Short and Long-run Impacts of Food Price Changes on Poverty

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Abstract

There is now considerable evidence that rapid increases in food prices raise poverty in most developing countries. Key reasons for this are that the poor spend large share of their incomes on food, and that many poor farmers are net buyers of food. However, there are reasons to suspect that high food prices may be less harmful for the poor in the longer run as producers and consumers adjust to higher agricultural prices. Using expenditure and agricultural production data for a sample of twenty-nine developing countries, and a household model designed for broad consistency with and solved in parallel with the widely-used GTAP model, we evaluate short and long-term consequences of increased food price changes on poverty. We find that high food prices have sharply adverse impacts on poverty in the short run, but much smaller impacts in the long run. However, bringing down food prices through raising productivity growth has particularly large favorable impacts on poverty by lowering the costs of food to consumers, raising agricultural incomes, and increasing wage rates for unskilled labor.

*This paper reflects the views of the authors alone and not necessarily those of the World Bank.

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Introduction

In the recent period of high and volatile food prices, there has been considerable concern about the impacts on global poverty. A number of analyses that have estimated the immediate impacts of higher food prices have concluded that in most developing countries higher food prices raise the poverty headcount because there are generally insufficient numbers of poor farming households who benefit from higher sales prices of their production (Ivanic and Martin 2008,de Hoyos and Medvedev 2011; Ivanic, Martin and Zaman 2011) to offset the negative impact of higher food prices on net consumers. This is despite the well-known fact that three-quarters of the world's poor live in rural areas, and most of them depend on agriculture for their livelihoods. A key to this apparent contradiction is the fact that many of the poorest farming households are actually net buyers of staple foods.

Much of the concern about high food prices in recent years—and the more intense price peak during the 1970s—has arisen in a context of intense price spikes such as those in 2007-8 and 2010. Deaton and Laroque (1992) characterize the price behavior of storable commodities, as being characterized by long periods in the doldrums, punctuated by intense but short-lived price spikes. If the poor are adversely affected by such surges in food prices, and if they frequently have little ability to buffer the effects of these price shocks, then these periods of high prices—whether seen as a problem of high prices or as a problem of volatility—would appear to be a serious concern.

Given the focus of the influential and provocative papers by Barrett and Bellemare (2011) and Bellemare, Barrett and Just (2010) on bringing down high prices, rather than attempting to reduce price volatility, it seems very important to distinguish between the poverty impacts of short periods of high prices and of sustained high prices. If the major concern is with high prices in general, then this concern would arise even with sustained high prices, with major potential implications for a wide range of policies that affect the long run level of the prices facing producers and consumers in developing countries.

Most of the available analyses of the impacts of food price impacts on poverty follow Deaton (1986) in taking into account the first order impacts of higher food prices on household incomes that are determined by the initial net-sales position of each household. Some, in addition, consider the impacts of food prices on the quantity of food demanded (Friedman and Levinsohn 2002). Others have pushed further on the demand side, assessing the impacts of food price increases on the quality of food consumed (Gibson and Kim 2011) and by comparing impacts on quantities of food consumed with impacts on calorie consumption (d'Souza and Joliffe 2010). Very few studies of the distributional impacts of food price changes appear to have examined the impacts of food price changes on the supply of different foods, and hence the longer-term impacts of changes in food supplies on farmers' incomes.

In the case of short-run price volatility, where producer outputs are likely close to fixed, the change in farmers' revenue from production is determined by the changes in output prices only. In the longer-run, farmers can be expected to respond to rising food prices in two distinct ways: by raising their overall output and by switching towards producing those items whose prices have risen relative to others. Expansion of overall output can be achieved by using more inputs and factors (such as labor) to raise overall farm output even if no additional land is available. Where the relative prices of different commodities change, switching between outputs is another potentially important way for farmers to achieve higher returns. In general, it is likely that there will be greater flexibility in the response of individual commodities than in the response of aggregate agricultural output.

In this paper we address some of the key linkages between food prices and global poverty. To understand the long-run adjustment options of the farmers who face changing output prices, we develop microeconomic simulation models which account for the changes in farmers' profits as a result of changes in output prices. Using the estimates from this model, we are then able to compare short- and long-run poverty impacts of higher food prices, both in the case when the prices of individual crops rise independently and when all food prices rise together.

When considering changes in food prices, it is very important to consider the source of the change. A change in food prices resulting from an exogenous shock such as a rise in demand for biofuels is likely to have quite different impacts on poverty than one that arises from a change in the rate of productivity growth—such as may arise from successful investments in Research and Development, or from climate change. In the first part of this paper we focus on changes in poverty that result from the first type of shock. In the second part of the paper we consider the implications of changes in food prices that result from changes in productivity.

Methodology

Measuring poverty impacts at the household level

Ideally one would analyze the impacts of shocks such as food price changes or policy reforms using a model in which demands for goods were determined as the total of demands from individual households, and supplies were similarly determined using models of individual firms. Given that food prices are determined in global markets, such a model would need to represent all households and firms in the world in order to capture the total impacts of major shocks such as those contributing to the food price spikes in 2008 and 2010.

Unfortunately, the development of such a model is not feasible at this point. As a feasible alternative, that retains the detailed information on the characteristics of each household, we link household models based on survey data for 29 countries with a global general equilibrium model (GTAP). Where our experiments involve policies—such as trade policies or changes in technology that affect world prices—a global general equilibrium model can be used to estimate the impacts of the relevant shocks on prices of internationally traded goods, and the prices of non-traded goods and factor returns in each region. These prices are then passed to household models based on survey data that are used to assess the impacts of the shock on the real income of each household.

At the household level, we analyze the implications of changes in food prices through a series of micro simulations where for each individual household we simulate the impact of food price changes and any mitigating effects on the households' welfare, both measured as equivalent variation. To measure households' welfare, we assume that the cost to the household achieving a given level of utility can be expressed using an expenditure function $e(\boldsymbol{p},u)$. Conventional practice in this type of modeling (see, for example, the studies in Hertel and Winters 2006) is to consider the impacts of changes in prices on the factor returns accruing to households, and to compare these impacts with those on the cost of living as measured using the expenditure function. Given our focus on the effects of changes in particular—and sometimes quite finely-specified—food prices, we adopt a different approach more frequently seen in microeconomic studies of the impact of changing food prices on poverty (see, for example, Ravallion 1990). Given the close links—and the substantial evidence of non-separability between firm and household decisions—between the small farm households of most concern to us and their farm businesses, we focus on the impact of price changes on the profits that farming households derive from their own farm firms.

We also consider the impacts of changes in factor prices on the returns that farm households obtain from their net sales of factors outside the farm firm. Given that farm firms are price takers and operate subject to constant returns to scale, the revenues obtained from sales of output (including "sales" to the household for its own consumption) must equal the returns to the factors employed by the firm.

A money measure of changes in household welfare is given by:

(1) $B = e(\boldsymbol{p},u) - \pi(\boldsymbol{p}) - \boldsymbol{w}.\boldsymbol{l} - \boldsymbol{f}$

where $\pi(\boldsymbol{p})$ is a function representing the revenues generated by the farm firm; $\boldsymbol{l}$ is a vector of net sales of factors outside the household; $\boldsymbol{w}$ is a vector of factor prices; and $\boldsymbol{f}$ represents other net transfers to the household, potentially including policy-based transfers.

We define a measure of the change in the household's welfare resulting from a price change as the difference between the change in profits , and the change in the cost of achieving the original level of utility , following the change in the vector of prices of factors and consumption goods . Where supplies of factors outside the household do not change substantially, we can write an equivalent variation measure of the change in household welfare as:

$$-\boldsymbol{f}$$

By the envelope theorem, we know that — and — where $\boldsymbol{q}$ is a vector of consumption quantities and $\boldsymbol{x}$ is a vector of firm outputs of the relevant goods. Given this, we can obtain a first-order approximation to the effect of a change in $\boldsymbol{p}$ on B as a share of initial expenditure as:

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where S_i is the share of good i in household expenditures; H_i is the value of firm output of i as a share of total household expenditure; and K_i is net sales of factor i as a share of household expenditure. This is the approach used by Ivanic and Martin (2008) to estimate the impacts of the 2006-8 price spike in staple foods on real household incomes in poor countries, and hence the impacts on poverty. Some simulations contained only estimates of the direct impacts of food price changes, while others included the effects through factor price changes (and particularly wage rates for unskilled labor) resulting from those food price changes.

To estimate the long-run implications of food price changes on poverty requires that we allow for the effects of changes in prices on the quantities of goods produced and consumed. We would like to do this in a way that ensures consistency between the behavior of the household models and the economy-wide models used to generate the changes in prices. Because of the complexity of the demand and production systems used in the economy-wide model, we proceeded using a second-order approximation that is broadly consistent with the economy-wide model.

On the demand side, we work with a second-order estimate of the change in the cost of utility for each household as – , where is the initial level of expenditure, is a matrix of compensated demand elasticities, is a vector of expenditures on individual items and is a vector of percentage changes in prices. The first term on the right hand side of this equation is a first-order approximation of the change in expenditure needed to achieve a given level of utility, while the second term takes into the ability of consumers to adjust their consumption patterns in response to changes in prices. The details of the approach used to obtain a demand system compatible with the demand system used in the GTAP model are given in the Appendix, together with the average own-price elasticities of demand for major commodities.

On the farm-firm profit side, we express the change in profits following a change in prices using another second-order approximation: – ,
where is a matrix of own and cross-price elasticities, the vector is the observed initial vector of the values of inputs and outputs. We infer the parameters of the matrix using a three-level nested production system. Following Dixon *et al* (1982), this system uses a Constant Ratio of Elasticities of Transformation, Homothetic (CRETH) function (Hanoch 1971; Vincent, Dixon and Powell 1980) to provide a reasonably tractable, semi-flexible representation of the transformation of output into different commodities. At a lower level, a two-level CES system is used to determine the household firm's aggregate output level as a function of the profitability of its output mix. More information on the specification used to represent production is given in the Appendix.

Measuring aggregate poverty levels

Aggregating across all households, we calculate poverty figures associated with each micro simulation for total population and various groups of households. The poverty lines used in our calculations, reported in the World Bank's PovCalNet, were calculated using our household surveys in conjunction with the published poverty rates at a $1.25-a-day poverty line.[1] Using the elasticity of 0.6 for the cost of living with respect to household size estimated by (Lanjouw and Ravallion 1995), we identified the effective per-capita expenditure level of the households at the poverty line and used this estimate as the poverty line throughout the study. If, as a result of a simulation, the effective per-capita expenditure of a household crosses the poverty line, we account for this and update the list of households in poverty and the poverty headcount.

Data

We base our work on an extensive dataset of household expenditures and incomes which has been constructed using the available household survey data for 29 developing countries listed in Table 1—all of the countries where we have been able to obtain data from the past ten years on both expenditures on and income derived from the food commodities of interest. In terms of population, our sample covers about half of the low- and middle-income countries and represents some large developing countries (e.g. India) as well as a number of small ones (eg Belize, Albania). Due to the availability of the data, our sample covers best the regions of South Asia (nearly 100 percent coverage) with other regions being represented by a smaller number of countries; however, each region is represented by at least one country.

The data collected in our dataset include household-level production and expenditure data for forty-two distinct food and agricultural items, and total household expenditure. The information on household finances is supplemented with a number of variables describing the characteristics of the household members which allows us to understand consumption and production patterns, and the impacts of any changes, on different socioeconomic and demographic groups.

[1] We used the PovCalNet web-based tool to obtain the latest estimates of the poverty rates at $1.25-a-day poverty line definition.

Simulations

In our first set of simulations, we measure the short and long run impacts on poverty of changes in individual food prices in the short and long run. For each commodity, we measure the corresponding poverty impact for a range of a ten-percent price rise. We do this first using fixed income and expenditure shares, an approach we term a short-run analysis. We then repeat the analysis taking into account adjustments in quantities demanded and supplied, in a long-run scenario.

In a second set of simulations, we estimate the impact of a reduction in food prices brought about through an increase in agricultural productivity on global poverty. Using the GTAP model and the latest version 8 GTAP database, we model the impact of a ten-percent productivity increase in all countries and, alternatively, all developing countries only. We then feed the key inputs obtained from the global model such as commodity price changes and wages into our set of micro-simulation models and estimate and decompose the resulting poverty impacts.

Results for Price Changes

In our first simulation, we compare the impacts of 10 percent increases in food prices on the $1.25 per day poverty headcount under alternative assumptions about the ability of producers and consumers to adjust their production and consumption quantities. The short-run results presented in Table 2 assume no changes in quantities produced or consumed. The long-run results presented in Table 3 allow for changes in quantities demanded and in quantities supplied.

In the short run, the largest impacts on the poverty rate tend to be for the composite of "Fruits and vegetables", and then for wheat and rice. A 10 percent increase in the price of fruits and vegetables raises the poverty headcount by an average of 0.19 percentage points. At the national level, the impact varies considerably, from -0.28 in Vietnam, to 0.88 in India. With this simple measure, the result depends only upon the initial net trade shares of each household—suggesting that there may be relatively more low-income households that are net sellers of fruits and vegetables in Vietnam than in India. For wheat, the average is 0.14, with a range from zero in Albania to 0.74 percentage points in Yemen. For rice, the average effect is 0.09, with a range from -0.35 in Vietnam to 0.53 in Timor-Leste. The negative impact on poverty in Vietnam is well known, and reflects a combination of Vietnam's excellent resource endowments for rice production, and its egalitarian distribution of resources which results in a large number of poor households being net sellers of rice. For all foods considered together, the total effect averages 1.14, with this effect in individual countries ranging from -3.04 in Cambodia to 3.81 for Tajikistan.

When we turn to the long run, the situation frequently changes. The overall average impact drops from 1.14 in the short-run to 0.48 in the long-run case. The average impacts of most commodities decline but stay the same sign. However, there are a few cases, such as cattle, where the sign does change from positive to negative as farmers near the poverty line increase their output. The total impact declines in most countries, sometimes by a small and sometimes by a much larger amount.

Results for Productivity Changes

The second set of simulations that we perform involves changes in productivity growth that result in changes in food prices. For comparability, we consider a ten percent increase in agricultural productivity world-wide. This increase in productivity has three major impacts that are relevant to poverty: (i) it lowers world prices by increasing global supply and (by assumption) the supply in each individual country, (ii) it raises producer returns at any given price; and (iii) it raises wage rates for unskilled labor, particularly in countries where agriculture accounts for a large share of GDP.

The price impacts of an improvement in productivity tend to be relatively large because the increase in output at any given output price level includes two effects (see Martin and Alston —the increase in output for any given level of resource use, and (ii) the increase in the desired input use resulting from higher profitability at that level of prices. The estimated impacts on the average real import prices for key foods are given in Table 5.

The impacts of this increase in productivity, and the consequent changes in prices, on the global poverty headcount are given in Table 6 for an increase in productivity for all agricultural commodities worldwide. These favorable impacts are generally much larger in absolute value than the adverse impacts of higher food prices on poverty. They also tend to be larger in the poorer, more agriculture-dependent economies such as Cambodia than in the middle income transition economies where agriculture is already a smaller share of total income. The largest source of poverty reduction in this scenario is a decline in the price of consumer goods. The second largest source of gain in most cases is increases in wage rates for unskilled labor sold off-farm. The gain in productivity experienced by farmers is only the third largest source of poverty reduction. The decline in producer prices pushes some net-selling farm households towards poverty. In some countries, and on average, the direct contribution to poverty reduction from higher farm productivity outweighs the impact of lower producer prices as a source of progress son poverty reduction, but in a few cases, the decline in producer prices outweighs the gain from higher productivity.

When productivity growth is more narrowly focused on developing countries, the overall impact on poverty is just as large, even though the impact on world prices, and the consumer gains from lower prices, are smaller. This suggests that research that focuses just on raising productivity in developing countries can have just as large an impact on global poverty as research that covers both industrial and developing countries.

Conclusions

In this study, we address some of the issues regarding the differences between the short- and long-run impacts of higher food prices on global poverty which can be attributed to the ability of farmers to adjust their production with regard to the changing prices of their output. Using an large set of household survey data, we simulate the effect of allowing for second-order impacts of consumers' demand responses and farmers' production responses on the poverty impacts of changes in the prices of individual crops.

The first-round impacts of increases in food prices—without allowing for quantity responses—tend to increase poverty when all food prices rise, and particularly when prices of products such as wheat, rice, vegetables and fruit rise. There are important exceptions such as rice in Vietnam and Cambodia, where countries with strong comparative advantage in key crops have many poor households who are net sellers of food.

When we allow for adjustments in demand and supply at the household level and move from first to second-order estimates of the impacts of food price changes on household welfare, we find some substantial changes in the poverty impacts of food price rises. The overall average impact declines from 1.14 to 0.48 with declines in the adverse impacts of food prices in most countries, although with few reversals of sign.

One key influence on the long-run level of prices is the rate of technical progress. We find that a 10 percent improvement in productivity will reduce world prices by more than 10 percent, but that the overall, long-run benefit in terms of poverty reduction will be greater than the benefit of a similar reduction in prices not associated with an improvement in productivity.

Our finding that higher food prices have adverse impacts on poverty even in the long run is consistent with the Barrett and Bellemare (2011) suggestion that there should be a long run focus on reducing food prices. However, the fact that the adverse impacts of high food prices on poverty are so large suggests a need for caution about the impacts of price volatility involving short periods of very high prices associated with difficult-to-predict price spikes. A better guide to longer-run policy than simply a focus on reducing high prices appears to be to try to identify and implement policies that contribute the most to poverty reduction.

Table 1: Household surveys used in this study

Albania	Living Standards Measurement Survey	2005
Armenia	Integrated Survey of Living Standards	2005
Bangladesh	Household Income-Expenditure Survey	2005
Belize	Household Income and Expenditure Survey	2009
Cambodia	Household Socio-economic Survey	2003
Côte d'Ivoire	Enquete Niveau de Vie des Menages	2002
Ecuador	Encuesta Condiciones de vida – Quinta Ronda	2006
Guatemala	Encuesta Nacional de Condiciones de Vida	2006
India	Socio-economic survey (schedules 33/59, 1/61 and 10/61)	2002–4
Indonesia	Indonesia Family Life Survey	2007
Malawi	Second Integrated Household Survey	2004
Moldova	Cercetarea Bugetelor de Familie	2009
Mongolia	Household Income and Expenditure Survey	2002
Nepal	Nepal Living Standards Survey II	2002
Nicaragua	Encuesta Nacional de Hogares sore Medicion de Nivel de Vida	2005
Niger	Enquete National sur Le Budget et la Consommation des Menages	2007
Nigeria	Nigeria Living Standards Survey	2003
Pakistan	Pakistan Social and Living Standards Measurement Survey	2005
Panama	Encuesta de Niveles de Vida	2003
Peru	Encuesta Nacional de Hogares	2007
Rwanda	Integrated Household Living Conditions Survey	2005
Sri Lanka	Household Income and Expenditure Survey	2007
Tajikistan	Living Standards Measurement Survey	2007
Tanzania	National Panel Survey	2008
Timor-Leste	Poverty Assessment Project	2007
Uganda	Socio-Economic Survey	2005
Vietnam	Household Living Standard Survey	2004
Yemen	Household Budget Survey	2006
Zambia	Living Conditions Monitoring Survey	2010

Table 2: Short-run poverty impacts of ten-percent commodity price increases, $1.25 per day

	Cattle	Fruits and vegetables	Maize	Milk	Oils	Other crops	Other food	Poultry	Rice	Sugar	Swine	Wheat	Total
Albania	-0.03	-0.07	0.00	-0.16	0.07	0.00	-0.10	0.00	0.00	0.00	0.00	0.00	-0.28
Armenia	0.01	-0.05	0.00	-0.22	0.15	0.01	0.55	0.07	0.10	0.11	0.00	0.14	0.86
Bangladesh	0.14	0.61	0.00	0.00	0.23	-0.01	1.45	0.06	0.16	0.00	0.00	0.04	2.70
Belize	0.02	0.13	0.00	0.27	0.07	0.05	0.50	0.10	0.05	0.05	-0.04	0.10	1.31
Côte d'Ivoire	0.08	0.48	0.09	0.02	0.01	-0.35	0.36	0.01	0.59	0.05	0.03	0.07	1.45
Ecuador	0.08	0.21	-0.04	0.07	0.06	0.00	0.28	0.05	0.07	0.04	0.00	0.02	0.83
Guatemala	0.08	0.28	0.11	0.05	0.04	-0.08	0.22	0.09	0.02	0.15	0.01	0.14	1.11
India	0.00	0.03	0.00	0.00	0.06	-0.04	0.49	0.00	0.07	0.06	0.00	0.00	0.67
Indonesia	0.01	0.51	0.01	0.35	0.22	0.14	0.47	0.03	0.49	0.11	0.01	0.18	2.53
Cambodia	-0.40	-0.25	-0.03	0.00	-0.06	-0.16	-0.34	-0.06	-1.52	-0.01	-0.20	0.00	-3.04
Malawi	0.00	0.46	0.00	0.20	0.15	-0.01	1.41	0.00	0.49	0.10	0.00	0.14	2.94
Moldova	0.00	0.20	0.00	0.19	0.11	0.03	0.39	0.04	0.06	0.10	0.01	0.19	1.33
Mongolia	-0.01	0.23	0.00	0.12	0.06	0.09	0.48	0.00	0.27	0.19	0.00	0.48	1.91
Nepal	0.00	0.11	0.13	-0.02	0.08	0.00	-0.02	0.03	0.00	0.12	0.05	0.03	0.51
Nicaragua	-0.07	-0.17	-0.01	0.02	0.21	0.62	0.17	-0.20	0.33	0.09	0.00	0.12	1.11
Niger	0.14	0.06	0.00	0.05	0.19	-0.08	0.26	0.00	0.22	-0.02	0.00	0.10	0.93
Nigeria	0.02	0.03	0.00	0.10	0.04	0.00	0.16	0.00	0.01	0.02	0.00	0.00	0.38
Pakistan	-0.15	-0.05	0.00	-0.10	0.20	0.04	0.32	0.00	0.07	0.12	-0.02	0.12	0.55
Panama	0.07	0.58	0.00	0.29	0.31	0.13	0.28	0.14	0.19	0.37	0.00	0.72	3.09
Peru	-0.01	0.07	0.03	0.03	0.05	0.06	0.22	0.05	0.13	0.14	0.02	0.00	0.80
Rwanda	-0.06	-0.01	-0.01	0.02	0.06	0.02	0.14	-0.01	0.09	0.10	-0.02	0.12	0.45
Sri Lanka	-0.04	0.28	-0.01	0.01	0.10	-0.01	0.29	-0.01	0.02	0.06	0.00	0.05	0.74
Tajikistan	0.49	0.88	-0.10	0.02	0.46	0.03	1.27	0.04	0.29	0.26	0.00	0.16	3.81
Tanzania	-0.05	0.14	0.01	0.01	0.17	-0.33	0.26	0.00	0.53	0.14	-0.03	0.00	0.86
Timor-Leste	0.06	0.17	0.39	-0.07	0.29	0.01	0.73	0.00	0.20	0.18	-0.07	0.07	1.97
Uganda	0.01	0.11	0.00	0.03	0.17	-0.07	0.40	-0.01	0.02	0.12	-0.01	0.00	0.78
Vietnam	-0.08	-0.28	-0.15	0.04	0.03	-0.09	0.43	0.02	-0.37	-0.05	-0.01	0.08	-0.42
Yemen	0.01	0.51	0.09	0.06	0.18	-0.38	0.23	0.20	0.12	0.35	0.00	0.74	2.09
Zambia	-0.02	0.25	-0.25	0.01	0.09	-0.02	0.73	0.04	0.06	0.14	-0.01	0.16	1.19
Average	0.01	0.19	0.01	0.05	0.13	-0.01	0.42	0.02	0.09	0.11	-0.01	0.14	1.14

Table 3: Long-run poverty impacts of ten-percent commodity price increases

	Cattle	Fruits and vegetables	Maize	Milk	Oils	Other crops	Other food	Poultry	Rice	Sugar	Swine	Wheat	Total
Albania	-0.03	-0.07	0.00	-0.21	0.07	0.00	-0.10	0.00	0.00	0.00	0.00	0.00	-0.33
Armenia	0.01	-0.06	0.00	-0.24	0.15	0.01	0.51	0.07	0.10	0.11	0.00	0.14	0.81
Bangladesh	0.14	0.51	-0.02	-0.03	0.23	-0.04	1.41	0.06	-0.38	0.00	0.00	0.04	1.94
Belize	0.02	-0.02	0.00	0.27	0.07	0.05	0.50	0.10	0.05	0.05	-0.04	0.10	1.15
Côte d'Ivoire	0.06	0.16	0.09	0.02	0.01	-0.42	0.35	0.01	0.47	0.05	0.03	0.07	0.90
Ecuador	0.08	0.14	-0.06	0.07	0.05	-0.01	0.21	0.04	0.06	0.04	0.00	0.02	0.65
Guatemala	0.08	0.26	-0.14	0.05	0.04	-0.08	0.22	0.09	0.02	0.15	0.01	0.13	0.83
India	-0.02	0.00	0.00	0.00	0.06	-0.07	0.45	0.00	-0.02	0.03	0.00	0.00	0.42
Indonesia	0.01	0.49	0.01	0.35	0.21	0.13	0.47	0.03	0.47	0.11	0.01	0.15	2.45
Cambodia	-0.42	-0.29	-0.03	0.00	-0.07	-0.16	-1.15	-0.06	-2.07	-0.01	-0.20	0.00	-4.46
Malawi	0.00	0.46	0.00	0.20	0.15	-0.07	1.41	0.00	0.49	0.10	0.00	0.14	2.88
Moldova	0.00	0.15	0.00	0.17	0.11	0.03	0.32	0.02	0.06	0.10	0.01	0.19	1.16
Mongolia	-0.45	0.23	0.00	-0.10	0.06	0.09	-0.71	0.00	0.27	0.19	0.00	0.48	0.05
Nepal	-0.01	-0.14	-0.22	-0.02	0.06	0.00	-0.17	0.00	-0.02	0.12	0.03	0.03	-0.33
Nicaragua	-0.22	-0.21	-0.01	-0.01	0.21	0.62	0.09	-0.26	0.33	0.09	0.00	0.12	0.76
Niger	0.12	-0.09	-0.02	0.05	0.19	-0.10	0.21	0.00	0.15	-0.02	0.00	0.10	0.59
Nigeria	0.02	0.03	0.00	0.08	0.04	0.00	0.13	0.00	0.00	0.02	0.00	0.00	0.32
Pakistan	-0.17	-0.07	0.00	-0.10	0.20	0.04	0.31	0.00	-0.09	0.12	-0.02	0.12	0.35
Panama	0.07	0.58	0.00	0.22	0.31	0.13	0.28	0.14	0.19	0.34	0.00	0.70	2.97
Peru	-0.01	0.04	0.01	0.03	0.05	0.06	0.16	0.03	0.13	0.14	0.02	0.00	0.65
Rwanda	-0.08	-0.05	-0.03	0.01	0.06	0.02	0.10	-0.01	0.08	0.10	-0.02	0.11	0.32
Sri Lanka	-0.12	-0.43	-0.01	0.01	0.10	-0.12	0.24	-0.01	0.00	0.06	0.00	0.01	-0.28
Tajikistan	0.47	0.77	-0.10	-0.03	0.37	0.02	0.46	0.04	0.27	0.24	0.00	0.03	2.54
Tanzania	-0.46	-0.38	-0.03	0.01	0.11	-0.90	-0.15	0.00	0.47	0.14	-0.08	0.00	-1.25
Timor-Leste	0.06	0.17	0.39	-0.11	0.29	0.01	0.73	-0.08	0.17	0.18	-0.07	0.07	1.83
Uganda	-0.02	-0.18	-0.03	0.00	0.16	-0.07	0.33	-0.01	0.01	0.12	-0.01	0.00	0.30
Vietnam	-0.08	-0.32	-0.18	0.04	0.03	-0.10	0.42	-0.01	-0.51	-0.05	-0.07	0.08	-0.75
Yemen	-0.13	0.18	0.04	0.06	0.17	-1.65	-2.75	-0.01	-0.08	0.34	0.00	0.66	-3.16
Zambia	-0.04	-0.11	-0.32	0.01	0.08	-0.02	0.65	0.04	0.05	0.14	-0.01	0.16	0.64
Average	-0.04	0.06	-0.02	0.03	0.12	-0.09	0.17	0.01	0.02	0.10	-0.01	0.13	0.48

Table 4. Impacts of a 10 percent improvement in productivity on average import prices

	Global 10-percent productivity increase
Rice	-14.6
Grains	-12.5
Fruits and vegetables	-11.5
Wheat	-12.6
Oils	-14.1
Beef	-15.3
Other meat	-15.6
Milk	-15.9
Sugar	-12.5
Other food	-12.3

Table 5: Poverty headcount impacts, 10% global productivity increase, % pts

	Prices		Productivity	Wages	Total
	Consumption	Production			
Albania	-0.2	0.1	-0.1	0.0	-0.2
Armenia	-0.7	0.3	-0.3	-1.6	-2.3
Bangladesh	-2.1	0.7	-0.7	-1.2	-3.4
Belize	-0.1	0.0	0.0	-2.5	-2.6
Côte d'Ivoire	-1.9	1.1	-1.1	0.1	-1.7
Ecuador	-1.0	0.4	-0.4	-1.1	-2.1
Guatemala	-1.8	0.7	-0.7	-0.8	-2.7
India	-1.1	0.2	-0.1	-0.2	-1.2
Indonesia	-1.6	0.2	-0.2	-1.6	-3.1
Cambodia	-4.1	3.8	-3.1	-1.9	-5.2
Malawi	-1.7	0.1	-0.1	-0.9	-2.6
Moldova	-1.6	0.2	-0.2	-0.3	-1.9
Mongolia	-3.3	-1.7	1.5	-1.0	-4.5
Nepal	-2.6	1.2	-1.7	-0.3	-3.4
Nicaragua	-1.3	0.5	-0.5	0.0	-1.4
Niger	-1.9	0.6	-0.4	0.2	-1.6
Nigeria	-0.6	0.3	-0.3	-0.2	-0.8
Pakistan	-1.5	0.9	-0.8	-0.7	-2.2
Panama	-2.2	0.2	-0.2	-3.1	-5.3
Peru	-0.8	0.3	-0.3	-0.1	-0.9
Rwanda	-0.9	0.4	-0.3	-0.3	-1.1
Sri Lanka	-0.8	-0.2	0.2	-0.1	-1.0
Tajikistan	-3.4	-0.1	0.2	-1.2	-4.5
Tanzania	-1.7	-1.3	1.3	-0.7	-2.4
Timor-Leste	-0.8	0.3	-0.6	-0.7	-1.8
Uganda	-1.3	0.8	-1.5	-0.2	-2.2
Vietnam	-1.3	1.6	-1.0	-0.9	-1.7
Yemen	-2.0	-2.3	2.3	-0.9	-2.9
Zambia	-1.4	0.5	-1.2	-0.7	-2.9
Average	-1.6	0.3	-0.4	-0.8	-2.4

Table 6: Poverty impacts, 10% productivity increase in developing countries, % pts

	Prices		Productivity	Wages	Total
	Consumption	Production			
Albania	-0.2	0.1	-0.1	0.0	-0.2
Armenia	-0.7	0.3	-0.3	-1.6	-2.3
Bangladesh	-1.9	0.6	-0.7	-1.2	-3.2
Belize	-0.1	0.0	0.0	-2.6	-2.6
Côte d'Ivoire	-1.6	1.0	-1.1	-0.2	-1.9
Ecuador	-0.8	0.3	-0.4	-1.5	-2.4
Guatemala	-1.5	0.5	-0.6	-0.9	-2.6
India	-0.9	0.2	-0.1	-0.3	-1.2
Indonesia	-1.5	0.2	-0.2	-1.6	-3.0
Cambodia	-3.9	3.6	-3.1	-1.8	-5.2
Malawi	-1.6	0.1	-0.1	-0.8	-2.5
Moldova	-1.2	0.2	-0.2	-0.4	-1.7
Mongolia	-2.9	-1.6	1.7	-1.2	-4.0
Nepal	-2.3	1.1	-2.0	-0.3	-3.6
Nicaragua	-1.2	0.5	-0.9	0.0	-1.5
Niger	-1.9	0.6	-0.4	0.2	-1.5
Nigeria	-0.4	0.1	-0.2	-0.9	-1.4
Pakistan	-1.4	0.9	-0.9	-0.8	-2.1
Panama	-2.1	0.2	-0.2	-3.1	-5.2
Peru	-0.7	0.3	-0.3	-0.2	-0.8
Rwanda	-0.8	0.4	-0.3	-0.3	-1.1
Sri Lanka	-0.7	-0.2	0.1	-0.1	-1.0
Tajikistan	-3.1	0.0	0.1	-1.3	-4.4
Tanzania	-1.5	-1.0	1.1	-0.7	-2.1
Timor-Leste	-0.7	0.3	-0.6	-0.8	-1.9
Uganda	-1.2	0.8	-1.6	-0.2	-2.2
Vietnam	-1.1	1.3	-1.4	-0.9	-2.1
Yemen	-1.9	-2.1	2.0	-0.8	-2.7
Zambia	-1.3	0.5	-1.2	-0.7	-2.8
Average	-1.4	0.3	-0.4	-0.9	-2.4

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Appendix

Details of the Approach Used to Represent Changes in Consumer Expenditure and Producer Profits

Demand Side

For consistency with the GTAP economy-wide model, we use the Constant Difference of Elasticities (CDE) specification to characterize consumer demand (Hertel 1997). The only parameters that need to be supplied are the elements of the matrix which can be calculated using the estimated demand parameters and observed consumption shares for each household. Following (Hanoch 1975), we define a matrix of compensated elasticities for CDE preferences as: , when , and —, when , where is the vector of CDE substitution parameters and is the vector of consumption shares.

We use the estimated parameter values for from the GTAP database (Dimaranan 2006) for all countries included in our model. In a few cases where country estimates were unavailable, we used the regional averages. The values of for each household were obtained directly from the household survey data by calculating the observed consumption shares for each commodity relative to total consumption. Because the expenditure shares vary by household, the matrix of elasticities is different for each household in a manner determined by budget shares.

As an indication of the broad range of the elasticities of demand implied by the CDE, we present in Appendix Table 1 the average own-price elasticities of demand for major commodities in each country. These values seem to be reasonable, with average values of less than 0.1 for the key staple foods of wheat, rice and maize. For dairy products, beef and pork, these elasticities average around 0.17, while for sugar they average just under 0.15.

Appendix Table 1. Average Own-Price Elasticities of Demand by Country

	Rice	Wheat	Maize	Dairy	Beef	Pork	Sugar
Albania	-0.093	-0.094	-0.092	-0.200	-0.195	-0.206	-0.230
Armenia	-0.121	-0.117	-0.121	-0.175	-0.174	-0.175	-0.170
Bangladesh	-0.073	-0.085	—	-0.155	-0.149	—	-0.110
Belize	-0.118	-0.118	-0.119	-0.188	-0.190	-0.190	-0.195
Côte d'Ivoire	-0.084	-0.091	-0.088	-0.153	-0.147	-0.151	-0.119
Ecuador	-0.128	-0.129	-0.129	-0.209	-0.209	-0.210	-0.215
Guatemala	-0.101	-0.101	-0.099	-0.192	-0.189	-0.197	-0.207
India	-0.118	—	-0.128	-0.181	-0.178	—	-0.168
Indonesia	-0.072	-0.079	-0.079	-0.170	-0.169	-0.160	-0.093
Cambodia	-0.113	-0.116	-0.116	-0.174	-0.174	-0.174	-0.160
Malawi	-0.109	-0.106	-0.110	-0.147	-0.154	-0.150	-0.136
Moldova	-0.132	-0.127	—	-0.180	-0.188	-0.197	-0.157
Mongolia	-0.045	-0.046	-0.038	-0.133	-0.131	-0.122	-0.063
Nepal	-0.087	-0.089	-0.087	-0.149	-0.146	—	-0.118
Nicaragua	-0.060	-0.059	-0.059	-0.205	-0.195	-0.203	—
Niger	-0.113	-0.116	-0.113	-0.161	-0.166	-0.168	-0.149
Nigeria	-0.064	-0.066	-0.066	-0.139	-0.145	-0.145	-0.088
Pakistan	-0.107	-0.103	-0.107	-0.146	-0.160	—	-0.129
Panama	-0.106	-0.105	-0.105	-0.228	-0.229	-0.233	-0.259
Peru	-0.121	-0.121	-0.121	-0.206	-0.209	-0.211	-0.219
Rwanda	-0.096	-0.098	-0.095	-0.160	-0.156	-0.152	-0.122
Sri Lanka	-0.099	-0.093	—	-0.168	-0.159	-0.165	-0.118
Tajikistan	-0.059	-0.065	-0.063	-0.164	-0.152	-0.152	-0.076
Tanzania	-0.061	-0.063	-0.061	-0.148	-0.141	-0.140	-0.089
Timor-Leste	-0.064	-0.064	-0.063	-0.148	-0.143	-0.145	-0.089
Uganda	-0.095	-0.101	-0.101	-0.163	-0.165	-0.157	-0.119
Vietnam	-0.118	-0.120	-0.118	-0.262	-0.257	—	-0.288
Yemen	-0.096	-0.095	-0.089	-0.160	-0.155	-0.157	-0.118
Zambia	-0.095	-0.095	-0.095	-0.174	-0.172	-0.172	-0.148
Average							

Production

As noted in the text, the structure of production is represented using a three-level system in which the household firm combines its fixed factors (land, capital) with mobile factors (labor) according to a CES production function. This value-added mix is combined with material inputs using another CES production function that defines total output. The transformation of the resulting composite output is represented by a Constant Ratio of Elasticities of Transformation, Homothetic function.

The top-level CRETH function can be described by the following system of equations. The first equation defines for all commodities the relationship between individual outputs and the farm output , and their relative prices and . Because is positive, this equation therefore allocates individual outputs towards whichever becomes relatively more expensive. The second equation which defines our production system is a zero profit condition which ensures that the value of all outputs equals the value of output capacity: where is the elasticity-weighted share of output devoted to good : .

The second nest is a CES function that links the output capacity to the level of value-added composite with price and inputs with price and the negative elasticity of substitution : and The zero-profit condition for inputs requires that , where is the share of inputs in output and is the share of value-added.

At the third, bottom level is the final CES function which determines how the value-added composite is produced using fixed and mobile factors with a negative elasticity of substitution and . We also include a zero-profit condition represented by , where is the share of the fixed factor in value-added and is the share of the mobile factor. We assume that a household firm is a price taker in its output, input and variable factor market. The fixed input is assumed to belong to the household and its shadow price is adjusted to ensure zero profits of the firm while its quantity is fixed ( ).

We construct in the matrix of cross-price elasticities of the production quantities which we seek to express as a linear combination of elasticities of substitution contained in the production structure. To illustrate the approach used to specify the cross-price output elasticities of supply, we include two output goods in the equation.

The values of the production elasticity matrix were calculated using the formula above. The values of and were obtained from the GTAP parameter file. The values of top-level output substitution parameters for agricultural commodities were calibrated to ensure consistency with the global GTAP model. We obtained these estimates by perturbing output taxes for each commodity, to measure the supply response within the GTAP model.

The logic of the own-price elements of the first matrix is very simple. An increase in the price of a particular good raises its price relative to other outputs and causes producers to shift towards that good to an extent determined by the elasticity of transformation for that good, , and the its adjusted share. The larger is the adjusted share, the greater the difficulty involved in achieving any given proportional increase in its output, so the elasticity of output declines as s_k* rises. The overall elasticity obtainable by shifting a given output between individual outputs is given by . The cross-price terms are negative, and reflect the movement of resources away from good k as the prices of other outputs rise.

The second matrix term involves substitution between intermediate inputs and value added. In our analysis, it is unused because we use the default GTAP default assumption of Leontief technology between value-added and intermediate inputs. The third matrix term is frequently important. The own-price effects, —— have a simple interpretation. An increase of one percent in the price of good k increases the price of overall output by s_k^{*}. This increases the price of the fixed factor by $s_f.s_v$ which is the inverse of the share of this good in the gross value of output. This creates an incentive for to increase use of the mobile factor by a proportion given by . The effect on output is given by the share of the mobile factor in the composite factor bundle.

The elasticities of supply at the household level vary depending upon the range of products they product, and their ability to expand their overall agricultural output in response to increases in the average price of agricultural goods. To give some idea of the magnitude of the resulting supply elasticities at the commodity level, average estimates across households are presented in Appendix Table 2 for cases where there is significant production, and where elasticities are below 10. From the table, it is clear that the elasticities of supply are generally substantially larger than those used in the classic modeling study by Tyers and Anderson (1989). They are an order of magnitude above the elasticity of aggregate output for calories of around 0.1 estimated by Roberts and Schlenker (2010, Table 3)

Appendix Table 2. Supply elasticities by commodity, averages over households

	Rice	Wheat	Maize	Sugar cane	Cattle	Swine	Soybeans	Peanuts
Albania		4.44	2.19		1.29	0.5		
Armenia		9.5	6.74		0.22	2.93		
Bangladesh	3.27	2.56	2.64	0.01	0.01			0.47
Belize	3.14					3.64		
Côte d'Ivoire	9.13		0.05	0	0.6	0.07		0.08
Ecuador	0.01	0	0.95	0.02	0.35	0.21	4.31	
Guatemala	0.37	5.92	4.63	0.01	0.5	0.1		
India	3.13		0.36	0.42	3.89	1.12	6.14	0.74
Indonesia	0.77	0.45	0.08	0.44	0.14	0.08	0.68	1.22
Cambodia	1.79	0	0.07	0	0.07	0.06	0.1	0.01
Malawi	6.42							
Moldova		0.32	0.02					
Mongolia		1.27			1.83			
Nepal	5.88	0.81	3.83	0	0.67	0.43	0.29	0.34
Nicaragua	9.58	0.05	0.12	0.02	2.02			0.09
Niger	8.73	0	0.06	1.49	4.46	0.14		3.18
Nigeria	4.14	5.35	1.28	0				
Pakistan	0.37	0.51	0.12	0.01	0.23	0.13	0.24	0.22
Panama	0.02	2.93	0.45		0.02			
Peru	0.09	0.34	0.15	0.28	0.33	0.27		
Rwanda	3.46	3.74	2.44		0.4	0.19		
Sri Lanka				0.02	9.69	2.97	2.14	1.76
Tajikistan	3.9	3.62	0.12		0.03			
Tanzania			2.3			4.21	5.35	8.25
Timor-Leste	6.82	4.12	0.41	0	0.17	0.33	1.08	0.15
Uganda	5.19	1.67	0.71	0	0.1	0.2	0.12	0.21
Vietnam	0.2	1.18	0.28	0.03	0.14	0.12	0.16	0.2
Yemen								
Zambia	7.1	6.91	0.58		0.48	0.22	0.29	0.14
Average	3.80	2.53	1.27	0.16	1.20	0.90	1.74	1.14