compensatory Financing Facility to help to offset the higher costs of subsidies or transfers in the 30 or so low income countries that import both food and oil. The Economics and Research Department of the Asian Development Bank also proposes similar policy options but depending on whether countries are net importers or net exporters with the former involving

reducing import restrictions and tariffs, while the latter involves adopting increased taxes and restrictions on exports (ADB, 2008). The Bank, however, notes that some responses such as imposing price controls, trade restrictions, and increasing general subsidies are inconsistent with the objectives of limiting food price rises and tend to cause more harm than good a contradiction arising from the fact that countries use policy responses to reduce price volatility rather than increase it, yet take measures that encourage consumption, discourage production, and stifle the deepening of international markets and the smooth development of trade.

Benson, et.al, 2008 highlight the main policy options available to policy makers including programs aimed at supporting increased agricultural production like giving subsidies to farmers for key inputs like fertilizer or improved seeds, agricultural extension and credit programs, investment in small-scale irrigation, and support for agricultural research and technology development. Price-oriented policies proposed include changes in tariffs on food commodities and use of public grain reserve stocks, while income-oriented policies proposed include cash transfers, conditional cash transfers, food vouchers or food stamps, food- or cash for-work schemes, and other public work schemes.

Kearney and van Heerden, 2004 using a Computable General Equilibrium Analysis for South Africa, found that Zero-rating food can reduce poverty by lowering food prices and at the same time lowering the regressiveness of VAT and that if combined with a proportional percentage increase in direct taxes to mitigate revenue losses from the policy, can improve the welfare of poor households, without impacting negatively on other households.

Nouve and Wodon, 2008, however, contend that for Mali, a reduction in indirect taxes on rice would have only a limited effect on prices, production, and poverty, but an increase in the productivity of the rice sector could have major effects, and could lead in the medium term to a reduction in poverty.

D. Justification of the Study

Whereas a lot of research has been undertaken to explain the phenomenon of high food prices and its impact on peoples' welfare, especially of the poor, no general equilibrium analyses has been undertaken on Uganda. It is usually taken for granted that high food prices would have a negative impact on the welfare of households, but because of the agrarian nature of the Ugandan economy some commentators and especially Uganda's political leaders have argued that these price increases may actually be a blessing to mainly the farmers, who are a major section of the population. It is conceivably possible that the food price increases will raise the real incomes of the rural household farmers but hurt net food consumers especially those in urban areas, yet they are also relatively poor. It is therefore important to find out what the average impact on poverty and people's welfare will be considering these counter-balancing effects. This is especially important in order to help policy makers take informed decisions on how to respond to these prices.

E. The Uganda Social Accounting Matrix (SAM) 2007

A Social Accounting Matrix (SAM) is a table which summarizes the economic activities of all agents in the economy. These agents typically include households, enterprises, government, and the rest of the world (ROW). The relationships included in the SAM include purchase of inputs (goods and services, imports, labour, land, capital etc.); production of commodities; payment of wages, interest rent and taxes; and savings and investment. Like other conventional SAMs, the Uganda SAM is based on a block of production activities, involving factors of production, households, government, stocks and the rest of the world.

The Uganda SAM is a 120 by 120 matrix. The various commodities (domestic production) supplied are purchased and used by households for final consumption (42 per cent of the total), but also a considerable proportion (34 per

cent) is demanded and used by producers as intermediate inputs. Only 7 percent of domestic production is exported, while 11 per cent is used for investment and stocks and the remaining 7 percent is used by government for final consumption. Households derive 64 per cent of their income from factor income payments, while the rest accrues from government, inter-household transfers, corporations and the rest of the world. The government earns 32 percent of its income from import tariffs – a relatively high proportion, but a characteristic typical of developing countries. It derives 42 percent of its income from the ROW, which includes international aid and interest. The remainder of government's income is derived from taxes on products (14 percent), income taxes paid by households (6 percent) and corporate taxes (5 percent).

Investment finance is sourced more or less equally from government (26 per cent), domestic producers (27 per cent) and households (26 per cent), with enterprises providing only 21 per cent. Imports of goods and services account for 87 percent of total expenditure to the ROW. The rest is paid to ROW by domestic household sectors in form of remittances; wage labour from domestic production activity; domestic corporations payments of dividends; income transfers paid by government; and net lending and external debt related payments.

The extent of household dis-aggregation is very important for policy analysis, and involves representative household groups as opposed to individual households. Pyatt and Thorbecke (1976) argue persuasively for a household dis-aggregation that minimizes within-group heterogeneity. This is achieved in the Uganda SAM through the disaggregating of households by rural and urban, and whether households are involved in farming or non farming activities.

The Uganda SAM identifies three labour categories disaggregated by skilled, unskilled and self employed. Land and capital are distributed accordingly to the various household groups.

F. Salient Features of the CGE Model

The CGE model used in the present study is based on a standard CGE model developed by Lofgren, Harris, and Robinson (2002). This is a real model without the financial or banking system (See Table A1). It cannot be used to forecast inflation. The CGE model is calibrated to the 2007 SAM. GAMS software is used to calibrate the model and perform the simulations.

Productions and commodities

For all activities, producers maximize profits given their technology and the prices of inputs and output. The production technology is a two-step nested structure. At the bottom level, primary inputs are combined to produce value-added using a CES (constant elasticity of substitution) function. At the top level, aggregated value added is then combined with intermediate input within a fixed coefficient (Leontief) function to give the output. The profit maximization gives the demand for intermediate goods, labour and capital demand. The detailed disaggregation of production activities captures the changing structure of growth due to the pandemic.

The allocation of domestic output between exports and domestic sales is determined using the assumption that domestic producers maximize profits subject to imperfect transformability between these two alternatives. The production possibility frontier of the economy is defined by a constant elasticity of transformation (CET) function between domestic supply and export.

On the demand side, a composite commodity is made up of domestic demand and final imports and it is consumed by households, enterprises, and government. The Armington assumption is used here to distinguish between domestically produced goods and imports. For each good, the model assumes imperfect substitutability (CES function) between imports and the corresponding composite domestic goods. The parameter for CET and CES elasticity used to calibrate the functions used in the CGE model are exogenously determined.

Factor of production

There are 6 primary inputs: 3 labour types, capital, cattle and land. Wages and returns to capital are assumed to adjust so as to clear all the factor markets. Unskilled and self-employed labor is mobile across sectors while capital is assumed to be sector-specific.

Institutions

There are three institutions in the model:, households, enterprises and government. Households receive their income from primary factor payments. They also receive transfers from government and the rest of the world. Households pay income taxes and these are proportional to their incomes. Savings and total consumption are assumed to be a fixed proportion of household's disposable income (income after income taxes). Consumption demand is determined by a Linear Expenditure System (LES) function. Firms receive their income from remuneration of capital; transfers from government and the rest of the world; and net capital transfers from households. Firms pay corporate tax to government and these are proportional to their incomes.

Government revenue is composed of direct taxes collected from households and firms, indirect taxes on domestic activities, domestic value added tax, tariff revenue on imports, factor income to the government, and transfers from the rest of the world. The government also saves and consumes.

Macro closure

Equilibrium in a CGE model is captured by a set of macro closures in a model. Aside from the supply-demand balances in product and factor markets, three macroeconomic balances are specified in the model: (i) fiscal balance, (ii) the external trade balance, and (iii) savings-investment balance. For fiscal balance, government savings is assumed to adjust to equate the different between government revenue and spending. For external balance, foreign savings are fixed with exchange rate adjustment to clear foreign exchange markets. For

savings-investment balance, the model assumes that savings are investment driven and adjust through flexible saving rate for firms. Alternative closures, described later, are used in a subset of the model simulations.

Recursive Dynamics

To appropriately capture the dynamic aspects of aid on the economy, this model is extended by building some recursive dynamics by adopting the methodology used in previous studies on Botswana and South Africa (Thurlow, 2007). The dynamics is captured by assuming that investments in the current period are used to build on the new capital stock for the next period. The new capital is allocated across sectors according to the profitability of the various sectors. The labour supply path under different policy scenarios is exogenously provided from a demographic model. The model is initially solved to replicate the SAM of 2007.

G: Net Buyers and Producers of Food in Uganda

Before undertaking any simulations it's important to distinguish between the net producers of food and net buyers. A net producer is defined as any household that produces more than what it consumes. Likewise, net consumers are defined as households that consume more than what they produce. The impact of a food price shock would have remarkably different effects on these two types of households. Using the 2005 household survey, we identify crops that are largely grown and consumed in Uganda. As expected, the distribution of households by crop production varies a lot by the regions. Households in the rural western and rural central region are net producers of matooke. In addition about 50 percent of the households in the western and central region are net producers of maize. On the contrary, owing to the agro climatic conditions, the eastern and northern regions are net purchasers of matooke. As for maize, the rural eastern region also turns out to be net producers. Rice, albeit the upland rice scheme efforts is still largely bought by most households.

Based on this analysis, there would be winners and loosers due to food price surges. The simulations below are guided by the fact that there are crops that are internationally traded and which Uganda is either a net exporter or importer. Hence we mainly focus on the changes in prices of maize and rice.

Household Net Buyers and Producers of Food Items in Uganda

		Region							
		Central Rural	Central Urban	Eastern Rural	Eastern Urban	Northern Rural	Northern Urban	Western Rural	Western Urban
Crop									
Matooke	Net Buyer	507,570	488,044	613,244	107,470	878,616	131,648	369,463	82,339
	%	45.1	90.4	55.9	91.3	97.8	98.3	30.9	68.5
	Net Producer	618,941	52,022	484,112	10,276	19,740	2,236	825,752	37,790
	%	54.9	9.6	44.1	8.7	2.2	1.7	69.1	31.5
Sweet Potatoes	Net Buyer	718,467	499,571	719,111	102,198	827,518	106,043	866,047	102,281
	%	63.8	92.5	65.5	86.8	92.1	79.2	72.5	85.1
	Net Producer	408,044	40,495	378,245	15,548	70,838	27,841	329,168	17,848
	%	36.2	7.5	34.5	13.2	7.9	20.8	27.5	14.9
Cassava	Net Buyer	702,835	505,359	716,854	105,964	734,414	119,563	829,618	97,422
	%	62.4	93.6	65.3	90.0	81.8	89.3	69.4	81.1
	Net Producer	423,676	34,707	380,502	11,782	163,942	14,321	365,597	22,707
	%	37.6	6.4	34.7	10.0	18.3	10.7	30.6	18.9
Maize	Net Buyer	564,860	487,026	470,854	89,840	663,387	114,417	615,388	87,273
	%	50.1	90.2	42.9	76.3	73.8	85.5	51.5	72.7
	Net Producer	561,651	53,040	626,502	27,906	234,969	19,467	579,827	32,856
	%	49.9	9.8	57.1	23.7	26.2	14.5	48.5	27.4
Rice	Net Buyer	1,118,710	540,066	1,050,772	115,159	883,368	132,268	1,160,860	118,311
	%	99.3	100.0	95.8	97.8	98.3	98.8	97.1	98.5
	Net Producer	7,801	-	46,584	2,587	14,988	1,616	34,355	1,818
	%	0.7	-	4.3	2.2	1.7	1.2	2.9	1.5
Millet	Net Buyer	1,096,678	539,180	1,031,280	117,025	809,294	129,821	831,273	111,140
	%	97.4	99.8	94.0	99.4	90.1	97.0	69.6	92.5
	Net Producer	29,833	886	66,076	721	89,062	4,063	363,942	8,989
	%	2.7	0.2	6.0	0.6	9.9	3.0	30.5	7.5
Sorghum	Net Buyer	1,109,487	540,066	986,218	111,566	719,772	116,261	1,058,423	115,096
	%	98.5	100.0	89.9	94.8	80.1	86.8	88.6	95.8
	Net Producer	17,024	-	111,138	6,180	178,548	17,623	136,792	5,033
	%	1.5	-	10.1	5.3	19.9	13.2	11.4	4.2
Beans	Net Buyer	579,513	493,576	703,671	100,433	660,921	112,260	465,598	84,155
	%	51.4	91.4	64.1	85.3	73.5	83.9	39.0	70.1
	Net Producer	546,998	46,490	393,685	17,313	237,435	21,624	729,617	35,974
	%	48.6	8.6	35.9	14.7	26.4	16.2	61.0	30.0

H. Simulation Results

Using the identified channels in section B as a guide, we apply the CGE model to evaluate the effect of rising world food prices by introducing a shock on import and export prices for cereals. Based on the background discussion, we increase the prices of maize, wheat and rice by 100 percent. Such a significant jump in world prices would inevitably have varied effects on producers and consumers of the items in question.

Cereals in Uganda constitute about 33 percent of total agricultural production with total export of maize estimated at 12.3 million dollars, while imports are about 14.5 million. In spite of the increase in the production of rice, Uganda remains a net importer of rice. The total import bill amounted to 5.7 million dollars in 2005. The bulk of the wheat is also largely imported to the tune of 0.7 million dollars in 2005[1].

With this background we run simulations based on specific crops. In particular, we differentiate between crops where Uganda is a net exporter from those where it is a net importer. The first simulation focuses on the increase of prices of maize. First we assume that the price increase is permanent (MAIZEP) and in the second simulation we assume that the price increase is temporary (MAIZET). Maize represents one of those crops where Uganda is a net exporter especially to neighboring countries. The next simulations are on nice both for the permanent (RICEP) and temporary price increase (RICET). Uganda is a net importer of rice and therefore a surge in rice prices would negatively impact the economy. Other cereals simulation (OTHCER) includes price increase for all other cereals excluding maize and rice. With the recent fuel price increase, this has been coupled with an increase in fertilizer prices perhaps due to increase in transportation costs. We therefore run a simulation of increasing fertilizer prices

[1] All estimates are for 2005; the latest available data from FAO, but more recent estimates may show marked increases in maize exports and rice imports making Uganda a net maize exporter and net rice importer.

(FERT). Lastly, we run a simulation where tariffs on cereals imported are reduced.

H.1 Baseline

We first perform a simulation where we assume that business remains as usual. The purpose of this simulation is to compare the case if prices where not changed at all, what would be the actual net gain or losses that can be attributed to the price changes. In this case we assume that for all the cereals prices remain the same during the simulation period. We also assume that total factor productivity growth is 1 percent. These assumptions are used through all other simulations except in the subsequent simulations where we assume that the productivity growth rate also changes.

H.2 Increase in Maize Price

We increase the world price of maize by 100 percent in the year 2008. We assume that this increase is a one-off spike that does not adjust back to the earlier levels (permanent increase). We also run simulations where the increase in the world price of maize is temporary. In essence this is a more realistic scenario since prices of most cereals have started to drop since the recent surge.

The results show that for a permanent increase in the price of maize, we do not observe a marked increase in aggregate GDP growth (Table 1). The average growth rate under this scenario is about 5.8 percent on an annual basis during the period 2008-16. However, we notice that significant resources would be shifted to the growing of maize. Maize production increases by 60 percent during the 2009. As expected there is a lag in response to the price increase. For the subsequent years the increase is marginal. Notwithstanding, this comes at the expense of switching from growing other crops. We note that the production of major crops like bananas and root tubers would decline by 1.2 and 1.4 percent, respectively. So, from the production front, we would mainly have a reallocation

of resources from other types of crops to maize. However the reallocation and reduction in production of other crops would depend whether the shock is temporary or permanent. For a permanent price shock the negative effects are not as adverse as farmers readjust permanently to the price shock. However, a temporary price increase would be more disruptive to the farmers because as prices revert back to their original levels farmers would have transferred resources to the booming crop. The benefits of food price increase for an exportable commodity are not restricted to primary production only. We notice that even the manufacturing sector would grow owing to the higher returns on the value-added products.

At a macroeconomic level as shown in Table 2, we note that there would be an increase in private consumption. This is mainly driven by the higher incomes obtained by farmers due to the higher prices. With increased incomes, this also results into higher investment levels where for the case of temporary price increase investments would grow at a rate of 1 percent higher than the baseline. For the case of rice, we do not see any significant changes at the macroeconomic level perhaps owing to that fact that its not the main staple food for most Ugandans.

Table 1. Average Growth Rate by Sectors (2008-2016)

	BASE	MAIZEP	MAIZET	RICEP	RICET	OTHCER	FERT	COMB	TARR
Overall GDP	5.7	5.8	5.8	5.7	5.7	3.7	5.7	5.8	5.9
Agriculture	3.7	3.8	4.2	3.7	3.7	0.9	3.6	3.8	4.2
Of which									
Cereals	2.0	13.1	20.1	2.6	2.8	(0.4)	2.0	13.5	13.5
Root Crops	3.9	2.5	(0.9)	3.8	3.8	0.9	3.9	2.4	2.4
Pulses	2.5	1.1	(2.7)	2.4	2.3	(0.7)	2.6	1.1	1.1
Matooke	4.1	2.8	(0.5)	4.0	4.0	1.2	4.1	2.7	2.7
Horticulture	4.5	3.3	0.2	4.5	4.4	1.8	4.4	3.3	3.2
Export Crops	2.5	1.8	(0.4)	2.5	2.5	(0.8)	1.5	1.8	1.8
Livestock	3.4	2.9	1.4	3.4	3.4	0.4	3.5	2.8	7.6
Forestry	4.4	4.9	6.5	4.4	4.4	1.9	4.3	4.9	4.8
Fishing	5.2	5.4	5.7	5.2	5.2	2.8	5.2	5.4	5.3
Industry	5.3	5.6	6.6	5.3	5.3	3.4	5.2	5.5	5.6
Of which									
Mining	5.6	6.1	7.3	5.6	5.6	3.8	5.6	6.1	6.0
Manufacturing	5.5	5.5	5.7	5.4	5.4	3.2	5.2	5.3	5.6
Food Processing	5.5	5.3	4.9	5.4	5.4	3.0	5.4	4.9	5.6
Meat Processing	3.3	2.5	0.4	3.2	3.2	0.2	3.4	2.6	7.0
Fish Processing	5.2	5.4	5.7	5.2	5.2	2.8	5.2	5.4	5.3
Grain Processing	5.6	5.0	3.7	5.4	5.3	2.8	5.5	4.1	4.8
Feed Processing	3.7	3.1	1.7	3.6	3.6	0.7	3.7	3.0	7.3
Other Food Processing	4.8	4.4	3.5	4.8	4.8	2.0	4.8	4.0	5.0
Beverages and Tobacco	6.3	6.5	7.3	6.3	6.3	4.3	6.2	6.3	6.5
Non-Food Processing	5.4	5.8	6.6	5.5	5.5	3.4	4.9	5.8	5.7
Textiles and Clothing	5.7	6.1	7.1	5.7	5.7	3.4	5.6	6.1	6.0
Wood and Paper	3.5	3.6	3.8	3.5	3.5	0.8	3.3	3.6	3.6
Fertilizer	4.1	4.1	4.3	4.1	4.1	1.3	49.5	4.2	4.1
Other chemicals	5.9	6.4	7.5	6.0	6.0	3.9	3.3	6.3	6.4
Machinery & equipment	4.8	5.0	5.6	4.8	4.8	2.6	4.8	5.0	4.9
Furniture	5.4	5.9	7.3	5.4	5.4	3.6	5.3	5.9	5.8
Other manufacturing	5.7	6.0	6.8	5.7	5.7	3.9	5.6	6.0	5.9
Utilities	6.6	7.2	8.9	6.6	6.6	4.9	6.4	7.1	7.1
Construction	4.7	5.1	6.2	4.7	4.7	3.1	4.7	5.1	5.1
Services	6.8	6.7	6.2	6.8	6.8	5.0	6.9	6.8	6.7
Private	7.9	7.7	6.9	7.9	7.9	6.3	8.0	7.8	7.7
Trade	5.2	5.3	5.9	5.2	5.2	3.0	5.3	5.2	5.5
Hotels & catering	16.8	16.3	11.6	16.8	16.8	16.6	17.4	16.4	15.9
Transport	6.2	6.5	7.2	6.2	6.2	4.2	6.2	6.5	6.5
Communications	5.6	5.9	6.6	5.6	5.6	3.5	5.6	5.8	5.9
Banking	4.0	3.9	3.3	4.0	4.0	1.3	3.9	3.8	4.0
Real estate	7.2	7.6	9.0	7.2	7.2	5.7	7.2	7.6	7.6
Community services	5.4	5.9	7.7	5.4	5.5	3.3	5.3	6.0	5.9
Public	3.5	3.6	4.1	3.5	3.5	0.6	3.5	3.6	3.6

Table 2: Macroeconomic Developments under Various Scenarios

(Average Growth 2008-2016)

	INITIAL	BASE	MAIZEP	MAIZET	RICEP	RICET	OTHCER	FERT	COMB	TARR
Absorption	26,446	5.26	5.42	6.28	5.26	5.26	5.21	5.21	5.43	5.41
Consumption	18,743	5.81	5.96	6.89	5.80	5.80	5.74	5.74	5.99	5.95
Investment	5,014	4.22	4.50	5.44	4.23	4.24	4.22	4.22	4.45	4.51
Exports	3,335	9.39	9.15	6.33	9.36	9.35	9.44	9.51	9.10	9.14
Imports	9,190	5.96	6.29	7.92	5.94	5.94	5.86	5.91	6.05	6.24
Real exchange rate	66	-1.29	-1.98	-4.51	-1.24	-1.07	-1.03	-0.52	-1.55	-1.90
Nominal exchange rate	100	-1.37	-2.21	-5.02	-1.42	-1.44	-1.43	-1.35	-2.20	-2.23
Producer price Index	151	-0.08	-0.10	-0.16	-0.08	-0.08	-0.08	-0.08	-0.10	-0.10
CPI	100	-0.07	0.03	0.17	-0.05	-0.04	-0.01	-0.07	0.13	0.06
Investment to GDP	22	-0.48	-0.52	-0.65	-0.48	-0.48	-0.48	-0.47	-0.53	-0.52
Private Savings to GDP	8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Foreign Savings to GDP	10	-0.28	-0.31	-0.42	-0.28	-0.28	-0.28	-0.27	-0.31	-0.31
Trade Deficit to GDP	25	-0.64	-0.69	-0.86	-0.65	-0.65	-0.65	-0.63	-0.70	-0.70
Government Savings to GDP	5	-0.24	-0.25	-0.27	-0.24	-0.24	-0.24	-0.23	-0.25	-0.24
Import duties to GDP	5	-0.03	-0.04	-0.06	-0.04	-0.04	-0.03	-0.03	-0.04	-0.04
Direct Taxes to GDP	3	0.00	-0.01	-0.04	0.00	0.00	0.00	0.00	-0.01	-0.01

Since maize is a crop that is largely grown by the rural population, we note that the increase would largely benefit the rural producers. As indicated in figure 13, the poverty level of the rural households would be reduced by 2 percent over the period 2008-16 owing to the price increase. On the other hand for the urban households which are not involved in farming activities, their poverty levels over the same period would remain the same as in the baseline.

From a macro economic perspective, for a maize producing country like Uganda, we find that total absorption in the economy would be higher than the baseline mainly due to higher consumption and private investments. The higher consumption and investment are due to the increased disposable income as a result of increased production sparked by the price boom.

From a policy perspective, this could indeed raise two important issues. First, if the main objective of government is to reduce rural poverty, then focusing on stimulating the supply response of the commodity in question would go a long way to meet that objective. Second, there has been a lot of migration away from the rural to urban areas. In this case government could initiate programs to encourage the urban poor who are unemployed to migrate back to the rural areas and be engaged in more productive activities.

Turning to a temporally increase in food prices; we note that the supply response in maize production is even smaller. The production of maize only increases by 30 percent compared to the permanent case. The uncertainty in commodity prices should therefore be addressed in a coordinated manner. If farmers are encouraged to grow the crop whose price has significantly increased, they would need to be reassured that they would recoup their investment with a profit. Hence with increased uncertainty in commodity prices, government should take an initiative where farmers could participate more in the futures markets for

Fig. 6: Price Shock and Agriculture Growth in Uganda

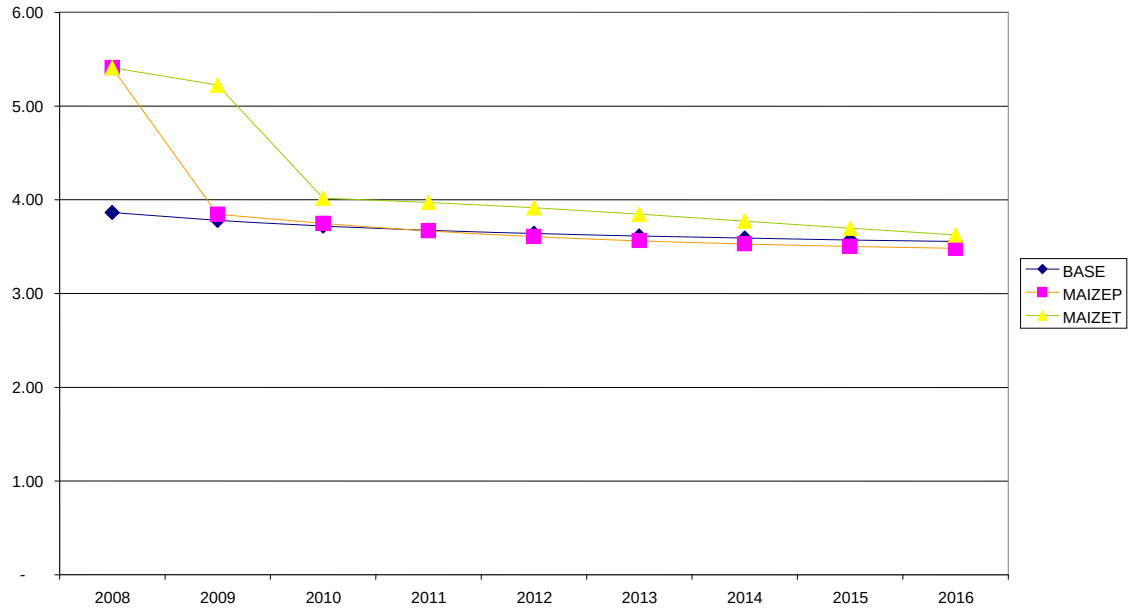
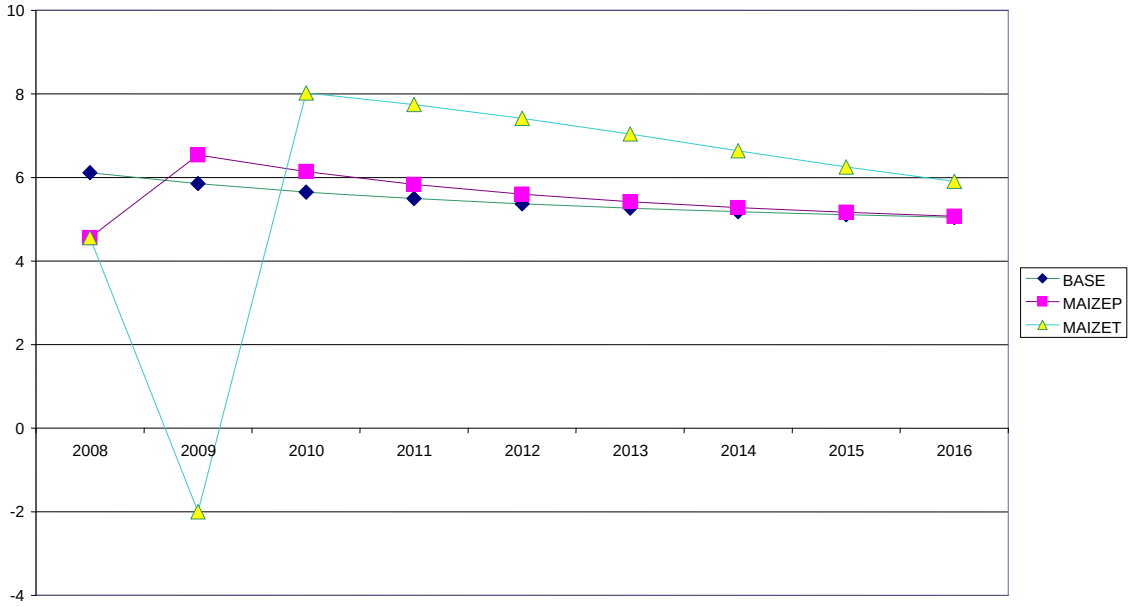


Fig. 7: Maize Price Shock and Manufacturing Growth in Uganda

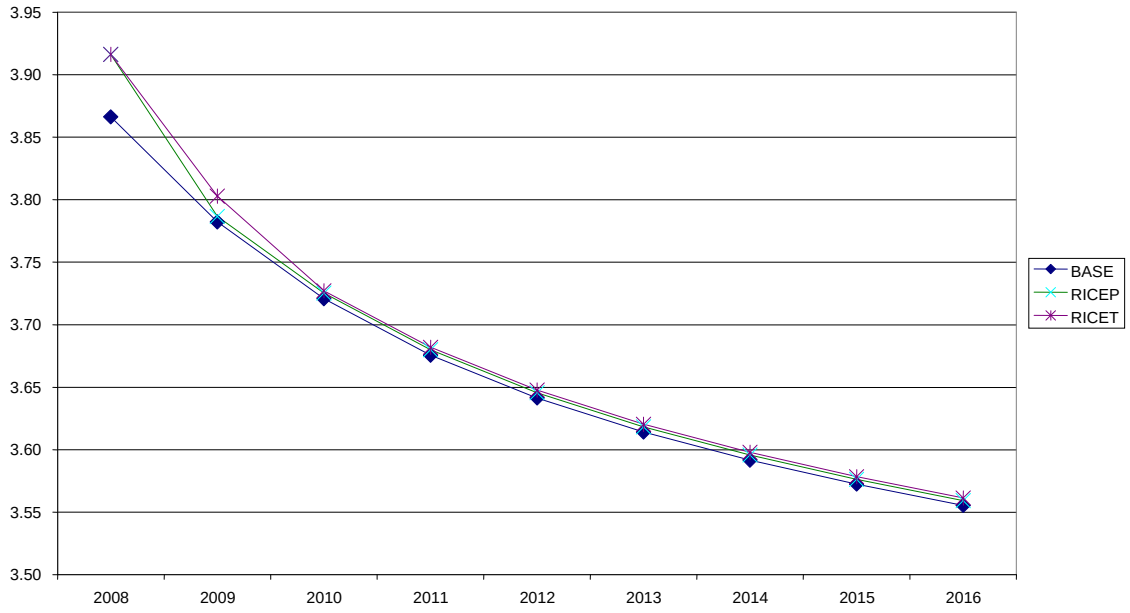


commodities. This in a way would guarantee prices for the future rather than being left to the volatile commodity markets and in the end could be a total disincentive to production of that given commodity.

H.3 Increase in Rice and Wheat Prices

The second simulation focuses on the scenario where we specifically increase the prices of crops of which we are net importers. It's important to differentiate between these crops because the net impact could be very different depending on whether the household is a net producer or consumer of the given commodity.

Fig. 8: Rice Price Shock and Agricultural Growth in Uganda



The domestic price of rice and wheat rises by 25 percent. In addition when prices are higher, we observe some form of import substitution as domestic consumers resort to consuming more domestic products than imported foods. This results into total food imports to fall by 6 percent in real terms.

With high world food prices for a product like rice, we notice a domestic supply response. More resources are put into other types of foods grown domestically like maize and pulses. The competition for resources as they get shifted causes returns to land to increase by 4 percent. The use of labor depends so much on the factor intensity for each crop. With increased production for other crops, we find that more labour is demanded for other domestically grown crops.

Under this scenario, we find that there is minor impact on the aggregate economy. First, GDP in real terms would grow by the same amount as in the baseline. The production response of rice production as a result of its world price increase is not as high as that of maize. Rice production would increase by 40 percent compared to the baseline where it grows by 2.5 percent. The lower, response in production level is due to the fact that production of rice is still at its infant stage and the immediate switch to production of rice should not be expected.

Owing to the lower production response, this simulation shows that households would not really benefit as in the former scenario. In essence, both the rural and urban households that are not involved in the production of rice or wheat would be negatively affected. The rural poor would presumably switch to consumption of other products rather than rice and wheat. The urban poor could also adjust accordingly. As expected, food takes a large weight in the consumers' basket for the poor. Hence, for the urban poor increasing prices would particularly take a larger negative impact.

H.4 Increasing Prices of Fertilizers

With the recent increase in oil prices, it's also been the case that fertilizer prices have been on the increase. This is partly due to the fact that a significant part of the fertilizers used in Uganda are imported. Albeit the fact that fertilizers are hardly used in Uganda, we run a simulation to explore the extent to which increasing fertilizer prices affect the economy especially the agricultural sector. As expected, given that the use of fertilizers is very limited (at least for the year 2007 when the SAM was compiled), there is a very marginal impact on the agricultural sector and the economy as a whole. The only agricultural crops that are affected as a result of increasing prices of fertilizers are the exportable crops which include coffee, tea, cotton and tobacco.

H.5 Reduction of Tariffs on Imported Food Items

The impact of increasing food prices depends so much on the type of crop in question as demonstrated in the earlier two sections. To the extent that increasing world food prices affect some sections of society, we now look at possible interventions by the government. In particular, we look at the possibility where the government abolishes all tariffs on food items.

This policy would have some macroeconomic consequences. First, the government would lose some revenue although this would be a very insignificant amount. . This would translate into a deterioration of the fiscal deficit coupled with less private investments due to the higher financing requirement of the government deficit. We note that in this case the urban dwellers would not be as affected as in the earlier scenarios.

However, this policy response depends on whether the world price increase is going to be temporary or permanent. If the objective of government is to protect the poor urban population and the price increase is permanent, it might be worth the government to intervene and forego the tariffs on the chosen food items imported. The extreme, is when the government resorts to providing subsidies. This could result into more distortion of price signals and resource allocation.

H.6 Poverty Impacts

From the above analysis, we have observed that the benefits of increasing food prices depend so much on whether the household or country is a net producer or consumer of the given commodity in question. This therefore requires to look at each individual commodity and assessing its impact on the given household. Likewise for the poverty levels, the rural households involved in agricultural activities would gain the most from a maize price increase. However, poverty for the non farming urban households and non farming rural households would remain the same if not worse than the baseline owing to the food price increase. The impact on poverty given a

rice price increase is marginal as consumers would have options of switching to domestically produced commodities.

However a study by Benson et. Al (2008) finds that in Uganda very many rural households are significant net buyers of food. In their analysis of the UNHS showed that about 61% of rural households are significant net buyers of all foods on a value basis, and 39% are significant net buyers of staples. This suggests that these results could be restricted by the construction of the SAM which does not disaggregate households along the lines of net food sellers of buyers.

Fig. 9: Impact of Food Price Increases on National Poverty Rates in Uganda by 2016

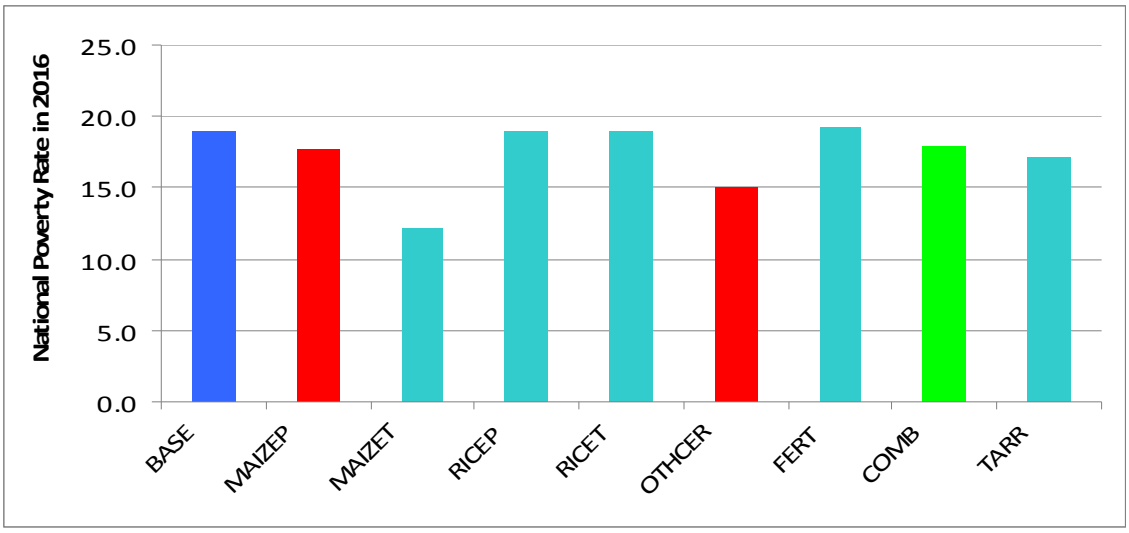


Fig. 10: Impact of Food Price Increases on Rural Farming Poverty Rates in Uganda by 2016

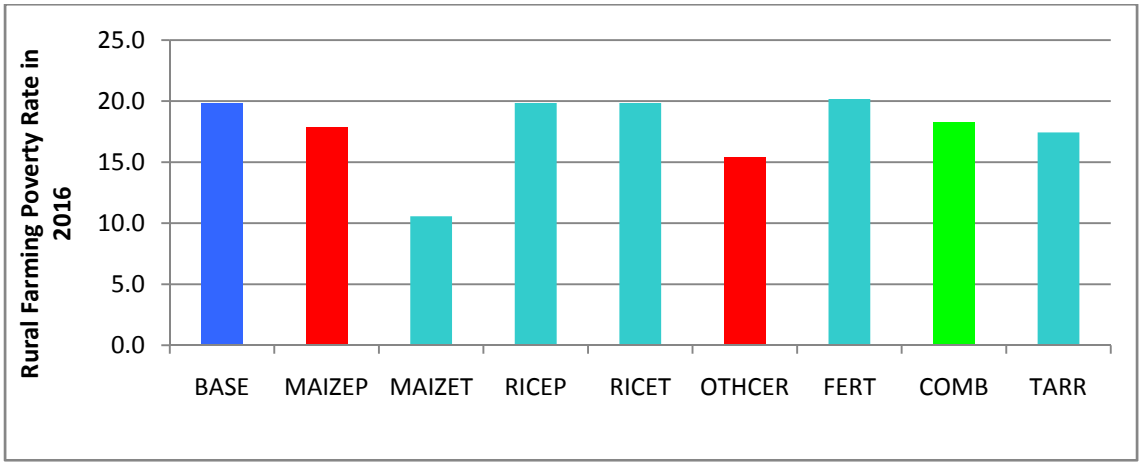


Fig. 11: Impact of Food Price Increases on Rural Non-Farming Poverty Rates in Uganda by 2016

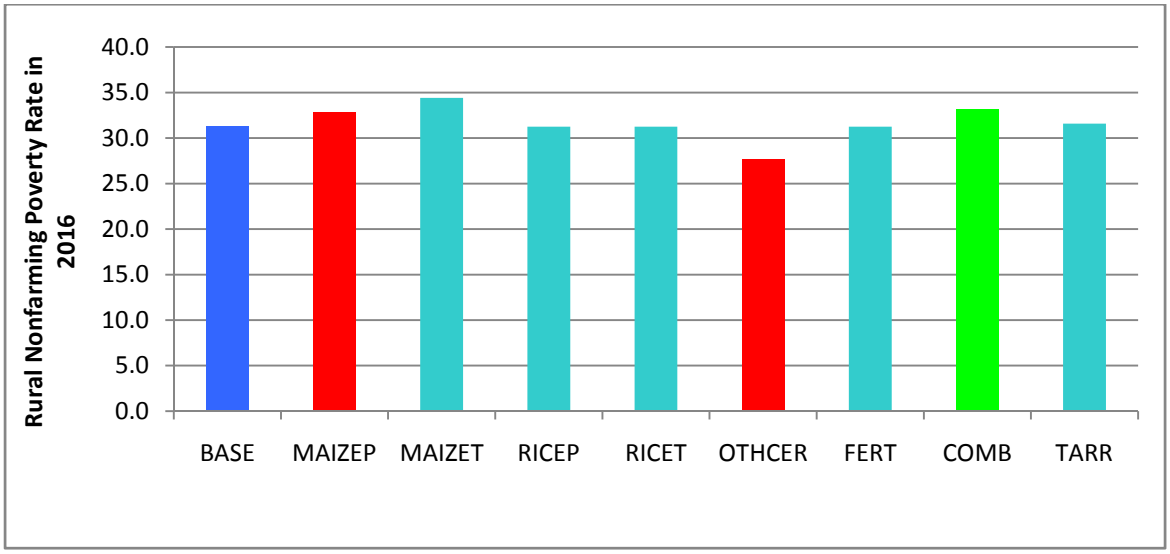


Fig. 12: Impact of Food Price Increases on Urban Farming Poverty Rates in Uganda by 2016

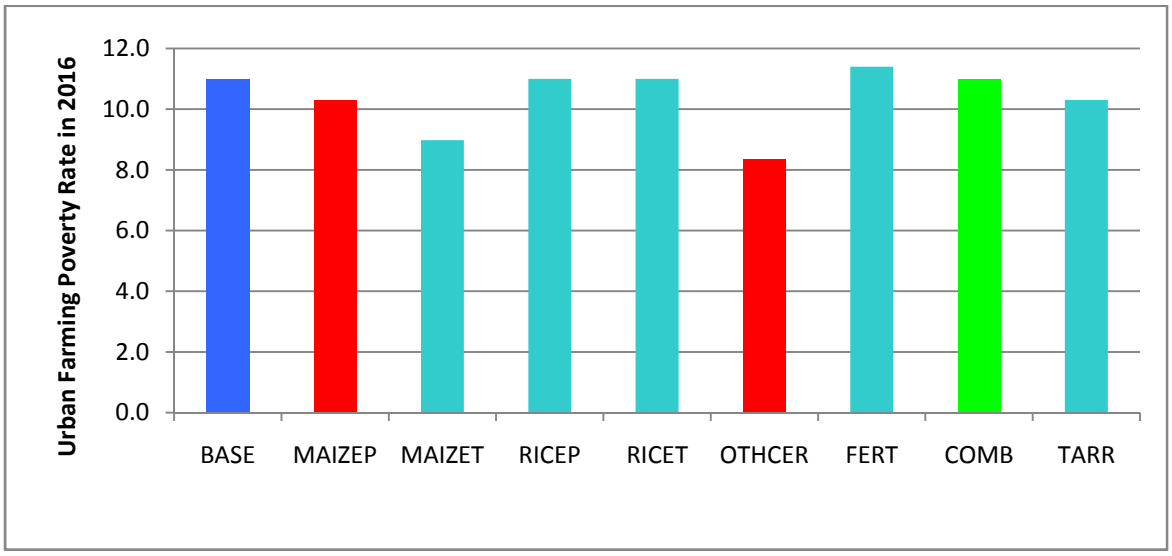


Fig. 13: Impact of Food Price Increases on Urban Non-Farming Poverty Rates in Uganda by 2016

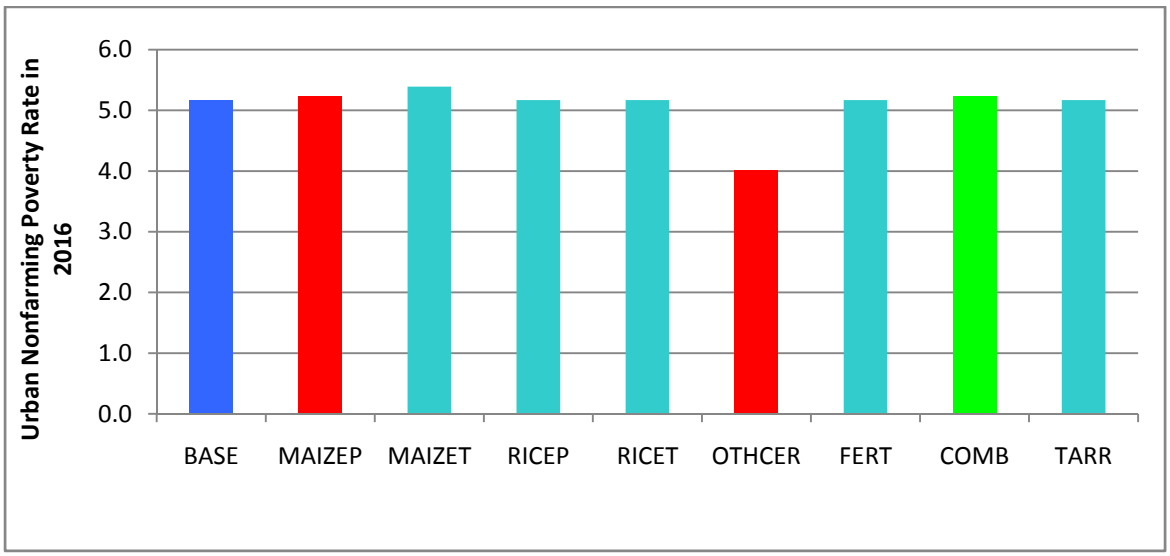


Table. 3: Poverty Indices in Uganda under Various Scenarios

BASE	MAIZEP	MAIZET	RICEP	RICET	OTHCER	FERT	COMB	TARR
				National Poverty (P0)				
2007	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1
2008	29.6	26.3	26.3	29.6	29.6	29.4	30.3	26.7	26.3
2009	27.8	24.9	17.1	27.8	27.8	26.8	28.7	25.5	24.9
2010	26.4	23.7	16.3	26.4	26.4	25.1	27.0	24.3	23.6
2011	25.1	22.5	15.4	25.1	25.1	22.8	25.7	22.8	22.4
2012	23.6	21.4	14.6	23.6	23.6	21.1	24.1	21.9	21.3
2013	22.0	20.6	14.0	22.0	22.0	19.6	22.7	20.9	20.3
2014	21.0	19.6	13.3	21.0	21.0	18.2	21.5	19.8	19.5
2015	20.0	18.7	12.8	20.0	20.0	16.7	20.5	19.2	18.4
2016	19.0	17.6	12.2	19.0	19.0	15.1	19.3	18.0	17.2
				Rural-Farming Poverty (P0)				
2007	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
2008	31.6	26.9	26.9	31.6	31.6	31.4	32.4	27.3	26.9
2009	29.4	25.4	15.2	29.4	29.4	28.2	30.5	26.1	25.4
2010	27.7	24.0	14.3	27.7	27.7	26.3	28.5	24.7	23.9
2011	26.3	22.7	13.3	26.3	26.3	23.9	27.0	23.0	22.6
2012	24.8	21.7	12.6	24.8	24.8	22.0	25.4	22.2	21.5
2013	23.0	20.8	12.0	23.0	23.0	20.4	23.8	21.2	20.5
2014	21.9	19.9	11.5	21.9	21.9	19.0	22.5	20.1	19.8
2015	20.9	19.0	11.0	20.9	20.9	17.3	21.4	19.6	18.7
2016	19.9	17.9	10.6	19.9	19.9	15.4	20.2	18.3	17.4
				Rural-Nonfarming Poverty (P0)				
2007	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6
2008	41.9	42.7	42.7	41.9	41.9	41.9	41.9	43.2	42.7
2009	41.0	41.9	41.9	41.1	41.1	40.3	41.1	41.9	41.9
2010	39.9	41.1	41.5	40.1	40.1	39.0	40.1	41.5	41.1
2011	38.9	40.1	40.7	39.0	39.1	37.0	39.1	40.3	39.9
2012	37.8	38.9	39.5	37.9	37.9	35.0	37.9	39.1	38.9
2013	36.0	37.8	38.9	36.0	36.0	32.9	36.0	38.4	37.2
2014	35.0	36.0	37.2	35.0	35.0	31.0	35.0	36.6	35.9
2015	33.1	34.5	36.0	33.1	33.1	29.6	33.7	35.0	34.0
2016	31.3	32.9	34.4	31.3	31.3	27.6	31.3	33.1	31.6
				Urban-Farming Poverty (P0)				
2007	19.7	19.7	19.7	19.7	19.7	19.7	19.7	19.7	19.7
2008	18.3	18.1	18.1	18.3	18.3	18.1	19.0	18.1	18.1
2009	17.7	17.5	14.0	17.7	17.7	17.4	17.8	17.6	17.5
2010	17.3	16.7	13.5	17.3	17.3	15.5	17.3	17.3	16.7
2011	16.1	15.2	12.5	16.2	16.2	13.7	16.7	15.5	15.2
2012	14.1	14.0	12.0	14.2	14.2	12.5	14.3	14.1	13.9
2013	13.5	13.0	11.2	13.5	13.5	11.4	13.7	13.5	13.0
2014	12.5	12.3	10.1	12.5	12.5	10.1	12.7	12.5	12.3
2015	12.0	11.5	9.4	12.0	12.0	9.3	12.2	12.0	11.4
2016	11.0	10.3	9.0	11.0	11.0	8.3	11.4	11.0	10.3
				Urban-Nonfarming Poverty (P0)				
2007	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
2008	9.2	10.4	10.4	9.2	9.2	9.2	9.2	11.0	10.4
2009	8.5	9.2	9.2	8.5	8.5	8.5	8.7	9.2	9.2
2010	8.3	8.5	8.5	8.3	8.3	7.7	8.3	8.5	8.5
2011	7.7	8.2	8.4	7.7	7.7	6.3	7.7	8.3	8.2
2012	6.5	6.5	7.1	6.5	6.5	5.5	6.5	7.1	6.5
2013	6.0	6.3	6.5	6.1	6.2	5.2	6.3	6.4	6.3
2014	5.5	5.9	6.3	5.5	5.5	4.9	5.5	6.0	5.6
2015	5.3	5.4	5.6	5.3	5.4	4.4	5.4	5.5	5.4
2016	5.2	5.2	5.4	5.2	5.2	4.0	5.2	5.2	5.2

I. Conclusions and Policy Implications

Overall, increase in world food prices especially for cereals which are exported like maize would benefit Uganda and reduce rural poverty. Therefore, the government could provide further support to farmers involved in crops whose world prices have increased (including extension services, access to fertilizers etc). The government could also improve access to markets for the profitable crops (improving roads). Government could target special programs to the non-farming households who are poor who seem to be affected as a result of increasing food prices. The other alternative is for the government to design programs where instead of the youth migrating to towns, they could be encouraged to migrate to villages and benefit by engaging in farming of crops whose prices have increased.

Albeit the positive aspects of the price increase, government would also need to take into account that commodity prices can be very volatile. While at some point during early 2008 commodity prices were very high, they have since reverted back to the original levels. With farmers, they would therefore need to engage in more sophisticated market transactions like futures in order to insure against the uncertainty in the market.

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Table A1. CGE model sets, parameters, and variables

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

	intermediate input per activity unit		tax rate for domestic institution i
iva_a	Quantity of aggregate intermediate input per activity unit	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$\overline{mps}_i$	Base savings rate for domestic institution i	tm_c	Import tariff rate
$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tq_c	Rate of sales tax
pwe_c	Export price (foreign currency)	$trnsfr_{i\,f}$	Transfer from factor f to institution i
pwm_c	Import price (foreign currency)		

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

Symbol	Explanation	Symbol	Explanation
Greek Symbols			
α_a^a	Efficiency parameter in the CES activity function	δ_{cr}^t	CET function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor *f* in activity *a*
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity c for household h
α_c^q	Armington function shift parameter	θ_{ac}	Yield of output c per unit of activity a
α_c^t	CET function shift parameter	ρ_a^a	CES production function exponent
β^a	Capital sectoral mobility factor	ρ_a^{va}	CES value-added function exponent
β_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	ρ_c^{ac}	Domestic commodity aggregation function exponent
δ_a^a	CES activity function share parameter	ρ_c^q	Armington function exponent
δ_{ac}^{ac}	Share parameter for domestic commodity aggregation function	ρ_c^t	CET function exponent
δ_{cr}^q	Armington function share parameter	η_{fat}^a	Sector share of new capital
υ_f	Capital depreciation rate		
Exogenous Variables			
$\overline{CPI}$	Consumer price index	$\overline{MPSADJ}$	Savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	Change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_f$	Quantity supplied of factor
$\overline{FSAV}$	Foreign savings (FCU)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	Government consumption adjustment factor	$\overline{WFDIST}_{fa}$	Wage distortion factor for factor f in activity a
$\overline{IADJ}$	Investment adjustment factor		
Endogenous Variables			
AWF_{ft}^a	Average capital rental rate in time period t	QG_c	Government consumption demand for commodity
$DMPS$	Change in domestic	QH_{ch}	Quantity consumed of

	institution savings rates (= 0 for base; exogenous variable)		commodity c by household h
DPI	Producer price index for domestically marketed output	QHA_{ach}	Quantity of household home consumption of commodity c from activity a for household h
EG	Government expenditures	$QINTA_a$	Quantity of aggregate intermediate input
EH_h	Consumption spending for household	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
EXR	Exchange rate (LCU per unit of FCU)	$QINV_c$	Quantity of investment demand for commodity
$GSAV$	Government savings	QM_{cr}	Quantity of imports of commodity c
QF_{fa}	Quantity demanded of factor f from activity a		

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

Symbol	Explanation	Symbol	Explanation
Endogenous Variables Continued			
MPS_i	Marginal propensity to save for domestic non-government institution (exogenous variable)	QQ_c	Quantity of goods supplied to domestic market (composite supply)
PA_a	Activity price (unit gross revenue)	QT_c	Quantity of commodity demanded as trade input
PDD_c	Demand price for commodity produced and sold domestically	QVA_a	Quantity of (aggregate) value-added
PDS_c	Supply price for commodity produced and sold domestically	QX_c	Aggregated quantity of domestic output of commodity
PE_{cr}	Export price (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity c from activity a
$PINTA_a$	Aggregate intermediate input price for activity a	RWF_f	Real average factor price
PK_{ft}	Unit price of capital in time period t	$TABS$	Total nominal absorption
PM_{cr}	Import price (domestic currency)	$TINS_i$	Direct tax rate for institution i (i $\in$ INSDNG)

PQ_c	Composite commodity price	$TRII_{ii'}$	Transfers from institution i' to i (both in the set INSDNG)
PVA_a	Value-added price (factor income per unit of activity)	WF_f	Average price of factor
PX_c	Aggregate producer price for commodity	YF_f	Income of factor f
$PXAC_{ac}$	Producer price of commodity c for activity a	YG	Government revenue
QA_a	Quantity (level) of activity	YI_i	Income of domestic non-government institution
QD_c	Quantity sold domestically of domestic output	YIF_{if}	Income to domestic institution i from factor f
QE_{cr}	Quantity of exports	ΔK^a_{fat}	Quantity of new capital by activity a for time period t

Table A2. CGE model equations

Production and Price Equations

$QINT_{c\,a} = ica_{c\,a} \cdot QINTA_a$	(1)
$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$	(2)
$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}-1}$	(4)
$QF_{f\,a} = \alpha_{f\,a}^{van} \cdot \left(\sum_{f' \in F} \delta_{f\,f'a}^{van} \cdot QF_{f'a}^{-\rho_{f\,a}^{van}} \right)^{-\frac{1}{\rho_{f\,a}^{van}}}$	(5)
$W_{f'} \cdot WFDIST_{f'a} = W_f \cdot WFDIST_{f\,a} \cdot QF_{f\,a} \cdot \left(\sum_{f'' \in F} \delta_{f\,f''a}^{van} \cdot QF_{f''a}^{-\rho_{f\,a}^{van}} \right)^{-1} \cdot \delta_{f\,f'a}^{van} \cdot QF_{f'a}^{-\rho_{f\,a}^{van}-1}$	(6)
$QVA_a = iva_a \cdot QA_a$	(7)
$QINTA_a = inta_a \cdot QA_a$	(8)
$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$	(9)
$QXAC_{a\,c} = \theta_{a\,c} \cdot QA_a$	(10)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(11)
$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$	(12)
$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}-1}$	(13)
$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c}$	(14)
$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}}$	(15)
$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PDS_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}}$	(16)

Table A3. CGE model equations (continued)

$QX_c = QD_c + \sum_r QE_{cr}$	(17)
$PX_c \cdot QX_c = PDS_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr}$	(18)
$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c}$	(19)
$PM_{cr} = pwm_{cr} \cdot (1 + tm_{cr}) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c}$	(20)
$QQ_c = \alpha_c^q \cdot \left(\sum_r \delta_{cr}^q \cdot QM_{cr}^{-\rho_c^q} + (1 - \sum_r \delta_{cr}^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}}$	(21)
$\frac{QM_{cr}}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \sum_r \delta_{cr}^q} \right)^{\frac{1}{1+\rho_c^q}}$	(22)
$QQ_c = QD_c + \sum_r QM_{cr}$	(23)
$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + \sum_r PM_{cr} \cdot QM_{cr}$	(24)
$QT_c = \sum_{c' \in C'} \left(icm_{cc'} \cdot QM_{c'} + ice_{cc'} \cdot QE_{c'} + icd_{cc'} \cdot QD_{c'} \right)$	(25)
$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c$	(26)
$DPI = \sum_{c \in C} PDS_c \cdot dwts_c$	(27)
Institutional Incomes and Domestic Demand Equations	
$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa}$	(28)
$YIF_{if} = shif_{if} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right]$	(29)
$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR$	(30)
$TRII_{ii'} = shii_{ii'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'}$	(31)
$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot (1 - MPS_h) \cdot (1 - \overline{tins}_h) \cdot YI_h$	(32)
$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m \right)$	(33)
$QINV_c = IADJ \cdot \overline{qinv}_c$	(34)
$QG_c = \overline{GADJ} \cdot \overline{qg}_c$	(35)

Table A3. CGE Model Equations (continued)

$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI}$	(36)
System Constraints and Macroeconomic Closures	
$YG = \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR$	(37)
$QQ_c = \sum_{a \in A} QINT_{c\,a} + \sum_{h \in H} QH_{c\,h} + QG_c + QINV_c + qdst_c + QT_c$	(38)
$\sum_{a \in A} QF_{f\,a} = QFS_f$	(39)
$YG = EG + GSAV$	(40)
$\sum_{r\ c \in CMNR} pwm_{cr} \cdot QM_{cr} + \sum_{f \in F} trnsfr_{row\ f} = \sum_{r\ c \in CENR} pwe_{cr} \cdot QE_{cr} + \sum_{i \in INSD} trnsfr_{i\,row} + FSAV$	(41)
$\sum_{i \in INSDNG} MPS_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$	(42)
$MPS_i = \overline{mps}_i \cdot \left(1 + MPSADJ\right)$	(43)
Capital Accumulation and Allocation Equations	
$AWF^a_{f\,t} = \sum_a \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right]$	(44)
$\eta^a_{f\,a\,t} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{AWF^a_{f\,t}} - 1 \right) + 1 \right)$	(45)
$\Delta K^a_{f\,a\,t} = \eta^a_{f\,a\,t} \cdot \left(\frac{\sum_c PQ_{c\,t} \cdot QINV_{c\,t}}{PK_{f\,t}} \right)$	(46)
$PK_{f\,t} = \sum_c PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}}$	(47)
$QF_{f\,a\,t+1} = QF_{f\,a\,t} \cdot \left(1 + \frac{\Delta K^a_{f\,a\,t}}{QF_{f\,a\,t}} - \upsilon_f \right)$	(48)
$QFS_{f\,t+1} = QFS_{f\,t} \cdot \left(1 + \frac{\sum_a \Delta K_{f\,a\,t}}{QFS_{f\,t}} - \upsilon_f \right)$	(4

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