MIGUEL ROBLES
MÁXIMO TORERO

Understanding the Impact of High Food Prices in Latin America

Since the late 1980s, almost all Latin American countries have adopted a series of far-reaching economic reforms, especially trade, financial, and capital account liberalization. Increased economic openness has gone hand in hand with large financial inflows—particularly in the first half of the 1990s—and has brought new sources of economic growth. As a result, economies grew, inflation declined, and there was a big surge in foreign capital inflows. Although overall growth slowed after 1995, the region has experienced strong growth in the past five years, the best sustained performance since the 1970s. With the exception of a handful of countries, this economic growth has been accompanied by relatively modest inflation.

Despite these positive results, virtually all Latin American countries share similar problems: uneven economic growth, unacceptably high poverty and malnutrition rates, and lagging agricultural growth. More than 60 percent of the region's poor live in rural areas, where slow economic growth, unequal distribution of assets, inadequate public investment and public services, and vulnerability to natural and economic shocks are major policy issues.

The 2007–08 food price crisis exacerbated these problems. Prior to the crisis, the region was considered relatively stable and capable of absorbing external shocks, thanks to its higher foreign exchange liquidity; decreased public sector and external borrowing needs; exchange rate flexibility; lower exposure to currency, interest rate, and rollover risks in public sector debt portfolios; and improved access to local-currency loans. Nevertheless, the food price crisis severely affected most of the Latin American countries in terms of inflation, especially food inflation.

Robles and Torero are with the International Food Policy Research Institute.

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The impact was greatest on net importing countries (specifically, Central America and Mexico) and on poor consumers in peri-urban and rural areas. Most Central American countries are net consumers of basic food. For example it is estimated that the share of the households that were net consumers before the crisis was 68.2 percent in El Salvador, 83.3 percent in Guatemala, 88.8 percent in Honduras, and 90.2 percent in Nicaragua. As a result, a rural household in El Salvador in 2008, for example, was able to buy only 56 percent of what it used to buy eighteen months before with the same amount of money (U.S.$0.17).[1]

Before the crisis, most Latin American countries were on track to reach the Millennium Development Goal of halving the proportion of people who suffer from hunger by 2015. A significant number of countries have since had to revise their ability to accomplish this goal. Furthermore, the fear of more permanent inflationary pressures coming from food prices alerted most central bankers in the region.

This paper examines the effects of food price changes and the distributional impact within countries. It analyzes the price transmission mechanism from world markets to local markets for different types of countries to better understand the net effects, and then examines the effect of food price changes on household welfare and consumption across different types of households in both urban and rural areas. In estimating welfare effects, we account for direct or first-round effects, as well as substitution effects. For the latter, we provide estimates of own-price and cross-price demand elasticities. In this respect we depart from other cross-country studies in which substitution effects are absent.[2] This is an important distinction, as substitution effects are far from negligible given the size of the observed food price changes. To our knowledge, no other cross-country study incorporates rigorous estimates of substitution effects in analyzing the impact of high food prices. Chávez, del Campo, and Villarreal Paez include these estimates for Mexico, in contrast to Valero-Gil and Valero; our methodology is closely related to the former.[3] Ivanic and Martin analyze the impact of high food prices on poverty rates in Nicaragua and Peru using household surveys from 2001 and 2003, respectively.[4] Our data are closer in time to the food crisis (2006 in both cases). This

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[1] De Márquez (2008), based on data from the 2003 Multipurpose Household Survey (carried out by the El Salvadoran Department of Statistics and Censuses) and from the Ministry of Agriculture and Livestock, Market Information Division, May 2006 to January 2008.

[2] Ivanic and Martin (2008); Zezza and others (2008).

[3] Chávez, del Campo, and Villarreal Paez (2008); Valero-Gil and Valero (2008).

[4] Ivanic and Martin (2008).

difference is also important, as production and consumption structures within countries matter for poverty and welfare impact estimates. Zezza and others analyze the cases of Guatemala and Nicaragua based on data for 2000 and 2001, respectively, which again might not reflect the internal conditions at the time of the food crisis.[5] Here our information on Guatemala is for 2006.

This paper is organized as follows: The next section reviews the global causes and consequences of the food price crisis. The paper then presents the modeling options for evaluating the impact of high food prices and describes our modeling strategy. A long section is dedicated to describing our empirical strategy and results, and the paper closes with a presentation of our main conclusions.

Global Causes and Consequences of the Price Crisis

The 2007–08 food price crisis had both demand- and supply-driven causes (see table 1 for a summary). Rising energy prices (through mid-2008), subsidized biofuel production, income and population growth, globalization, and urbanization are among the major forces contributing to surging demand. On the supply side, land and water constraints, underinvestment in rural infrastructure and in agricultural innovation and access to inputs, and weather disruptions are impairing productivity growth and the needed production response. Between 2000 and 2007, cereal demand exceeded cereal production, causing cereal stocks to decline. Demand for agricultural commodities for food, feed, and fuel use is likely to continue to escalate. Furthermore, climate change risks and rising energy demand could accelerate food prices again in the future.[6]

In addition to the supply and demand fundamentals, there is substantial evidence that the crisis was exacerbated by the malfunctioning of world grain markets and by the protectionist response of many countries. These reactions began as consequences, not causes, of the crisis, but they exacerbated it and, in turn, led to even higher prices and volatility, with adverse consequences for the poor and for long-term incentives for agricultural production. Because these market failures impede the free flow of food to where it is most needed

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[5] Zezza and others (2008).

[6] See von Braun and others (2008); von Braun (2008a, 2008b, 2008c); Brahmbhatt and Christiaensen (2008); OECD (2008); Sommer and Gilbert (2006); UNCTAD (2008); World Agricultural Outlook Board (2008). See also “The New Face of Hunger,” *The Economist,* 17 April 2008.

TABLE 1. Explanations for Rise in Agricultural Commodity Prices

Factor	*Mechanism*	*Impact*
Demand-side factors		
Income growth, population growth, and urbanization resulting in rising world demand	Developing Asia, especially China and India, continues to show strong sustained growth (9 percent a year between 2005 and 2007). Cereal demand has been growing at 2–3 percent a year, thanks to rising incomes in China, India, and, more recently, sub-Saharan Africa (6 percent a year between 2005 and 2007). As incomes rise, people diversify their diet and consume more meat and other animal products, increasing the demand for feed, particularly maize. Meanwhile, yield growth in these cereals has declined from 3 percent in the 1970s to 1–2 percent in the 1990s, largely due to declining public investment in agricultural research.	This resulted in a significant reduction of cereal reserves from 700 million tons in 2000 to less than 400 million tons in 2007 (for further detail, see von Braun and others, 2008, and von Braun, 2008a, 2008b, 2008c.)
Ethanol and biofuels	With oil prices at an all-time high of more than US$120 a barrel in May 2008 and with the United States and the European Union subsidizing agriculture-based energy, farmers have massively shifted their cultivation toward crops for biofuel. In the United States, as much as one-third of the corn crop goes toward ethanol production (up from 5 percent a decade ago), and biofuel subsidies range between US$11 billion and $13 billion a year. The large subsidies in developed countries also have for a long time distorted markets and the competitive advantage of developing-country farmers.	Lipsky (2008) estimates that the increased demand for biofuels accounted for 70 percent of the increase in maize prices and 40 percent of the increase in soybean prices. Collins (2008) uses a mathematical simulation to estimate that about 60 percent of the increase in maize prices from 2006 to 2008 may have been due to the increased use of maize in ethanol. Using a general equilibrium model, Rosegrant and others (2008) calculate the long-term impact on weighted cereal prices of the acceleration in biofuel production from 2000 to 2007 to be 30 percent in real terms. This is the same order of magnitude as the World Bank's linkages model (van der Mensbrugghe 2006).

Supply-side factors		
Increased oil and fertilizer prices	Oil prices increased significantly.	The increases in oil prices directly affect transportation costs and indirectly affect the price of fertilizer, which in some countries had increased by more than 300 percent. (See *IMF Fiscal Affairs,* 2008.)
Low R&D investments in agriculture	The neglect of agriculture in public investment, research, and service policies in the past decade has undermined its key role for economic growth.	As a result, agriculture productivity growth has declined and is too low to meet the present challenges. This is only slowly being corrected at the country level and in development assistance. China and India, however, increased their agricultural budgets by 20 to 30 percent this year (see Trostle, 2008).
Drought and climate change	Climate change and droughts in large grain-producing nations have lowered worldwide production.	More volatile weather patterns related to climate change are expected to increase over the coming decades and negatively affect agricultural production. This is happening at a time when strong population growth in many parts of the world continues to contribute to the difficulty of supply keeping up with demand.
Other factors		
Dollar devaluation	Most commodity prices are quoted in U.S. dollars, and the dollar went through a substantial depreciation.	Despite the dollar depreciation, when adjusted for inflation and the dollar's decline (by reporting in euros, for example), food price increases are smaller but still dramatic, with often serious consequences for the purchasing power of the poor (for example, 134 percent for wheat from January 2000 to January 2004).
Large excess liquidity in G7 countries	Today's explosion of commodity prices is the result of a very real global financial storm associated with large excess liquidity in several non-G7 countries, nourished by the low interest rates set by G7 central banks. This price explosion could be a leading indicator of future inflation driven by fundamentals.	Commodity prices are the result of portfolio shifts against liquid assets by sovereign investors, sovereign wealth funds, partly triggered by lax monetary policy, especially in the United States (for details, see Calvo, 2008, and Rojas-Suarez, 2008).

and the free flow of price signals to farmers, they imposed enormous efficiency losses on the global food system, hitting the poorest countries hardest.

As a result, changes in supply and demand fundamentals cannot fully explain the price spike that occurred during the first six months of 2008. There are two major explanations for this price spike. First, ad hoc trade policy interventions—such as export bans, high export tariffs, and high import subsidies—were partly triggered by the price crisis and exacerbated its symptoms. As of April 2008, fifteen countries, including major producers, had imposed export restrictions on agricultural commodities, thereby narrowing the global market.[7] Policy responses such as export bans or high export tariffs may reduce the risks of food shortages in the short-term for the respective country, but they are likely to backfire by making the international market smaller and more volatile. At the country level, price controls reduce farmers' incentives to produce more food and divert resources away from those who need them most. Export restrictions also have harmful effects on import-dependent trading partners. International Food Policy Research Institute (IFPRI) simulations with the MIRAGE global trade model show that these trade restrictions can explain as much as 30 percent of the increase in prices in the first half of 2008.[8]

The second explanation is that excessive speculation in the commodity futures market could, in principle, push up futures prices and—through arbitrage opportunities—spot prices above levels justified by supply and demand fundamentals. The supposed impact of speculation is sometimes confused, however, with the impact of hedging, which reflects consumers' genuine concerns about future fundamentals and a desire to hedge against risks. Robles, Torero, and von Braun statistically test whether speculative activity in the futures market can be identified as a source of the increasing agricultural commodity prices in 2007–08.[9] The results show that speculative activities might have been influential. The analysis also tested the extent to which selected indicators for speculative activity can help forecast spot price movements, producing evidence that some speculation indicators affect the current commodity prices of wheat, rice, maize, and soybeans.

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[7] The countries are Argentina, Bangladesh, Bolivia, Cambodia, China, Egypt, Ethiopia, India, Kazakhstan, Malaysia, Pakistan, Russia, Tanzania, Vietnam, and Zambia.

[8] These IFPRI modeling results from the MIRAGE model should be taken as a conservative estimate. IFPRI models do not factor in either speculation over and above market fundamentals or the increased price impacts of any quantity change in the much more narrow international market.

[9] Robles, Torero, and von Braun (2009).

Modeling Options to Evaluate the Impact of High Food Prices

This section briefly discusses the modeling options available for understanding the economic impact of high international food prices on small developing economies.[10] The first step is to understand whether the price shock is transmitted into changes in domestic prices—in other words, to determine the degree of price transmission. We then need to assess the effects on the domestic population and on the economy in general as the shock is fully or partially transmitted from the outside.

Several factors affect the degree of price transmission. First, a higher price transmission might be expected in countries that are more integrated with international markets and that have no or minimum barriers to trade. Second, some domestic prices are more likely than others to be affected by changes in the price of a given commodity on the international market. In principle, many prices might change, including the price of nontradable goods, since the international commodity might be used as an intermediate good (wheat and bread are an example). Changes can also be expected through substitution effects or general equilibrium effects. Furthermore, policy responses can lead to effects on the general economy and most prices. Third, the timing of the transmission can be expected to vary, with some domestic prices reacting more rapidly than others. Fourth, prices can react differently across regions within a country. Regions that are economically isolated are an extreme example; they can basically be regarded as closed economies, so they will experience no or very limited price transmission will be observed. Other regions might be better integrated, but transportation costs could still affect the degree of transmission.

Different methods can be used to determine the degree of price transmission. The simplest approach would be to examine the correlation coefficients of contemporaneous prices (or change in prices). However, more elaborated time-series econometric techniques can simultaneously incorporate several commodities into the analysis, examine the possibility of smooth transmission over time, and control for other factors that might affect domestic prices. These include error correction models (ECMs), which would permit modeling the long-run relationship between international and domestic prices, as well as short-run deviations from it.

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[10] Here, *small* means that the country is a price taker in the international market and its actions have no effect on international commodity prices.

Several modeling strategies can be used to estimate the economic impact of high domestic food prices. We organize these strategies along two dimensions: the degree of heterogeneity among households and producers, and the degree of economic response (from first-round effects to general equilibrium effects). Some models are rich along one dimension but fairly simple on the other, while others are either simple or rich along both dimensions.

One strategy for determining the degree of heterogeneity would be to model the economy as if it were populated by a representative agent that makes all relevant economic decisions, for example, all intertemporal consumption and production decisions. Such a framework cannot take into account allocations and adjustments across households and production units or any impact on the income distribution. This type of model would mainly focus on the macroeconomic or aggregate effects of changes in international commodity prices and could be used in a macroeconomic modeling approach to assess the economy's adjustment to terms-of-trade shocks. In contrast, a microeconomic strategy would account for the effects of high international food prices at the household and firm or farm levels or even at the individual level, based on intra-household allocation. For this type of analysis, one would use representative national household surveys to estimate the effects for each household or individual in the survey. An intermediate approach would consider several representative types of households or economic units in the economy. For example, the analysis could focus on one representative household for each income (or expenditure) decile or quintile in the population or could differentiate between rural and urban households and between rural households that are net buyers or net sellers of food.

The degree of economic response refers to a model's capacity to incorporate mechanisms through which the economy adjusts when faced by an exogenous change in food prices. One extreme would be to assume that the economy does not adjust at all. For example, at the national level one may assume that quantities of imports and exports are not affected by prices, and that consumption, investment, and production decisions remain unaffected. Clearly, these assumptions might not be consistent with internal and external intertemporal equilibriums in a macroeconomic framework. However, assuming no adjustment might be useful in estimating an upper bound on the effects of a negative shock, or the lower bound of a positive shock. At a household or microeconomic level, a similar assumption can be made to approximate the welfare effects of a shock. The opposite extreme would be to account for all possible adjustments and responses to a commodity price shock in the economy. This would require a general equilibrium model in which consump-

TABLE 2. Modeling Options to Assess the Effects of Changes in Commodity Prices

Degree of heterogeneity →

Degree of economic response ↓

Option	*Aggregate economy (as if one representative agent)* *(A)*	*Several industries, economic sectors, regions* *(B)*	*Types of households: urban, rural, net buyers, net consumers, quintiles* *(C)*	*All households / individuals* *(D)*
No response, fixed quantities and prices (other than shock) (1)	WB, IMF, IDB, OECD, FAO		Valdes and Foster (2008)	Ivanic and Martin (2008); Coady, Dorish, and Minten (2008) Zezza and others (2008)
Partial equilibrium response: demand and/or supply elasticity (2)				Chávez and others (2008)
Static general equilibrium models (3)			Diao, Doukkali, and Yu (2008)	
Full response, intertemporal general equilibrium effects and policy response (4)				Highly complex

tion, investment, and production decisions respond to the shock. It may also be useful to incorporate policy responses from the government and account for short- and long-run adjustment. This modeling strategy could become quite complex, especially if changes in expectations and heterogeneous agents are incorporated. An intermediate degree of economic response can be introduced using a partial equilibrium framework. For example, at the national level, one can incorporate the idea of an import and export elasticity without paying close attention to an intertemporal external balance. Similarly, at the household level, one can estimate changes in quantities demanded as prices increase by assuming or estimating demand elasticities. This leaves out other economic responses, however, such as adjustments in labor markets, adjustments in markets of related nontradable goods, and policy responses by the government.

Table 2 shows both dimensions, with the degree of heterogeneity increasing across columns and the degree of economic response increasing across rows. We have tried to summarize the different modeling strategies according to the degree of complexity of analysis along each of these dimensions. Certainly, higher degrees of complexity in both dimensions can allow researchers to analyze the effects of a price shock in greater detail. However, achieving full heterogeneity in terms of households and producers and at the same time incorporating intertemporal general equilibrium adjustments (and policy responses) in a model requires a high order of complexity that might make the task impractical.

In the next section, we present our empirical work. Our modeling strategy when studying the welfare impact of high food prices incorporates household-level heterogeneity and partial equilibrium responses. This corresponds to cell D2 of table 2.

Modeling Strategy

We use three approaches to analyze price transmission from international prices to domestic prices. Our first exercise relies on simple graphical representations. We compare twelve-month growth rates of domestic price time series with international price time series and evaluate whether accelerations in the growth rates move together. Our second approach relies on finding cointegration relationships among domestic prices and international prices. Third, we use moving-average first-difference models to test whether the growth rate of international prices has explanatory power on the growth rate of domestic prices.

Our approach to modeling the welfare effects of high food prices incorporates heterogeneity at the household level and partial equilibrium effects. Using data from nationally representative household surveys, we estimate the impact of high food prices for each household and compute aggregate estimates based on those original estimates. We take into account the fact that households might consume as well as produce agricultural commodities and the fact that price changes might make them revise their consumption and production decisions.

To motivate our modeling strategy, we start describing the simple case in which households do not revise their quantity decisions when faced with changes in food prices. We assume the household not only consumes but also produces food (as is the case for many rural households in the developing world). We then allow for a change in food prices and ask what extra net income should be transferred to this household so that it would be still feasible to consume (and sell) the same bundle of food commodities despite the price changes. This transfer can be expressed as follows:

$$\left(\mathbf{q}_0\mathbf{p}_1 - \mathbf{y}_0\mathbf{p}_1\right) - \left(\mathbf{q}_0\mathbf{p}_0 - \mathbf{y}_0\mathbf{p}_0\right) = \left(\mathbf{q}_0 - \mathbf{y}_0\right)\Delta\mathbf{p},$$

where $\mathbf{q}_0$ is the vector of quantities consumed before the change in prices, $\mathbf{y}_0$ is the vector of quantities produced before the change in prices, $\mathbf{p}_0$ and $\mathbf{p}_1$ are price vectors before and after price changes, and $\Delta\mathbf{p}$ is the vector of change in prices. Hence, net consumers will require a positive transfer if faced by an increase in prices, while net sellers will benefit from an increase in prices.

Because we want to analyze a more general case in which we allow households to revise their consumption and production decisions when facing higher prices, we examine what happens to the household's net expenditure, $B(\mathbf{p}, \mathbf{w}, U)$, when prices change. We define $B(\mathbf{p}, \mathbf{w}, U)$ as

$$B(\mathbf{p},\mathbf{w},U) = e(\mathbf{p},\mathbf{w},U) - \pi(\mathbf{p},\mathbf{w}),$$

where $e(\mathbf{p}, \mathbf{w}, U)$ is the expenditure function, $\pi(\mathbf{p}, \mathbf{w})$ is the profit function, $\mathbf{p}$ is the vector of good prices, $\mathbf{w}$ is the vector of factors of production prices, and U stands for the welfare (or utility) level. Using a second-order Taylor expansion around initial prices and welfare level, $B(\mathbf{p_0}, \mathbf{w}, U)$, and after some algebraic manipulation of terms, we get the following expression for the change in the household's net expenditure in response to a change in good prices:[11]

$$(1) \qquad dB(\mathbf{p},\mathbf{w},U) = \left[(\mathbf{s}_h) - (\mathbf{s}_y)\right]' \left(\frac{d\mathbf{p}}{\mathbf{p}}\right) e + \frac{1}{2}\left(\frac{d\mathbf{p}}{\mathbf{p}}\right)' (\mathbf{s}_h)(\mathbf{E}_{hp})\left(\frac{d\mathbf{p}}{\mathbf{p}}\right) e,$$

where $(d\mathbf{p}/\mathbf{p})$ is a vector of percent changes in prices; $\mathbf{s}_h$ is a vector of consumption shares (value of consumption of each commodity item divided by total consumption expenditure); $\mathbf{s}_y$ is a vector of production shares (value of production of each commodity item divided by total consumption expenditure); and $\mathbf{E}_{hp}$ is the matrix of demand elasticities (own price elasticities in the diagonal and cross-price elasticities off the diagonal, accordingly). This expression for $dB(\mathbf{p}, \mathbf{w}, U)$ corresponds to the concept of compensating variation. It provides a measure of the amount of extra income needed to achieve the original level of welfare, U, given the change in prices, $d\mathbf{p}$.

In expression 1, we have suppressed supply price elasticities, as we do not have access to data with which to make our own estimates and we are not aware of any reliable estimates at the household level. In principle, setting these elasticities to zero leads us to overestimate the compensating variations for households that are producers and that otherwise would have responded

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[11] See the appendix for a complete derivation.

to higher prices by increasing supply. The assumption is not unreasonable, however, as most small farmers in Latin America face constraints that make their responsiveness to high prices very inelastic, at least in the short run. In addition, equation 1 is not linear in the growth rate of prices, implying that if the growth rate of prices is increased by a factor λ, the compensating variation does not increase by this factor. However, for small price changes, the second term (quadratic term) in equation 1 becomes negligible.

Expression 1 also allows us to discuss two related concepts that we use in our empirical work. The first term in our compensating variation expression (equation 1) is known as the direct (or first-round) effect:

$$\text{Direct effect } = \left[\left(\mathbf{s}_h \right) - \left(\mathbf{s}_y \right) \right]' \left(\frac{d\mathbf{p}}{\mathbf{p}} \right) e.$$

This would be the estimated compensating variation under the assumption that households do not revise their consumption and production quantities as prices change. The second term is the substitution effect:

$$\text{Substitution effect } = \frac{1}{2} \left(\frac{d\mathbf{p}}{\mathbf{p}} \right)' \left(\mathbf{s}_h \right) \left(\mathbf{E}_{hp} \right) \left(\frac{d\mathbf{p}}{\mathbf{p}} \right) e.$$

This term accounts for the idea that households would revise their consumption decisions as relative prices change. Therefore, this term is added to the direct effect to estimate an overall compensating variation that allows households to adjust their consumption pattern when relative prices change.

We also make a distinction between price transmission on consumption and price transmission on production. Our basic assumption is that as consumers, households face full price transmission: for whatever price change we consider, households will face this price change when behaving as consumers. In the case of producer households, we assume the following cases: full transmission, partial transmission, and no transmission. No transmission implies that producers do not receive higher prices when they sell their output in the market. This means that if, for a particular household and commodity, the amount of production exceeds the amount of consumption, then this difference is not subject to a price change. If the household consumes more than it produces, then we consider a higher price but just for the difference. Our implicit assumption is that the opportunity cost of that self-consumption is given by the market price. Our partial production price transmission case assumes that the amount of output farmers sell in the market is subject to only half of the price increase. Thus, the household faces full transmission as a consumer, but only 50 percent of the price change as a producer. In the appendix, we provide the required adjustments to the compensating variation expression (equation 1) to account for partial production transmission and no transmission.

Finally, as mentioned above, estimating compensating variations at the household level requires demand price elasticities (own-price and cross-price elasticities). We estimate them using household survey data, first estimating demand equations and then producing estimates of the elasticities. We follow Banks, Blundell, and Lewbel in computing a quadratic almost-ideal demand system (QUAIDS).[12] We depart slightly from their proposed system of demand equations since we incorporate control variables other than prices and total consumption expenditure. In particular, we include dummy variables to control for whether the head of household is male or female and for the fraction of household members who are thirteen years old or younger.[13] The appendix describes the estimated demand system and how we estimate compensated demand elasticities.

Empirical Results: Guatemala, Honduras, Nicaragua, and Peru

In this section, we first present evidence of price transmission from international markets to domestic food prices for four Latin American countries: Guatemala, Honduras, Nicaragua, and Peru. We then describe our empirical strategy for estimating the welfare impact of high food prices in these four countries and identify our data sources. Finally, we present our results of the welfare estimates.

Evidence on Price Transmission

This subsection provides empirical evidence on price transmission from international prices to domestic prices. For this purpose we use available monthly time series data for a number of selected food prices. The selection of the commodities is based on the availability of relatively long time series; and the domestic price series correspond to the national average for the main

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[12] Banks, Blundell, and Lewbel (1997).

[13] Both control variables are included to reflect differences in households' preferences.

cities in each country. The sample period and selected food items available by country are as follows:

—Guatemala: December 2000 to April 2008. Wheat-related items: Bread, pasta, pastry. Corn-related items: Tortillas, corn, corn flour, milled corn. Rice.

—Honduras: March 2000 to March 2008. Wheat-related items: Bread loaf, pasta, crackers, wheat flour. Corn-related items: Tortillas, corn, cornflakes. Rice.

—Nicaragua: March 2000 to March 2008. Wheat-related items: Bread, bread loaf, bread loaf sliced, pasta, crackers, cookies, wheat flour, *polvorón* (a type of shortbread). Corn-related items: Tortillas, corn, corn flour, cornflakes. Rice.

—Peru: January 1996 to September 2008. In this case, we only have access to a price index for bread, cereals, and grains, so this index is potentially related to all three commodities (wheat, corn, and rice).

We also collected international price series for wheat, corn, and rice, as well as and national consumer price indexes and exchange rates.[14] For international prices, we use the following specific prices: wheat, No.1 Hard Red Winter, ordinary protein, FOB Gulf of Mexico; Maize, U.S. No.2 Yellow, FOB Gulf of Mexico; and Rice, 5 percent broken milled, white rice, Thailand nominal price quote. We removed the seasonal component from all series using the X12-ARIMA procedure.

Our first exercise to find evidence of price transmission is simply to analyze a graphical representation of the available food price series. We compute the twelve-month growth rate for each country, each price, and every month since January 2002, as well as for the consumer price index and the exchange rate (see figure 1). Our graphical representations show that the growth rate of food prices in all four countries started to accelerate in mid-2006 and exceeded the inflation rate and domestic depreciation rates. This coincides with the period in which international agricultural commodity prices were also growing vigorously. We take this as a first crude indication of price transmission from international markets to domestic prices for the period 2006 onward. This evidence is far from conclusive, however, as some food prices also experienced periods of high growth before 2006, with rates that were well above the domestic inflation rate, especially in the case of Guatemala. This shows that other factors can strongly affect domestic relative food prices even when international prices are stable. Nevertheless, the

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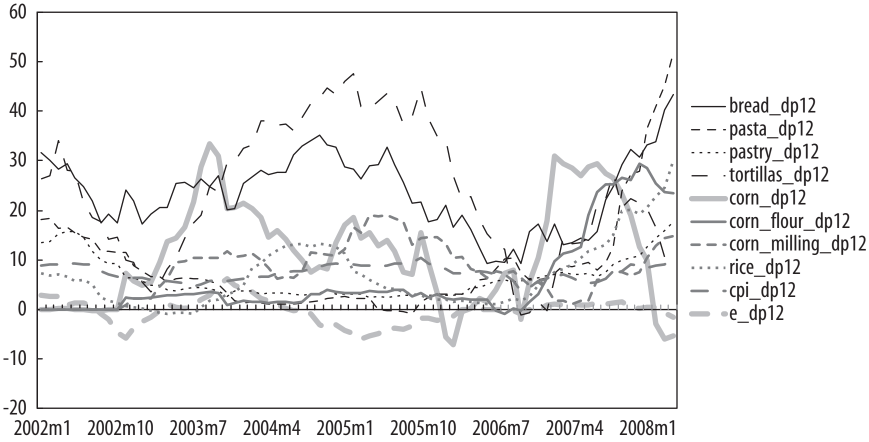
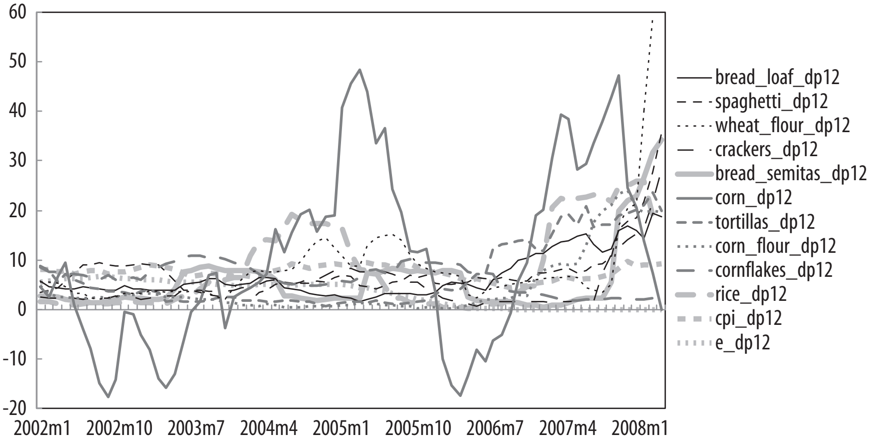
[14] These series are from the International Monetary Fund (IMF) Primary Commodity Prices data set, available online at www.imf.org/external/np/res/commod/index.asp.

FIGURE 1. Twelve-Month Growth Rate of Prices in Guatemala, Honduras, Nicaragua, and Peru

A. Guatemala

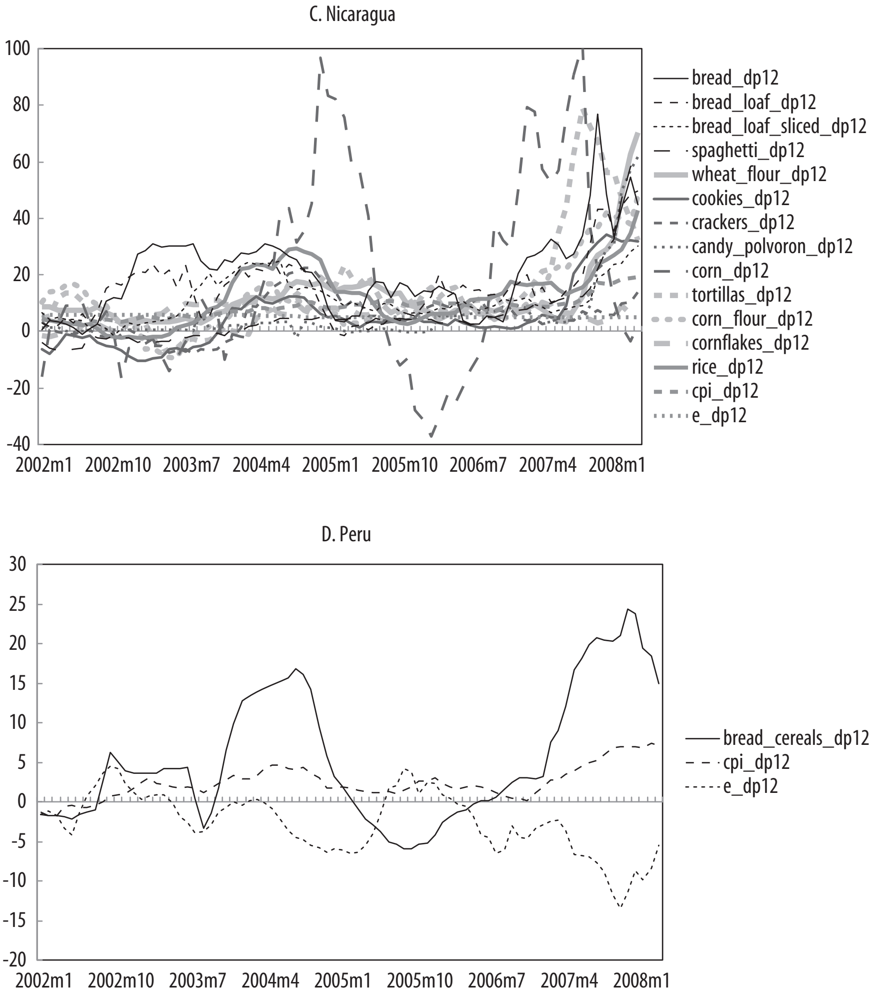


B. Honduras



(*continued*)

FIGURE 1. Twelve-Month Growth Rate of Prices in Guatemala, Honduras, Nicaragua, and Peru (*Continued*)



acceleration of domestic prices after 2006 seems to be quite general or at least more general than before 2006. This is clear in the case of Honduras and Nicaragua.

Our second approach looks for evidence of cointegration relationships among domestic prices and the corresponding related international price. When we test for the order of integration of our series, we cannot reject that they are integrated of order one. We used augmented Dickey-Fuller and Phillips-Perron tests with and without a time trend and with no lags, three lags, and six lags. We concluded that all series are integrated of order one, which is not surprising for this kind of data. We therefore disregarded running regressions of domestic prices on international prices using levels and instead tested for the presence of cointegration vectors. For this, we used the Johansen cointegration test in which the underlying VAR model included a domestic price, the corresponding related international price, and the exchange rate. All models had two lags by default. Our results are summarized in table 3. They show strong evidence of cointegration relationships for almost all food goods in Honduras and Nicaragua. In Guatemala, there is evidence only for corn flour. In Peru, we found evidence of cointegration between the bread/cereals/grain index, the international price of corn, and the exchange rate.

Finally, we also used moving-average first-difference models to test whether the growth rate of international prices has explanatory power on the growth rate of domestic prices. Similar estimations have been used by Rigobón.[15] Our regressions are of the following form:

$$d\ln\left(P_t\right) = \alpha_0 + \beta_0 d\ln\left(P_t^*\right) + \cdots + \beta_4 d\ln\left(P_{t-4}^*\right) + \gamma d\ln\left(e_t\right) + \varepsilon_t,$$

where $d\ln(P_t)$ represents the growth rate of a given domestic price, $d\ln(P_t^*)$ denotes the growth rate of the related international price, $d\ln(e_t)$ is the depreciation rate, and ε_t is independent and identically distributed (i.i.d.). Our results are summarized in table 4.[16] For Guatemala, we find statistical evidence of a positive β coefficient in all cases except tortillas and milled corn. In the case of Honduras, we only find evidence on four products related to wheat. In Nicaragua, there is evidence for all products tested except corn and tortillas. Finally, in Peru, we find that the first, second, and third lags

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[15] Rigobón (2008).

[16] Given the high number of regressions, we do not report them, but they are available on request.

TABLE 3. Cointegration Rank of a Vector Error Correction Model (VECM): Johansen Test for Cointegration[a]

International price in VECM:	*Guatemala*		*Honduras*		*Nicaragua*		*Peru*	
ln_wheat_int	ln_bread	0	ln_bread_loaf	—	ln_bread	2	ln_bread_cereals_grains	0
	ln_pasta	0	ln_crackers	1	ln_bread_loaf	2		
	ln_pastry	0	ln_pasta	—	ln_bread_loaf_sliced	2		
			ln_wheat_flour	1	ln_polvoron	2		
					ln_cookies	1		
					ln_crackers	1		
					ln_wheat_flour	2		
					ln_pasta	2		
ln_maize_int	ln_tortillas	0	ln_cornflakes	1	ln_corn_flour	—	ln_bread_cereals_grains	0
	ln_corn	0	ln_corn_flour	1	ln_cornflakes	1		
	ln_corn_flour	1	ln_corn	0	ln_corn	1		
	ln_corn_milling	0	ln_tortillas	1	ln_tortilla	1		
ln_rice_int	ln_rice	0	ln_rice	1	ln_rice	1	ln_bread_cereals_grains	1

a. The table reports the number of cointegrating equations chosen by multiple trace tests with level (95). We report "—" when the null is rejected for maximum rank equal to 1, 2, . . . , N–1.

TABLE 4. Number of Statistically Significant Positive Coefficients[a]

International price in regression	Left-hand-side price in first-difference model							
	Guatemala		*Honduras*		*Nicaragua*		*Peru*	
ln_wheat_int	ln_bread	1	ln_bread_loaf	0	ln_bread	1	ln_bread_cereals	3
	ln_pasta	2	ln_spaghetti	1	ln_bread_loaf	1		
	ln_pastry	1	ln_wheat_flour	1	ln_bread_loaf_sliced	1		
			ln_crackers	2	ln_spaghetti	2		
			ln_bread_semitas	1	ln_wheat_flour	1		
					ln_cookies	2		
					ln_crackers	1		
					ln_candy_polvoron	1		
ln_corn_int	ln_corn	1	ln_corn	0	ln_corn	0	ln_bread_cereals	1
	ln_tortillas	0	ln_tortillas	0	ln_tortillas	0		
	ln_corn_flour	1	ln_corn_flour	0	ln_corn_flour	1		
	ln_corn_milling	0	ln_cornflakes	0	ln_cornflakes	1		
ln_rice_int	ln_rice	2	ln_rice	0	ln_rice	2	ln_bread_cereals	1

a. The table reports all statistically significant (at the 10 percent level) positive coefficients for contemporaneous prices and four lags of the international price, based on first-difference models.

of the growth rate of the international price of wheat positively affect the growth rate of the bread/cereals/grain index.

Overall, we conclude that there is empirical evidence of price transmission from international markets to the domestic prices of several food products across four countries, although we did not find formal evidence for some domestic prices. This may reflect the adoption of domestic policies in response to the surge of international food prices, including tariff reductions, export restrictions, subsidies, and price controls; we did not control for any of these factors in our empirical analysis.

Welfare Impact at the Household Level

Before we present our results, this section describes the empirical strategy used to estimate the welfare impact of an increase in food prices in Honduras, Guatemala, Nicaragua, and Peru and identifies our data sources. In all cases, we conduct the following exercise. Using information from at least one national representative household survey (two in the case of Guatemala), we estimate for each household j in the survey the amount of income needed to compensate the household for an increase in food prices, such that the household can achieve the same level of welfare it had before the change in prices.

In other words, we estimate the compensating variation $dB(\mathbf{p}, \mathbf{w}, U)$ for every household according to equation 1 for a given increase in food prices. We then use this compensating variation as a proxy for the household's loss of real income (expenditure) as a result of the price increase. Hence, after subtracting the compensating variation from the household's original expenditure, we are able to estimate a new expenditure value adjusted by the change in prices. Since we do this for each household in the survey, we can trace the entire expenditure distribution with and without the change in prices.

Our empirical strategy defines six food commodity groups, which we index by *i:* rice, which includes all rice types; corn, which includes all corn-based items (such as tortillas and corn flour); bread, wheat-based items, and other grains, which includes all wheat-based food items and other grains (such as oatmeal and quinoa); beans, roots, vegetables and fruits; Meat, fish, and dairy; and other food, which includes all food items not included in previous food groups.[17] Since we are interested in changes in the food prices, we put all nonfood goods in one group.

For each household *j,* we obtain information about its consumption, production, and price for each group *i* of goods. For consumption, we compute the vector of expenditure shares for each group *i,* which we label as $\mathbf{s}_h$ with elements $\mathbf{s}_{hi}$. For production, we compute the production value of each group as a share of total expenditure; this is the vector $\mathbf{s}_y$ with elements $\mathbf{s}_{yi}$. For price, we construct a price index for every group to generate the price vector **p.**[18]

Using consumption expenditure shares $\mathbf{s}_h$, consumption expenditure *e,* and prices **p,** we estimate a system of demand equations for each group, following the quadratic almost-ideal demand system (QUAIDS) approach as explained earlier. We conduct separate estimations for urban and rural households to better reflect differences in consumption patterns across these two areas.

From our estimation of demand shares, $\mathbf{s}_h$, we are able to compute a matrix of compensated demand elasticities $\mathbf{E}_{ij}$ that we use in our estimates of compensating variations.

We define the vector of price changes, $d\mathbf{p}$, by conducting two exercises. First, we compute the observed real price change for each of the previously defined commodity groups from the first quarter of 2006 to the first quarter

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[17] A detailed list of all food items and the food group in which they are classified is available on request.

[18] See the appendix for details on the construction of price indexes.

TABLE 5. Real Change in Food Prices
Percent

Group	*Guatemala*	*Honduras*	*Nicaragua*	*Peru*	*Common*
Rice	12.87	24.22	18.16	6.2	10.00
Corn	5.95	19.63	27.73	20.2	10.00
Bread and dried	29.17	13.07	27.56	15.6	10.00
Beans, roots, vegetables, and fruits	0.45	17.83	34.58	−1.2	10.00
Meat, fish, dairy	−0.45	0.40	5.16	3.7	10.00
Other food	0.00	0.00	0.00	0.0	0.00
Nonfood	0.00	0.00	0.00	0.0	0.00

a. Real change in observed consumer prices between the first quarter 2006 and the first quarter 2008. Observed prices are from the corresponding country's bureau of statistics.

of 2008, using available price data for each country.[19] The assumption here is that the observed real change in prices for our food groups already incorporates the transmission from international prices to domestic prices. As we showed in a previous section, there is evidence of such transmission. However, other factors might help explain changes in domestic prices; we do not control for any of those factors here. Second, we simulate a 10 percent real increase in all food prices to generate a common shock across countries and make cross-country comparisons. Table 5 shows the real food price changes for Guatemala, Honduras, Nicaragua, and Peru. An implicit assumption in our household-level analysis is that other effects of high international food prices besides the increase in domestic food prices are not present or are negligible. For example we do not incorporate changes in real wages, employment opportunities, or relative prices of tradables and nontradables reflecting adjustments in the exchange rate. We are not aware of any study showing the presence and importance of such effects for this set of countries.

Using consumption shares, production shares, price changes, and elasticities, we estimate the compensating variation, dB, for every household in the available sample. We deduct this compensating variation from the household's original total expenditure to estimate the adjusted total expenditure given the new high prices.

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[19] These data are typically based on prices in the country's capital or an average for the main cities. It would be ideal to estimate the price transmission effect at local levels, but at the time of writing this paper, we were not able to get the relevant data. We are currently developing a simple model of transportation costs to simulate heterogeneity in price transmission at local levels, which we expect to incorporate in the future.

DATA. For Guatemala, we use the 2006 national survey on living conditions, which divides the country into regions, departments, municipalities, and population centers (*lugares poblados*) and is representative at the regional level. It includes 13,686 households, of which 7,878 (58 percent) are from rural areas and 5,808 (42 percent) are from urban areas.

For Honduras, we use the 2004 national survey on living conditions The survey covers a total of 8,175 households, including 5,583 urban households and 2,592 rural households. The survey is representative at the department level and by urban and rural regions.

For Nicaragua, we use the "2001 national household living standards survey." The survey covers 4,959 households, of which 2,786 (56 percent) are urban and 2,173 (44 percent) are rural. The survey divides the country into regions, departments, and municipalities. It is representative at the regional level: Managua, Urban Pacific, Rural Pacific, Urban Center, Rural Center, Urban Atlantic, and Rural Atlantic.

For Peru, we use the 2006 national household survey, which has information on 20,577 households. Of these, 56.5 percent are urban and 43.5 percent are rural.

Descriptive statistics of all the variables and for all four countries are available on request.

Results

After estimating the quadratic almost-ideal demand systems, we were able to compute compensated price elasticities as explained in the previous section.[20] Most of these estimates are negative, ranging from –0.5 and –1.0. Our estimates are disappointing in only one case: we obtained a positive own-price elasticity for rice in Honduras. However, rice has the lowest consumption share of all our food groups in rural and urban households in Honduras, so a lack of variation in the data on rice consumption might explain this result. In any case, since rice is relatively unimportant in Honduras, our estimates of substitution effects are not contaminated by this elasticity. In a very few other cases, we obtained own-price elasticities very close to zero, as in the case of corn in urban Honduras and nonfood goods in both rural and urban Nicaragua. The latter case does not present a problem, since we do not empirically simulate change in prices for nonfood items.

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[20] We do not include regression results owing to space considerations, but they are available on request. Sample medians for the full set of cross-price and own-price elasticities are also available.

In our empirical work we examine poverty dynamics using the following concepts: poverty intensification (that is, poor households that become even poorer); poverty alleviation (poor households that are better off, but are still poor); poverty entry (nonpoor households that become poor); poverty exit (poor households that are better off and become nonpoor); nonpoor deterioration (nonpoor households that are worse off, but do not become poor); and nonpoor improvement. We also consider different scenarios. Our baseline scenario considers the direct and substitution effects of high food prices and full price transmission to consumers and producers (scenario A). We also consider scenarios in which substitution effects are not allowed (scenarios B and E), producers are not affected by high prices when selling in the market (scenarios C and E), and producers only get 50 percent of price changes when selling in the market (scenario D). All these cases incorporate the observed real food price changes. We also consider a case in which domestic real food prices increase by 10 percent (scenario 10 percent). A summary of all the scenarios considered is available in table A1 in the appendix.

GUATEMALA. In our baseline scenario, we estimate that 98 percent of households in Guatemala are worse off as a result of high food prices. In rural areas, 4 percent of households are better off, while almost no urban households benefit from the increase in food prices. These results are very similar across expenditure quintiles in rural as well as urban areas. The lack of winners is explained by the fact that most rural farmers produce corn, beans, and fruits—food groups with small price increases. In contrast, bread and wheat-based commodities, which represent on average almost 10 percent of the consumption expenditure in rural and urban areas, exhibit the highest price rise (almost 30 percent).

Our estimates, summarized in table 6, suggest that the average loss among all households in the country is 2.0 percent of the household's expenditure. In urban areas, high food prices had a regressive negative effect: the average loss among urban households in the poorest quintile is 2.5 percent, versus slightly more than 1.0 percent in the richest quintile. In rural areas, this regressive effect is also present, but it is less clear than in urban centers.

The aggregate loss in the economy is estimated to be on the order of 1.7 percent of aggregate household expenditure. Rural areas contribute with an aggregate loss of 1.0 percent, while in urban areas the loss is 0.7 percent. However, the cost of compensating the losses of the two poorest quintiles in the country represents only 0.45 percent of the national aggregate expenditure. If the government were to compensate only the two poorest quintiles in

TABLE 6. Guatemala: Compensating Variation[a]
Percent of household expenditure

	Urban		*Rural*		*National*	
Quintile	*Mean*	*Median*	*Mean*	*Median*	*Mean*	*Median*
First	2.5	2.4	2.4	2.3	2.4	2.3
Second	2.5	2.4	2.5	2.4	2.4	2.3
Third	2.0	1.9	2.3	2.1	2.3	2.1
Fourth	1.6	1.5	2.1	1.9	1.9	1.7
Fifth	1.1	1.0	1.6	1.5	1.3	1.1
Total	2.0	1.8	2.2	2.0	2.0	1.9

a. Only includes losing households; scenario A.

rural areas, it would require only 0.18 percent of the national household expenditure.[21]

Table 7 shows the impact of high food prices on poverty rates and poverty dynamics under different scenarios. We estimate that the increase in food prices raises the national poverty rate by 0.9 percentage points. In urban areas, this estimate is slightly higher: 1.1 percent. Our estimates also show a zero poverty exit effect—so the increase in poverty rate coincides with the fraction of households entering poverty—and a low poverty alleviation effect of 1.5 percent. When we omit the substitution effect in our estimates (scenario B), the increase in the national poverty rate is 1.0 percent instead of 0.9 percent. Overall the substitution effect among losing households represents 12.5 percent of the direct effect. When we assume no price transmission to producers who sell their goods on a market (scenario C), our poverty estimates basically do not change. This channel essentially eliminates the possibility of winners, but the effect is negligible because we have few winning households.

HONDURAS. Our simulations for Honduras reveal a much more mixed situation than for Guatemala. In our baseline scenario, 10 percent of all households in the country benefit from high food prices. The share is almost twice as large in rural areas (18.0 percent) and much lower in urban areas (1.6 percent).[22] This is largely due to the high real price increase of corn and beans/roots—almost 20 percent in both cases. In rural Honduras, 55 percent of

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[21] This estimate is computed as the aggregate loss of the two poorest rural quintiles as a fraction of the aggregate consumption expenditure of all households in the country.

[22] We use the definitions of rural and urban areas provided by the corresponding documentation of the national survey.

TABLE 7. Guatemala: Poverty Dynamics
Percent of households

	Scenario A			*Scenario B*			*Scenario C*		
Dynamic	*Rural*	*Urban*	*National*	*Rural*	*Urban*	*National*	*Rural*	*Urban*	*National*
Poverty intensification	68.9	33.8	50.2	69.3	33.8	50.4	71.4	34.0	51.5
Poverty alleviation	2.8	0.4	1.5	2.4	0.3	1.3	0.3	0.0	0.2
Poverty exit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poverty entry	0.7	1.1	0.9	0.8	1.3	1.0	0.7	1.1	0.9
Nonpoor worse	26.7	64.5	46.8	26.6	64.4	46.7	27.5	64.6	47.3
Nonpoor better	1.0	0.3	0.6	0.9	0.3	0.6	0.2	0.2	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Change in poverty	0.7	1.1	0.9	0.8	1.3	1.0	0.7	1.1	0.9

TABLE 8. Honduras: Compensating Variation[a]
Percent of household expenditure

	Urban		*Rural*		*National*	
Quintile	*Mean*	*Median*	*Mean*	*Median*	*Mean*	*Median*
First	3.2	3.2	3.5	3.5	3.5	3.4
Second	2.9	2.8	3.3	3.1	3.1	3.1
Third	2.4	2.4	3.2	3.2	2.8	2.7
Fourth	2.0	2.0	2.8	2.7	2.4	2.3
Fifth	1.4	1.3	2.1	2.0	1.6	1.5
Total	2.4	2.3	3.0	2.7	2.6	2.4

a. Only includes losing households; scenario A.

households are corn producers, and 74 percent of households are producers of beans, roots, and fruits. Our estimates are thus driven by the high proportion of farmers in rural Honduras and the assumption that farmers benefit from high prices. In rural areas, the proportion of winning households is higher among the two poorest quintiles (about 25 percent) than the two richest quintiles (about 12 percent). However, even under this relatively favorable situation, 90 percent of all households in the country are net losers, and nearly all urban households (98.4 percent) are negatively affected.

Table 8 shows average compensating variations, as a fraction of household expenditure, by regions and by expenditure quintiles. We estimate that losing households suffer a 2.6 percent loss in household expenditure, on

TABLE 9. Honduras: Poverty Dynamics
Percent of households

	Scenario A			*Scenario B*			*Scenario C*		
Dynamic	*Rural*	*Urban*	*National*	*Rural*	*Urban*	*National*	*Rural*	*Urban*	*National*
Poverty intensification	67.8	23.4	45.1	67.8	23.4	45.1	68.1	23.4	45.3
Poverty alleviation	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0
Poverty exit	0.3	0.0	0.1	0.3	0.0	0.1	0.0	0.0	0.0
Poverty entry	1.1	1.6	1.4	1.3	1.7	1.5	1.2	1.6	1.4
Nonpoor worse	29.8	74.8	52.8	29.7	74.7	52.7	30.5	74.9	53.2
Nonpoor better	0.9	0.2	0.5	0.9	0.2	0.5	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Change in poverty	0.9	1.6	1.2	1.0	1.7	1.3	1.2	1.6	1.4

average, but there are important differences among different groups of losing households. For these households, an increase in food prices is clearly regressive in both urban and rural areas. The average loss for the poorest quintile of rural areas is 3.5 percent of household expenditure, versus only 2.1 percent for the richest quintile. In urban areas, the average losses measured as a share of household expenditure are slightly lower, since urban households are generally richer than rural ones, but a similar regressive pattern is found.

At the aggregate level, we estimate that it is relatively inexpensive to fully compensate the poorest net losing households. In rural areas, it would require only 0.13 percent of the aggregate national household expenditure to compensate all losing households in the two poorest quintiles. This cost would be larger in urban areas, but would still be inexpensive at 0.33 percent.

When examining poverty dynamics (see results in table 9), we observe that under our baseline scenario, overall poverty increases by 1.2 percentage points. This increase is lower in rural areas (0.86 percentage points), which is the result of 1.14 percent households entering poverty and 0.27 households escaping from poverty. In urban areas, we estimate that 1.6 percent of households enter poverty, and no households exit. Our results are essentially unchanged when we disregard substitution effects, which account for 7 percent of the direct effect. However, our estimates do change slightly when we analyze the case in which farmers do not benefit from higher prices as producers. Under this situation (scenario C in table 9), national poverty increases by 1.4 percentage points and urban poverty by 1.6 percent

TABLE 10. Nicaragua: Compensating Variation[a]
Percent of household expenditure

	Urban		Rural		National	
Quintile	*Mean*	*Median*	*Mean*	*Median*	*Mean*	*Median*
First	8.5	8.2	7.7	7.5	7.8	7.6
Second	8.0	8.0	7.3	6.9	7.9	7.8
Third	7.4	7.3	7.2	7.0	7.5	7.4
Fourth	6.7	6.3	6.8	6.8	6.9	6.9
Fifth	5.0	4.6	6.3	6.0	5.4	5.2
Total	7.1	6.9	7.1	6.8	7.1	6.9

a. Only includes losing households; scenario A.

NICARAGUA. We estimate that 91 percent of all households in Nicaragua are worse off as a result of high prices, which leaves 9 percent of households that benefit. As expected, almost all urban households lose out. The share of winners is twice as high in rural areas (20 percent), and it is higher still among the poorest quintile of rural households (23.3 percent). This result holds under the assumption that these households benefit from higher prices as producers. The relatively high proportion of winning households in rural Nicaragua is mainly explained by two factors. First, the high increase in the price of corn and beans/roots/vegetables/fruits—28 percent and 35 percent, respectively. Second, 54 percent of rural households engage in the production of corn and 63 percent in the production of beans/roots/vegetables/fruits. The 5 percent increase in the price of meat/fish/dairy was also significant, since more than half of rural households also participate in the production of this food group. In contrast, the 35 percent increase in the price of beans/roots had a negative effect, since this group on average represents 11 percent of household expenditure in urban areas and 15 percent in rural areas.

As is shown in table 10, losses are estimated at around 7 percent of household expenditure, on average, taking into account only those households that are net losers. As in the case of Honduras, we confirm a regressive effect since the poorest households are the ones that suffer the most. In the poorest urban quintile, the average loss is around 8.5 percent of household expenditure, versus only 5 percent for the richest quintile. The regressive effect is also present in rural areas, but the difference between the poorest and richest quintiles is smaller. This is probably due to lower income dispersion in rural areas.

The amount of resources needed to compensate losing households in Nicaragua is around 6 percent of aggregate expenditure. However, it would only cost 1.2 percent of aggregate expenditure to fully compensate the two

TABLE 11. Nicaragua: Poverty Dynamics
Percent of households

	Scenario A			*Scenario B*			*Scenario C*		
Dynamic	*Rural*	*Urban*	*National*	*Rural*	*Urban*	*National*	*Rural*	*Urban*	*National*
Poverty intensification	57.2	22.8	36.8	57.3	22.8	36.8	58.7	22.9	37.4
Poverty alleviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poverty exit	1.5	0.1	0.7	1.5	0.1	0.6	0.0	0.0	0.0
Poverty entry	3.7	5.6	4.8	3.8	5.9	5.0	4.4	5.6	5.2
Nonpoor worse	37.1	71.5	57.5	37.0	71.2	57.3	36.8	71.5	57.4
Nonpoor better	0.5	0.1	0.3	0.5	0.1	0.2	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Change in poverty	2.2	5.5	4.2	2.4	5.8	4.4	4.4	5.6	5.2

poorest quintiles in the country. In the rural sector alone, only 1.5 percent of the national expenditure would be needed to compensate all net losing households.

Impact on poverty rates and poverty dynamics are summarized in table 11. Poverty is expected to increase by 4.2 percentage points as a result of higher prices, with a larger expansion in urban areas (5.5 percent) than in rural ones (2.2 percent). Interestingly, we estimate some poverty exit in rural areas (1.5 percent), but at the same time, 3.7 percent enter poverty. However, those households that stay poor become even poorer. The same is true in urban areas. If we disregard the substitution effect, the rise in poverty is no different: 4.4 percentage points instead of 4.2 percentage points. In the case of all losing households, the aggregate substitution effect represents only 2.3 percent of the direct effect. The difference is larger when we eliminate the positive price transmission effect to producers. In this case, poverty increases 5.2 percent, with most of the change occurring in rural areas (4.4 percentage points).

PERU. The fraction of Peruvian households that benefit from high food prices is 3.18 percent at the national level, but 5.5 percent in rural areas. High food prices thus leave the vast majority of households worse off than before, especially in urban areas, where almost all households suffer. This relatively low proportion of winners is explained in part by the fact that only 20 percent of rural households participate in the production of corn, which is the commodity with the largest price hike. In Peru, 40 percent of rural households produce beans/roots/vegetables/fruits, which has experienced

TABLE 12. Peru: Compensating Variation[a]
Percent of household expenditure

	Urban		*Rural*		*National*	
Quintile	*Mean*	*Median*	*Mean*	*Median*	*Mean*	*Median*
First	1.7	1.7	2.7	2.5	2.2	2.0
Second	1.7	1.7	2.6	2.3	2.0	1.9
Third	1.5	1.5	2.4	2.2	1.8	1.7
Fourth	1.3	1.3	2.2	2.1	1.5	1.5
Fifth	1.0	0.9	1.9	1.8	1.1	1.0
Total	1.4	1.4	2.4	2.1	1.7	1.6

a. Only includes losing households; scenario A.

no price increases. This clearly limits the chances of observing a higher proportion of winners.

Compensating variations expressed as fractions of household expenditure are presented in table 12. We estimate that in Peru, losses are small relative to household expenditures. On average, net losing households suffer a 1.7 percent decrease in their real expenditure. The loss is slightly higher in rural areas (2.4 percent). Two factors explain this relatively low negative impact. First, food price increases are low in Peru, especially compared to Honduras and Nicaragua. Second, the share of consumption devoted to those food groups experiencing important price increases (namely, rice, corn, and wheat-based food commodities plus other cereals) is relatively low. In urban Peru, these food groups account for only 8 percent of total household expenditure. In rural areas, the percentage is somewhat higher, but it is still low at 14 percent. Despite the relatively low negative impact, the regressive effect of high food prices is present. Households in the poorest rural quintile lose 2.7 percent of real expenditure, on average, versus 2.0 percent for the richest quintile. Urban areas display a similar regressive effect.

Given the relatively low negative impact, the cost of compensating the households in the poorest quintiles is also quite low. It would take just 0.35 percent of Peru's aggregate national expenditure to fully compensate the net losing households in the two poorest quintiles. The impact on poverty rates is summarized in table 13. We find that the impact on national poverty rate is also modest: we estimate poverty increases of less than one percentage point. This result is the same regardless of whether substitution effects are included or whether the price transmission to producers is eliminated, as can be seen in table 13. The poverty increase is slightly higher in rural areas (1.2 percentage points) than in urban centers (0.8 percentage points). Our estimates indi-

TABLE 13. Peru: Poverty Dynamics
Percent of households

	Scenario A			Scenario B			Scenario C		
Dynamic	*Rural*	*Urban*	*National*	*Rural*	*Urban*	*National*	*Rural*	*Urban*	*National*
Poverty intensification	70.5	39.6	50.5	70.5	39.6	50.5	70.8	39.7	50.6
Poverty alleviation	0.3	0.2	0.3	0.3	0.2	0.3	0.1	0.2	0.2
Poverty exit	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Poverty entry	1.3	0.8	0.9	1.3	0.8	1.0	1.3	0.8	1.0
Nonpoor worse	27.3	59.0	47.9	27.2	59.0	47.8	27.6	59.1	48.0
Nonpoor better	0.6	0.3	0.4	0.6	0.3	0.4	0.2	0.3	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Change in poverty	1.2	0.8	0.9	1.3	0.8	1.0	1.3	0.8	1.0

cate that the total substitution effect among losing households is 3.5 percent of the total direct effect for losing households.

CROSS-COUNTRY COMPARISON. Our cross-country comparisons are based on a common price shock scenario: all real food prices (with the exception of the group "other food") increase by 10 percent. This is a relevant scenario as it isolates the effect of domestic policies to counteract the external food price shock; in this sense, it allows us to simulate equal price transmission across countries. First, as expected, we find that almost all urban households (around 99 percent) in all four countries are negatively affected by the price shock, with the exception of net food sellers living in urban areas according to survey classifications. The picture in rural areas is less homogeneous. In Guatemala, only 3.8 percent of rural households benefit, whereas the figure is over 10.0 percent in Nicaragua and Honduras. In Peru, our evidence shows that 5.0 percent of households become net winners. When we analyze the impact on households by expenditure quintiles, we find that the share of winning households is higher among the poorest quintiles in rural Guatemala, Nicaragua, and Honduras. The difference is somewhat significant in Nicaragua and Honduras, where 18 percent of the poorest households become winners. In Peru, the highest proportion of winners is found in the richest quintile (9 percent).

Second, when we compare the size of the losses among net losing households (see table 14), we find that the impact of high food prices is regressive in the urban areas of all four countries. Thus, the poorest urban households suffer the most when we measure their losses relative to their total expendi-

TABLE 14. Mean compensating variation as of household expenditure
Percent of household expenditure

	Guatemala		Honduras		Nicaragua		Peru	
Quintile	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*
First	4.1	4.2	3.2	2.5	4.1	3.3	3.1	4.4
Second	3.8	4.3	3.5	2.8	4.1	3.5	3.4	4.5
Third	3.4	4.0	3.2	3.1	4.0	3.7	3.1	4.2
Fourth	2.9	3.8	2.8	3.3	3.7	3.6	2.8	4.1
Fifth	2.0	3.0	2.0	2.9	2.9	3.4	2.1	3.7
Total	3.2	3.9	2.9	2.9	3.7	3.5	2.9	4.2

a. Only includes losing households; scenario 10 percent change in food prices.

ture. This is not the case in rural areas, however, where the regressive pattern is less clear. Similarly, it is not clear which households suffer the most in relative terms. For example, in Guatemala the average relative loss (4.1 percent) in the poorest urban quintile, which accounts for the biggest relative losses in urban areas, is of the same order of magnitude as the average loss of a median-income rural family. Hence, rural households suffer more than urban ones. We find a very similar situation in Peru. However, in Nicaragua and Honduras we find that urban households suffer slightly more than rural ones. When we compare losses across countries, we find that on average the largest losses overall take place in rural Peru (4.4 percent), while the largest losses in urban areas occur in Nicaragua (3.7 percent). The smallest average losses are found in Honduras, where losing households suffer a 2.9 percent reduction in their expenditures, on average.

Third, total aggregate losses (measured as a share of total national aggregate consumption expenditure) range from 2.5 percent in Honduras to 3.2 percent in Nicaragua. If we consider only rural losses, then less than 1.0 percent of national household consumption expenditure is needed to fully compensate all rural net losers, with the exception of Guatemala, where the figure is 1.2 percent. The aggregate losses in urban areas are around 2.0 percent of the national aggregate household expenditure, for all four countries.

Fourth, in all four countries, poverty rates increase in response to a 10 percent increase in food prices, and this is the case for both urban and rural areas (see table 15). The growth of poverty ranges from 1.5 percentage points in Honduras to 2.3 percentage points in Nicaragua. In all countries but Peru, the poverty rate increases more in urban than in rural areas. The largest difference among urban and rural areas occurs in Nicaragua, where urban poverty

TABLE 15. Poverty Dynamics (10 percent increase in food prices)

Percent of households

	Guatemala			*Honduras*			*Nicaragua*			*Peru*		
Dynamic	*Rural*	*Urban*	*Total*	*Rural*	*Urban*	*Total*	*Rural*	*Urban*	*Total*	*Rural*	*Urban*	*Total*
Poverty intensification	67.7	33.6	49.5	67.8	23.4	45.2	58.0	22.8	37.1	70.6	39.8	50.7
Poverty alleviation	3.9	0.5	2.1	0.1	0.0	0.1	0.0	0.0	0.0	0.3	0.0	0.1
Poverty exit	0.1	0.0	0.0	0.2	0.0	0.1	0.7	0.1	0.3	0.0	0.0	0.0
Poverty entry	1.6	1.7	1.6	1.3	1.8	1.6	2.3	3.0	2.7	2.3	1.8	2.0
Nonpoor worse	25.1	63.7	45.6	29.8	74.6	52.7	38.8	74.1	59.8	26.0	58.3	46.9
Nonpoor better	1.7	0.5	1.1	0.7	0.1	0.4	0.2	0.1	0.1	0.7	0.1	0.3
Total	100	100	100	100	100	100	100	100	100	100	100	100
Change in poverty	1.5	1.7	1.6	1.1	1.8	1.5	1.5	2.9	2.3	2.3	1.7	1.9

increases by 2.9 percentage points versus only 1.5 percentage points in rural areas.

Conclusions and Policy Recommendations

Our empirical estimations of the welfare effects of high food prices between 2006 and 2008 in Guatemala, Honduras, Nicaragua, and Peru reveal several facts. First, the rise in food prices represented a negative shock for the great majority of households in both urban and rural areas. In urban areas, almost all households were negatively affected. Moreover, under an optimistic scenario in which rural producers benefit from high prices, we estimate that no more than 20 percent of rural households in Honduras and Nicaragua would have benefited from high food prices, and the figure is only 4 percent benefiting in Guatemala and 5 percent in Peru. Second, there are important disparities across countries in terms of the magnitude of the shock and its impact on households. The average loss (as a share of total consumption expenditure) ranges from 1.7 percent in Peru to 7.1 percent in Nicaragua, and in all four cases losing households in rural areas suffer more than their urban counterparts. Third, within countries, high food prices have a negative and regressive effect, whereby poorer households suffer proportionally more than richer ones because they spend a larger proportion of income on food. This regressive effect is extremely marked in the urban areas of all four countries, and it is present in rural areas though it is less pronounced. Fourth, the aggregate magnitude of the losses as a share of national consumption expenditure is not minor, ranging from 1.4 percent in Peru to 5.8 percent in Nicaragua. However, in all countries but Nicaragua, the resources needed to fully compensate the two poorest quintiles are only about half a percentage point of the aggregate national consumption expenditure. In Nicaragua, this compensation requires just over 1.5 percent of aggregate consumption. Fifth, the food price shock contributes to increasing poverty rates by about one percentage point in Guatemala, Honduras, and Peru and by about four percentage points in Nicaragua. In terms of poverty dynamics, the dominant effect was an intensification of poverty. In all countries and regardless of the region, we found that almost all poor households become even poorer as a result of high food prices. The only exception was rural Nicaragua, where 2.6 percent of initially poor households escape poverty under the assumption of full price transmission to producers. Sixth, accounting for substitution effects is not a minor issue in quantifying the effects of the rising food prices between 2006 and 2008. Our estimates indicate that the effects of the price hikes (among losing households) will be overestimated by 12 percent in Guatemala and 7 percent in Honduras if substitution effects are omitted. The overestimation is lower in Nicaragua and Peru, but it is still significant at 2.3 percent and 3.5 percent, respectively. Seventh, our overall estimates of the impact of high food prices do not change much if we relax the assumption that rural farmers benefit from high prices when they sell goods in the market. In this case, all households will be negatively affected when we shut down the channel through which rural food producers might enjoy benefits. This channel does not have a strong impact on the aggregate results, however, as we estimate that only a small proportion of households might become net winners from rising prices. For example, our estimates of changes in poverty rates are nearly the same in Guatemala, Peru, and Honduras when we do not allow for price transmission to producers; in Nicaragua the national poverty rate rises one percentage point.

Finally, we simulate a common price shock across countries (10 percent increase in most food items) to facilitate cross-country comparison. In the data, the size of the price shocks varies across countries, in part because of domestic policy responses. In the simulation, however, any differences in the welfare impact are due only to differences in production and consumption structures between countries. First, we confirm that at the national level, most households are negatively affected, but winning households are more likely in rural areas of Honduras and Nicaragua (more than 10 percent). In rural Guatemala, Honduras, and Nicaragua, and the share of winning households is highest among the poorest quintiles. In particular, 18 percent of the poorest households become winners in Honduras and Nicaragua. Therefore, as rural farmers face higher prices for their produce, there is potential for even the poorest households to accrue benefits. Second, we confirm that the impact of high food prices is regressive in urban areas, although we do not find a clear regressive or progressive pattern in rural areas. Cross-region comparisons indicate that rural households suffer more (in relative terms with respect to household expenditure) than urban ones in Guatemala and Peru. The opposite is the case in Honduras and Nicaragua, where urban households suffer slightly more, on average, than rural ones. Third, when we compare losses across countries, we find that the largest average losses take place in rural Peru (4.4 percent), while the largest urban losses are found in Nicaragua (3.7 percent). The smallest average losses are found in Honduras, where losing households suffer a 2.9 percent reduction in their expenditures, on average. Fourth, disparities in total aggregate losses remain, ranging from 2.5 percent in Honduras to 3.2 percent in Nicaragua. Fifth, the growth in poverty rates ranges from 1.5 percentage points in Honduras to 2.3 percentage points in Nicaragua, and the increase is largest in urban areas in all countries but Peru. Overall, our controlled common price shock scenario indicates that differences in the internal structure of the countries do matter for understanding the welfare impact of an increase in the relative price of food. Honduras and urban Peru are relatively more immune to high food prices, while rural Guatemala and rural Peru suffer the most.

In terms of policies, the major question is how to minimize the costs and maximize the benefits of situations similar to the 2007–08 food crisis. To minimize the costs, policymakers should focus on the extreme poor, as we have shown they are the most negatively affected. Countries can take advantage of existing social protection programs. Unlike developing countries in Africa and Asia, Latin America has successfully developed conditional cash transfer programs that could play a significant role in addressing the risks that high food prices represent for the poor, not only because of the negative income effects, but also as a result of reduced access to food. Where such programs do not exist, targeted cash transfer programs could be an alternative in the short term. However, whenever food markets function poorly or are absent, food provision programs should be considered. Microfinance programs, which include both credit and savings, should also be considered as part of the policy response. This will help to avoid drastic actions by the poor, such as distress sales of productive assets that can permanently damage future earning potentials.

With regard to maximizing the benefits for Latin American farmers, there is clearly a need to scale up investments for sustained agricultural growth in the medium run. The transition to long-term investments, particularly in the areas of market access, agricultural science, and technology, is urgently needed to transform the crisis into opportunities and to build resilience to food crises in the future. Investments for sustained agricultural growth include expanded public spending for rural infrastructure, services, agricultural research, and technology. These investments have high returns not only in terms of agricultural growth, but also with regard to reducing poverty in both rural and urban areas through increased production and employment and lower food prices. In particular, improving market access will have implications for price transmission. As our simulations show, when farmers are able to benefit from higher prices, there is a chance for even poor farmers to become winners. Our analysis here shows that transmission from international prices to domestic prices is present in major urban areas, but more research is needed to assess the degree of transmission in minor urban centers and rural areas and to determine whether farmers are able to sell their output at these higher prices.

Finally, Latin American countries have to grow their way out of poverty through productive investment that increases the earning capacity of the poor. The transfer-based strategy can only be a stopgap solution, and only a targeted investment approach can permanently reduce the vulnerability of the poor to large increases in food prices while also reducing poverty.

Appendix

Compensating Variation

Household net expenditure is defined as

$$B\left(\mathbf{p},\mathbf{w},U\right) = e\left(\mathbf{p},\mathbf{w},U\right) - \pi\left(\mathbf{p},\mathbf{w}\right),$$

where $e(\mathbf{p},\mathbf{w},U)$ is the expenditure function, $\pi(\mathbf{p}, \mathbf{w})$ is the profit function, $\mathbf{p}$ is the vector of good prices, $\mathbf{w}$ is the vector of factors of production prices, and U denotes the welfare (or utility) level. We approximate $B(\mathbf{p},\mathbf{w},\mathrm{U})$ around initial prices $(B(\mathbf{p_0},\mathbf{w_0},U))$ using a second-order Taylor expansion:

$$\text{(A1)}\quad B\left(\mathbf{p},\mathbf{w},U\right) = B\left(\mathbf{p}_0,\mathbf{w}_0,U\right) + \left[\frac{\partial e\left(\mathbf{p}_0,\mathbf{w}_0,U\right)}{\partial \mathbf{p}} - \frac{\partial \pi\left(\mathbf{p}_0,\mathbf{w}_0\right)}{\partial \mathbf{p}}\right]' d\mathbf{p}$$

$$+\frac{1}{2}d\mathbf{p}\left[\frac{\partial^2 e\left(\mathbf{p}_0,\mathbf{w}_0,U\right)}{\partial \mathbf{p}^2} - \frac{\partial^2 \pi\left(\mathbf{p}_0,\mathbf{w}_0\right)}{\partial \mathbf{p}^2}\right]' d\mathbf{p},$$

where, $\frac{\partial e\left(\mathbf{p}_0,\mathbf{w}_0,U\right)}{\partial \mathbf{p}}, \frac{\partial \pi\left(\mathbf{p}_0,\mathbf{w}_0\right)}{\partial \mathbf{p}}$, and $d\mathbf{p}$ are all vectors and $\frac{\partial^2 e\left(\mathbf{p}_0,\mathbf{w}_0,U\right)}{\partial \mathbf{p}^2}$ and $\frac{\partial^2 \pi\left(\mathbf{p}_0,\mathbf{w}_0\right)}{\partial \mathbf{p}^2}$ are matrices. Using the Envelope Theorem, $\frac{\partial e\left(\mathbf{p},\mathbf{w},U\right)}{\partial \mathbf{p}} =$ $\mathbf{h}\left(\mathbf{p},\mathbf{w},U\right)$ is the vector of Hicksian demands and $\frac{\partial \pi\left(\mathbf{p},\mathbf{w}\right)}{\partial \mathbf{p}} = \mathbf{y}\left(\mathbf{p},\mathbf{w}\right)$ is the vector of supply functions. We then rewrite equation A1 as

$$\text{(A2)} \qquad dB\left(\mathbf{p},\mathbf{w},U\right) = \left[\mathbf{h}\left(\mathbf{p}_0,\mathbf{w}_0,U\right) - \mathbf{y}\left(\mathbf{p}_0,\mathbf{w}_0\right)\right]' d\mathbf{p}$$

$$+\frac{1}{2} d\mathbf{p}\left[\frac{\partial \mathbf{h}\left(\mathbf{p}_0,\mathbf{w}_0,U\right)}{\partial \mathbf{p}} - \frac{\partial \mathbf{y}\left(\mathbf{p}_0,\mathbf{w}_0\right)}{\partial \mathbf{p}}\right]' d\mathbf{p}.$$

The first term of this last expression was studied by Deaton (1989); it corresponds to a simple case in which quantities are kept fixed at their original levels. The second term measures change in quantities as prices change. Then, $dB(\mathbf{p},\mathbf{w},U)$ is the compensating variation, as it provides a measure of the amount of extra income needed to achieve the original level of welfare, U, given the change in prices, $d\mathbf{p}$. We can also express the compensating variation, $dB(\mathbf{p},\mathbf{w},U)$, as a fraction of total expenditure, $e \equiv e(\mathbf{p_0},\mathbf{w_0},U)$ and get an expression with expenditure shares and elasticities. First, define $\mathbf{X} \equiv \text{diag}(\mathbf{x})$, such that $\mathbf{X}$ is a square matrix with vector $\mathbf{x}$ in its main diagonal and zeros elsewhere.

$$\frac{dB\left(\mathbf{p},\mathbf{w},U\right)}{e} = \frac{1}{e}\left[\mathbf{h}\left(\mathbf{p}_0,\mathbf{w}_0,U\right) - \mathbf{y}\left(\mathbf{p}_0,\mathbf{w}_0\right)\right]' \mathbf{PP}^{-1} d\mathbf{p}$$

$$+\frac{1}{2}\frac{1}{e} d\mathbf{p}\,\mathbf{PP}^{-1}\left[\mathbf{HH}^{-1}\frac{\partial \mathbf{h}\left(\mathbf{p}_0,\mathbf{w}_0,U\right)}{\partial \mathbf{p}}\mathbf{PP}^{-1} - \mathbf{YY}^{-1}\frac{\partial \mathbf{y}\left(\mathbf{p}_0,\mathbf{w}_0\right)}{\partial \mathbf{p}}\mathbf{PP}^{-1}\right]' \mathbf{PP}^{-1} d\mathbf{p}.$$

Rearranging terms yields

$$\text{(A3)} \quad \frac{dB\left(\mathbf{p},\mathbf{w},U\right)}{e} = \left[\mathbf{s}_h - \mathbf{s}_y\right]'\left[\frac{d\mathbf{p}}{\mathbf{p}}\right] + \frac{1}{2}\left[\frac{d\mathbf{p}}{\mathbf{p}}\right]'\left[\mathbf{S}_h\mathbf{E}_{hp} - \mathbf{S}_y\mathbf{E}_{yp}\right]'\left[\frac{d\mathbf{p}}{\mathbf{p}}\right],$$

where $\left[\frac{d\mathbf{p}}{\mathbf{p}}\right]$ is a vector of percent changes in prices; $\mathbf{s}_x$ is a vector of shares defined as

$$\mathbf{s}_x = \begin{bmatrix} \frac{x_1 p_1}{e} \\ \frac{x_2 p_2}{e} \\ \vdots \\ \frac{x_n p_n}{e} \end{bmatrix} \text{ for } x = h, y, \text{ and the appropriate prices,}$$

and

$$\mathbf{S}_x \equiv \operatorname{diag}\left(\mathbf{s}_x\right) \text{ and } \mathbf{E}_{xp} = \begin{bmatrix} \frac{\partial x_1}{\partial p_1}\frac{p_1}{x_1} & \cdots & \frac{\partial x_1}{\partial p_n}\frac{p_n}{x_1} \\ \vdots & \ddots & \vdots \\ \frac{\partial x_n}{\partial p_1}\frac{p_1}{x_n} & \cdots & \frac{\partial x_n}{\partial p_n}\frac{p_n}{x_n} \end{bmatrix}$$

is the matrix of elasticities for $x = h,y$ and the corresponding prices **p.** A similar expression is used by Minot and Goletti.[1]

In practice, in our empirical work we use the following expression to estimate the compensating variation for each household:

$$\text{(A4)} \qquad dB\left(\mathbf{p},\mathbf{w},U\right) = \left[\mathbf{s}_h - \mathbf{s}_y\right]' \left[\frac{d\mathbf{p}}{\mathbf{p}}\right] e + \frac{1}{2}\left[\frac{d\mathbf{p}}{\mathbf{p}}\right]' \left[\mathbf{S}_h \mathbf{E}_{hp}\right]\left[\frac{d\mathbf{p}}{\mathbf{p}}\right] e.$$

The first term in our compensating variation expression is the direct effect:

$$\text{Direct effect} = \left[\mathbf{s}_h - \mathbf{s}_y\right]' \left[\frac{d\mathbf{p}}{\mathbf{p}}\right] e.$$

The second term is the substitution effect:

$$\text{Substitution effect} = \frac{1}{2}\left[\frac{d\mathbf{p}}{\mathbf{p}}\right]' \left[\mathbf{S}_h \mathbf{E}_{hp}\right]\left[\frac{d\mathbf{p}}{\mathbf{p}}\right] e.$$

In the case of no price transmission in production, we adjust our estimate of the direct effect as

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[1] Minot and Goletti (2000).

$$\text{Direct effect} = \left[\mathbf{s}_h - \mathbf{s}_y\right]' \left[\frac{d\ddot{\mathbf{p}}}{\mathbf{p}}\right] e,$$

where for every (group) commodity *i,*

$$\frac{d\ddot{p}_i}{p_i} = 0 \qquad \text{if } s_{hi} - s_{yi} < 0;$$

$$\frac{d\ddot{p}_i}{p_i} = \frac{dp_i}{p_i} \qquad \text{if } s_{hi} - s_{yi} \geq 0.$$

In the case of partial price transmission in production,

$$\frac{d\ddot{p}_i}{p_i} = 0.5\frac{dp_i}{p_i} \qquad \text{if } s_{hi} - s_{yi} < 0;$$

$$\frac{d\ddot{p}_i}{p_i} = \frac{dp_i}{p_i} \qquad \text{if } s_{hi} - s_{yi} \geq 0.$$

QUAIDS and Elasticities

We estimate a system of demand equations following Banks, Blundell, and Lewbel (1997), namely, the quadratic almost-ideal demand system (QUAIDS). We depart slightly from their proposed system of demand equations since we incorporate control variables other than prices and total expenditure. We estimate the following system of expenditure shares:

$$s_{hi} = \alpha_i + \sum_{j=1}^{m}\rho_{ij}x_j + \sum_{j=1}^{n}\gamma_{ij}\ln p_j + \beta_i \ln\left[\frac{e}{a(\mathbf{p})}\right] + \frac{\lambda_i}{b(\mathbf{p})}\left\{\ln\left[\frac{e}{a(\mathbf{p})}\right]\right\}^2,$$

where *n* is the number of goods (or groups of goods) that are indexed by *i,* p_i is the price of good *i,* and *m* is the number of control variables, and where

$$\ln a(\mathbf{p}) = \alpha_0 + \sum_{i=1}^{n}\alpha_i \ln p_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\gamma_{ij}\ln p_j \ln p_i;$$

$$b(\mathbf{p}) = \prod_{i=1}^{n} p_i^{\beta};$$

$$\lambda(\mathbf{p}) = \sum_{i=1}^{n} \lambda_i \ln p_i .$$

From this system we can obtain all the elements of the Jacobian matrix,

$$\frac{\partial \mathbf{h}(\mathbf{p}_0, \mathbf{w}_0, U)}{\partial \mathbf{p}}.$$

The following additional constraints on the parameters must be imposed:

$$\sum_{i=1}^{n} \alpha_i = 1, \sum_{i=1}^{n} \beta_i = 0, \sum_{i=1}^{n} \lambda_i = 0, \sum_{i=1}^{n} \gamma_{ij} = 0, \sum_{j=1}^{n} \gamma_{ij} = 0, \gamma_{ij} = \gamma_{ji}, \text{and} \sum_{i=1}^{n} \rho_{ij} = 0.$$

To obtain a system of demand functions such that

$$\sum_{i=1}^{n} s_{hi} = 1,$$

demand functions are homogeneous of degree zero on prices and total expenditure, and they satisfy Slutsky symmetry:

$$\frac{\partial h_i(\mathbf{p}, \mathbf{w}, U)}{\partial p_j} = \frac{\partial h_j(\mathbf{p}, \mathbf{w}, U)}{\partial p_i}.$$

To estimate this system of equations, we use a nonlinear, seemingly unrelated regressions approach with cross-equations constraints on the parameters. For this estimation, we build on the procedure proposed by Poi, which we modify to accommodate a flexible number of equations and incorporate control variables.[2] From our estimation of demand shares, $\mathbf{s}_h$, we are able to compute compensated demand elasticities $\mathbf{E}_{hp}$.

Uncompensated demand elasticities are expressed as follows:

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[2] Poi (2002, 2008).

TABLE A1. Scenarios for Direct and Substitution Effects, Price Transmission to Production, and the Size of the Price Shock

	Observed change in real prices					
Scenario	*A*	*B*	*C*	*D*	*E*	*10%*
Direct effect[a]	Yes	Yes	Yes	Yes	Yes	Yes
Substitution effect on consumption[b]	Yes	No	Yes	Yes	No	Yes
Price transmission						
Consumption	Full	Full	Full	Full	Full	Full
Production	Full	Full	No[c]	Partial[d]	No[c]	Full

a. Refers to the first term of Taylor's expansion.
b. Refers to the second term of Taylor's expansion.
c. No price change for output sold in the market.
d. A 50 percent of price change for output sold in the markets.

$$E_{hp}^{u} = \frac{\partial s_{hi}}{\partial \ln p_j}\frac{1}{s_{hi}} - \delta_{ij} \qquad \delta_{ij} = 1 \text{ if } i = j, 0 \text{ otherwise.}$$

Then, using the Slutsky equation, we can obtain the compensated demand elasticities as

$$E_{hp} = E_{hp}^{u} + E_e s_{hj},$$

where E_{ei} is the income elasticity of commodity

$$E_{ei} = \frac{\partial s_{hi}}{\partial \ln e}\frac{1}{s_{hi}} + 1.$$

TABLE A2. Definitions

Variable	*Definition*
xx	Index for food items
hh	Index for households
ss	Index for food group: rice; corn; bread, wheat-based items and other grains; beans, roots, vegetables and fruits; meat, fish, dairy; other food
pp	Index for primary sampling unit
P_{xx}^{R}	Reference price for food item *xx*
P_{xx}^{hh}	Food item *xx* implicit price for household *hh*
Q_{xx}^{hh}	Consumed quantity of item *xx* by household *hh*
P_{ss}^{hh}	Food group *ss* price index for household *hh*
P_{ss}^{pp}	Food group *ss* price index for primary sampling unit *pp*

Supplementary Tables

Price Indexes

We construct a price index for each group of goods using implicit prices from the household surveys. Since households report expenditures and quantities purchased on every item of consumption, it is possible to infer prices from this information. In doing this, we take into account the following:

—We are interested in the difference of prices across households rather than the level of prices, so we can choose a normalization of prices. We arbitrarily chose to use the prices observed in the capital of each country as reference prices.

—Given the potential endogeneity of implicit prices at the household level, we use the median regional prices or the median of the primary sample unit level.

—Since we need to construct price indexes for each group, we aggregate the prices of the items in each group.

As a reference price for each food item *xx,* we use the median price for that item among all the households in the capital of the country:

$$P_{xx}^{R} = \text{Median}\left(P_{xx}^{hh} \middle| hh\!:\!hh \in \text{capital city}\right).$$

Then, we then compute the group *ss* price index for household *hh* according to

$$P_{xx}^{hh} = \frac{\sum\limits_{xx\in ss} P_{xx}^{hh} Q_{xx}^{hh}}{\sum\limits_{xx\in ss} P_{xx}^{R} Q_{xx}^{hh}} = \sum_{xx\in ss} \frac{P_{xx}^{hh}}{P_{xx}^{R}} \left(\frac{P_{xx}^{R} Q_{xx}^{hh}}{\sum\limits_{xx\in ss} P_{xx}^{R} Q_{xx}^{hh}} \right).$$

Finally, for each food group, we compute the median price index among all households in the same primary sampling unit *pp:*

$$P_{xx}^{pp} = \text{Median}\left(P_{ss}^{hh} \middle| hh\!:\!hh \in \text{pp}\right).$$

This is the price index for food group *ss* that we use for all households in the primary sampling unit *pp.*

For the group of nonfood goods, we used the following methodology to construct a price index. First, we gathered information from the local bureau of statistics on price indexes by group of expenditure and by region if available. For example, in Peru the National Institute of Statistics and Information provides price indexes for the following types of expenditures: food and beverages; clothing and shoes; rental housing, fuel, and electricity; furniture, appliances, and home maintenance; health care and medical services; transportation and communications; entertainment and cultural and educational services; and other goods and services.

Second, we use the household survey as the basis for computing expenditures on each of these groups of goods and services for every household. Third, we compute a price index for each household under the assumption that for each group of expenditure, the household faces the price index reported by the domestic bureau of statistics for the region in which the household is located. In particular, we use the following formula:

$$P^{pp}_{\text{non-food}} = \sum_{ss \neq \text{food}} \frac{\mathrm{I}^{\mathrm{z:hh \in z}}_{\mathrm{ss}}}{\mathrm{I}^{\mathrm{z:z \in capital}}_{\mathrm{ss}}} W^{hh}_{ss},$$

where $P^{pp}_{\text{non-food}}$ is the price index for the nonfood group for household *hh;* $\mathrm{I}^{\mathrm{z:hh \in z}}_{\mathrm{ss}}$ is the price index for the nonfood expenditure subgroup *ss* in region *zz* to which household *hh* belongs; $\mathrm{I}^{\mathrm{z:z \in capital}}_{\mathrm{ss}}$ is the price index for the nonfood expenditure subgroup *ss* in the capital of the country; and W^{hh}_{ss} is household *hh* expenditure share on nonfood expenditure subgroup *ss.* In computing this share we do not count food groups.