Public Disclosure Authorized

Public Disclosure Authorized

WPS6455

Policy Research Working Paper 6455

Long-Term Drivers of Food Prices

John Baffes
Allen Dennis

The World Bank
Development Prospects Group
&
Poverty Reduction and Economic Management Network
Trade Department
May 2013

Policy Research Working Paper 6455

Abstract

It is becoming increasingly apparent that the post-2004, across-the-board, commodity price increases, which initially appeared to be a spike similar to the ones experienced during the early 1950s (Korean War) and the 1970s (oil crises), have a more permanent character. From 1997–2004 to 2005–12 nominal prices of energy, fertilizers, and precious metals tripled, metal prices went up by more than 150 percent, and most food prices doubled. Such price increases, especially in food commodities, not only fueled a debate on their key causes, but also alarmed government officials, leading to calls for coordinated policy actions. This paper examines the relative contribution of various sector and macroeconomic drivers to price changes of five food commodities (maize, wheat, rice, soybeans, and palm oil) by applying a reduced-form econometric model on 1960–2012 annual data. The drivers include stock-to-use ratios, crude oil and manufacturing prices, the United States dollar exchange rate, interest rate, and income. Based on long-run elasticity estimates (approximately –0.25 for the stock-to-use ratios, 0.25 for the oil price, –1.25 for the exchange rate, and much less for others), the paper estimates the contribution of these drivers to food price increases from 1997–2004 to 2005–12. It concludes that most of the price increases are accounted for by crude oil prices (more than 50 percent), followed by stock-to-use ratios and exchange rate movements, which are estimated at about 15 percent each. Crude oil prices mattered most during the recent boom period because they experienced the largest increase.

This paper is a joint product of the Development Prospects Group and the Trade Department of the Poverty Reduction and Economic Management Network. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at jbaffes@worldbank.org.

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

Produced by the Research Support Team

Long-Term Drivers of Food Prices

John Baffes
jbaffes@worldbank.org

Allen Dennis
adennis@worldbank.org

JEL Classification: E31, O13, Q02, Q11, Q18
Key Words: Commodity prices, food prices, commodity boom
Sector Boards: ARD, EPOL

The authors are senior economists with the Development Prospects Group. The research was funded by the Multi-Donor Trust Fund for Trade and Development 2. The views expressed here should not be attributed to the World Bank. We would like to thank Ataman Aksoy, Ian Gillson, Tassos Haniotis, Aira Htenas, and Hans Timmer for helpful comments and suggestions on earlier drafts. The paper has benefited greatly from seminar participants at the following institutions: U.S. Department of Agriculture (November 2011), University of Georgia (November 2011), Oxfam America (June 2012), and the European Commission (October 2012).

Introduction

It is becoming increasingly apparent that the post-2004 commodity price increases, which initially appeared to be a spike similar to the ones experienced during the early 1950s (Korean War) and the 1970s (oil crises), have a more permanent character. Most commodity prices are now two or even three times higher compared to a decade earlier. From 1997-2004 to 2005-12 nominal prices of energy, fertilizers, and precious metals tripled, metal prices went up by more than 150 percent, and most food prices doubled. The price increases, especially those of food, alarmed governments and, not surprisingly, led to calls for coordinated policy actions, reminiscent of the 1970s. Because understanding the relative contribution of key drivers to commodity price movements should be an essential part of any policy recommendation, this paper focuses on assessing such contributions.

The increases in commodity prices took place in a period when most economies, especially emerging ones, sustained strong economic growth. For example, during the 2004-12 period, income and industrial production growth in middle-income countries averaged 6.2 percent and 7.3 percent, respectively, up from 4.6 percent and 5.4 percent, respectively, during the previous eight-year period. Fiscal expansion and loose monetary policies in many countries created an environment that favored high commodity prices. The depreciation of the U.S. dollar—the currency of choice for most international commodity transactions—strengthened demand and limited supply from non-U.S. dollar commodity consumers and producers, thus supporting higher prices. Other factors mentioned often include low past investment, especially in extractive commodities (in turn, a response to a prolonged period of low prices), investment fund activity by financial institutions that chose to include commodities in their portfolios, and geopolitical concerns, especially in energy markets.

In addition to the above drivers, prices of agricultural commodities were affected by higher energy and chemical input prices, more-frequent-than-usual adverse weather conditions, and the diversion of some food commodities to the production of biofuels—notably maize in the United States and edible oils in Europe. These conditions led global stock-to-use ratios of some grains down to levels not seen since the early 1970s. Last, policy responses, including export bans and high export taxes (especially in the rice market) implemented to offset the impact of increasing world prices, contributed to creating the conditions of what has often been termed a "perfect storm."

The co-existence of so many factors implies that any analysis of commodity price movements should entail both sectoral and common drivers. In fact, the importance of common factors was a key conclusion reached by Cooper and Lawrence (1975) for the commodity price boom of the 1970s (the comparison between the 1970s price boom and the recent one has been made frequently; see, for example, Radetzki 2006, Piesse and Thirtle 2009, and World Bank 2009).

This paper applies a reduced-form price-determination model to maize, wheat, rice, soybeans, and palm oil, using annual data for 1960-2012 (see figure 1 for the nominal and real food price index). The price determinants include one supply-side variable (energy prices), three macroeconomic indicators (exchange rate, interest rate, and inflation), income on the demand side, and a driver reflecting market fundamentals (stocks and consumption expressed as a single stocks-to-use ratio variable).

The paper finds that food prices respond strongly to stocks-to-use (S/U) ratios (except rice), crude oil prices (all commodities), and exchange rate movements (in a mixed manner). With a few exceptions, interest rate and income growth do not matter. Crude oil prices matter the most because they experienced the largest increase after 2004. The remaining portion of the paper proceeds as follows. The next section discusses the model, data, and estimation procedure. The third section identifies and elaborates on the relative impact of each driver. The fourth section applies a number of robustness checks to assess the performance of the model, especially the post-2004 price movements. The last section concludes and identifies likely directions for future research.

Explaining Long-Term Price Trends

To identify the relative impact of various drivers on long-term food price trends, we use a reduced-form price-determination model. The model is based on equating aggregate demand to the supply of a commodity, and then expressing the equilibrium price as a function of sectoral and macroeconomic fundamentals. The theoretical underpinning of the model can be found in Turnovsky (1983), Stein (1986), Holtham (1988), and Deaton and Laroque (1992). Empirical applications include Gilbert (1989) who looked at the effect of developing country debt on commodity prices; Pindyck and Rotemberg (1990), who examined comovement among various commodity prices; Reinhart (1991) and Borensztein and Reinhart (1994) who analysed the factors behind the weakness of commodity prices during the late 1980s and early 1990s; Baffes (1997) who examined the long term determinants of metal prices; and Frankel and Rose (2010) who analyzed the effects of various macroeconomic variables on agricultural and mineral commodities.

Model

The model takes the following form:

$$log(P_t^i) = \beta_0 + \beta_1 \, log(S/U_{t-1}) + \beta_2 \, log(P_t^{OIL}) + \beta_3 \, log(XR_t) \\ + \beta_4 \, log(R_t) + \beta_5 \, log(GDP_t) + \beta_6 \, log(MUV_t) + \varepsilon_t,$$

where P_t^i denotes the nominal price of commodity i (i = maize, wheat, rice, soybeans, and palm oil). S/U_{t-1} denotes the lagged stock-to-use ratio (use includes human, animal, and industrial consumption), P_t^{OIL} is the price of crude oil, XR_t is the exchange rate, R_t

denotes the interest rate, GDP_t denotes gross domestic product (GDP), and MUV_t represent a price index of manufacturing exports. The β_is are parameters to be estimated, and ε_t is the error term.

Although some of the drivers often cited as key in explaining post-2004 price movements do not appear explicitly in the model, they are accounted for indirectly by the *S/U* ratio. The diversion of food commodities to the production of biofuels increases consumption and reduces stocks, therefore leading to a lower *S/U* ratio. Similarly, to the extent that weather patterns affect global production, they are accounted for by the *S/U* ratio. Furthermore, the *S/U* ratio captures the income effect because higher (lower) income leads to higher (lower) food consumption, with reverse impacts on the *S/U* ratio. Investment fund activity is likely to affect price variability rather than long-term trends; therefore, its exclusion is unlikely to alter the results. The most notable exclusion is trade policies, which remained stable at a global level during the recent boom period, except for interventions with impacts within a specific year that targeted a few commodities (mostly rice and less so wheat).

The interpretation and signs of most of the parameters are straightforward. The *S/U* ratio is expected to be negative because a low *S/U* ratio (associated with scarcity) leads to high prices and vice-versa. To account for likely simultaneity bias between stocks and prices, the *S/U* ratio enters the regression in lagged form. The price of crude oil should have a positive effect on the prices of food commodities because it is a key factor of production (Baffes 2007). The depreciation of the U.S. dollar—the currency of choice for most international commodity transactions—strengthens demand and limits supply from non-U.S. dollar commodity consumers and producers, thus increasing prices. In contrast, the effect of interest rates is ambiguous. High interest rates can be associated with lower commodity prices because they dampen current commodity demand and may change expectations about future economic activity because of lower investment; however, they may be associated with higher prices because high interest rates increase the required rate of return on storage (Newbery and Stiglitz 1989). Income growth (proxied by GDP of low- and middle-income countries, where most of the commodity demand growth is taking place) is expected to lead to higher prices. Last, because of the long period under consideration, the MUV was also included in the model, but it was treated as an explanatory variable (instead of adjusting prices) to relax the homogeneity restriction and obtain a direct estimate of the effect of manufacturing prices (Houthakker 1975).

Data

World prices were taken from the World Bank's database and represent annual (calendar) averages, expressed in U.S. dollar per metric ton (mt), except crude oil which is expressed in US dollars per barrel. The description of commodity prices is as follows:

maize (United States), no. 2, yellow, f.o.b. (free on board) U.S. Gulf ports; ***rice*** (Thailand), 5 percent broken, white rice, milled, indicative price based on weekly surveys of export transactions, government standard, f.o.b. Bangkok; ***wheat*** (United States), no. 1, hard red winter, ordinary protein, export price delivered at the U.S. Gulf port for prompt or 30 days shipment; s***oybeans*** (United States), c.i.f. (cost, insurance, freight) Rotterdam; ***palm oil*** (Malaysia), 5 percent bulk, c.i.f. N. W. Europe; and ***crude oil***, average price of Brent, Dubai and West Texas Intermediate, equally weighed. Finally, the manufacture unit value (MUV) was used as a proxy of global deflator index. The MUV is a US dollar trade weighted index of manufactures exported from 15 economies (Brazil, Canada, China, Germany, France, India, Italy, Japan, Mexico, the Republic of Korea, South Africa, Spain, Thailand, the United Kingdom, and the United States). More details on the prices along with the MUV can be found at the World Bank's Commodity Price Database.[1]

The *S/U* ratio was calculated as the ratio of end-of-season stocks to total consumption taken from the U.S. Department of Agriculture's Production, Supply, and Distribution Online.[2] The exchange rate measure was the International Monetary Fund's Special Drawing Rights rate representing an index of the U.S. dollar against four currencies, namely the Euro, Pound sterling, Japanese yen, and U.S. dollar.[3] The 10-year US Treasury bill was used as interest rate proxy, taken from the U.S. Federal Reserve's Selected Interest Rates database.[4] Last, GDP was taken from the World Bank's World Development Indicators database.[5]

Estimation

Prior to estimating the model, we examined the stationarity properties of all variables, applying unit root tests to levels with and without trend as well as first differences. Two tests were used, the ADF (Augmented Dickey-Fuller) and the PP (Phillips-Perron). Results are reported in table 1. The statistics indicate overwhelming rejection of stationarity and trend stationarity for all five food prices and the crude oil price in favor of stationarity in first differences (see upper panel of table 1). Stationarity and trend stationarity were rejected for all three macroeconomic variables and GDP, again in favor of stationarity in first differences (see middle panel of table 1). However, the unit root test results for the *S/U* ratios were mixed. The statistics of maize and rice point to difference stationarity, and to a lesser extent, this is the case with wheat and palm oil. However, both unit root statistics indicate stationarity for soybeans (see lower panel of table 1).

[1] http://worldbank.org/prospects/commodities

[2] www.fas.usda.gov/psdonline

[3] http://www.imf.org/external/np/fin/data/rms_five.aspx

[4] www.federalreserve.gov/releases/h15/data.htm

[5] http://data.worldbank.org/indicator

Given that, with the single *S/U* soybean exception, the variables are non-stationary, the performance of the models must be complemented by cointegration statistics (in addition to conventional statistics).

Table 2 reports parameter estimates for 1960-2012 for maize, wheat, and rice and (because of data unavailability) for 1965-2012 for soybeans and palm oil. Half of the parameter estimates are significantly different from zero at the 5 percent level while the *adjusted-*R^2 averaged 0.82 (ranging from 0.67 for palm oil to 0.90 for wheat). More important, in most cases the ADF and PP statistics confirm stationarity of the error term at the 1 percent level.

Discussion

Stock-to-Use Ratios

As expected, the *S/U* ratio estimates are negative ranging from a high of -0.61 for maize to a low of -0.21 for rice—the only *S/U* estimate not significantly different from zero. These estimates imply that, on average, a 10 percent decline in the *S/U* ratio is associated with a 3 percent increase in food prices. The smaller parameter estimate for soybeans (compared to wheat and maize) may reflect not only the fact that soybean stocks can be held in bean, meal, or oil form, while only beans were used in this study, but also the generally low levels of stock-holding in that sector. From an econometric perspective, such result may also be associated with the stationarity properties of the *S/U* ratio for soybeans—perhaps not surprisingly since it was the only variable for which stationarity was not rejected according to both ADF and PP statistics.

The *S/U* ratio elasticity estimates for grains reported here are remarkably similar to findings reported elsewhere. For example, Bobenrieth, Wright, and Zeng (2012) estimated correlation coefficients between *S/U* ratios and real de-trended prices for wheat, maize, and rice of -0.40, -0.50, and -0.17, respectively (compared to -0.61, -0.50, and -0.21, respectively, in the present study.) Similarly, FAO (2008, p. 6, figure 3) reported correlation coefficients between the cereals price index and various measures of *S/U* ratios ranging from -0.47 and -0.65. These correlations led FAO (2008) to conclude not only that the low stock levels caused grain prices to spike during 2007/08, but also that prices are expected to remain elevated for some time.

The *S/U* ratio estimate for rice (low and not significantly different from zero) is both troubling and interesting. It most likely reflects policy distortions, including the substantial quantities of rice stocks—especially in East Asia where rice is considered a strategic commodity—that are either handled by state trading enterprises (STE) or heavily influenced by government policies (Alavi and others 2012). Indeed, Anderson and others (2009, p. 489, table 12.11) estimated that during 2000-04, rice exhibited the highest level of distortion (43 percent) compared to wheat (4 percent) and maize (3 percent), as measured by the trade restrictiveness index (TRI). The economies that contributed the most to the TRI were (in order): India; Japan; Taiwan, China; Vietnam; the Republic of Korea; China; and the United States. Similar distortion patterns apply to earlier years as well. More recently, Martin and Anderson (2012, p. 426) found that restrictive trade policies during the 2006-08 price spike may explain as much as 45 percent of the increase in the international rice price. They also concluded that trade policies induced a 30 percent increase in wheat prices during the boom years.[6]

Not only is the global rice market subjected to large distortions, but also such distortions apply to both export and import sides. Timmer and Slayton (2009), for example, discuss how large tenders by the Philippines—a large rice importing country—may have affected rice prices. Examples of countries whose rice marketing and trade is either handled exclusively by STEs or heavily influenced by policies include (but are not limited to) India (Food Corporation), Indonesia (Badan Urusan Logistik or BULOG), the Philippines (National Food Authority), and Thailand (Rice Paddy Pledging Program).

It is often argued that high rice price volatility observed during the past few years is partly due to the thin nature of the export market. Indeed, only 8 percent of global production is traded internationally, the lowest among the commodities examined in this study (table 3). Yet, historically, rice price volatility has been remarkably similar to that of other grains and oilseeds; in fact, during 2010-12, rice and soybean price volatility was the lowest among the five commodities examined here. Furthermore, concentration of the global trade of rice is, again, in line with other commodities. The Herfindahl concentration index for the rice export market is 15 percent, higher than maize (12 percent) but much lower than wheat (21 percent).[7] These characteristics suggest that it is policy concentration (not market concentration, market thinness, or price volatility) that matters most in the rice market and distinguishes it from other markets.[8]

Crude Oil

The estimate for oil price elasticity was significantly different from zero in all five regressions—the only highly significant driver across all models (see table 2). It ranged

[6] In addition to affecting world prices, such distortions may be associated with high domestic costs. For example, Thai rice policies during 2011/12 may have cost as much as 1 percent of Thailand's total GDP (World Bank 2012a).

[7] The Herfindahl index of market concentration (used often in the industrial organization literature) is calculated as $\Sigma_{i=1,N}S_i^2$, where S_i is the export share of country i; values close to zero indicate low concentration while values exceeding 0.25 (or 25 percent) indicate high concentration—however, when there are close substitutes (as in the case of palm oil, which has many close substitutes such as soybean oil), even an index close to unity may not be consistent with high concentration; same argument applies to market thinness. The upper bound of the index is 1 (100 percent), implying that the industry (global commodity market in our case) is dominated by one firm (country).

[8] The different nature of the problems relevant to the rice market (compared to other grains) has been highlighted by Gilbert (2012).

from 0.23 (maize) to 0.50 (palm oil), implying that, on average, a 10 percent increase in the price of crude oil is associated with a 3 percent increase in food prices. These estimates confirm findings of earlier studies that have used the price of energy as an explanatory variable and concluded that energy plays a key role in food price movements.

The strong relationship between energy and non-energy prices has been established long before the recent boom. Gilbert (1989), for example, using quarterly data between 1965 and 1986, estimated transmission elasticity from energy to non-energy commodities of 0.12 and from energy to food commodities of 0.25. Hanson, Robinson, and Schluter (1993) based on a General Equilibrium Model found a significant effect of oil price changes to agricultural producer prices in the United States. Borensztein and Reinhart (1994), using quarterly data from 1970 to 1992, estimated transmission elasticity to non-energy commodities of 0.11. Baffes (2007), using annual data from 1960 to 2005 estimated elasticities of 0.16 and 0.18 for non-energy and food commodities, respectively. A strong relationship between energy and non-energy prices was found by Chaudhuri (2001) as well.

Pindyck and Rotemberg (1990) analyzed the nature of the comovement among seven commodity prices (cocoa, copper, cotton, crude oil, gold, lumber, and wheat) and concluded that not only these prices co-moved, but they also co-moved in excess of what the macroeconomic fundamentals could explain, in turn leading to the "excess comovement" hypothesis. Interestingly, they assumed that none of these commodities is used as a major input for the production of another, clearly a strong assumption considering that energy is the most important cost-production component to most agricultural commodities (either directly through fuel or indirectly through chemical inputs, especially fertilizers).[9]

Income

The results show no contemporaneous effect of income on food prices (maize is an exception, but the sign of the parameter estimate is negative). Although table 2 reports results for GDP purchasing power parity (PPP) of low and middle income countries, we run the models by using a total of six measures of GDP: Global, low and middle income countries, low income countries, each in PPP terms and current prices. None of these measures resulted in coefficients significantly different from zero.

Income growth by emerging economies has been often cited as a key driver to the post-2004 food price increases. For example, the June 2009 issue of *National Geographic* noted that demand for grains has increased because people in countries like China and India have prospered and moved up the food ladder. Similarly, Krugman

---

[9] Subsequent research, however, challenged the "excess" part of the excess comovement hypothesis. See, for example, Ai, Chatrath, and Song (2006); Cashin, McDermott, and Scott (1999); Deb, Trivedi, and Varangis (1996); and LeyBourne, Lloyd, and Reed (1994).

(2008) argued that the upward pressure on grain prices is due to the growing number of people in emerging economies, especially China, who are becoming wealthy enough to emulate Western diets. Likewise, Wolf (2008) argued that strong income growth by China, India, and other emerging economies, which boosted demand for food commodities, was the key factor behind the post-2007 increases in food prices. The role of demand has been highlighted by Hochman and others (2011) as well.

The results on income growth in the present analysis, which are in sharp contrast to what has been assumed in the above cited (and other) literature, should not be surprising. In the context of the present model, it was noted earlier that income affects prices indirectly through the lagged *S/U* ratio, because higher income leads to higher consumption. Therefore, the inclusion of income as a separate variable would capture only the contemporaneous effect; hence the insignificant parameter estimate implies that, if income affects prices, it does so with lags. Indeed, most empirical models that have explicitly used the income variable have not found a significant direct impact (for example, Ai, Chatrath and Song 2006).

More important, there is no evidence that grain consumption by emerging economies has experienced growth rates that are either high by historical standards or comparable to their income growth rates. For example, Alexandratos (2008, p. 673) concluded that China's and India's combined average annual increment in grain consumption—in terms of both growth rates and absolute increments—was lower in 2002-08 than in 1995-2001. In a similar vein, FAO (2008, p. 12) noted the following:

> *China and India have usually been cited as the main contributors to this sudden change [in cereal prices] because of the size of their populations and the high rates of economic growth they have achieved. However, since 1980, the imports of cereals in these two countries have been trending down, on average by 4 percent per year, from an average of 14.4 million tonnes in the early 1980s to 6.3 million tonnes over the past three years. Moreover, mainland China has been a net exporter of cereals since the late-1990s, with one exception in the 2004-2005 season. Similarly, India has been a net importer of these commodities only once, in the 2006-07 season, since the beginning of the twenty-first century.*

Numerous other studies have reported similar findings, including Alexandratos and Bruinsma (2012), Sarris (2010), Baffes and Haniotis (2010), FAO (2009), and Lustig (2008). In fact, Deaton and Drèze (2008), based on household survey data in India found that, despite growing incomes, there has been a downward trend in calorie intake since the early 1990s. They added that although the reasons behind this trend are not clear, one likely explanation may be that calorie requirements have declined as a result of better health and lower physical activity levels.

It is important to note, however, that demand growth by emerging economies, especially China, has played a key role in the post-2004 evolution of most industrial commodity prices, notably, metals and energy (Baffes 2012). For example, during the

1990s global metal consumption grew at an annual rate of 2.4 percent. During the first decade of the millennium, however, it grew at 4.5 percent. More importantly, China accounts now for more than 40 percent of the world's metal consumption, up from a mere 4 percent two decades earlier. Similarly, nonmember countries of the Organization for Economic Co-operation and Development (OECD) consume currently almost half of world's crude oil, up from one third 15 years ago. Indeed, between 1997-2004 and 2005-12 crude oil consumption by OECD economies did not change whereas that of non-OECD economies increased by more than 30 percent. The role of demand in crude oil prices has been emphasized by numerous authors (for example, Kilian 2009).

It is also important to reiterate that, to the extent that strong growth by emerging economies boosts energy demand and hence oil prices, food prices have been driven by the growth patterns of these economies.[10] In fact, this point has been highlighted by Heady and Fan (2010, p. 15). However, what matters most from a policy perspective, is the channels through which income growth affects food prices. Is it the cost side (high oil prices which are associated with a leftward shift of the aggregate supply schedule), changing of dietary preferences (consumption of more processed and animal products instead of grains, which is associated with a change in the composition of aggregate demand), or consumption of more food (a rightward shift of aggregate demand)? The results of this study show that the cost side matters most.

Macroeconomic Drivers

Results on the effect of the exchange rate on food prices are mixed but they are highly consistent with expectations. Exchange rate movement matters a lot in rice (the parameter estimate is -2.45, *t-ratio* = 3.88), followed by a moderate impact on soybeans (-1.08, *t-ratio* = 2.91) and wheat (-0.86, *t-ratio* = 2.45). It is not significantly different from zero for palm oil and maize. The smallest (maize) and largest (rice) elasticity estimates are consistent with initial expectations, given that the United States is the dominant player in the maize market and only marginal player in the rice market.[11]

The effect of the exchange rates on commodity prices and trade was highlighted immediately following the collapse of Breton Woods (Schuh 1974). In the context of US agriculture, Gardner (1981) concluded that the exchange rate was the most significant variable in explaining real US farm prices with an elasticity of 0.4. Lamm (1980) and

---

[10] The differences in the way food and energy demand respond to income should not be surprising. Food commodities are subjected to Engel's Law (that is, the share of income spent on food declines as income increases) while energy commodities are not. Webster, Paltsev, and Reilly (2008, Table 1, p. 2786), for example, based on a review of the parameter values used in various integrated assessment models reported that the income elasticity for energy demand exceeds unity.

[11] See Radetzki (1985) for a graphical exposition of the latter point and Sjaastad (2008) for an empirical application to the market of gold.

Chambers and Just (1981) reported similar findings for U.S. Agriculture. Dawe (2002) estimated that a 10 percent depreciation of the Thai baht against the US dollar is associated with a $22/mt decline in world rice prices, a result which is consistent with the present model considering Thailand's importance in the rice export market. Numerous other authors have highlighted the role of exchange rates during the post-2004 food price increases, including Abbott, Hurt, and Tyner (2008), Mitchell (2008), and Gilbert (2010).

With the single exception of maize, MUV is not significantly different from zero in any of the remaining models, thus underscoring the importance of not imposing the homogeneity restriction.[12] Arguably, the only period during which food prices may have been subjected to inflationary pressures is the 1970s. However, this is also the period during which crude oil prices increased the most. Indeed, when the MUV is removed from the maize equation, the parameter estimate for crude oil increases to 0.31 with a *t-ratio* of 7.36 (up from 0.23, *t-ratio* = 4.89 as reported in table 2), bringing the effect of oil price in par with the other commodities. Removal of the MUV reduces the income elasticity to -0.17 (*t-ratio* = 1.86), a result which is in line with the other price equations.

The parameter estimate for interest rate was zero for wheat, soybean, and palm oil and positive for maize (0.16, *t-ratio* = 1.80) and rice (0.31, *t-ratio* = 2.07) (see table 2). As noted earlier, interest rate is the only driver whose effect on commodity prices is ambiguous and depends on the relative impact on the demand side (through higher purchasing power of consumers) or the supply side (through changes in the required rate of return on storage). Although most empirical studies have found a strong link between exchange rate movements and agricultural commodity prices, the link between interest rate and prices is less strong (for example, Stamoulis and Rausser 1987, Frankel and Hardouvelis 1985).

Even recent studies give mixed evidence on the role of interest rates in commodity price movements, despite the near-zero interest policy rate policies pursued by several Central Banks. For example, Frankel and Rose (2010) found no interest rate impact

---

[12] This paper analyzes world food price movements in nominal terms. If the objective was to analyze domestic food price movements of a particular country (such as prices received by producers or paid by consumers), the analysis could be carried out in nominal or real terms adjusted by, say CPI or GDP, deflator. In the context of world prices, such deflators do not exist. Thus, the only feasible alternative would be to use a proxy for another price (or price index), in which case the elasticities represent measurement of effects on the terms-of-trade <u>not</u> nominal prices. MUV is the most commonly used (and, perhaps, best) alternative. In such modeling framework, the size and sign of the parameter estimates are likely to change. For example, the exchange rate parameter estimate would be lower because the demand and supply schedules of food and manufacturing commodities are likely to respond to US$ movements in a similar fashion. Similarly, the parameter estimate of income could be negative, since the income elasticity of food commodities is bounded by Engel's Law while that of the manufacturing commodities is not (see Kindleberger 1943 and Sapsford, Sarkar, and Singer 1992).

for maize, soybeans and wheat prices in a reduced form econometric model. However, Byrne, Fazio, and Fiess (2013) using commodity data spanning over a century concluded that a common-factor drives comovement among ten prices and related such factor to the real interest rate. Yet, to extent that interest rates may alter both consumption of commodities and stockholding behavior, the *S/U* ratio variable may capture the effect of interest rate as well. Such mixed evidence could also reflect that fact that low interest rates (by the United States) depress the U.S. dollar. Thus, the exchange rate elasticity could potentially capture part of the interest rate effect. However, this is an unlikely explanation for the commodities examined here because even in the cases where exchange rate did not matter much (wheat) or it was insignificant (palm oil), the parameter estimate of the interest rate was not significantly different from zero.

Assessing Post-2004 Price Movements

The impact of the drivers on the post-2004 food price movements were further assessed in four ways. First, the model was re-estimated by excluding the post-2004 observations in order to examine by how much (and in what direction) the parameter estimates changed from the limited sample model (1960-2004) to the full sample model (1960-2012). Second, by using the parameter estimates of the full sample model, we measured the relative contribution of all explanatory variables to food price changes from 1997-2004 to 2005-12—these two 8-year periods can be viewed roughly as pre-boom and boom periods. Third, to check the forecasting power of the model, the parameter estimates from the 1960-2004 model were used to derive predicted prices for the 2005-12 period (that is, out-of-sample forecasts) and compare them with predicted prices from the full sample model (that is, in-sample forecasts). Fourth, the robustness of the model was further examined by re-estimating the equations as a panel by examining both conventional and cointegration statistics. The rest of this section elaborates on these extensions.

Excluding Post-2004

Table 4 reports parameter estimates based on 1960-2004 observations. In terms of model performance, the average *adjusted-*R^2 is the same as in the full sample model while the unit root statistics indicate a stationary error term. In terms of individual performance, the explanatory power of palm oil is lower while that of rice is higher. A comparison of the full sample with the pre-2005 model yields mixed results for the *S/U* ratio; its elasticity increases for maize and palm oil but declines for wheat, rice, and soybeans (figure 2, panel a). Interestingly, the *S/U* ratio elasticity for rice is higher in the 1960-2004 model compared to the full sample model, implying that during the post-2004 period, the *S/U* ratio of rice played limited role in the determination of rice prices. The relatively small and insignificant *S/U* ratio elasticity for rice has important policy implications, especially in view of calls to introduce regional or global interventions, including virtual reserves (Von Braun and Torero 2009), emergency reserves (Sarris 2010), or other insurance mechanisms (Mendoza 2009).

In contrast, the crude oil price elasticity increased across all five food commodities (figure 2, panel b), consistent with the view that the role of energy has strengthened after 2004. Notwithstanding this result, the literature on the post-2004 relationship between energy and non-energy prices is rather mixed. Serra (2011) found a long run linkage between ethanol and sugarcane prices in Brazil and also that crude oil and sugarcane prices lead ethanol prices but not vice versa. Saghaian (2010) found strong correlation among oil and other commodity prices (including food) but the evidence for a causal link from oil to other commodities was mixed. Gilbert (2010), based on quarterly data and Granger causality tests found correlation between the oil price and food prices both in terms of levels and changes, but also noted that it is the result of common causation and not of a direct causal link. Zhang and others (2010) found no direct long-run relationship between fuel and agricultural commodity prices and only a limited short-run relationship. Reboredo (2012), using weekly data from 1998 to 2012, concluded that the prices of maize, wheat, and soybeans are not driven by oil price fluctuations. Baffes (2010) in an update to earlier work, found that the link between energy and non-energy prices increases across all commodity groups when the post-2006 observations are added into the model, a result which is consistent with the view that common factors have played a prominent role during the recent boom (Gilbert 2010), as they did during the early 1970s price increases (Cooper and Lawrence 1975). Baffes (2010) also found that the transmission elasticity increase is more pronounced in non-food than food commodities, a result which is in accord with the weaker link identified by some other authors.

To the extent that production of biofuels is driven by mandates, the mixed evidence on the link between energy and food prices should not be surprising.[13] To see this, consider an exogenous shock which pushes crude oil prices up, in turn, lowering fuel consumption. Under a mandated ethanol/gasoline mixture ethanol <u>and</u> maize prices will decline, *ceteris paribus*, leading to a negative relationship between food and oil prices (de Gorter and Just 2009). From a statistical perspective, the mixed evidence on the energy/non-energy price linkage during the recent boom may reflect the frequency of the data used in various models. Indeed, Zilberman and others (2012) noted that higher frequency (and hence "noisier") data are typically associated with weaker price relationships. The key conclusion from the studies based on time series analysis—especially the ones that include the recent boom period—is that the strength of the energy/food price relationship should not be used as a metric associated with the impact

[13] If biofuels are profitable, in which case food commodities become another source of energy, food and oil prices will be moving in a synchronous manner. For the conditions under which biofuels become profitable see Gilbert (2010) and Schmidhuber (2007).

of biofuels on food prices.

In addition to excluding the post-2004 observations, we estimated the model with dummies for the *S/U* ratio and crude oil—due to limited degrees of freedom, we estimated separate regressions for each dummy. The changes in the elasticities were quantitatively similar to the changes observed from the limited to the full sample model, that is, increases in the effect of crude oil and mixed results on the effect of the *S/U* ratio.

What Matters Most?

Next, using the parameter estimates of the full sample, we calculated the relative contribution to price changes of each explanatory variable (table 5). Specifically, the estimated elasticities that were significantly different from zero were applied to the changes in the average values of the explanatory variables between the 1997-2004 and 2005-12. During these two periods, the World Bank's food price index increased by 80 percent whereas the price of crude oil increased by 228 percent (figure 3). In contrast, the changes in *S/U* ratios were more moderate and mixed, ranging from a 35 percent decline in maize to a 17 percent increase in soybeans (figure 4).[14]

Most of the contribution to food price changes from 1997-2004 to 2005-12 comes from the price of crude oil, which for maize and wheat is 52 percent and 64 percent, respectively with the corresponding *S/U* ratio contribution of 22 percent and 9 percent, respectively. The contribution of exchange rate ranged from zero (maize and palm oil) to 29 percent for rice. Crude oil's strong effect compared to the *S/U*'s ratio's more limited impact reflects the large increase in the price of oil during these two periods compared with the changes in the *S/U* ratios. In view of the (mostly) insignificant parameter estimates of the macroeconomic drivers, we also present parameter estimates from regressions that include only the three key drivers, namely, *S/U* ratio, oil price, and exchange rate. Results are reported in table 6; the upper panel shows parameter estimates and the lower panel shows the contributions to price changes. Again the results broadly confirm the findings of the decomposition based on table 2 estimates. That is, oil prices account for almost two thirds of the price changes from 1997-2004 to 2005-12, followed by *S/U* ratios and exchange rate with less than 10 percent each.[15]

It is important to emphasize that the larger (smaller) influence of crude oil (*S/U*

[14] Similar decompositions have been used elsewhere (for example, World Bank 2012b and Von Witzke and Noleppa 2011). A distinct advantage of the present decomposition is that it uses elasticities that have been generated by the same data set used for the decomposition analysis.

[15] The average absolute deviations of the sum of contributions from actual price changes reported in table 6 (12.6 percentage points) is less than the one reported in table 5 (19.4 percentage points). Average absolute contributions are calculated as 12.6 = (15+1+30+9+8)/÷5 and 19.4 = (32+2+17+10+36)÷5. In the case of maize (first column, bottom panel, table 6), 15 = 90–75, where 90 is the percentage change in price and 75 is the sum of contributions from *S/U* ratio (11%), oil price (61%), and exchange rate (3%).

ratio) on food prices is period specific. For example, during the late-1980s, when stocks were declining and oil prices were relatively stable, the *S/U* ratios accounted for most of the food price movements. Indeed, from 1985-87 to 1988-90, the price of maize increased by 19 percent. However, because the *S/U* ratio declined by 32 percent (and the crude oil price declined by 7 percent), almost all change in the price of maize is explained by the *S/U* ratio [(-0.61)*-32% + 0.23*(-7%) = 19.5% - 1.6% ≈ 18%].[16]

The limited impact of the *S/U* ratio on food prices following the post-2004 price increases is in line with Dawe (2009) who noted that stocks did not have an important effect on the evolution of world grain prices during the recent boom, a conclusion shared by Heady and Fan (2008). Our results are also in line with Von Witzke and Noleppa (2011), who concluded that the combined contribution of crude oil prices and freight rates to price changes of wheat, maize, and soybeans during the 2007/08 spike ranged between 45 percent and 75 percent (calculations based on p. 15, figure 8). However, they are in contrast to Wright (2012) who argued that low stocks during 2007/08—at a time of strong biofuel demand and increased incomes by China and India—were the key causes of the post-2007 grain price increases. And, to the extent that biofuels affect prices through the *S/U* channel, our results imply that their effect on food prices is not as strong as has been reported in previous studies (for example, Mitchell 2008).

These findings are critical in view of the frequent calls for the establishment of stockpile mechanisms, especially for rice. For example, Mendoza (2009, p. 13) proposed a combination of an Asian grain reserve and a financing facility that could be accessed by member countries when their rice supplies face unexpected shocks. Likewise, Gilbert (2012, p. 135) argued that unless export restrictions come under World Trade Organization discipline there is merit in considering the establishment of national or international rice stockpiles that poor rice-importing countries can access in the event of shortage.

Attractive as it may appear, such recommendation is questionable for at least two reasons. First, if the objective of stockpiling is to moderate price increases or reduce price variability, then *S/U* ratio's limited impact on rice prices implies that such mechanisms may not be very effective. Moreover, rice price volatility is similar to other grains and edible oils (see table 3) and much lower than other food commodities. For example, during the three decades prior to the recent boom (1975-2004), rice price volatility (measured as the standard deviation of monthly returns) averaged 5.4—much lower than 7.2, the median volatility of 25 food commodity prices. Such volatility measures imply that there is no apparent need to stabilize world rice prices. Second, if, as Martin and Anderson (2012) reported, almost half of the post-2007 increase in the price of rice is due to trade policies, then one could question whether the policy makers who engaged in such actions will adhere to the rules and conditions of stockpiling mechanisms

[16] In a trivial way, exchange rates have no impact on commodity price movements prior to 1973 because they did not move.

which historically have had a very poor record of success. Thus, instead of exploring second best alternatives by seeking international or regional cooperation to build and manage stocks, not engaging in *ad hoc* trade policies should be the avenue to pursue—indeed, a no-cost first best alternative.[17]

Assessing the Model

We assessed the sensitivity of the results by comparing actual prices with the predicted prices generated by the 1960-2012 and 1960-2005 models (table 7). First, both models show that prior to 2006, prices were higher than what the fundamentals suggest, about the same in 2007, and much lower after 2008. That is, both models indicate "under-shooting" prior to the boom and "overshooting" during the boom. For example, in 2005, fitted and actual prices differed between 28 percent (soybeans) and 54 percent (palm oil). Conversely, the difference in 2011 ranged from -20 percent (soybeans) to -27 percent (maize). As expected, such differences are smaller for 2005 (and larger for 2011) when the 1960-2004 period is used, which is consistent with the differences in the elasticity estimates reported in tables 2 and 4.

The model identifies one similarity and one difference with respect to the patterns observed during the commodity price boom of the 1970s. The similarity is that in 1972 (the year before the spike), prices undershot by an average of 10 percent, whereas during 1973 and 1974 they overshot by an average of 22 percent. The difference is that the undershooting and overshooting of the 1970s was of much smaller magnitude and less duration compared with the recent price increases. That difference, in turn, indicates that while price increases of the 1970s could be characterized as a spike (quite visible in figure 1), the recent price increases appear to have a more permanent character.

Consistent with the statistics reported earlier, the models for maize and wheat performed the best while that of rice performed the worst. For example, the Mean Absolute Percent Error (MAPE) for the full sample model (table 8, first row of top panel) is the lowest for maize and wheat and the highest for rice and palm oil with similar results applying to pre- and post-2005 fitted prices based on both models.

In addition to the MAPE criterion, the performance of the model was assessed by using Theil's inequality coefficient (*U-statistic*, table 8). The *U-statistic* lies between zero and one, with zero indicating perfect fit. The covariance proportion of the *U-statistic* is a measure of the unsystematic forecasting error, thus measuring the quality of the forecasts (values close to unity indicate higher quality forecasts), and the other two components of the *U-statistic* are the bias proportion and the variance proportion; all three add

[17] One may argue that the process of establishing and managing a regional rice stockpile could facilitate the discussion of policy-related issues among the various stakeholders and therefore help to avoid the types of trade interventions undertaken in 2008. Thus, even if it generates limited (or no) gains to its members, the stockpiling mechanism might be considered successful as long as it averts welfare losses.

to unity. Most *U-statistics* are less than 0.1, which implies that the model's forecasting ability is quite good (an exception to this is the bottom panel of table 8, which reports the out-of-sample forecast, where the out-of-sample component corresponds to the post-2004 period). In contrast, the covariance proportion for the rice model of the 2005-12 fitted prices based on the 1960-2004 model is much higher than the other commodities (0.618, see bottom panel), implying that, while the addition of the post-2004 period improves the performance of the model for all four commodities, it does not do so for rice. That finding, combined with the insignificant estimate for the *S/U* ratio, further confirms that rice stocks did not play an important role during the recent price boom.

Checking Robustness

To check the model's robustness, we estimated it as a panel (Pedroni 2004). Table 9 reports a total of four panel estimates: full sample (1960-2012) and shorter sample (1960-2004) for all five food prices (left-hand two columns) and the three grains (right-hand two columns). In all four regressions the *adjusted-*R^2s meet or exceed 0.90 while the parameter estimates for the *S/U* ratio, oil price, and exchange rate are significantly different from zero at the 1 percent level.

The panel regressions, which broadly confirm the results of the individual regressions, offer a useful summary assessment of the relative impact of the key drivers. First, both the crude oil and the *S/U* ratio elasticities are highly significant in all regressions, thus further confirming the importance of these two drivers (especially the former) in determining long term price trends. Second, when the post-2004 observations are included, the oil price elasticity increases but the *S/U* ratio elasticity does not. In fact, the *S/U* ratio elasticities for the three grains were identical in both regressions (-0.26, with *t-ratios* of 4.41 and 5.15). Third, the exchange rate elasticities of all four models were remarkably similar (around -1.25) and highly significant at the 1 percent level. Fourth, the impact of interest rates is positive and strong for 1960-2004 but weakens considerably when the entire sample is used. Fifth, inflation does not seem to matter. Last, income has either a marginal (albeit negative) or zero impact.

However, based on the unit root statistics, cointegration could not be confirmed—it was rejected by four panel measures (v, ϱ, PP, and ADF) as well as three group measures (ϱ, PP, and ADF) with all *p*-values exceeding 0.30. Such rejection is important for at least two reasons. First, it establishes the presence of significant qualitative and quantitative differences in the way in which food prices respond to fundamentals. Thus, analyses regarding the causes of food price movements—and the accompanied policy recommendations and likely actions—should be undertaken on a commodity-specific rather than a broad-based approach. To see this, consider the similarities and differences between maize and rice prices from the individual regressions. Both respond almost identically to oil price changes; yet, maize prices respond strongly to *S/U* ratio but not to exchange rate movements, while rice prices do not respond to *S*/*U* ratio but respond strongly to exchange rate movements. Second, from a methodological perspective, the rejection of cointegration may lead to the erroneous conclusion that there is no long-run relationship between food prices and fundamentals whereas such relationship not only exists but is very strong.

Conclusions and Further Research

This paper uses a reduced-form price-determination model on 1960-2012 annual data of five food commodities (maize, wheat, rice, soybeans, and palm oil) to assess the relative contribution of various factors to their respective price changes. The factors include crude oil prices on the supply side, stock-to-use ratios, three macroeconomic indicators (exchange rate movements, interest rates, and inflation), and income on the demand side. The paper concludes that food commodity prices respond strongly to energy prices, stock-to-use ratios, and (in a mixed manner) to exchange rate movements. With a few exceptions, interest rates and income growth do not matter. Yet, crude oil prices mattered the most during the recent boom period because they experienced the largest increase. In terms of model performance, wheat and maize performed the best, while rice performed poorly, the latter a likely reflection of the fact that the rice market is subjected to policy distortions the most among the commodities analyzed.

From a methodological perspective, the research presented here can be extended in a number of ways. By applying the model to other commodities (either food or raw materials and metals), one could explore whether the drivers discussed here are relevant to these commodities as well. Extending the sample back to the 1950s would give us enough observations to examine the way in which food prices behaved during a period (that is, before 1973) when the macroeconomic fundamentals moved little or did not move at all. Reconciling the mixed evidence on the food-energy price relationship during the recent boom could give insights as to whether the expansion of biofuels has been driven solely by policies or profitability has played a role. Another direction could entail the use of alternative measures of the key drivers and examining whether they are associated with significant differences in the elasticity estimates (for example, using a broad index of currencies instead of the SDR as an exchange rate proxy or a policy rate instead of a US Treasury Bill as an interest rate proxy). In contrast, the differences between the limited and full sample models imply that a time-varying parameter (or a switching regime) model may yield further insights into the nature and timing of commodity price booms (and busts) and, perhaps, confirm whether the recent price increases signify a transition from a prolonged period of low or declining prices to a period of high prices. The role of policies is another important extension that can shed more light on the undershooting and overshooting observed before 2005 and after 2004 as well as the poor performance of the rice model. Last, measuring price volatility through the lenses of higher-frequency data (for example, monthly or even daily data) and exploiting price comovement across a wide spectrum of commodities are directions where further research is warranted, especially in view of the ongoing policy debate surrounding the causes and consequences of food price volatility.

Table 1: Stationarity Properties

	——*Levels without trend*——		——*Levels with trend*——		——*First differences*——	
	ADF	*PP*	*ADF*	*PP*	*ADF*	*PP*
Prices						
Maize	-1.06	-0.90	-2.12	-2.17	-6.41***	-6.61***
Wheat	-1.40	-1.21	-2.45	-2.43	-5.70***	-6.20***
Rice	-2.00	-1.87	-2.60	-2.54	-5.64***	-6.29***
Soybeans	-1.14	-1.28	-1.83	-2.29	-6.75***	-6.87***
Palm oil	-0.78	-1.65	-1.52	-2.64	-6.24***	-8.21***
Crude oil	-0.70	-0.76	-1.59	-1.79	-6.59***	-6.58***
Macroeconomic variables						
MUV	-1.55	-1.36	-1.45	-1.08	-3.90***	-3.83***
Exchange rate	-1.47	-0.88	-4.05**	-2.92	-5.35***	-5.48***
Interest rate	-1.36	-1.45	-1.46	-1.11	-6.66***	-4.61***
GDP	-0.65	-0.22	-2.72	-1.48	-3.54**	-3.53**
S/U ratios						
Maize	-1.88	-1.91	-1.22	-1.89	-7.30***	-7.37***
Wheat	-2.54	-3.92***	-2.53	-3.89***	-5.88***	-10.65***
Rice	-1.66	-2.35	-1.01	-1.26	-3.85***	-5.97***
Soybeans	-3.41**	-3.34**	-4.22***	-3.71**	-3.07**	-10.25***
Palm oil	-2.98**	-2.83*	-2.82	-2.58	-9.80***	-10.66***

***Source*:** Authors' estimates.

***Note*:** All variables are expressed in logarithms. ADF and PP denote the Augmented Dickey-Fuller and Phillips-Perron statistic for unit roots, respectively (Dickey and Fuller 1979; Phillips and Perron 1988). The lag length of the ADF statistic was based on the Akaike information criterion (up to 10 lags were allowed), while the spectral estimation for the PP statistics was based on the Bartlett kernel method. GDP = gross domestic product; MUV = manufacture unit value; S/U = stock-to-use. Significance level of stationarity: * = 10 percent, ** = 5 percent, *** = 1 percent.

Table 2: Parameter Estimates from Ordinary Least Squares Regressions, 1960-2012

	Maize	*Wheat*	*Rice*	*Soybeans*	*Palm oil*
Constant (β_0)	8.21***	5.29***	6.74	6.69**	10.92**
	(5.92)	(3.95)	(1.62)	(2.04)	(2.49)
Stock-to-Use ratio (S/U_{t-1})	-0.61***	-0.50***	-0.21	-0.20*	-0.39**
	(5.92)	(3.12)	(0.81)	(2.13)	(2.38)
Oil price (P_t^{OIL})	0.23***	0.28***	0.27**	0.34***	0.50***
	(4.89)	(6.05)	(2.22)	(6.42)	(5.05)
Exchange rate (XR_t)	0.33	-0.86**	-2.45***	-1.08***	-1.02
	(1.01)	(2.45)	(3.88)	(2.91)	(1.34)
Interest rate (R_t)	0.16*	-0.02	0.31**	-0.03	-0.04
	(1.80)	(0.22)	(2.07)	(0.21)	(0.25)
Income (GDP_t)	-0.54***	-0.12	-0.11	-0.14	-0.43
	(3.79)	(1.17)	(0.48)	(0.61)	(1.45)
Manufacture prices (MUV_t)	0.87***	-0.02	-0.42	-0.13	-0.12
	(3.34)	(0.13)	(0.79)	(0.70)	(0.36)
Adjusted-R^2	0.87	0.90	0.73	0.84	0.67
DW	0.88	1.00	0.77	1.14	1.16
ADF	-4.08***	-5.00***	-3.47**	-4.42***	-4.17***
PP	-3.47**	-3.47**	-3.52**	-4.42***	-4.16***

***Source*:** Authors' estimates.

***Note*:** The independent variable is the logarithm of the respective price. Heteroskedasticity-consistent absolute *t-statistics* are reported in parentheses; they are based on White's method. DW denotes the Durbin-Watson statistic of serial correlation. Because of data unavailability, the regressions for soybeans and palm oil begin in 1965. For other notes see table 1. ADF = Augmented Dickey-Fuller (statistic for unit roots); GDP = gross domestic product; MUV = manufacture unit value; PP = Phillips-Perron (statistic for unit roots). Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

Table 3: Key Characteristics of Commodity Markets

	Maize	*Wheat*	*Rice*	*Soybeans*	*Palm oil*
Global production (million mt), 2011-12	857	674	457	251	49
Global exports (million mt), 2011-12	103	145	37	91	38
Exports as % of production, 2011-12	12.0	21.5	8.1	36.1	77.1
H-index, exports (%), 2010-12	11.9	21.2	15.2	32.0	40.0
H-index, imports (%), 2010-12	2.7	2.9	6.3	41.4	9.3
Price volatility, 1975-2004	5.4	4.9	5.4	5.4	7.7
Price volatility, 2005-09	8.0	8.3	9.1	6.9	9.4
Price volatility, 2010-12	6.6	8.8	4.4	4.4	5.2
Global TRI (%), 1965-99	6	12	48	6	na
Global TRI (%), 2000-04	3	4	43	6	na

***Source*:** Authors' calculations based on data from World Bank, US Department of Agriculture, and Anderson and others (2009).

***Note*:** 'mt' refers to metric tons. Exports as a share of production is a measure of market thinness. *H* is the Herfindahl index of market concentration. Price volatility has been calculated as 100*STDEV[log *p(t)*) - log *p(t-1)*], where STDEV denotes standard deviation, *p(t)* is the current, and *p(t-1)* is the lagged monthly average price of each commodity. Global TRI (Trade Restrictiveness Index) was taken from Anderson and others (2009, p. 489, Table 12.11).

Table 4: Parameter Estimates from Ordinary Least Squares Regressions, 1960-2004

	Maize	*Wheat*	*Rice*	*Soybeans*	*Palm oil*
Constant (β_0)	7.92***	4.98***	3.98	5.49	9.77*
	(8.37)	(3.25)	(1.23)	(1.64)	(1.98)
Stock-to-Use ratio (S/U_{t-1})	-0.53***	-0.54***	-0.33*	-0.24***	-0.28
	(6.89)	(3.36)	(1.73)	(2.86)	(1.64)
Oil price (P_t^{OIL})	0.13***	0.22***	0.10	0.23***	0.40***
	(3.20)	(4.19)	(0.88)	(4.41)	(4.11)
Exchange rate (XR_t)	0.32	-0.79**	-2.38***	-0.90**	-1.13
	(1.20)	(2.09)	(3.71)	(2.58)	(1.46)
Interest rate (R_t)	0.05	0.14*	0.69***	0.18	0.16
	(1.06)	(1.79)	(6.85)	(1.31)	(0.90)
Income (GDP_t)	-0.55***	-0.14	-0.04	-0.13	-0.35
	(5.86)	(1.09)	(0.22)	(0.53)	(0.97)
Manufacture prices (MUV_t)	0.96***	0.09	-0.14	0.08	-0.16
	(5.24)	(0.42)	(0.28)	(0.33)	(0.41)
Adjusted-R^2	0.91	0.90	0.83	0.84	0.55
DW	1.50	1.24	1.24	1.41	1.21
ADF	-4.13***	-4.16***	-5.05***	-4.70***	-3.72**
PP	-4.90***	-4.43***	-4.30***	-4.46***	-3.68**

Source: Authors' estimates.

Note: The independent variable is the logarithm of the respective price. For other notes see tables 1 and 2. ADF = Augmented Dickey-Fuller (statistic for unit roots); DW = Durbin-Watson (statistic of serial correlation); GDP = gross domestic product; MUV = manufacture unit value; PP = Phillips-Perron (statistic for unit roots). Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

Table 5: Contribution of Each Driver to Food Price Changes, 1997-2004 to 2005-2012 (percentage changes)

	Maize	*Wheat*	*Rice*	*Soybeans*	*Palm oil*
Change in nominal price	*90*	*81*	*99*	*77*	*81*
Stock-to-Use ratio (S/U_{t-1})	22	9	—	-3	5
Oil price (P_t^{OIL})	52	64	61	77	114
Exchange rate (XR_t)	—	10	29	13	—
Interest rate (R_t)	-4	—	-8	—	—
Income (GDP_t)	-32	—	—	—	—
Manufacture prices (MUV_t)	20	—	—	—	—
SUM	*58*	*83*	*82*	*87*	*119*

Source: Authors' calculations based on table 2 estimates.

Note**:** The contribution was based on the 1960–2012 model parameter estimates reported in table 2. "—" implies that the respective parameter estimate was not significantly different from zero. GDP = gross domestic product; MUV = manufacture unit value.

Table 6: Parameter Estimates from Ordinary Least Squares Regressions, 1960-2012 (excluding 3 macro variables) and Contribution to Price Changes (percentage changes)

	Maize	*Wheat*	*Rice*	*Soybeans*	*Palm oil*
Parameter estimates					
Constant (β_0)	3.41*** (24.97)	3.42*** (21.63)	4.32*** (19.12)	4.10*** (23.42)	4.20** (10.74)
Stock-to-Use ratio (S/U_{t-1})	-0.30*** (3.88)	-0.55*** (3.37)	-0.26** (2.46)	-0.25*** (3.24)	-0.39*** (2.84)
Oil price (P_t^{OIL})	0.27*** (10.17)	0.25*** (11.70)	0.21*** (5.76)	0.28*** (11.23)	0.36*** (6.94)
Exchange rate (XR_t)	0.23 (0.96)	-0.55** (3.01)	-1.14*** (3.92)	-0.71*** (3.62)	-0.12 (0.75)
Adjusted-R^2	0.85	0.91	0.67	0.85	0.66
DW	0.74	0.98	0.67	1.06	1.01
ADF	-3.15**	-3.46**	-3.32**	-4.13***	-3.41**
PP	-3.17**	-5.00***	-3.25**	-4.16***	-3.78***
Contribution to price changes					
Change in nominal price	*90*	*81*	*99*	*77*	*81*
Stock-to-Use ratio (S/U_{t-1})	11	9	8	-4	5
Oil price (P_t^{OIL})	61	64	48	64	82
Exchange rate (XR_t)	3	6	13	8	1
SUM	*75*	*80*	*69*	*68*	*89*

***Source*:** Authors' estimates.

***Note*:** The independent variable is the logarithm of the respective price. Heteroskedasticity-consistent absolute *t-statistics* are reported in parentheses; they are based on White's method. DW denotes the Durbin-Watson statistic of serial correlation. Because of data unavailability, the regressions for soybeans and palm oil begin in 1965. For other notes see table 1. ADF = Augmented Dickey-Fuller (statistic for unit roots); PP = Phillips-Perron (statistic for unit roots). Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent. Contributions of the lower panel are based on the parameter estimates reported in upper panel. Numbers may not add up exactly due to rounding.

Table 7: Comparing Actual to Model-Generated Prices

	2005	2006	2007	2008	2009	2010	2011	2012
Maize								
Actual ($/mt)	99	122	164	223	166	186	292	280
Fitted ($/mt), 1960-2012	146	150	167	184	158	173	212	207
Difference (%), 1960-2012	48	23	2	-17	-5	-7	-27	-26
Fitted ($/mt), 1960-2004	120	127	140	138	112	120	142	138
Difference (%), 1960-2004	22	5	-15	-38	-32	-36	-51	-51
Wheat								
Actual ($/mt)	152	192	255	326	224	224	316	280
Fitted ($/mt), 1960-2012	214	227	256	288	219	213	238	245
Difference (%), 1960-2012	40	18	0	-12	-2	-5	-25	-12
Fitted ($/mt), 1960-2004	193	209	237	249	182	173	192	197
Difference (%), 1960-2004	27	9	-7	-24	-19	-22	-39	-30
Rice								
Actual ($/mt)	286	305	326	650	555	489	453	550
Fitted ($/mt), 1960-2012	420	462	512	497	361	366	415	412
Difference (%), 1960-2012	47	52	57	-24	-35	-25	-24	-25
Fitted ($/mt), 1960-2004	352	417	467	366	236	231	256	254
Difference (%), 1960-2004	23	37	43	-44	-58	-53	-53	-54
Soybeans								
Actual ($/mt)	275	269	384	523	437	450	541	540
Fitted ($/mt), 1965-2012	351	361	373	444	390	392	432	459
Difference (%), 1965-2012	28	34	-3	-15	-11	-13	-20	-15
Fitted ($/mt), 1965-2004	293	314	322	343	286	280	302	324
Difference (%), 1965-2004	7	17	-16	-33	-34	-38	-44	-40
Palm oil								
Actual ($/mt)	422	478	780	949	683	901	1,125	1,125
Fitted ($/mt), 1965-2012	649	670	687	889	699	739	871	883
Difference (%), 1965-2012	54	40	-12	-6	2	-18	-23	-18
Fitted ($/mt), 1965-2004	585	629	650	732	552	576	661	667
Difference (%), 1965-2004	39	32	-17	-23	-19	-36	-41	-38

Source: Authors' calculations based on table 2 and 4 estimates.

***Note*:** 'mt' refers to metric tons. The first row of each panel denotes the price of the commodity, the logarithm of which is the dependent variable. The second row denotes the fitted price–based full sample model, and the third row denotes the percentage difference between the actual and fitted prices (based on the 1960–2012 sample, generated from the estimates reported in table 2). The fourth and fifth rows report fitted prices along with their percentage differences from actual prices based on the pre-2005 sample model (1960–2004, generated from the estimates reported in table 4).

Table 8: Assessing the Fit of the Models

	Maize	*Wheat*	*Rice*	*Soybeans*	*Palm oil*
1960–2012 fitted prices based on the 1960–2012 model					
Mean Absolute Percent Error	10.97	10.57	18.34	12.11	20.03
Theil's Inequality coefficient (*U*)	0.092	0.075	0.128	0.077	0.116
Covariance proportion of *U*	0.767	0.921	0.878	0.839	0.829
1960–2004 fitted prices based on the 1960–2012 model					
Mean Absolute Percent Error	9.42	9.88	15.14	11.06	19.70
Theil's Inequality coefficient (*U*)	0.070	0.067	0.098	0.069	0.123
Covariance proportion of *U*	0.996	0.994	0.976	0.996	0.907
1960–2004 fitted prices based on the 1960–2004 model					
Mean Absolute Percent Error	7.42	9.34	12.16	10.23	18.57
Theil's Inequality coefficient (*U*)	0.055	0.062	0.081	0.062	0.120
Covariance proportion of *U*	0.967	0.985	0.981	0.977	0.817
2005–12 fitted prices based on the 1960–2012 model (in-sample forecast)					
Mean Absolute Percent Error	19.45	14.32	35.94	17.33	21.64
Theil's Inequality coefficient (*U*)	0.120	0.085	0.168	0.088	0.106
Covariance proportion of *U*	0.015	0.358	0.705	0.089	0.179
2005–12 fitted prices based on the 1960–2004 model (out-of-sample forecast)					
Mean Absolute Percent Error	31.14	22.11	45.44	28.84	30.51
Theil's Inequality coefficient (*U*)	0.257	0.144	0.293	0.208	0.189
Covariance proportion of *U*	0.069	0.364	0.618	0.127	0.163

Source: Authors' estimates based on table 2 and 4 estimates.

Note**:** The Mean Absolute Percent Error (MAPE) is the percentage difference between actual and fitted price. For example, the value of the MAPE statistic for maize in the in-sample forecast panel, 19.45, is the average of the absolute values reported in the third row of the maize panel in table 6 (48 percent, 23 percent, 2 percent, −17 percent, −5 percent, −7 percent, −27 percent, and −26 percent. The Theil's inequality coefficient (*U-statistic*) shows how well the fitted prices compare with the actual prices.

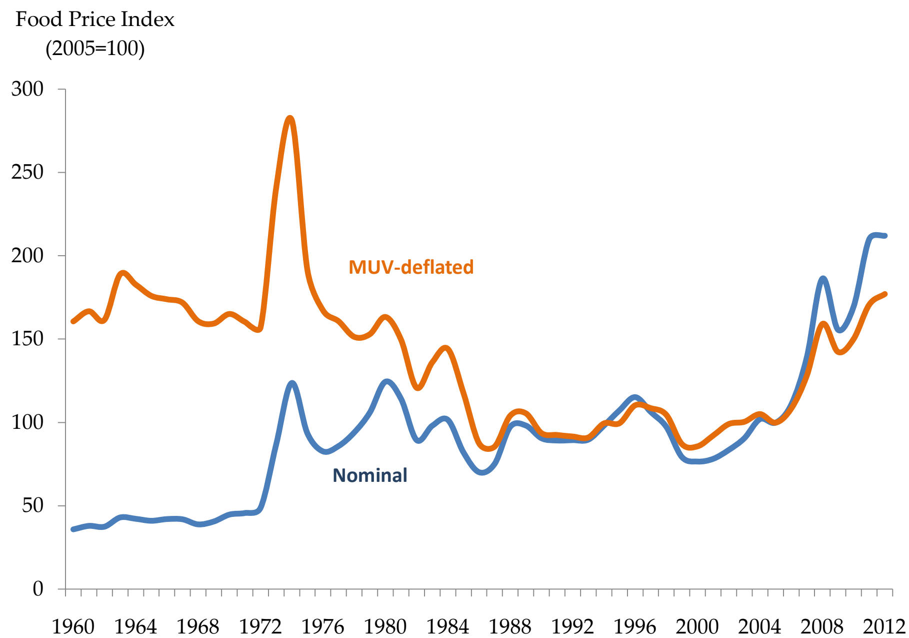
Table 9: Parameter Estimates from Panel Regressions

	All 5 commodities		*Three grains*	
	1960-2012	*1960-2004*	*1960-2012*	*1960-2004*
Constant (β_0)	7.08*** (6.05)	6.37*** (5.73)	6.14*** (4.51)	5.64*** (4.71)
Stock-to-Use ratio (S/U_{t-1})	-0.22*** (5.07)	-0.23*** (5.55)	-0.26*** (4.41)	-0.26*** (5.15)
Oil price (P_t^{OIL})	0.34*** (11.23)	0.24*** (7.62)	0.28*** (7.37)	0.18*** (4.98)
Exchange rate (XR_t)	-1.25*** (5.60)	-1.20*** (5.71)	-1.28*** (4.52)	-1.27*** (5.15)
Interest rate (R_t)	0.06 (1.15)	0.28*** (5.51)	0.10* (1.76)	0.33*** (6.04)
Income (GDP_t)	-0.17** (2.04)	-0.18** (2.08)	-0.15 (1.50)	-0.17* (1.78)
Manufacture prices (MUV_t)	0.18 (1.63)	-0.03 (0.27)	-0.09 (0.63)	0.04 (0.24)
Adjusted-R^2	0.92	0.93	0.90	0.92
DW	0.88	1.08	0.77	0.99

Source: Authors' estimates.

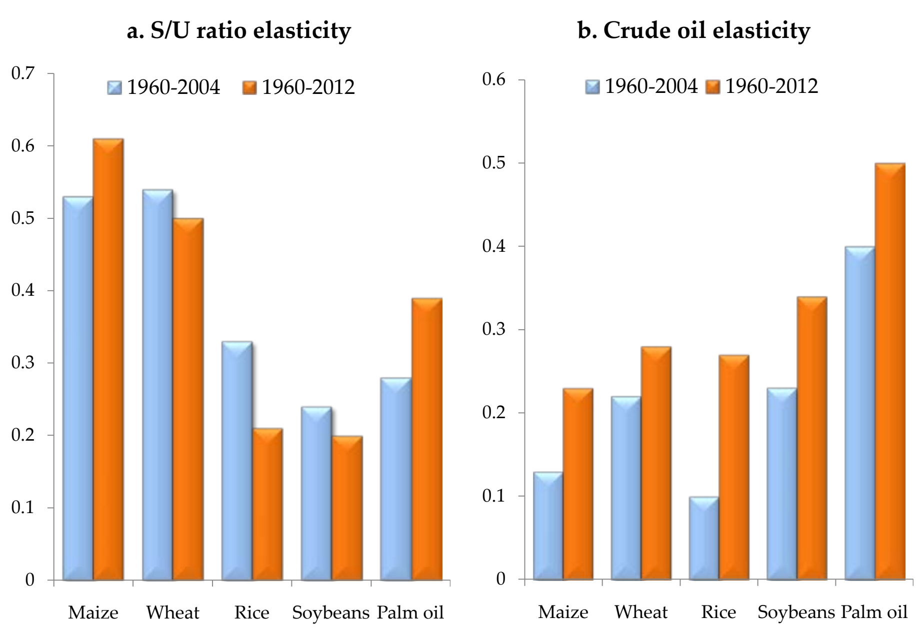
***Note*:** See table 1. DW = Durbin-Watson (statistic of serial correlation); GDP = gross domestic product; MUV = manufacture unit value. Significance level: * = 10 percent, ** = 5 percent, *** = 1 percent.

Figure 1: Food Price Index, 1960-2012



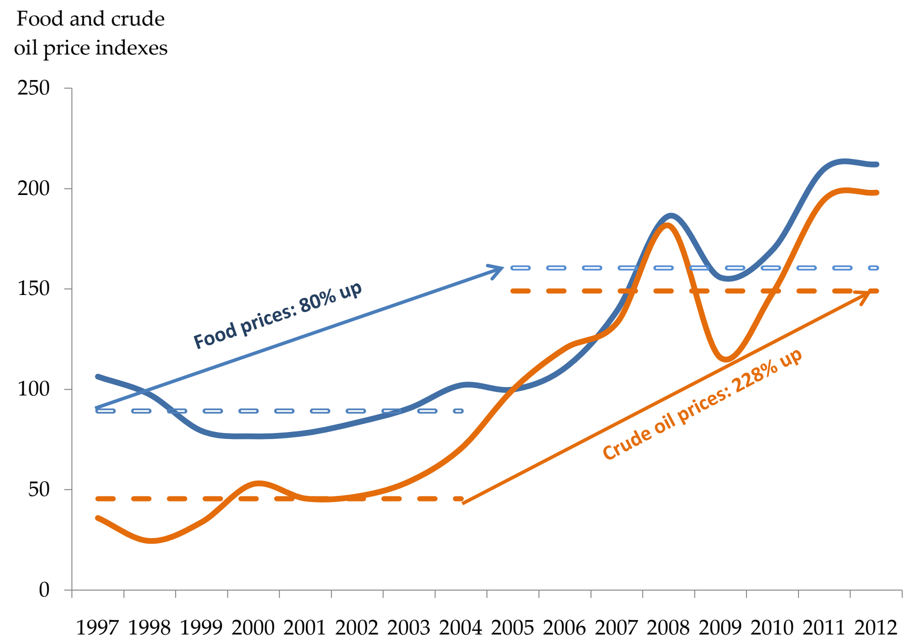
Source: Based on World Bank data.

Figure 2: Elasticities (Absolute Values)



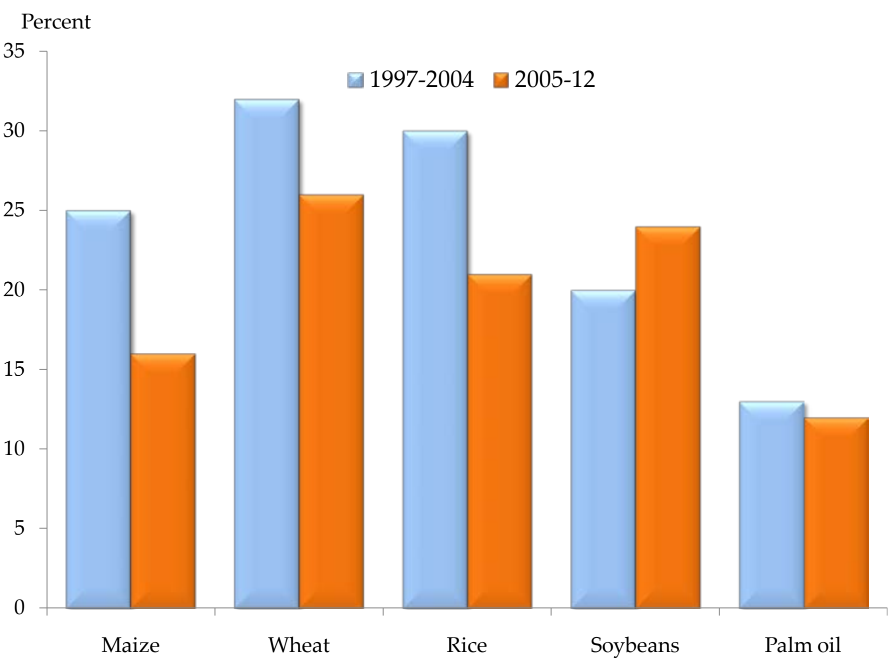
Source: Authors' calculations
Note: S/U = stock-to-use

Figure 3: Price Indexes (nominal, 2005 = 100)



Source: World Bank

Figure 4: Stock-to-use Ratio



Source: Based on US Department of Agriculture

References

Abbott, Phillip C., Christopher Hurt, and Wallace E. Tyner (2008). *What's Driving Food Prices?* Oak Brook, IL: The Farm Foundation.

Ai, Chunrong, Arjun Chatrath, and Frank Song (2006). "On the Co-movement of Commodity Prices." *American Journal of Agricultural Economics*, vol. 88, pp. 574–588.

Alavi, Hamid A., Aira Htenas, Ron Kopicki, Andrew W. Shepherd, and Ramon Clarete (2012). *Trusting Trade and Private Sector for Food Security in Southeast Asia.* Directions in Development Series. Washington, DC: World Bank.

Alexandratos, Nikos (2008). "Food Price Surges: Possible Causes, Past Experience, and Long-term Relevance." *Population and Development Review*, vol. 34, pp. 599-629.

Alexandratos, Nikos and Jelle Bruinsma (2012). *World Agriculture towards 2030/2050: the 2012 Revision.* ESA Working Paper No. 12-03. Agricultural Development and Economics Division, Food and Agriculture Organization of the United Nations, Rome.

Anderson, Kym, Johanna L. Croser, Signe Nelgen, and Ernesto Valenzuela (2009). "Global Distortion to Key Commodity Markets." In *Distortions to Agricultural Incentives: A Global Perspective, 1955-2007*, ch. 12, pp. 459-504, ed. Kym Anderson. Washington, DC: Palgrave and McMillan for the World Bank.

Baffes, John (2012). "Going Against the Grain on the Post-2005 Commodity Price Boom." *International Economic Bulletin*, April. http://www.carnegieendowment.org/2012/04/19/going-against-grain-on-post-2005-commodity-price-boom/ad8j

Baffes, John (2010). "More on the Energy/Non-Energy Commodity Price Link." *Applied Economics Letters*, vol. 17, pp. 1555-1558.

Baffes, John (2007). "Oil Spills on Other Commodities." *Resources Policy*, vol. 32, pp. 126-134.

Baffes, John (1997). "Explaining Stationary Variables with Nonstationary Regressors." *Applied Economics Letters*, vol. 4, pp. 69-75.

Baffes John and Tassos Haniotis (2010). "Placing the Recent Commodity Boom into Perspective." In *Food Prices and Rural Poverty*, ch.2, pp. 40-70, ed. Ataman Aksoy and Bernard Hoekman. Washington DC: Centre for Economic Policy Research and the World Bank.

Bobenrieth, Eugenio, Brian Wright, and Zi Zeng (2012). "Stocks-to-Use Ratios as Indicator of Vulnerability to Spikes in Global Cereal Markets." Paper presented at the Second Session of the Agricultural Marketing Information System, Global Food Market Group. Food and Agriculture Organization of the United Nations, Rome, October 3.

Borensztein, Eduardo and Carmen M. Reinhart (1994). "The Macroeconomic Determinants of Commodity Prices." *IMF Staff Papers*, vol. 41, pp. 236-261.

Byrne, Joseph P., Giorgio Fazio, and Norbert Fiess (2013). "Primary Commodity Prices: Co-movements, Common Factors and Fundamentals." *Journal of Development Economics*, vol. 101, pp. 16-26.

Cashin, Paul, C. John McDermott, and Alasdair Scott (1999). "The Myth of Co-moving Commodity Prices." IMF Working Paper 169, International Monetary Fund, Washington, DC.

Chambers, Robert G. and Richard E. Just (1981). "Effects of Exchange Rate Changes on US Agriculture: A Dynamic Analysis." *American Journal of Agricultural Economics*, vol. 63, pp. 32-46.

Chaudhri, Kausik (2001). "Long-run Prices of Primary Commodities and Oil Prices." *Applied Economics*, vol. 33, pp. 531-538.

Cooper, Richard N. and Robert Z. Lawrence (1975). "The 1972-75 Commodity Boom." *Brookings Papers on Economic Activity*, vol. 3, pp. 672-715.

Dawe, David (2009). "The Unimportance of 'Low' World Grain Stocks for Recent World Price Increases." ESA Working Paper No. 09-01, Agricultural Development and Economics Division, Food and Agriculture Organization of the United Nations, Rome.

Dawe, David (2002). "The Changing Structure of the World Rice Market, 1950–2000." *Food Policy*, vol. 27, pp. 335-370.

Deaton, Angus and Jean Dréze (2008). "Nutrition in India: Facts and Interpretations." *Economic and Political Weekly*, vol. 44, pp. 42-65.

Deaton, Angus and Guy Laroque (1992). "On the Behaviour of Commodity prices." *Review of Economic Studies*, vol. 59, pp. 1-23.

Deb, Partha, Pravin K. Trivedi, and Panayotis Varangis (1996). "The Excess Co-movement of Commodity Prices Reconsidered." *Journal of Applied Econometrics*, vol. 11, pp. 275–291.

De Gorter, Harry and David R. Just (2009). "The Economics of a Blend Mandate for Biofuels." *American Journal of Agricultural Economics*, vol. 91, pp. 738-750.

Dickey, David A. and Wayne A. Fuller (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." *Journal of the American Statistical Association*, vol. 74, pp. 427-431.

Gardner, Bruce (1981). "On the Power of Macroeconomic Linkages to Explain Events in U.S. Agriculture." *American Journal of Agricultural Economics*, vol. 63, pp. 871-878.

Gilbert, Christopher L. (2012). "International Agreements to Manage Food Price Volatility." *Global Food Security*, vol. 1, pp. 134-142.

Gilbert, Christopher L. (2010). "How to Understand High Food Prices." *Journal of Agricultural Economics*, vol. 61, pp. 398-425.

Gilbert, Christopher L. (1989). "The Impact of Exchange Rates and Developing Country Debt on Commodity Prices." *Economic Journal*, vol. 99, pp. 773-783.

FAO, Food and Agriculture Organization of the United Nations (2009). *The State of Agricultural Commodity Markets: High Food Prices and the Food Crisis—Experiences and Lessons Learned*. Rome: Food and Agriculture Organization.

FAO, Food and Agriculture Organization of the United Nations (2008). "Soaring Food Prices: Facts, Perspectives, Impacts, and Actions Required." Technical report presented at the FAO's "High—Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy," Rome June 3-5.

Frankel, Jeffrey A. and Andrew K. Rose (2010). "Determinants of Agricultural and Mineral Commodity Prices." In *Inflation in an Era of Relative Price Shocks*, pp. 9-51, ed. Renée Fry, Callum Jones, and Christopher Kent. Sydney, Australia: Reserve Bank of Australia and Centre for Applied Macroeconomic Research.

Frankel, Jeffrey A. and Gikas Hardouvelis (1985). "Commodity Prices, Monetary Surprises, and Fed Credibility." *Journal of Money, Credit, and Banking*, vol. 17, pp. 425-438.

Hanson, Kenneth, Sherman Robinson, and Gerald E. Schluter (1993). "Sectoral Effects of a World Oil Price Shock: Economywide Linkages to the Agricultural Sector." *Journal of Agricultural and Resource Economics*, vol. 18, pp. 96-116.

Heady, Derek and Shenggen Fan (2008). "Anatomy of a Crisis: The Causes and Consequences of Surging Food Prices." *Agricultural Economics*, vol. 39, pp. 375-391.

Heady, Derek and Shenggen Fan (2010). "Reflections on the Global Food Crisis: How it Happened? How it Hurt? And, How we Can Prevent the next One?" *Research Monograph 165.* Washington, DC: International Food Policy Research Institute.

Hochman, Gal, Deepak Rajagopal, Govinda Timilsina, David Zilberman (2011). "The Role of Inventory Adjustments in Quantifying Factors Causing Food Price Inflation." *Policy Research Working Paper 5744.* Washington, DC: World Bank.

Holtham, Gerald H. (1988). "Modeling Commodity Prices in a World Macroeconomic Model." In *International Commodity Market Models and Policy Analysis*, ed. Orhan Guvenen. Boston, MA: Kluwer Academic Publishers.

Houthakker, Hendrik S. (1975). "Comments and Discussion on 'The 1972-75 Commodity Boom' by Richard N. Cooper and Robert Z. Lawrence." *Brookings Papers on Economic Activity*, vol. 3, pp. 718-720.

Kilian, Lutz (2009). "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market." *American Economic Review*, vol. 99, pp. 1053–1069.

Krugman, Paul (2008). "Grains Gone Wild." Op-Ed, *New York Times*, April 7.

Lamm, McFall R., Jr. (1980). "The Role of Agriculture in the Macroeconomy: A Sectoral Analysis." *Applied Economics*, vol. 12, pp. 19-35.

LeyBourne, Stephen J., Tim A. Lloyd, and Geoffrey V. Reed (1994). "The Excess Comovement of Commodity Prices Revisited." *World Development*, vol. 22, pp. 1747-1758.

Lustig, Nora (2008). "Thought for Food: The Challenges of Coping with Soaring Food Prices." Working Paper no 155, Center for Global Development, Washington, DC.

Martin, William and Kym Anderson (2012). "Export Restrictions and Price Insulation During Commodity Price Booms." *American Journal of Agricultural Economics*, vol. 94, pp. 422-427.

Mendoza, Ronald U. (2009). "A Proposal for an Asian Rice Insurance Mechanism." *Global Economy Journal*, vol. 9, pp. 1-31.

Newbery, David M.G. and Joseph E. Stiglitz (1981). *The Theory of Commodity Price Stabilization: Study in the Economics of Risk*. Oxford, UK: Oxford University Press.

Mitchell, Donald (2008). "A Note on Rising Food Prices." *Policy Research Working Paper 4682*. Washington, DC: World Bank.

Pedroni, Peter (2004). "Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis." *Econometric Theory*, vol. 20, pp. 597-625.

Phillips, Peter C.B. and Pierre Perron (1988). "Testing for a Unit Root in Time Series Regression." *Biometrika*, vol. 75, pp. 335– 346.

Piesse, Jenifer and Colin Thirtle (2009). "Three Bubbles and a Panic: An Explanatory Review of the Recent Food Commodity Price Events." *Food Policy*, vol. 34, pp. 119-129.

Pindyck, Robert S. and Julio J. Rotemberg (1990). "The Excess Co-movement of Commodity Prices." *Economic Journal*, vol. 100, pp. 1173–1189.

Radetzki, Marian (2006). "The Anatomy of Three Commodity Booms." *Resources Policy*, vol. 31, pp. 56-64.

Radetzki, Marian (1985). "Effects of a Dollar Appreciation on Dollar Prices in International Commodity Markets." *Resources Policy*, vol. 11, pp. 158-159.

Reinhart, Carmen M. (1991). "Fiscal Policy, the Real Exchange Rate, and Commodity Prices." *IMF Staff Papers*, vol. 38, pp. 506-524.

Reboredo, Juan C. (2012). "Do Food and Oil Prices Co-Move?" *Energy Policy*, vol. 49, pp. 456-467.

Saghaian, Sayed H. (2010). "The Impact of the Oil Sector on Commodity Prices: Correlation or Causation?" *Journal of Agricultural and Applied Economics*, vol. 42, pp. 477-485.

Sapsford, David, Prabirjit Sarkar, and Hans W. Singer (2992). "The Prebisch-Singer Terms of Trade Controversy Revisited." *Journal of International Development*, vol. 4, pp. 315-332.

Sarris, Alexander (2010). "Trade-Related Policies to Ensure Food (Rice) Security in Asia." In: *The Rice Crisis*, pp. 61–87, ed. David Dawe. London: Earthscan.

Schmidhuber, Joseph (2007). "Impact of Increased Biomass Use on Agricultural Markets, Prices and Food Security: A Longer Term Perspective." Proceedings from the Conference *Energy Security in Europe*, pp. 133-169. The Centre for European Studies, Lund University.

Schuh, G. Edward (1974). "The Exchange Rate and U.S. Agriculture." *American Journal of Agricultural Economics*, vol. 56, pp. 1-13.

Serra, Teresa (2011). "Volatility Spillovers between Food and Energy Markets: A Semiparametric Approach." *Energy Economics*, vol. 33, pp. 1155-1164.

Sjaastad, Larry A. (2008). "The Price of Gold and the Exchange Rates: Once Again." *Resources Policy*, vol. 33, pp. 118-124.

Stamoulis Kostas and Gordon Rausser (1987). "Overshooting of Agricultural Prices." *Working Paper No. 493*, Department of Agricultural and Resource Economics, University of California, Berkeley.

Stein, Jerome L. (1986). *The Economics of Futures Markets*. Oxford: Basil-Blackwell.

Timmer, C. Peter and Tom Slayton (2009). "Arson Alert: Philippines Is Playing with Fire! Again!" *Center for Global Development Notes*. Washington, DC: Center for Global Development.

Turnovsky, Stephen J. (1983). "The Determinants of Spot and Futures Prices with Storable Commodities." *Econometrica*, vol. 51, pp. 1363-1387.

Von Braun, Joachim and Maximo Torero (2009). *Implementing Physical and Virtual Food Reserves to Protect the Poor and Prevent Market Failure.* IFPRI Policy Brief. Washington, DC: International Food Policy Research Institute.

Von Witzke, Harald and Steffen Noleppa (2011). "Why Speculation is not the Prime Cause of High and Volatile International Agricultural Commodity Prices: An Economic Analysis of the 2007-08 Price Spike." HFFA Working paper.

Webster, Mort, Sergey Paltsev, and John Reilly (2008). "Autonomous Efficiency Improvement or Income Elasticity of Energy Demand: Does It Matter?" *Energy Economics*, vol. 30, pp. 2785-2798.

Wolf, Martin (2008). "Food Crisis is a Chance to Reform Global Agriculture." *Financial Times*, April 27.

World Bank (2012a). *Thailand: Economic Monitor—December 2012*. Bangkok, World Bank Regional Office.

World Bank (2012b). *Responding to Higher and More Volatile Food Prices*. Report No. 68420-GLB. World Bank, Washington, DC.

World Bank (2009). *Global Economic Prospects: Commodities at the Crossroads*. Washington, DC: World Bank.

Wright, Brian (2012). "International Grain Reserves and Other Instruments to Address Volatility in Grain Markets." *World Bank Research Observer*, vol. 27, pp. 222-260.

Zhang, Zibin, Luanne Lohr, Cesar Escalante, and Michael Wetzstein (2010). "Food versus Fuel: What Do Prices Tell Us?" *Energy Policy*, vol. 38, pp. 445-451.

Zilberman, David, Gal Hochman, Deepak Rajagopal, Steve Sexton, and Govinda Timilsina (2013). "The Impact of Biofuels on Commodity Food Prices: Assessment of Findings." *American Journal of Agricultural Economics*, vol. 95, pp. 275-281.