Food Security in an Era of Economic Volatility

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The recent upheavals in staple food prices, financial markets, and the global economy raise questions about the state of food insecurity, the nature of price variability, and the appropriate strategies for international agricultural development. For decades preceding this turmoil, agriculture had received waning attention from the global development community as real food prices declined on trend. Analysts who worried about food insecurity focused on the fate of poor producers. The dramatic upswing in prices in 2007–08 turned attention toward poor consumers as many countries struggled with food riots, mounting malnutrition, and the adoption of grain self-sufficiency policies (Naylor and Falcon 2008). New debates have been spurred over whether real agricultural prices will resume their long downward decline or whether there has been a more general reversal in the real price of food (OECD and FAO 2010; IAASTD 2009).[1]

Three-quarters of the world's poor—the 2.5 billion people who exist on less than $2 per day—live in rural areas and are both consumers and producers of food (Ravallion et al. 2007; World Bank 2008). Because they spend the majority of their disposable income on food and have minimal savings, they are particularly vulnerable to agricultural price spikes. This vulnerability persists in both urban and rural environments, underscoring the general principle that poverty, not geography, is mainly responsible for food insecurity (Ruel 2010).

Our objectives in this article are to delineate the nature and causes of recent food price volatility, to gauge whether movements in world prices for the major cereal crops (maize, wheat, and rice) are good indicators of movements in food prices actually paid by poor households, and to delve deeper into the question of how price instability affects food security among different groups in low-income countries. Three main factors distinguish food price volatility in the twenty-first century and underlie our analysis: the important role of financial markets in determining international and domestic com-

modity prices; the new connection between agriculture and energy markets; and changes in agricultural trade policies that have caused some developing countries to rely more heavily than previously on trade in staples, and others to move toward self-sufficiency.

We begin by discussing the concept of volatility and its measurement; we next examine the factors causing food price variations. A central concern is whether the recent rise and fall in food prices represents a price bubble, with faulty expectations at its core, or whether it predominantly reflects exogenous shocks (e.g., weather and macro policy) and structural dynamics related more directly to the agricultural sector. We then assess how governments respond to price volatility. Has recent price volatility caused developing countries to alter their trade orientation fundamentally in order to pursue a more self-sufficient strategy? If so, what are the implications of this strategy for food security?

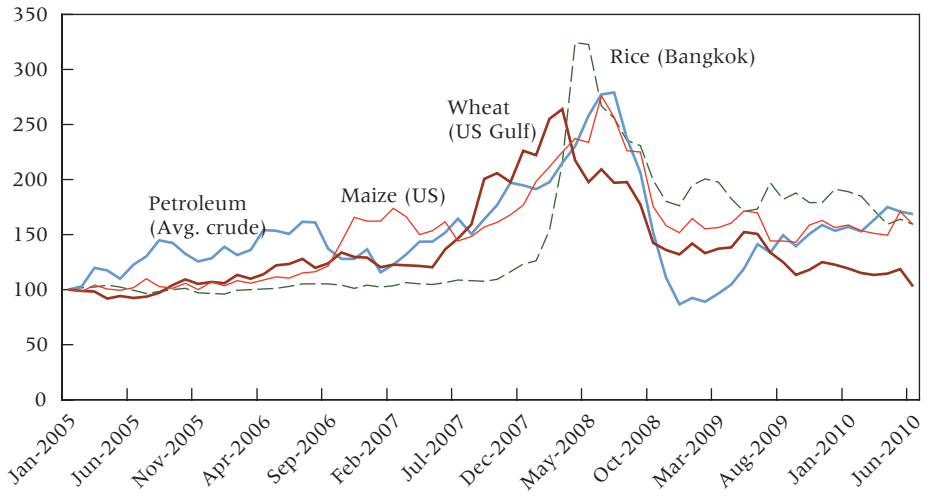
In the final section of the article, we trace the impacts of international price variability to the local level. By merging macro- and micro-level analyses of international commodity price fluctuations, food policy in a range of countries, and food security conditions within the lowest income groups of the developing world, our hope is to say more than: "high prices help farmers and low prices help consumers."

Magnitudes of recent volatility in world prices

The sharp rise in 2008 food prices caught virtually all economists by surprise. World prices (in dollars) of the four commodities of primary interest in this article—wheat, rice, maize, and petroleum—roughly tripled in real terms during the first half of 2008. They then fell to about 1.5 times their 2005 level during the last half of 2008 before again leveling off in 2009 and 2010 (see Figure 1). These price movements raise serious concerns about the plight of the world's poor; they also raise analytic questions about the magnitude of food price variability, and whether the recent episode was an abnormal event when viewed within a longer-run assessment of food-price variations.

General assessments of post-2000 price variability are surprisingly disparate with respect to both causes and magnitudes. Alternative views are related in large part to differences in terminology, measurement concepts, and what various authors deem to be important. For this article, we think it useful to decompose volatility into price trends, "normal" variability about those trends, and price spikes, all of which contribute to measured variation in prices. If all three components are deemed important in the variability calculation, then the coefficient of variation (CV)—the standard deviation divided by the mean—provides a useful standardized statistic for comparing variation across time. However, if the primary concern is about variations

FIGURE 1 Real commodity price indexes, January 2005–June 2010 (Index, January 2005 = 100)



NOTE: Deflated using the IMF US GDP index.
SOURCE: IMF International Financial Statistics «http://www.imfstatistics.org».

around trends, a different formulation is required.[2] Finally, there are "exceptional" price movements, which we refer to as spikes or bubbles and which typically involve elements of misguided expectations. They are of special concern, particularly to poor consumers; yet there is no general agreement on how they should be defined or analyzed.

To provide the variability measurements, we use a simple breakdown of monthly data by decade.[3] No time interval is perfect for all purposes, but monthly data by decade seemed an appropriate compromise for the decision-making and welfare impacts that are our major concern. We also chose to analyze real prices,[4] since inflation-adjusted comparisons across time periods seemed more appropriate for our focus on food security.

Table 1 shows the most straightforward comparison of total price volatility by decade using coefficients of variation. Among the grains, rice prices were the most variable through time. This result is not surprising given the multiple end uses for maize and wheat and the well-functioning futures markets that exist for them, but not for rice. Perhaps more importantly, CVs for the grains during the post-2000 period were approximately the same as those that characterized the very volatile 1970s.

Declining trends in real agricultural prices have long been noted (see Figure 2). If these time trends show up within decade intervals, and if these changes are more or less accommodated into everyone's expectations, then there are good analytical reasons for examining variation after time trends have been removed. Table 2 shows the variability estimates after removing

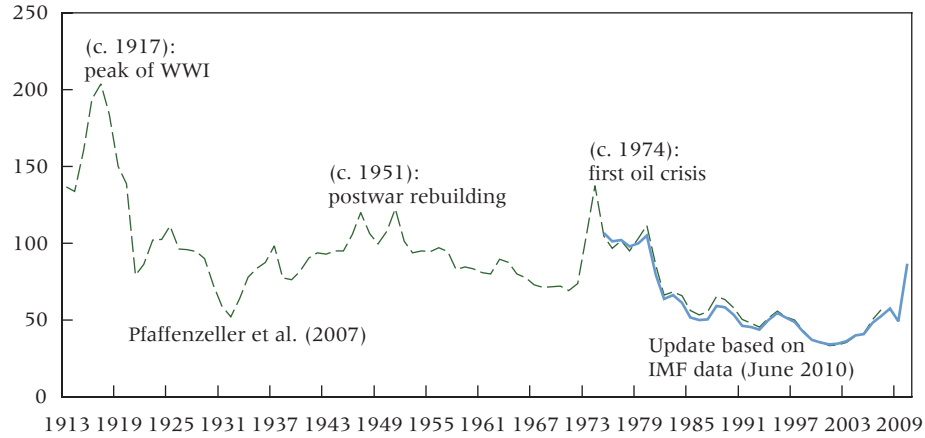
TABLE 1 Monthly variations, by decade, for selected real commodity prices

	Coefficient of variation, in percent[a]			
	1970–79	1980–89	1990–99	2000–09
Wheat	36	24	21	32
Maize	25	27	20	29
Rice	44	43	14	49
Petroleum	69	41	25	46

[a]Standard deviation of each price series by decade, divided by its mean.
SOURCE: IMF International Financial Statistics «http://www.imfstatistics.org».

decadal time trends.[5] They indicate that monthly price variability about time trends in real prices also differed somewhat by commodity. For example, the root mean square error—our measure of de-trended volatility—was about 50 percent higher for rice in the 1970s (15.5 percent) than for maize (10.3 percent). Maize and wheat again showed less price variation through time than did rice. Perhaps more importantly, price volatility for all commodities during the post-2000 period was below that of the 1970s, a different conclusion than suggested by the CV analysis. Numeric conclusions about recent volatility are thus dependent on whether or not trends are included in the analysis. There were, in fact, significant time trends for all four commodities for all four decades.[6] For the grains, all of the trends were significantly negative for the 1970s, 1980s, and 1990s, but significantly positive for the 2000s.

FIGURE 2 Real non-fuel commodity price index, 1913–2010 (Index, 1977–79 = 100)



NOTE: Deflated using the US BLS consumer price index (CPI).
SOURCE: Prior to 1995, Pfaffenzeller et al. (2007); spliced and updated through June 2010 using IMF International Financial Statistics «http://www.imfstatistics.org».

TABLE 2 Monthly variations from trends, by decade, for selected real commodity prices

	Root mean square error, in percent[a]			
	1970–79	1980–89	1990–99	2000–09
Wheat	13.7	6.6	8.4	7.6
Maize	10.3	8.2	7.6	7.3
Rice	15.5	10.7	6.3	9.0
Petroleum	14.2	7.6	8.8	10.6

[a]Standard error of the estimate, calculated from deviations about the equation: Log Real Price = a + b Time.
SOURCE: IMF International Financial Statistics «http://www.imfstatistics.org».

The data shown in Figures 1 and 2 and Tables 1 and 2 raise an additional analytic issue: namely, is it useful to distinguish underlying or "structural" price variability from price spikes? The answer is probably yes, in large part because the causes of price change and their implications for food security may be quite different between the two types. As shown in Figure 2, severe price spikes occur about every 30 years. They are typically precipitated by multiple events or crises, and they are often amplified by food- and trade-policy interventions designed to stabilize domestic markets (Naylor and Falcon 2008). Spikes are also fueled by panic hoarding, particularly in the case of rice (C. P. Timmer 2010). In measurement terms, the handling of spikes matters. When 18-month price spikes are removed for both the l970–79 and 2000–09 periods, CVs for the grains are reduced by about one third.

To provide additional information on extreme variation, we also examined yearly differences in prices by month. For each of the grains for each month, we calculated a percentage difference in price from the previous year. Aggregating the three grains provides a total of 360 data points per decade.[7] We assume, somewhat arbitrarily, that a price change of more than 75 percent over a year's time constitutes a spike. There were 20 months when the change exceeded 75 percent for the 1970s, no months in the 1980s, 2 months in the 1990s, and 15 months in the 2000s. All of the greater-than-75-percent changes had positive signs, creating an exceedingly difficult situation for consumers, especially poor consumers, during those periods.

Three conclusions can be drawn from our efforts to measure volatility. First, decomposing price volatility into a series of components seems helpful in understanding what is happening in terms of trends, variability around the trends, and spikes; decomposition also helps avoid confusion about what is being analyzed and debated. Second, from a measurement perspective, spikes really matter; analyzing them properly is still a work in progress for us and for the profession as a whole. Given that all three components (trends, variability around trends, and spikes) are evident in our commodity price series, the CV measure is arguably the most appropriate historical measure of volatility. Our third conclusion, therefore, is that post-2000 variation in real prices was

substantially greater than for the 1980s and 1990s, and was broadly similar to the 1970s when measured by CVs. The most interesting dimension of the comparison between the 1970s and 2000s, however, is whether the causes and effects of extreme variation were substantially different between the two periods—topics we discuss in the next section.

Causes of recent price volatility in world prices

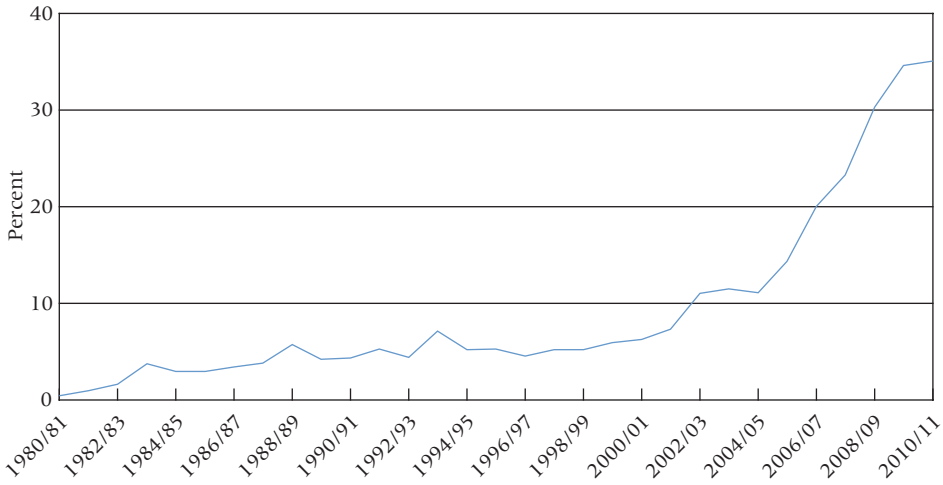
Although price volatility in 2000–09 may not have been unprecedented, it was certainly significant and had dramatic impacts on the estimated 1 billion people living in chronic hunger by the end of the period. For many developing countries facing heightened food insecurity, the origins of price volatility were largely external, related to the continuing surge in biofuels; major changes in policies, macroeconomic conditions, and financial markets in rich countries; and the global recession. These factors compounded the problems of low crop productivity and increased reliance on food imports, and aggravated other internal causes of instability—conflict, weak institutions, and inadequate infrastructure—that typically plague the world's poorest countries (World Bank 2010).

Structural causes

An essential distinction between the recent price environment and that of the 1970s is the growing influence of demand-side determinants. A human population nearing 7 billion, coupled with increased incomes in many developing countries, has created greater demand for meat, vegetable oils, and other high-end food products, and has put additional pressure on the agricultural land base. This point is most clearly seen in the case of maize, where global demand for animal feeds and biofuels is consuming a greater share of total production. For the United States, the dominant world producer and exporter of maize, ethanol production continues to rise almost irrespective of variations in maize and petroleum prices, and despite profitability turmoil within the ethanol industry itself. The biofuels industry now consumes over one third of total US maize production (see Figure 3). This rising share has been linked to the substitution of ethanol for methyl tertiary-butyl ether (MTBE) as a gasoline additive following 2005 environmental regulations to phase out MTBE in the United States. It has also been linked to mandates, blender subsidies, and import tariffs on ethanol designed to encourage renewable fuels production (Naylor et al. 2007; Naylor and Falcon 2008; USDA 2010a).

As maize prices increased in 2006–07, American farmers in the Midwest substituted maize for soybeans, causing prices for soybeans in international markets to rise as well. The jump in maize and soybean prices led to additional

FIGURE 3 Percentage of US corn crop used for ethanol, 1980–2010



NOTE: Percentage for 2010/11 is estimated by USDA.
SOURCE: USDA Feed Grains Database
«http://www.ers.usda.gov/data/feedgrains/FeedYearbook.aspx#USacre».

price pressure on alternative feedstuffs, such as wheat. Maize prices resumed their pre-spike levels after the financial markets collapsed in late 2008 (Figure 1), prompting the question of how much of the price increase had been caused by speculative activity in the market as opposed to structural supply and demand forces.

Similar to the case of maize, the wheat situation during 2005–10 was partly a story of rising feed demand. However, relative to maize, wheat was influenced more by supply shocks and anticipated production losses. Australia, a major wheat exporter, suffered a massive drought. During 2006–07 and 2007–08, Australian wheat exports averaged about 8.5 million metric tons (mmt), compared with 16 mmt the three prior years. This decline alone amounted to about 7 percent of total wheat exports (FAO, *Food Outlook* 2010). The rebound of Australian wheat exports to about 14 mmt in 2009–10 helped to recalibrate the market, but then a second climate shock occurred. Russia, Ukraine, and Kazakhstan were hit by an extreme heat wave in the summer of 2010, causing (projected) wheat production in these countries to drop by 27 percent, 19 percent, and 35 percent, respectively, from a year earlier (USDA 2010b). Given that the three countries typically account for roughly 14 percent of global wheat production and 27 percent of exports, the estimated 26 mmt annual loss in wheat output from the region has major implications for world wheat markets as well as other grain markets that supply food and feed. World wheat prices jumped by 66 percent between early June and August 2010, and wheat futures reached their highest price in almost two years after Russia announced a not-so-temporary ban on wheat exports (Javier et

al. 2010). This recent shock raises the specter of the 2008 commodity price spike and underscores the interconnectedness of commodities and countries in any assessment of market volatility and global food security.

In addition to recent weather problems, wheat stem rust (a fungus) has affected wheat yields in more than 20 countries since 2005.[8] Spores from this pathogen, named Ug99 for its discovery in Uganda in 1999, were carried by winds northward in Africa and then into Iran via Yemen; they have since been found in many other wheat-producing areas. Although stem rust had not been a significant problem for more than 30 years before 1999, four new rust mutations have now overcome existing sources of genetic resistance to the disease. Virtually all wheat varieties in use are susceptible to this rust, and the great fear was (and is) that this pathogen would invade the Indo-Gangetic Plain where hundreds of millions of wheat producers and consumers are dependent on wheat.[9] The average Indian, for example, consumes more than 500 calories daily from wheat and wheat products (FAO 2010). Perhaps more significantly, Ug99's potential for major damage influenced government policy in several key countries. In spring 2008 the Indian government banned exports of rice—the country's other major staple—when it feared significant increases in grain prices and a spread of Ug99 in wheat. This ban affected food prices from Asia to Africa; it added to global grain price variability and underscored the growing food-security and crop interdependencies among countries arising from pathogens, prices, and policies.

A great many factors were involved in the decline of wheat and maize prices following their price spikes in 2007–08. In part the high prices carried the seeds of their own price corrections. High prices induced farmers to grow more cereals; between 2006–07 and 2008–09 global wheat and coarse grain production grew by 14.6 percent and 15.4 percent, respectively (FAO, *Food Outlook* 2010). This upswing was reversed, however, by serious climate conditions in 2010, leaving the near-term outlook for staple grain supplies and prices uncertain.

Structural features of the rice market are perhaps the most clear-cut among the cereals. Commodity analysts have long been interested in rice prices, precisely because of their volatility. The market is sharply divided between long and short grain varieties; rice is only thinly traded internationally (about 5 percent of total production); key rice-importing countries are buffeted by El Niño events; there are many state actors in the trade; and there is no robust futures market for rice comparable to the Chicago markets for wheat and maize. Price expectations under these circumstances often drive "destabilizing speculative behavior" among billions of market participants (C. P. Timmer 2010). On the fear that prices might rise even further, millions of consumers could (and did) put an extra bag of rice into their larders. The demand was real, but this panic hoarding was a principal early cause of the rice price spike. Government policies then tended to aggravate the situation.

The ban on Indian rice exports, noted earlier, affected several African countries that had relied on India for low-cost rice. Export restrictions also created mini-panics within importing countries, such as the Philippines, which in spite of the shortness of global supplies attempted to purchase more rice for precautionary purposes. When the new-crop rice finally did become available, world prices plummeted as de-stocking took place at both household and national levels.

An examination of structural features thus underscores several long-known, but frequently forgotten points. First, commodities with low price elasticities of demand and supply, limited storage, and frequent policy interventions are prone to substantial price variability and occasionally to price spikes. Second, changed price levels sometimes create substitution possibilities in both production and consumption that were not previously thought possible. And third, similarities in price movements among food crops highlight the critical role played by macro variables such as growth in GDP and movements in exchange rates.

Exchange rates and energy

It is clear from the discussion above that structural features of the world food economy have contributed to price volatility and substitution among individual commodities in recent years. But it is also clear from Figure 1 that a set of external, macro factors causes all food prices to move together in the same general pattern. These factors include exchange rate movements, petroleum prices, and aggregate demand as measured by GDP and trade (Headey and Fan 2008; Abbott et al. 2008). Table 3 shows high correlations among real international prices for wheat and maize—commodities heavily traded in international markets and denominated in US dollars (USD)—the US/Euro exchange rate, the IMF's nominal effective exchange rate (NEER) for the USD, and real petroleum prices during the past decade.[10] There is a firm three-way connection among grain and petroleum prices and the value of the USD. Although the correlations are high, it is more difficult to determine causality among these variables because of problems of simultaneity.[11]

Given the strong relationships shown in Table 3, we make four points about the role of the macro variables in food price volatility and food security. First, a depreciation of the USD has the expected effect of increasing international prices of commodities that are commonly denominated in US dollars. Plotting the Commodity Research Bureau's (CRB) price index of 13 food commodities against the NEER shows this connection clearly, with a correlation coefficient of 0.9 (see Figure 4).[12] When maize and wheat prices are mapped individually against the NEER, the correlations are still very significant, but slightly smaller. In the post-2008 period, for example, the increased supplies of wheat described previously caused wheat prices to diverge from the prices

TABLE 3 Correlations among real monthly commodity prices and exchange rates, January 2000–April 2010

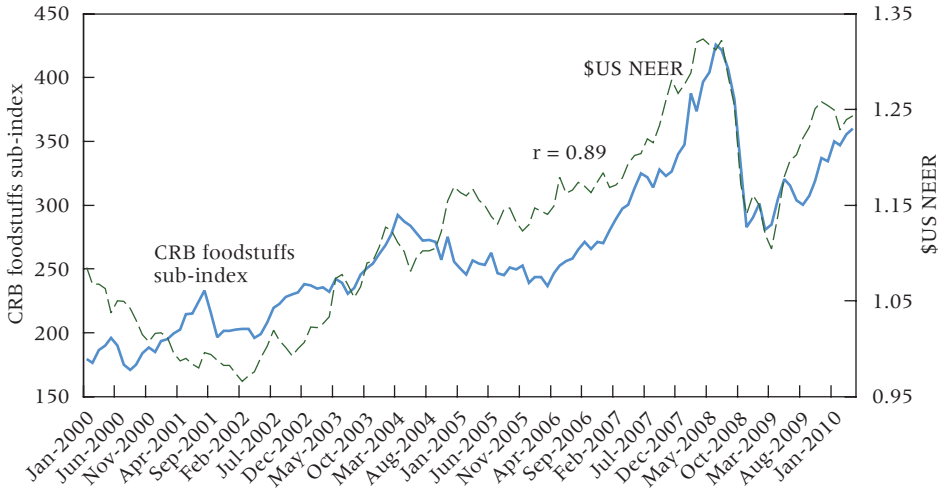
	Wheat	Maize	Petroleum	US$ per Euro	US$ nominal effective exchange rate (NEER)
Wheat	1.00				
Maize	0.86	1.00			
Petroleum	0.79	0.78	1.00		
US$ per Euro	0.73	0.74	0.83	1.00	
US$ NEER	–0.74	–0.75	–0.91	–0.96	1.00

SOURCE: IMF International Financial Statistics «http://www.imfstatistics.org». Nominal prices deflated using IMF GDP deflator, 2005 = 100.

of other food commodities, resulting in a correlation coefficient of 0.8. Our conclusion, based on this evidence, is that exchange rate movements are significant determinants of the variability in international grain prices, but that the fundamentals of agricultural demand and supply continue to have a substantial influence, especially for particular years.

Second, price movements for grain commodities and petroleum reinforce each other, with petroleum prices being the dominant determinant. Energy-related inputs represent a large variable cost in the agricultural budget

FIGURE 4 Correlation between the CRB foodstuffs index and US$ nominal effective exchange rate



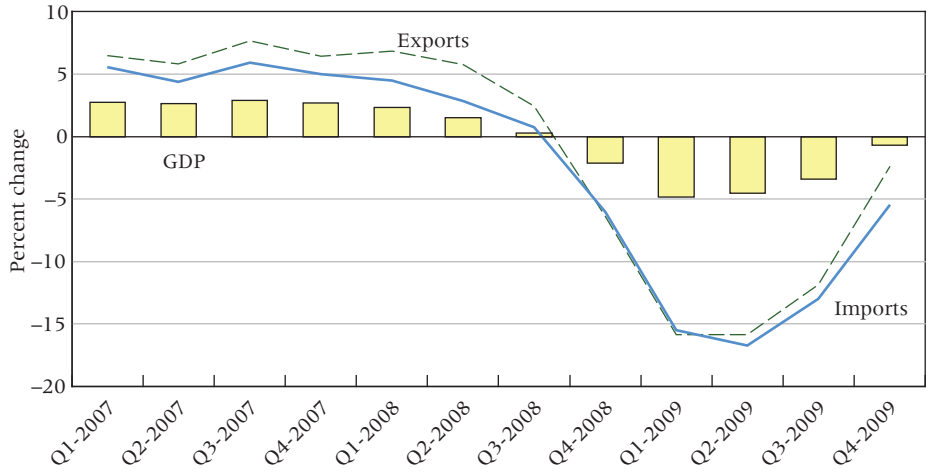
NOTE: NEER index is inverted so as to more easily see its correspondence with commodity prices; the NEER index has been reset so that November 2002 = 100.
SOURCE: IMF International Financial Statistics «http://www.imfstatistics.org»; Commodity Research Bureau «http://www.crbtrader.com/».

(Huang et al. 2009), particularly for US grain production, which accounts for 55 percent of global maize exports, 20 percent of global wheat exports, and 10 percent of global rice exports. Costs of energy-related inputs (fertilizers, pesticides, and fuel for farm machines and drying operations) rose with crude oil prices through mid-2008 and continued to rise in 2009 even as petroleum prices plummeted and then rebounded partially after the global financial collapse.[13] For example, real petroleum-related farm costs for high-yield maize in Iowa rose 17 percent between the 2002 and 2008 crop seasons, and another 40 percent between the 2008 and 2009 crop seasons.[14] The latter rise reflected some forward purchasing of fertilizer and fuel by farmers in 2008, and more generally the phenomenon of panic buying and hoarding during price spikes.

Petroleum prices also serve as a reference point for the profitability of maize-based ethanol, and hence affect the demand for and price of maize (Naylor et al. 2007; Babcock 2008; Naylor and Falcon 2008). Despite bankruptcies of several American maize-ethanol plants following the financial downturn and oil price collapse, the renewable fuels target coupled with rising crude oil prices later in 2009 has helped to bolster ethanol demand and maize prices. The ongoing policy discussion about the ethanol-to-gasoline blending mandate has also added to price uncertainties and expectations. In the words of an unnamed leader of a major grain trading business, "the U.S. policy debate over whether to set the blending mandate at 10 percent or 15 percent is equivalent to projecting whether the corn price will settle at $3/bushel or $5/bushel."

A third point related to macro variables is that changes in GDP, particularly in OECD countries, tend to amplify fluctuations in global trade. During the past decade, the rate of growth in OECD trade has been twice as high as the rate of growth in aggregate demand (OECD and FAO 2010). But the rise and fall in trade has been asymmetric with respect to the recent boom and bust in the global economy. Robust economic growth in the 2007 to mid-2008 period was accompanied by annual growth in trade of around 5 percent, while the economic downturn in October 2008 through 2009 was matched by a 15 percent drop in annual trade growth (see Figure 5). The sharp decline in trade reflected the sheer size of the economic downturn—the most severe since the Great Depression in the 1930s—and had major implications for commodity demand and hence prices in international markets. It also had serious repercussions on employment, incomes, and food security in many developing countries that service the import demands of the OECD countries. Equally important, if not more so, was the dramatic fall in net financial flows to developing countries that resulted from the financial collapse, which led to a quick and significant decline in consumer spending and investment activities (H. Timmer 2010; World Bank 2010).[15] The sudden decline in consumer spending in these countries was in large part panic-oriented and was associated with consumer and investment uncertainty.

FIGURE 5 Quarterly growth rates of OECD countries, 2007–2010, for real GDP, exports, and imports



NOTE: Measured as the percent change from the same quarter of the previous year.
SOURCE: OECD Statistics Portal
«http://www.oecd.org/statsportal/0,3352,en_2825_293564_1_1_1_1_1,00.html».

According to World Bank measures, more than 100 million people fell back into severe poverty (under $1.25/day) at the time of the financial downturn (World Bank 2009). FAO estimates (2009) show that 1.02 billion people were malnourished in 2009, up from 872 million in 2006 and higher than in any year since 1970 when comparable statistics have been available (see Table 4).[16] South Asia still dominated the hunger category in absolute numbers, but the percent of population suffering undernutrition in 2004–06 was much higher in sub-Saharan Africa (about 30 percent) than in South Asia (about 23 percent) or in all of Asia and the Pacific (about 16 percent). Exceeding one billion people signaled a troubling threshold that was brought on first by the spike in food prices and then by the global economic downturn—the latter having a pervasive effect on disposable incomes and food purchasing power in many poor countries. Moreover, the impact of the economic downturn reached beyond the poorest populations to the middle class of the developing world, whose assets lost significant value. Even when food prices fell in international markets during the collapse, they remained high in a large number of developing countries as a consequence of food and exchange rate policies.

A final and related point concerns the role of emerging economies such as Brazil, Chile, China, India, and Mexico. Aggregate economic growth and currency values in emerging economies have been stronger than in the United States and Europe in recent years—both before and after the global economic

TABLE 4 Undernourishment in 2004–06 and 2009, by region

	Millions of people	
	2004–06	2009[a]
Asia and Pacific	566	642
Sub-Saharan Africa	212	265
Latin America and Caribbean	45	53
Near East and North Africa	34	42
Developed countries	15	15
World total	872	1,017

[a]Estimated by FAO.
SOURCE: FAO (2009).

downturn—despite the fall in net international capital flows noted above. The ability of these countries to weather the storm is partially the result of good policy. External debt as a percent of GDP is only 7 percent in China, 14 percent in Brazil, and 20 percent in Mexico—far lower than the rates of 98 percent in the United States, 155 percent in Germany, 416 percent in the UK, and 1004 percent in Ireland.[17] The macro debates have turned since the earlier debt crisis in the early 1980s when many of the emerging economies were negotiating with international lending institutions and bankers in the United States and Europe to reschedule debt and adopt structural adjustment policies.

There are two key implications of this shift for grain prices and food security: demand for grains is likely to be more robust in middle-income economies than in the poorer parts of the developing world; and stronger currency values mean that prices for grains and other foods have not dropped much in the former group of countries. Although rich countries may have been largely responsible for the volatility in global financial markets that has affected food prices and demand since 2000, the middle-income economies will probably be more important in the future in guiding the structural components of world grain supply and demand.

Speculation and stocks

The recent correlations between dollar and petroleum prices, and between those two variables and food prices, emphasize the power of external forces on agriculture. But these were not the only forces affecting food prices, and the roles of two other variables—stocks and speculation—have been vigorously debated. Much of the debate has been emotional: in parts of the world, grain merchants were chastised for holding inadequate stocks to prevent price rises; in other areas, they were vilified for being anti-social hoarders.[18] Similarly, excess speculation was seen by some as a major cause of the price bubble, and seen by others as irrelevant to what was happening in physical (cash) markets.

As in the case of volatility itself, definitions and timing are crucial when analyzing speculation and stocks. So too is a broad understanding of futures markets.[19] Our primary interest in this article is the nature of monthly price movements in cash markets, not the intricacies of futures markets. Speculative fortunes were made (and lost) in these markets in very short periods of time—days, minutes, and even seconds—but this general phenomenon is not our concern. On the other hand, it is not possible to disregard futures markets completely: they are where global price discovery takes place for wheat and maize;[20] virtually all international trade contracts for these commodities are written in dollars; and contracts are typically priced with reference to prices prevailing currently or anticipated in the future at one of the US commodity exchanges, often in Chicago.

Numerous allegations have been made about excessive speculation and the role that commodity index trading played in increasing food prices during 2008 (US Senate 2009; Sanders et al. 2008; IFPRI 2008; Aulerich et al. 2009; Irwin et al. 2009; C. P. Timmer 2009; Wright 2009). There is no doubt that trading activity (open interest) soared after 2003. The number of contracts being traded in Chicago corn futures markets was about three times greater in 2007 and 2008 than in 2003; the number of wheat contracts was about two times greater. However, whether this increased activity affected price variations and/or price trends seems doubtful. If changes in volume per se were the issue, the data indicate that the price spike should have occurred two to three years before it actually did.

The composition of the wheat and maize market participants might also have changed, however, especially with respect to the numbers and relative shares of hedgers and speculators. Given the market uncertainties that prevailed at the time, merchants, millers, and feeders who had not previously been using futures markets to manage risks (so-called hedgers) might have increasingly used these markets in the post-2005 period. Alternatively, the increased market volume and volatility could have come about primarily because futures markets represented a "new" market for speculative activities by hedge funds, index traders, and others not linked directly to the commodities as producers or processors.[21]

Once key market roles are specified, the issue of "excessive" speculation becomes an empirical question. The disagreements center on three key issues: what was happening to the number of contracts being traded by various participant categories; what was happening to supply and demand balances (stocks) in the cash market; and what was happening to the efficiency with which the markets seemed to be working as measured by convergence of cash and futures markets at the end of contract periods.

A substantial amount of increased futures-market activity was the result of increased hedging. Between January 2006 and January 2008, commercial use of corn futures in Chicago increased by a factor of about 2.0 and wheat by

a factor of 1.5. In contrast, the contracts held by index traders increased by a factor of only 1.4 in the case of corn and 1.1 in the case of wheat (Aulerich et al. 2009). During the spike period of August 2006 to August 2008, the net positions of commodity index traders, measured in numbers of futures contracts, were essentially constant for the corn and wheat markets in Chicago. Based on these data, there does not seem to be a *prima facie* case that the behavior of commodity index traders was a principal cause of the sharp upward price movements for maize and wheat.

Second, the level of grain stocks, at first glance, appears to have been very low during the price run-up period. Most economists argue that speculation in futures markets could have affected cash prices only if it caused the actual holders of grain to bring forth "less" of their available stocks than they otherwise would have supplied, even in the face of rising prices (Wright 2009; Krugman 2008). Defining available stocks—stocks not already committed to a particular use—thus becomes an important empirical matter, as does the formation of future price expectations for those with the capacity to deliver.

Closer inspection of the stock data reveals a murky picture. Lower stock-to-use ratios in 2008 have frequently been cited as evidence of supply/demand tightness and the basic cause of rising prices. Much of the drawdown on global grain stocks occurred in China, however, and Dawe (2009) has argued persuasively that the de-stocking there was policy, not market, determined, and that the drawdown did not have international repercussions in the cash market. Once Chinese stocks are removed from the calculation, there are no sharp dips in stocks for any of the grains; therefore, there is little empirical basis for claiming stock-to-use ratios as the driving force of the price spike.[22]

The third piece of the puzzle is whether the maize and wheat markets were working efficiently. If futures and cash prices consistently came close to converging at the end of contract periods, the case for excessive speculation would be virtually impossible to defend. Most of the time this equilibration occurred, but not always; several grain markets showed significant cash–futures divergence during various contract closing periods in 2008 (Irwin et al. 2009). Much of the convergence problem between cash and futures contracts appears directly linked to specific delivery destinations. For example, wheat futures prices were about $0.80 per bushel higher than in the cash market in Toledo in July 2008. Our informal discussions with traders indicate that there were simply insufficient quantities of wheat of the requisite quality (protein content) in place to force price convergence. Non-convergence has been an irregular event since 2005, not just a phenomenon of 2008. These divergences have created very serious problems, especially for hedgers, who depend on approximate futures–cash price parity at the end of contracts to limit price risks. But the divergences per se do not seem to have been a primary cause of the price spike.

Tight market conditions and limited uncommitted stocks drove the price rise in cash grain markets for wheat and maize. Much of the convergence

problem between cash and futures contracts appears directly linked to specific delivery problems, such as protein content in the case of wheat. Flurries of short-run speculation in the futures markets probably also caused some participants in the cash market to alter their behavior.[23] Because of changed expectations about the future, suppliers of uncommitted wheat and maize inventories became more reluctant to release stocks, and demanders of these commodities became more insistent about purchasing them before prices rose even higher. More generally, the surge of activity in futures markets created uncertainty about what was happening in cash markets. In several instances (e.g., in rice, maize contracts to ethanol plants, and fertilizer) this uncertainty influenced expectations and prompted (what turned out to be) ill-conceived precautionary purchases by households, firms, and governments.

Transmitting volatility—World prices to country prices, and vice versa

Movements in world prices provide one obvious starting point for assessing the effects of price volatility on food security. Yet few consumers or producers actually "see" world prices. Chicago prices for wheat and maize and Bangkok prices for rice must be transmitted to country currencies via exchange rates, which, as noted previously, have dynamics of their own.[24] There are then subsequent transmission processes that link country border prices with local markets. In a theoretical world of free trade, no policy interventions, and zero transport costs, these issues of transmission could be disregarded; however, these assumptions are so far from reality that they cannot be ignored.

We are most concerned about what happens to poor households if world prices go up (or down) substantially—say, by 50 percent. Do local prices typically tend to go up by more or less than 50 percent? And if local prices vary less, does this difference in variation have a feedback effect on world prices and their variability? The answers to these questions—and their food security implications—depend primarily on food (and trade) policy in key countries and on transportation costs.

The role of transport costs in linking food exporters and importers is often underestimated as a source of price volatility. Freight rates are determined by much more than agricultural commodity shipments, and they are thus sensitive to global economic activity. For interior countries, for example, D.R. Congo, Laos, Mali, Nepal, Niger, Paraguay, and Zambia, the problems of having to move shipments across neighboring countries to link with international markets add substantially to transport costs and may also limit trading partners and food-policy options. For land-locked countries, the combined effects of international and regional transport widen the difference between import (c.i.f.) and export (f.o.b.) parity.[25] This expansion of the so-called f.o.b.–c.i.f. band has very important public policy implications. Countries cannot expect

import or export markets to influence food prices while domestic prices are within that band, and if the bandwidth is large, internal price variations are likely also to be large unless the government intervenes with some type of subsidy scheme.[26]

The importance of transport cost volatility is illustrated by the International Grains Council price series for ocean freight rates (FAO, *Food Outlook*, various issues). During 2007 ocean freight rates doubled. Then between June and December 2008, ocean rates fell by about two-thirds. Costs of shipping grain from US Gulf ports to East Asia, for example, fell from about $125 per metric ton (mt) to $35 per mt. Since mid-2008 when maize and wheat prices have been about $300 and $350 per mt, respectively, the impact of precipitously falling freight prices helped importantly to "de-spike" grain prices in importing countries.

Exchange rates and transport costs affect price volatility within countries; however, national food and trade policy interventions may be even more important for explaining divergences from world to local prices. During the 2008 price spike, country prices varied far less than world prices. For a wide array of developing countries (for example, Bangladesh, Colombia, Ethiopia, Guatemala, India, Mexico, Nigeria, and Zambia) domestic price rises in the 2005–10 period for rice, wheat, and maize were substantially less (in local currencies) than the peaks in world prices for these crops as measured in dollars. That stabilization necessarily resulted in substantial lost income to local producers, and/or lower prices to consumers, and/or higher government expenditures. If all price indexes are set at 100 in January 2005, the country peaks in 2008 typically average about half of the peak in world prices; interestingly, Anderson and Nelgen's (2010) much more thorough assessment of all developing countries during the earlier 1972–76 price spike shows almost identical results—54 percent for a set of 12 agricultural commodities.

Domestic-to-international food price ratios, especially during price spikes, are at the heart of much of the global political economy for agriculture. Since the 1970s, many of the poorest developing regions have increased the ratio of their imports to consumption. Sub-Saharan Africa, for example, now imports 42 percent of its rice and 69 percent of its wheat. Similarly, Central America imports about half of its maize and rice and virtually all of its wheat.[27] The tonnages implied by these percentages and those for other countries are also rather startling (see Table 5). In 1960, Africa was self-sufficient in cereals, but by 2009 cereal imports had grown to 48 million metric tons; Asian imports for the same period grew from 6 mmt to 84 mmt. These changing self-sufficiency ratios and expanded tonnages reflect an uncertain combination of emerging liberalization and comparative advantage; failed production strategies in some poor countries; the growth of livestock industries in some regions; and quasi-subsidized exports from rich nations. Whatever the cause(s), many individual countries still seek to stabilize internal prices. As

imports increase, countries face a growing potential problem of imported instability. Domestic stabilization thus becomes more costly in terms of actual budget outlays or in economic opportunities forgone.

The provision of domestic food-price stabilization also affects international prices. There is a vast literature on the ways in which domestic price stabilization adds to international price de-stabilization (e.g., Anderson 2009; Newbery and Stiglitz 1981; Tyers and Anderson 1992; Johnson 1975; C. P. Timmer 1996). As countries use combinations of food and trade policy to avoid importing international price variability, they further amplify international price movements. Unwinding this spiral makes coping with price bubbles extremely difficult from a political economy perspective. Jayne et al. (2010) report that a number of countries in Eastern and Southern Africa have sought to solve this problem by returning to domestic marketing boards, especially for maize, and to policies that proved almost universally ineffective in the 1970s and 1980s. Most attempts to become more fully self-sufficient have been expensive, created market uncertainties, exacerbated domestic price instability, and curtailed benefits deriving from the principle of comparative advantage.

The nexus of trade, domestic price instability, and international price instability creates particularly difficult issues for "large" countries, whose actions can affect international prices significantly even during "normal" years. Some countries, for example Indonesia in the case of rice, have established policy goals of holding real staple prices constant. Indonesia has frequently been the world's largest importer of rice, and the country has pushed hard to produce enough paddy domestically so as to be "self-sufficient on trend." It has then used international trade to limit domestic price instability by buffering supplies during years in which domestic production is either very good or very poor.

TABLE 5 Net trade flows of total cereals (wheat, maize, and rice), by region, selected years

	Million tons		
	1960	**1990**	**2009**
Asia	–6	–83	–84
Africa	0	–25	–48
South America	1	–11	4
North America	23	113	72
Western Europe	–22	22	9
Eastern Europe	0	–31	30
Oceania	3	14	17

NOTE: Positive sign indicates net exports, negative sign indicates net imports.
SOURCE: Adapted from FAOSTAT «http://faostat.fao.org» and FAO *Food Outlook* (various issues).

Finding sensible ways to deal with the political economy of domestic food-price stability is at the heart of food policy in many countries. Price spikes are the scourges of poor consumers. They also present impediments to the adoption of improved technologies by farmers. Calculating efficiency losses from less-than-free trade is helpful in looking at alternative policy scenarios; however, cost-effective solutions for moderating extreme price instability are still as badly needed as they are difficult to find. One possible approach—risk layering—has been suggested by Barnett et al. (2008). They argue that poor households can often self-insure against small price risks and can use social networks to deal with intermediate levels of price changes.[28] With catastrophic risks, however, solutions take on the character of a public good that only governments can provide. We conjecture that governments spend far too much time worrying about small variations better handled by markets, and far too little time preventing and mediating large price changes. Both the politics and the economics of this conjecture appear to warrant much deeper study.

What price volatility means for the rural poor

To the extent that international food price volatility radiates to local markets, the question remains: how do price shocks and variability affect food security for people on the ground? Poor households spend the majority of their income on food and therefore tend to be particularly vulnerable to food price spikes. It is also widely known that most of the poor live in rural areas and depend on agricultural production for their livelihoods (World Bank 2008). But who actually wins and loses from food price increases and food price declines? The answer requires a more thorough characterization of the poor: where they live, what level of poverty they experience, and what they produce, consume, and sell. Only a few generalizations can be made for all countries. Our goal here is to draw on results from household and production survey analyses, conducted by several scholars in a range of poor countries, to highlight some key points about price movements and food security at the local level.

Hundreds of agricultural production and household expenditure surveys have been conducted in various countries around the world; the problem is that relatively few combine consumption and production variables in a single survey instrument. Using the World Bank's Living Standards Measurement Study (LSMS), it is possible to explore both consumer and producer behavior of poor households through data on their expenditures, incomes, calorie availabilities, and agricultural production.[29] Our analyses of LSMS data for Ghana, Guatemala, Malawi, Uganda, and two poor and largely rural states in India (Uttar Pradesh (UP) and Bihar) depict some of the key determinants of food insecurity for low-income households.[30] To capture behavioral re-

sponses to price spikes and variability by income class, we group the data by consumption expenditure into three categories: extremely poor (per capita expenditures of less than $1.25/day); poor (per capita expenditures of less than $2.50/day); and near-poor (per capita expenditures between $2.50 and $4.00/day).[31] Analyzing production and consumption behavior by expenditure group helps illuminate patterns of food security and insecurity that might otherwise be obscured by using the more accessible national average data.

Although much attention was focused on urban consumers during the 2007–08 price spike because of their dependence on imported food, our analysis underscores the tenuous position of the rural poor. Most extremely poor and poor households in our selected countries are located in rural areas and are thus dependent to some extent on agriculture (see Table 6). The near-poor population is also predominantly rural, although to a lesser extent than people living on less than $2 per day.

Our results indicate that the majority of extremely poor households consist of those that farm and sell some produce in markets, but not enough to be net producers—they remain net consumers. These households depend on other sources of income as well, such as wage labor that is often associated with agriculture. Across survey countries, the poorest households earn 62–74 percent of their incomes either from selling agricultural goods in the market or from farm wages (see Table 7). Non-agricultural income accounts for only 13 percent of total income on average for these households, as opposed to 23 percent and 34 percent for poor and near-poor households. The question thus arises: are the poorest of the poor hurt or helped by commodity price swings?

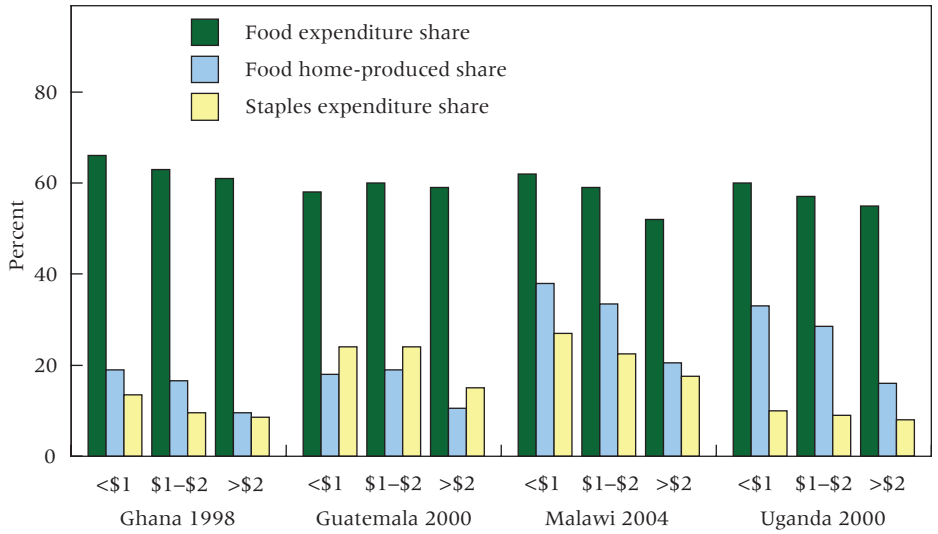
One of the most important points to emerge from our analysis and related studies is that the poorest households generally tend to operate at a thin margin between net production and net consumption. Food expenditures account for 58–66 percent of their total expenditures across countries, but a significant share of these expenditures is accounted for by home-produced items, which shields them, as consumers, from price increases (see Figure 6).

TABLE 6 Extremely poor, poor, and near-poor as a percent of total respondents and of respondents in rural areas, selected LSMS surveys

Country	Year	Average daily per capita expenditures ($PPP)	Under $1.25		Under $2.50		$2.50–$4.00	
			% of HHs	% rural	% of HHs	% rural	% of HHs	% rural
Ghana	1998	3.21	27	85	63	78	22	57
Guatemala	2000	7.89	8	89	39	82	25	70
Malawi	2004	1.92	52	94	86	91	12	80
Uganda	1999	2.29	46	93	83	88	13	64
India (UP and Bihar)[a]	1998	1.03	75	100	97	100	2	100

[a]The Indian data set includes rural households only.
SOURCE: Wang (2009).

FIGURE 6 Household expenditure patterns by poverty category from selected LSMS surveys



SOURCE: World Bank Living Standards Measurement Studies (LSMS) as reported in Wang (2009).

Surprisingly, although most of the poorest households are net consumers, the majority of net producers in the surveys are also in the extremely poor (under $1/day) and poor (under $2/day) categories.[32] They are generally poorer than net consumers in the overall survey and have less diversified income sources. They might benefit marginally from a price increase, but they sell such small amounts that they often lose (on net) from other cost increases in the market (e.g., for purchased foods or household needs).

Jayne et al. (2010) clearly illustrate the marginal market role played by poor farmers in their analyses of production surveys in Ethiopia, Kenya, Mozambique, Rwanda, and Zambia. Their results show that only 20–35 percent of smallholder farms sell grain in a given year, usually in small amounts (0.1 to 1.0 ton per farm). Net purchasers of grain comprise 50–70 percent of the farm population and an even higher percentage in drought years. It is these smallholder, net consuming households that are likely to be hurt the most by sharp price hikes. A much smaller group of farmers—1 to 4 percent of the total farm population who have access to good-quality land and capital—are responsible for over 50 percent of total grain sales. The latter group clearly stands to benefit when grain prices rise and is likely to be hurt financially when grain prices fall. Recent theoretical and empirical work by Bellemare et al. (2010) reinforces the idea that the poorest group might suffer from a sudden price increase in their staple foods, but that the more wealthy group, which has a significant marketable surplus, stands to lose the most from agricultural price volatility.[33]

TABLE 7 Household expenditures on food and income source, by poverty category, selected LSMS surveys

Poverty category, country, and year	% household expenditures per person per day on food	Income source (% of all income per person per day)					
		Agriculture	Agricultural wage	Non-agricultural wage	Self-employment	Remittances/ transfers	Other
Extremely poor (<$1.25/day)	**62**	**45**	**23**	**13**	**10**	**7**	**6**
Ghana 1998	66	32	30	16	8	8	6
Guatemala 2000	58	38	36	11	8	3	4
Malawi 2004	62	54	16	12	10	8	0
Uganda 2000	60	55	11[a]	N/A	12	7	15
Poor ($1.25–$2.50/day)	**60**	**39**	**18**	**23**	**13**	**7**	**6**
Ghana	63	29	20	27	11	8	5
Guatemala	60	35	30	17	8	5	5
Malawi	59	42	7	24	18	8	1
Uganda	57	49	15[a]	N/A	15	8	13
Near-poor ($2.50–$4.00/day)	**57**	**30**	**16**	**34**	**16**	**8**	**5**
Ghana	61	24	15	36	13	9	3
Guatemala	59	33	23	25	10	6	3
Malawi	52	25	6	40	18	7	4
Uganda	55	36	21[a]	N/A	23	9	11

[a]Uganda survey did not distinguish agricultural from non-agricultural wages.
SOURCE: Wang (2009).

Another surprising result of our LSMS analysis is that many net producing households in the "under $1/day" and "under $2/day" groups are calorie deficient, accounting for 10–20 percent of the survey populations. This result dispels the notion that net producers are *de facto* feeding themselves sufficiently. By combining consumption and production data, our analysis shows that poor households are making decisions to purchase more attractive calories, and are using the income from selling staple calories to buy other foods, particularly sugar, meat, and fish. Thus even among poor and calorie-deficient households, the cheapest calories are not always being purchased or eaten. Banerjee and Duflo (2007) documented a similar pattern for food versus non-food expenditures in their analysis of household survey data for 13 poor countries around the world.[34] In particular, they showed that poor households that might be food-insecure often spend incremental income on non-food items such as alcohol, tobacco, and cultural ceremonies. Such consumption behavior offers some buffer when prices rise and disposable incomes fall; households can return to staple consumption, albeit at the expense of diet quality (protein, micronutrients). Ulimwengu and Ramadan's (2009) study

of consumption patterns among the poor in Uganda during the recent period of price volatility also illustrates this coping strategy.

Although net producers sell staples and buy other foods, our analysis demonstrates that they sell more than staple grains in many areas, which can provide income stability when grain prices are volatile and the other products are less so (see Table 8). For the African countries, these households grow at least four crops and sell at least two crops on average. In Guatemala, the story is different (Nybo 2009). Among our survey countries, Guatemala has the highest average daily per capita expenditure (Table 6) but the largest absolute net position both for producers and consumers. Poor households in Guatemala are also more dependent on agricultural income and have a lower share of off-farm income and remittances than do those in the other survey countries (Table 7). This evidence suggests high inequality between large landholders and the smaller landholding (mostly indigenous) population. Moreover, Guatemala also has the lowest degree of crop diversification, with maize and beans being the primary crops and staples (Table 8). One-half of Guatemalan children are malnourished, ranking among the worst in the world.[35] In this case, grain price spikes are bound to have serious consequences for food insecurity, despite the fact that average per capita income in Guatemala is relatively high in comparison with our other survey countries.

A central conclusion that emerges from these studies is that poor net producers and net consumers living on less than $1/day or $2/day are threatened by price spikes and have limited ability, in particular, to adapt to extremely unstable price environments or "catastrophic risk" (Barnett et al. 2008). In some parts of the world, inadequate market linkages exacerbate price instability. In East and Southern Africa, for example, the number of buyers of staple crops in the countryside following harvest has increased, but commodity flows are asymmetric. Once staples leave the rural region, Jayne et al. (2010) report, well-developed return pathways for these crops are largely absent. In addition to the usual forms of price uncertainty, rural people must also deal with missing or irregular markets should they need to make consumption purchases later in the year.

Ensuring commodity flows and stabilizing prices are increasingly thought of by governments as public goods that only they can provide. The difficulties arise because of instruments, institutions, and magnitudes. Governments would often like to control all variability for many crops, but they cannot because of inadequate financial and human resources. The gaps in the debate are huge, with free-trade efficiencies dominating one end of the debate and state control of food markets the other.

Although price stability has been a topic of debate for decades, it is still surprising how little attention price stability per se receives in arguments by economists and, equally surprising, how reluctant governments are to concede that direct interventions into food markets are not something that they

TABLE 8 Percent of households that are net producers of selected crops and livestock, selected LSMS surveys

Ghana, 1998	Maize (24), rice (4), cassava (5), beans (4), vegetables (4), plantain (5)
Guatemala, 2000	Maize (11), beans (7)
Malawi, 2004	Maize (13), sweet potatoes (5), groundnuts (12), soybeans (5), beans (4), eggs (5), fruits (9), vegetables (9), chickens (17), goats (8)
Uganda, 2000	Maize (25), cassava (11), sweet potatoes (5), groundnuts (9), beans (23)

NOTE: Figures in parentheses represent percent of households producing specified crop or livestock product.
SOURCE: Wang (2009).

do very well. Moreover, most price stabilization efforts aimed at the poor, however well intended, end up helping larger net producers much more than those at the margin (Bellemare et al. 2010). Creating an economic environment conducive to private trade and two-way flows of food commodities in poor regions is an important part of the solution.

Conclusions

"Since summer, an increasingly volatile market for grains" was the headline on a lead *New York Times* article (13 October 2010) as maize futures in the Chicago exchange rose to $6 per bushel, up 70 percent from late June. Grain prices have been increasingly variable in 2010, and the overall surge has analysts worried about a repeat of the 2008 price run-up. That spike left over 1 billion people in a food-insecure state—a threshold symbolic in its extreme order of magnitude and in the challenges it presents for combating global hunger in the future.

Price volatility since the turn of the century has not been unprecedented, however, and the relative impact of volatility on global food security was probably lower in the late 2000s than in the 1970s, mainly because of the phenomenal per capita income growth experienced in Asia since that time. This fact is small consolation, however, in a world in which almost 15 percent of the total population still suffers protein–calorie malnutrition.

Despite comparable episodes of price volatility in the past, the current price environment has several unique features. Macro policy, exchange rates, and petroleum prices have been primary determinants of food prices during 2005–10 and will likely remain so in the future. The realm of global food price volatility broadened in the recent decade to include new linkages between agriculture–energy and agriculture–finance markets. Information about future commodity price patterns is now as likely to come from financial managers and energy analysts as from agricultural specialists. Moreover,

climate variability and climate change now loom as growing threats to the level and variability of global crop production.

The abundance and multiple sources of information can be both a help and a hindrance to global food security. Expectations—often faulty—played a key role in the price spike of 2008. They were most visible in the panic hoarding of rice in 2008, but they influenced fertilizer and feed markets as well. Uncertainty surrounding exchange rates and macro policies added to price misperceptions, as did flurries of speculative activity in organized futures markets. Events since 2005—including the most recent period of price variability in 2010—underscore the point that uncertainty and expectations can be as important as or even more important than actual changes in grain demand and supply in driving price variability.

How price volatility in international markets influences food policy and price stability in national markets is the key issue for food security. Changes in world (dollar) prices for wheat, maize, and rice are imperfect metrics for assessing the effects of volatility on most poor consumers. Dependence on imported grains increased since the 1970s in many of the world's poorest regions. However, price changes at the local level during the 2008 price spike were frequently half the movement in international prices, primarily as a consequence of domestic food and trade policies. The price bubble was undeniably grim for poor consumers, but not as debilitating as many commentators suggested.

The price protection of consumers in the short run, and its effects on domestic producers in the longer run, is at the heart of a great many food-policy debates in poor countries. There appears to be a long-lasting impact of spikes on food policy, with self-sufficiency targets often replacing a reasonable level of involvement in world markets even after the markets have settled. Such policy reactions can cause instability in domestic prices when governments lack resources to defend a targeted price. They can also cause volatility in international markets, particularly when countries are "large actors" with significant shares of global production or consumption.

The consequences of price volatility for the rural poor at the local level have not been well measured or documented. Our specific assessment of five countries, combined with analyses by other scholars on the topic, indicates that the dual categories of "net producer" and "net consumer" are of limited usefulness. The poorest households tend to operate at a thin margin between net production and net consumption. Food shortages and price spikes can easily throw these households into a food-insecure state, particularly since they spend 50–60 percent of their income on food and do not sell much in the market. To the extent that governments can successfully prevent sizable price spikes, food security among the poorest populations will be enhanced through policy intervention. However, if the goal and outcome of food policy are to stabilize prices that are not in the catastrophic peak range, the main

beneficiaries will be the larger producers who account for the majority of marketable sales.

With the 2008 price spike over, the outlook for food price variability and global food security still remains tenuous. The climate shocks in Russia and Eastern Europe in the summer of 2010, coupled with floods in Pakistan, declining estimates of maize stocks in the United States, and uncertainties about global GDP growth, have captured the attention of many analysts and policymakers. What will happen to prices in terms of spikes, trends, and variations during 2011–13 and beyond is unclear. The main conclusion from our work is that food price variability, particularly price spikes, deserves much more attention in order to improve food security globally. Such variability has profound effects on poor consumers; it also is a major impediment to improved food and trade policy in developing countries.

Notes

Figures in this article are available in color in the electronic edition of the journal.

This article is the third in a sequence of essays on food security. The first article (Falcon and Naylor 2005) argued the case for making food security an integral part of national security; the second (Naylor and Falcon 2008) assessed the role of demand forces, especially meat and biofuels, in the food-price bubble. We thank Katherine Johnson for her extraordinary research assistance. We are also grateful for Karen Wang's lead role in the LSMS research reported upon in the penultimate section of this article. Christopher Barrett, William Fuller, Donald Kennedy, David Lobell, and Gordon Nelson provided very helpful review comments on an earlier draft.

1 IFPRI, for example, projects real prices for rice, wheat, and maize to rise by 21 percent, 62 percent, and 42 percent, respectively, between 2000 and 2050 (IAASTD 2009, p. 320).

2 One has only to envisage a price series that is increasing (or decreasing) through time at a very rapid but consistent rate. The CV statistic for such a series would provide a large variability estimate, whereas removing the time trend from the data would provide a variance estimate of zero.

3 Unless otherwise specified, all price data come from the IMF International Financial Statistics database «http://www.imf.org/external/data.htm».

4 We have done the various calculations in nominal terms as well. The numeric estimates are different, but in virtually all cases the patterns of variability are similar.

5 Variability was calculated by fitting the equation Log Real Price = a + b Time. The difference between the actual Log Real Price and the fitted Log Real Price results in the standard deviations shown in Table 2. Fitting the equation in logarithms produces percentage estimates (approximately), which facilitate comparisons across time periods and with CV estimates.

6 Many of the "t" values on the trend variable are greater than 10, although there is also considerable serial correlation in most of the equations.

7 Selection of a 12-month lag is arbitrary, although it has the advantage of eliminating certain seasonal difficulties.

8 A good recent summary of the wheat rust problem can be found in O'Brien (2010).

9 This region also accounts for roughly 16 percent of global wheat production, so a serious pathogen shock would have a major effect on the world wheat market as well as on hunger in this poverty-stricken area.

10 Both the USD/Euro and the US$ nominal effective exchange rate (NEER) were examined to assess the influence of the US dollar's value on international commodity prices and show qualitatively similar results.

The NEER for the USD represents the relative value of the USD compared to other major currencies weighted by their share in either international trade or payments (see «http://stats.oecd.org/glossary/detail.asp?ID=1792», accessed July 15, 2010).

11 As one example of simultaneity, high oil prices can lead to greater current account deficits in the US and a depreciation of the USD; depreciation of the USD can also lead to higher crude oil prices as valued in USD.

12 The same result holds when the CRB commodity spot index is mapped against the US/Euro exchange rate (r=0.92), but with a more pronounced effect of the European financial crisis in 2010. When maize and wheat prices are mapped individually against the NEER, the correlation is slightly smaller. In the post-2008 period, for example, the increased supplies of wheat described in the text caused wheat prices to diverge from the prices of other food commodities.

13 As points of reference, the nominal price average for UK Brent Crude in 2008 was $97.66/barrel and the average for 2009 was $61.86/barrel (with a high of $133.90 in July 2008 and a high of $77.04 in November 2009) «www.imfstatistics.org» (accessed June 22, 2010). The price in 2010 has settled around $80/barrel. Natural gas prices showed much more variability than crude oil prices from 2000 to mid-2006 and then followed the general pattern of crude price movements until 2009. Since then, crude oil has risen more rapidly than natural gas: Energy Information Administration «http://www.eia.doe.gov/emeu/steo/pub/contents.html» (accessed July 27, 2010).

14 Derived from the long-term data series on agricultural production cost estimates representative of farms in Iowa, maintained by Iowa State University: see «http://www.extension.iastate.edu/agdm/» (accessed July 15, 2010). Deflated by the IMF US-GDP deflator.

15 Net private capital flows to emerging and developing economies fell from $1.2 trillion in 2007 to $700 billion in 2008 and $360 billion in 2009. Growth in global industrial production (often considered the pulse of the global economy) fell precipitously at the end of 2008. Meanwhile, remittances have remained surprisingly robust.

16 The recent numbers are estimates. The last complete survey of undernourishment at the country level was in 2003–05 when the number of malnourished people was approximately 850 million (FAO 2009).

17 These data come from the World Economic Outlook Database April 2010, International Monetary Fund. «http://www.imf.org/external/ft/weo/1010/o1/weodata/index.aspx», accessed on June 16, 2010.

18 Harris Polls reveal great variability in opinions among countries as to the importance of speculation as a cause of price changes. In France 49 percent of respondents said speculation was the primary cause of food-price movements, in Germany and Spain 35 percent, and in the US and UK only 11 percent (*Financial Times*, October 11, 2010).

19 There is a vast literature—and a special vocabulary within that literature—on futures markets for agricultural commodities. This article intentionally does not deal with intricacies of futures markets, but rather tries to present more general conclusions on futures-market performance during the post-2005 period. Two sets of ideas are nonetheless assumed to be generally understood: the distinction between hedgers and speculators, and the approximate convergence of futures and cash markets at the end of futures contract periods. Good explanations of these points can be found in Working (1953) and CME (2009).

20 The large direct involvement of governments in the rice trade has greatly complicated both delivery enforcement and the development of effective futures contracts suitable for a sizable portion of the rice traded internationally.

21 One set of new participants, who are the focus of controversy, are index fund managers and selected speculative- and managed-fund traders. "Index traders look like speculators; however, unlike speculators, their investment style is not based on a view of current or expected individual commodity prices, but rather on gaining a long-side exposure to a broad index of commodity prices in an unrevealed and passively managed manner. Fund managers use this strategy for assets in an entire fund…and are commonly called 'long-only' investors because they consistently hold a long position" (Aulerich et al.

2009, p. 14). There has also been increased activity of exchange-traded funds (ETFs) that have provided a financial opportunity for fund managers and retail investors, but appear not to have had a significant direct effect on agricultural commodity prices in the cash market (Robison et al. 2010).

22 The global stock situation is further muddied by the poor quality of data on "available" quantities held by the private sector. Data are insufficiently precise to know the level of truly uncommitted stocks in grain markets. How holders of inventory were actually behaving is simply unknown, and is probably unknowable.

23 Liquidity was a related source of the problem. As prices accelerated, large firms with sizable hedged inventories were forced to cover growing losses from their short positions in futures markets. As the cumulative effects of margin calls reached billions of dollars for the larger international grain firms, they were faced with increasingly tight liquidity constraints. They could either limit new grain purchases from farmers (which they did) or leave additional inventories unhedged (which to some extent they also did) in a very volatile market situation.

24 On August 31, 2010, for example, the *Wall Street Journal* reported that "Currency trading soars: market hits $4 trillion a day as investors chase profits in growing economies." On September 28, 2010, the *Financial Times* published a column by Martin Wolf headlined: "Currencies clash in a new age of beggar-my-neighbor."

25 C.i.f. refers to cost, insurance, and freight. It is shorthand for the price a country or firm would pay at the port to import a commodity. F.o.b. refers to free on board, and indicates the price that a country or firm would receive (clear of the port) to export a commodity.

26 It is possible that a land-locked country, such as Nepal, could import or export grains to India. But nothing in that regional trade necessarily forces a link to world prices.

27 These results were derived from the USDA Production, Supply, and Demand Database «http://www.fas.usda.gov/psdonline/psdhome.aspx».

28 The extent to which these characterizations apply to the very poor in various societies is an important empirical question.

29 The Living Standards Measurement Study (LSMS) was initiated by the World Bank in 1980 to understand microeconomic behavior and policy outcomes. It is now in its fifth phase and covers a wide range of developing countries. Household surveys in the LSMS represent snapshots for one period of time; there are no time series data for individual households. The country survey data used in this article were collected during the period 1998–2004. For more information, see «http://go.worldbank.org/WKOXNZV3X0» (accessed July 21, 2010).

30 This work was conducted as part of a project entitled "The Agricultural Lives of the Poor" (ALP), led by Karen Wang and Marshall Burke at Stanford's Program on Food Security and the Environment in 2007–09. See Wang (2009).

31 In this article, the often-cited $1 a day and $2 a day international poverty lines are updated using the revised poverty lines of $1.25 a day and $2.50 a day, respectively (Ravallion et al. 2007). The new poverty lines use 2005 purchasing power parity (PPP) numbers from the International Comparison Program. The near-poor expenditure range of $2.50 to $4.00 a day corresponds to the categories used in Banerjee and Duflo's analysis (2007). We use the vernacular of "under $1 per day" or "under $2 per day" in the text and figures.

32 This point is particularly true for Ghana and Uganda and less true for Malawi, where more net producers are in the wealthier group.

33 Deaton (1997) uses the "net benefit ratio" to illustrate how the immediate welfare effects of a price shock are directly proportional to a household's marketable surplus in that particular commodity. Bellemare et al. (2010) extend this concept to multiple commodities and use panel data for Ethiopian households to show how price stabilization policies benefit wealthier net producers (upper 40 percent of income distribution) as opposed to poorer net consumers (including households that operate at the thin margin of production and consumption).

34 In our analysis, expenditures are converted into calories available at the household level using a methodology similar to Smith and Subandoro (2007). Calorie-deficient and severely calorie-deficient households are calculated using recommended daily values by sex and age at medium and low activity levels, respectively (UNU, WHO, and FAO 2004). Banerjee and Duflo (2007) argue that although poverty lines are historically constructed to denote calorie sufficiency, it is clear from household survey data that the poor make decisions based on other priorities.

35 See UNICEF 2009 (accessed July 22, 2010 at «http://www.unicef.org/infobycountry/guatemala_48087.html»).

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