WPS7589

Policy Research Working Paper 7589

# What Explains Agricultural Price Movements?

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World Bank Group
Development Economics Vice Presidency
Development Prospects Group
March 2016

Policy Research Working Paper 7589


## Abstract

After 2005, commodity prices experienced their longest and broadest boom since World War II. Agricultural prices have now come down considerably since their 2011 peak, but are still 40 percent higher in real terms than their 2000 lows. This paper briefly addresses the main arguments on the causes of the agricultural price cycle. It broadens the scope of analysis by focusing on six agricultural commodities, and identifies the relative weights of key quantifiable drivers of their prices. It concludes that increases in real income negatively affect real agricultural prices, as predicted by Engel's Law. Energy prices matter most (not surprisingly, given the energy-intensive nature of agriculture), followed by stock-to-use ratios and, to a lesser extent, exchange rate movements. The cost of capital affects prices only marginally, probably because it not only influences demand, but also evokes a supply response.


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**JEL CLASSIFICATTION:** E31, O13, Q02, Q11, Q18

**KEY WORDS:** Agricultural prices, commodity boom, commodity prices, price cycle

An earlier version of the paper was presented at the *Forum on Markets and Trade*, co-organized by AAEA, IAMO, and IATRC in Halle, Germany, June 25-27, 2014. We would like to thank Koen Dillen, Xiaoli Etienne, Mark Felsenthal, Charlotte Gong, Koen Mondelaers, Rachel Weaving, and conference participants for helpful comments and suggestions on earlier draft.

# 1. INTRODUCTION

During the first decade of the new millennium, commodity prices experienced their longest and broadest boom since World War II, reversing a nearly three-decade decline. World prices of food commodities doubled within just ten years. Agricultural prices have now come down considerably from their early 2011 peaks, but in real terms they are still 40 percent above their 2000 lows.

The price movements of agricultural commodities after 2005 were exceptional, in that they evolved in parallel with those of other commodities, and they aroused concerns about food security. In developed and developing countries alike, consumers felt the impact of higher food prices—especially in times of overall inflationary pressures—while producers felt pressures from higher costs. At the same time, all were feeling the impact of the general commodity price boom—one that has often been characterized as the "perfect storm" and that persisted even after the immediate impacts of the Great Recession seemed to subside.[1]

The agricultural price movements had a lasting effect on public perceptions. Although most commodity prices[2] are now much lower than in 2011, and their volatility appears to have moderated, price volatility and ways to address its effects on producers and consumers still preoccupy both market participants and policy makers. Policies to address perceived and real problems linked to agricultural price uncertainties can be misconceived if they are not based on a solid understanding of what drives price developments.

This paper examines the sources of agricultural commodity price movements. We first briefly review the main explanations offered by the literature about the causes of the post-2005 movements in agricultural commodity prices, and especially their upward path in 2003-11. The debate has produced a voluminous literature and is still open.[3] Its focus has shifted away from the topics of "yesterday"—notably, whether it was sectoral fundamentals that explained price developments, price volatility, or price co-movement—and toward issues that are more pertinent today—such as whether real prices will stay high or return to pre-boom levels; the nature of links between agricultural prices and the broader economy; and whether the terms of trade for agriculture have changed.

Because uni-dimensional approaches tend to overestimate the impact of whichever single driver they have assigned explanatory power to, we broaden the scope of analysis to assess the relative contributions of five measurable variables—used as proxies for five macroeconomic and sectoral drivers of prices—to changes in the prices of six agricultural commodities.

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[1] Baffes and Haniotis (2010) argued that the confluence of various factors reflects these "perfect storm" conditions. Wright (2012) on the other hand argued that reductions in stocks, induced by strong biofuel production, explain the agricultural price spike. Swinnen (2010) seemed to concur with the "perfect storm" position.

[2] Including that of oil, which in early 2016 reached 13-year lows.

[3] For literature reviews see Baffes and Haniotis (2010), Brümmer and others (2013), Tadesse and others (2014).

Our analysis shows that, among these variables, energy prices matter most, followed by stock-to-use ratios and, to a lesser extent, exchange rate movements. Changes in real income negatively affect real commodity prices, as predicted by Engel's Law. The lower cost of capital impacts prices only marginally, probably because it not only raises demand but also evokes a supply response. The added value of these results lies in that, when examined in tandem and against market fundamentals, they challenge the conclusions from uni-dimensional approaches.

## 2. Assessing the Main Drivers of Food Price Developments

Like its predecessors, the post-2005 boom in food prices triggered concerns about food security and availability. But in the years following the 2008-09 recession the debate on food security and its repercussions for agriculture assumed a different twist than previous assessments of food price jumps. This was because the weight that different observers assigned to different perceived causes of price developments led to different policy recommendations on issues as diverse as biofuels or strategic stocks.

Figure 1, showing real commodity price indices for agriculture, metals, and energy, provides the background to the debate. Looking solely at the evolution of agricultural prices, one would point to 2000 as the start of a clear reversal in the downward trend of previous decades. This trend, seen separately from the price paths of other commodities, could suggest that agricultural market price signals alone would lead farmers to adjust production—following the old dictum that low (high) prices are the best cure for low (high) prices.

Yet from looking at the parallel movement that took place in the prices of industrial commodities (energy and metals), and especially at higher frequency data (Figure 2), it becomes evident that three distinct features characterized commodity price movements during the recent decade. These are: higher price *volatility*, significant price *co-movement*, and a higher real price *level* for all three commodity groups.[4]

Recognition of these features brought to the fore the wider macroeconomic influences on agriculture. First and most prominent at the early stages of the debate (spring 2008) was the association drawn between the agricultural price boom and growth in global population and income, especially in China and India, as well as changes in diets towards more protein consumption (see, for example, Krugman 2008 and Wolf 2008).

The prevalence of low interest rates during much of the decade was seen to complicate the interaction of macroeconomic variables with GDP growth, globally, not just in China and India. The impressive increase in China's GDP, compared to the growth in either the major developed countries or the emerging economies, played a role by raising demand and pushing up the prices of food commodities. The depreciation of the U.S. dollar also

[4] The same picture emerges when prices of fertilizer (see Appendix A) and precious metals are considered.

helped push up prices, since these commodities are traded in U.S. dollars.

The continuous and at times sharp increase in the price levels of all commodities suggested another possible explanation: that the post-2005 upward price trend was linked to the impact from "financialization," that is, the transformation of commodities into asset values and the consequent significant increase in funds invested in commodities (Figure B2). Here the discussion focused on market failures, real or perceived, that were exacerbated by the results of the financial crisis.

Among the sectoral approaches to explaining agricultural price movements, one that had been sidelined by market developments in the late 1990s returned with a vengeance a few years later when analysts linked what was happening in commodity prices to changes in stocks. Stock changes are a constant feature of commodity markets, and especially of grain markets. But the significant shrinkage that had been taking place in stocks of wheat and especially maize, relative to consumption (Figure A1), led observers to claim that prices were volatile not because markets were failing but simply because markets were playing their role.

In wheat and maize, the two commodities that dominated the food security debate, the inverse relationship between stock levels and prices clearly played a role in the price increases. And, looking at prices expressed in real terms, after 2005 maize prices seem to have been more sensitive than wheat prices to changes in stocks. However, in retrospect, it is interesting to emphasize that, had policy recommendations on strategic or virtual stocks been implemented, they would have had severe implications for cereal prices, as well as for the budgets of countries managing stocks, given the post-2011 price reversal.[5]

The focus on stocks in turn pointed to an increasing link between agricultural markets and energy markets, through what was at the time a new development: the significant rise in the use of food commodities as feedstuff for biofuels: maize for ethanol in the United States and, less so, edible oilseeds for biodiesel in the European Union (Figure A2). This rise, driven mostly by policy mandates, provided a new and clearly observable component of demand growth for agricultural commodities and inevitably affected the market balance for cereals.

However, it caused some observers to attribute too much responsibility to biofuels for the rise of agricultural prices. During 2005-14, total demand for wheat by the world's three largest consumers (the United States, the European Union, and China) rose modestly, by 36 million metric tons. China accounted for two-thirds of the demand increase, using it almost entirely for animal feed (unlike in India, where almost all the increase was for food). A decline in wheat demand in the European Union, reflecting a decline in EU demand for feed, offset an increase in wheat demand in the United States, which was for food.

The moderate overall increase in wheat demand explains why stocks recovered

[5] See Von Braun and Torero (2009) for virtual reserves, Sarris (2010) for emergency reserves, Gilbert (2012) for rice security stocks, and Mendoza (2009) for other insurance mechanisms.

faster in wheat than in maize, for which the rise in global demand was much larger, at 105 million metric tons over 2005-14. Most of the addition to global maize demand—100 million metric tons—came from U.S. industry and was essentially for biofuels; some of the price pressure from biofuels was mitigated by a decline of 45 million metric tons in U.S. demand for maize as feed. The other notable change in demand for maize feed was in China, with an increase of 43 million metric tons. Therefore, the role of biofuels in pushing up prices applies mainly to one commodity—maize—and even in that case the perception about it seems to exceed the actual impact.

More recent developments—a slowdown in the global growth of demand for biofuels, and agricultural prices that are lower than their 2011 peaks but still higher than in 2000—indicate that the link between agriculture and energy may be more complex than believed, especially with regard to future developments. For example, the link seems to have been broken between U.S. crude-oil and natural gas prices, and the latter have been moving in tandem with the price of coal (Figure A3). The link was also broken between the markets for natural gas in the U.S., Europe, and Japan. As a result, the United States has been making huge investments in energy-intensive industries, benefitting both directly, from lower energy costs, and indirectly, by lowering the costs of energy-intensive products such as fertilizers (Figure A4).

Each of the above macroeconomic and sectoral influences clearly played a role in determining agricultural commodity prices, but not in isolation. It is interesting that, unlike the developments in 2006-08, agricultural commodity prices recently declined independently of some of the factors affecting them. For example, biofuels use is still high, although it is growing much more slowly than before, and interest rates are still low and even negative when adjusted by quantitative-easing policies. Yet energy, fertilizer, and agricultural prices continue to be characterized by a degree of co-movement.

## 3. Reconciling Theory and Evidence

### *3.1 Modeling food price trends*

To identify the long-term impact of the various sectoral and macroeconomic fundamentals on real commodity prices, this section presents estimates from a reduced-form econometric model. The theoretical underpinnings of the model are outlined in Holtham (1988) and Deaton and Laroque (1992). The model has had numerous empirical applications: Gilbert (1989) used it to look at the effect of developing countries' debt on commodity prices; Pindyck and Rotemberg (1990) examined co-movement among various commodity prices; Reinhart (1991) and Borensztein and Reinhart (1994) analyzed the factors behind the weakness of commodity prices during the late 1980s and early 1990s; Frankel and Rose (2010) analyzed the effects of a range of macroeconomic variables on agricultural and mineral commodities; and Baffes and Dennis (2015) and Baffes and Etienne (2016) examined the effect of income growth in emerging economies on real food prices.

The model takes the following form:

$$\log(P_t^i) = \beta_0^i + \beta_1^i \log(Y_t) + \beta_2^i R_t + \beta_3^i \log(X_t) + \beta_4^i \log(S_{t-1}^i) + \beta_5^i \log(P_t^E) + \varepsilon_t^i.$$

$P_t^i$ is the real price of commodity $i$ ($i$ = maize, soybeans, wheat, rice, palm oil, and cotton). $Y_t$ denotes real income (proxied by GDP), $R_t$ denotes the real interest rate, $X_t$ is the U.S. dollar exchange rate, $S_t^i$ denotes the stock-to-use ratio of commodity $i$, and $P_t^E$ is the real price of crude oil. For each commodity $i$ equation, the $\beta_j^i$s are parameters to be estimated and $\varepsilon_t^i$ is the error term. Because the variables (except the interest rate) are expressed in logarithmic levels, the estimated parameters, $\widehat{\beta}_j^i$s, can be interpreted as elasticities.

Although the model directly incorporates only a sub-set of the fundamentals represented in Table 1, it accounts for most of them. For example, the impact of adverse weather, which lowers yields (and hence supply), is captured by lower stock-to-use ratios. The stock-to-use ratio also accounts for the diversion of food commodities to biofuels. The only two variables not accounted for in the model are funds invested in commodities and trade policies. For graphical illustrations of sectoral and macroeconomic fundamentals, see Appendices A and B, respectively.

As a cautionary note, it should be emphasized that the model is intended to capture long-term trends, not short-term price variability.

### *3.2 Evidence*

The model is applied to five food commodities (maize, soybeans, wheat, rice, and palm oil) and to cotton, whose inclusion was motivated by a desire to account for as much of the world's arable land as possible. Commodity prices are annual averages from 1960 to 2014, expressed in U.S. dollars per metric ton for crops and in U.S. dollars per barrel for crude oil. All commodity prices have been deflated by the Manufacturing Unit Value index (MUV).[6] To obtain the real interest rate, the interest rate on the 3-month U.S. Treasury bill is adjusted by the U.S. Consumer Price Index. The exchange rate is the U.S. dollar real effective exchange rate against a broad basket of currencies. Income is proxied by the real GDP of middle-income countries measured in PPP (purchasing-power-parity) terms.

Before estimating the model, we examined the unit root properties of all the variables under consideration by using the modified Dickey-Fuller (Dickey and Fuller 1979) and Phillips-Perron (Phillips and Perron 1988) testing procedures. The results of the stationarity tests indicate that each of the variables other than the stock-to-use ratio contains a unit root (results are not reported here). Thus, to assess the performance of the model will require co-integration tests in addition to conventional statistics.

[6] The MUV—often viewed as a global deflator—is a U.S. dollar trade-weighted index of manufactured goods exported from 15 economies (Brazil, Canada, China, Germany, France, India, Italy, Japan, Mexico, Republic of Korea, South Africa, Spain, Thailand, United Kingdom, and United States). More details on commodity prices and the MUV can be found at www.worldbank.org/commodities.

The model was estimated within an OLS (ordinary least-squares) and a panel framework. This choice was motivated by the desire to estimate the effects of the fundamentals on the prices of individual commodities (OLS estimates, reported in the first six columns of Table 2) and also to have a sense of the average effects across all commodities (panel estimates, reported in the last column of Table 2). Based on a Hausman test, the fixed effect model was rejected in favor of a random effect model (the chi-square statistic was 0.40 with a p-value of 0.995).

Both the conventional and co-integration statistics and the expected signs of the parameter estimates indicate a satisfactory performance of the OLS models.[7] For example, 23 out of the 30 parameter estimates of all six regressions (excluding the constant terms) are significantly different from zero at the 5 percent level, and almost 60 percent of the price variation is accounted for by the five fundamentals. The $R^2$ ranges from 0.50 for soybeans and wheat to 0.70 for rice.

In all six equations, the parameter estimate of *income* is negative and highly significant, with values ranging within a remarkably tight band. The panel estimate of -0.48 indicates that a 10 percent increase in the income of low- and middle-income countries reduces the real price of agricultural commodities by about 5 percent. Counterintuitive as it may seem, this result is consistent with the Prebisch-Singer hypothesis—which states that as income grows the price ratio of primary commodities over manufactured goods declines—as well as with Engel's Law of less-than-unitary income elasticity for food commodities.[8] Thus, the negative sign of the income elasticity (-0.5 in the case of the panel model) should be interpreted as the difference between the effect of income on nominal food prices and the effect of income on the deflator. The former is generally lower than one, the latter greater than one.

Though it has often been argued, especially in the context of the 2008 food price spike, that the changing consumption patterns of emerging economies, especially China and India, were key drivers of rising prices,[9] the evidence points to a lower impact than

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[7] Based on the same tests, all the statistics but one confirm co-integration at the 1 percent level of significance (co-integration statistics are not reported here). Detailed stationarity tests of all variables can be found in Baffes and Etienne (2016), who used the same data within a panel autoregressive distributed lag model to estimate the long-run impact of income on commodity prices.

[8] The declining terms of trade of primary commodities versus manufactured goods were first observed in the mid-19th century, when the German statistician Ernst Engel observed that poor families spent a greater proportion of their total expenditure on food compared to their wealthier counterparts, leading to Engel's Law of less than unitary income elasticity of food commodities (Engel 1875). Almost a century later, Kindleberger (1943, p. 349) argued that "[t]he terms of trade move against agricultural and raw-material countries as the world's standard of living increases … and as Engel's Law of consumption operates." Kindleberger's thesis was empirically verified by Prebisch (1950) and by Kindleberger (1958) himself; it was also emphasized by Singer (1950). The decline of the terms of trade was later dubbed the Prebisch-Singer hypothesis.

[9] See, for example, Krugman (2008), Wolf (2008), and Bourne (2009). On the empirical side, Gilbert (2010) concluded that demand-side variables, including GDP growth, are important in explaining aggregate food

often thought. Alexandratos (2008) concluded that China's and India's combined average annual increase in grain consumption was smaller in 2002-08 than in 1995-2001. Similar findings have been reported by the European Commission (2015), Alexandratos and Bruinsma (2012), Baffes and Haniotis (2010), Sarris (2010), the Food and Agriculture Organization of the United Nations (2009), FAO (2008), Lustig (2008). Deaton and Drèze (2008) noted that in India, despite growing incomes, caloric intake has followed a downward trend since the early 1990s.[10]

The impact of a rise in the *real interest rate* is found to be negative but small on the prices of individual commodities, ranging from -0.02 for maize to -0.06 for soybeans, wheat, and palm oil, and the parameter estimate from the panel regression, -0.01, is not statistically different from zero (t-statistic = -1.25). A weak relationship between interest rates and commodity prices is a common finding in the empirical literature. Gilbert (1989) used an error-correction model to conclude that high interest rates negatively affect the metal price index, though with considerable lags. Baffes (1997), who used a reduced form price model for five metals, estimated an effect that was mostly negative but not significantly different from zero elasticities. Frankel and Rose (2010), based on annual data for a number of commodities, found little support for the argument that easy monetary policy and low real interest rates are an important source of upward pressure on real commodity prices. Their finding was confirmed by a subsequent paper (Frankel 2014). Some other studies (e.g., Anzuini and others 2010, Akram 2009) found that interest rates had a moderate effect. Baffes and Savescu (2014) found a positive relationship between nominal interest rates and metals prices and argued that while a lower cost of capital may induce a rightward shift in the demand schedule, it may also induce a rightward shift in the supply schedule due to the lower cost of input financing—thus rendering the relationship between interest rates and commodity prices ambiguous.

We find that a rise in the *real exchange rate* has a negative effect on prices of individual food commodities. This is consistent with expectations in terms of sign, but it is highly significant only for rice. In the panel regressions, however, the parameter estimate is significantly different from zero (-0.46, t-statistic = -1.81).[11] The large parameter estimate for rice (-1.44) is consistent with the fact that the United States does not play a significant role in the rice market. The negative relationship between U.S. dollar appreciation and

price indices and Hochman and others (2011) found that income accounted for almost one third of 2001-08 food price increases.

[10] See the recently published briefs by the Directorate-General for Agriculture and Rural Development of the European Commission (http://ec.europa.eu/agriculture/markets-and-prices/index_en.htm) for detailed information on developments in demand, supply, and prices of major agricultural commodities during different periods and regions of the world since 1960.

[11] Given that real prices are expressed in a "currency-free" unit, it could be argued that the exchange rate will not affect prices. However, this is not necessarily the case because changes in the U.S. exchange rate induce movements in aggregate demand and supply schedules. Thus the significant parameter estimate.

commodity prices has been well established by numerous authors. See, for example, Lamm (1980), Gardner (1981), and Baffes and Dennis (2015) for agriculture and Gilbert (1989), Baffes (1997), and Akram (2009) for metals.

Among the sectoral fundamentals, the effect of a rise in the *stock-to-use ratio* is, as expected, negative and highly significant, with a panel estimate of -0.37. The estimates are remarkably similar to findings reported elsewhere. For example, Bobenrieth, Wright, and Zeng (2012) estimated correlation coefficients between stock-to-use ratios and real de-trended prices for wheat, maize, and rice of -0.40, -0.50, and -0.17, respectively (compared to -0.46, -0.48, and -0.49 in the present study). Similarly, FAO (2008, p. 6) reported correlation coefficients between the cereals price index and various measures of stock-to-use ratios, ranging from -0.47 and -0.65.

Likewise, the effect of a rise in the *real oil price* is found to be significantly different from zero for all six commodities. The panel estimate at 0.15 implies that a 10 percent increase in oil prices is associated with a 1.5 percent increase in agricultural prices. The strong relationship between energy and non-energy commodity prices was established in the literature long before the post-2004 price boom. Gilbert (1989), for example, using quarterly data from 1965-86, estimated the transmission elasticity from energy to non-energy commodities at 0.12 and that from energy to food commodities at 0.25. Hanson and others (1993), based on a general equilibrium model, found a significant effect of oil price changes on agricultural producer prices in the United States. Borensztein and Reinhart (1994), using quarterly data from 1970 to 1992, estimated a transmission elasticity to non-energy commodities of 0.11, and Chaudhuri (2001), too, found a strong relationship between energy and non-energy prices. Baffes (2007), using annual data from 1960 to 2005, estimated elasticities for non-energy and food commodities of 0.16 and 0.18, respectively. Moss and others (2010) found that the demand of U.S. agriculture for energy responds strongly to changes in the energy prices.[12]

### *3.3 What matters most?*

During the commodity price boom, most of the macroeconomic and sectoral fundamentals

[12] Yet not all studies concur with a strong oil-non-oil price relationship. Saghaian (2010) established a strong correlation among oil and other commodity prices (including food prices) but the evidence for a causal link was mixed. Gilbert (2010) found a correlation between oil and food prices, but noted that this could reflect common causation rather than a 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) concluded that grain prices are not driven by oil price fluctuations. The mixed evidence on the energy-non-energy price link could reflect the frequency of the data series used in the analysis or the presence of biofuels (Baffes 2013). Zilberman and others (2013) noted that higher frequency (and hence "noisier") data are typically associated with weaker correlations. On the other hand, an exogenous shock pushing crude oil prices down under a mandated ethanol-gasoline mixture would increase fuel consumption and push ethanol and maize prices up, and thus lead to a negative relationship between food and oil prices, other things being equal (De Gorter and Just 2008).

moved in a way that was consistent with higher commodity prices, but some of them moved considerably more than others (Table 1). This means that to identify the importance of each factor, the elasticity estimates must be complemented by data on the actual changes that took place in the fundamentals during the boom period.

As estimated by the random effect model, the elasticities for the oil price and stock-to-use ratio are 0.15 and -0.37—both significant at the 1 percent level (t-values equal to 3.22 and 8.05, respectively). As noted above, these estimates are in line with the empirical literature. During the boom period (as shown by comparing 1998-2004 to 2005-11, in Table 1), real oil prices increased by 146 percent while the stock-to-use ratio (average of wheat, maize, and rice) declined by 26 percent. Thus, while the decline in the stock-to-use ratio contributed 10 percent [10% = -0.37*(-26%)] to the 40 percent increase in food prices, the increase in the oil price contributed more than twice as much, at 22 percent [22% = 0.15*(146%)]. Therefore, even though the stock-to-use-ratio elasticity was higher than the oil price elasticity, the actual effect of the stock changes was less than half as big as that of the oil price changes.

The implication is that if the post-2014 plunge in crude oil prices proves long-lasting—as did the comparably sized price decline in the mid-1980s, after which energy prices remained low for almost two decades (Baffes and others 2016)—then the post-2011 downward slide in agricultural prices could be long-lasting too.

Applying the decomposition analysis to individual commodities confirms that the increase in energy prices was the dominant force behind the increase in food commodity prices during the recent boom. Stock-to-use ratios and exchange rates played lesser, but still important, roles.[13]

## 4. Relevance for the Policy Debate

Several policy- and methodology-related conclusions of the analysis in this paper are relevant in an environment of weakening commodity prices:

First, the analysis confirms the negative impact of income (as measured by low and middle-income country GDP) on real food prices is already established in the literature. Although growth in income is obviously associated with growth in demand for food, during the commodity-price boom years the high rates of income growth that emerging economies experienced were associated more with growth in manufacturing and services than with growth in demand for food. And during these years, demand for most food items stagnated in high-income countries.

Second, we find no clear effect of interest rates on agricultural commodity prices. The literature typically assumes that when interest rates are low, increased consumption

[13] Similar decompositions have often been used in the literature (for example, World Bank 2012 and Von Witzke and Noleppa 2011). The advantage of the present decomposition is that it uses elasticities that have been generated by the same data set that generated the changes in the fundamentals.

and larger stock holding will raise the pressure on demand. But perhaps the lower cost of capital also engenders an increase in supplies. In effect, the low cost of capital during most of the past decade may have induced parallel rightward shifts in both demand and supply schedules.

This is a hypothesis that needs further testing, but if confirmed it would add another dimension to the debate on commodity-related stress on resources and the environment. That is, while a lower cost of capital due to low interest rates and quantitative easing policies may not necessarily change commodity prices (due to its mutually offsetting effects on commodity demand and supply), it may magnify the pressures on natural resources by expanding the commodity production and consumption base.

Third, our analysis confirms the importance of both stocks and energy prices in explaining agricultural price movements. The elasticity values are more than twice as high for stock-to-use ratios as for crude oil prices, meaning that a given percentage change in stock-to-use ratios has twice as great an influence on agricultural prices as does the same percentage change in the crude oil price. But the actual percentage change in oil prices that took place was significantly larger than the actual percentage change in stock-to-use ratios—implying that a much larger impact has emanated from energy prices than from stocks.

This energy/agriculture link is crucial for several reasons. First, it applies as much to the pre-2014 high energy prices as it does to the post-2014 low energy price environment. Second, it is not limited to the direct energy costs to agricultural producers, as it also affects the relative energy costs between various players in global commodity markets (e.g., through the impact of natural gas supplies and prices on fertilizers). Third, there are indirect costs linked to the upstream and downstream industries (transport, storage etc.). Fourth, energy security concerns, a key justification behind biofuel mandates (which were intended to produce more feedstocks for biofuels, and thus raised concerns about taking land away from food crops), are less relevant in a low energy price environment.

The post-2011 downward trend in most commodity prices further emphasizes the need to use a multivariate approach in identifying drivers of price developments, as well as for a closer look at the extent to which agricultural market fundamentals have changed. Not all of the factors affecting price developments can be captured with such an approach (for example, the potential impact of financialization was not covered in the present analysis). Yet as a new and lower price environment sets in, and market fundamentals seem to be playing again their distinctive role, the above conclusions are pertinent to the public policy debate. This is especially true given that policy responses to address the perceived and real problems linked to price uncertainties are often influenced by perceptions about the role and extent of the factors affecting agricultural price developments, without sufficient evidence.

## Table 1: Commodity prices and fundamentals

| | 1998-2004 | 2005-11 | Change (%) |
|---|---|---|---|
| **Nominal commodity price indices (2010 = 100)** | | | |
| Agriculture | 52.7 | 89.1 | 69.0 |
| *Food* | 53.0 | 91.3 | 72.1 |
| Metals | 37.0 | 92.0 | 148.6 |
| Energy | 35.4 | 98.6 | 178.5 |
| *Crude oil (US$ per barrel)* | 25.0 | 75.8 | 202.7 |
| Fertilizer | 36.9 | 107.7 | 191.5 |
| **Real commodity price indices (2010 = 100)** | | | |
| Agriculture | 65.9 | 90.6 | 37.5 |
| *Food* | 66.3 | 92.8 | 39.9 |
| Metals | 46.2 | 94.1 | 103.5 |
| Energy | 44.3 | 100.5 | 126.9 |
| *Crude oil (US$ per barrel)* | 31.3 | 77.1 | 146.2 |
| Fertilizer | 46.1 | 108.5 | 135.1 |
| **Macroeconomic drivers** | | | |
| GDP (low and middle income countries, trillion real US$, 2010) | 10.7 | 16.4 | 53.6 |
| Industrial production (emerging economies, billion real US$, 2010) | 351.4 | 564.3 | 60.6 |
| Exchange rate (US$ against a broad index of currencies) | 95.0 | 78.4 | -21.2 |
| Interest rate (10-year US Treasury bill, %) | 5.0 | 3.8 | -23.6 |
| Funds invested in commodities (US$ billion, nominal) | 57.0 | 206 | 261 |
| **Population (billion)** | | | |
| Global | 6.18 | 6.73 | 8.9 |
| China | 1.27 | 1.32 | 4.2 |
| India | 1.06 | 1.17 | 10.9 |
| **Sectoral drivers** | | | |
| Stocks (maize, wheat, and rice, months of consumption) | 3.5 | 2.5 | -26 |
| Biofuel production (thousands of barrels per day equivalent) | 233 | 858 | 267 |
| Growth in yields (% per annum) | 1.2 | 0.8 | -36 |
| *Yields (average of wheat, maize, and rice, metric tons/hectare)* | 3.7 | 4.1 | 10 |
| Natural disasters (droughts, floods, and extreme temperatures) | 180 | 223 | 24 |
| OECD policies (Producer NPC) | 1.3 | 1.1 | -13 |

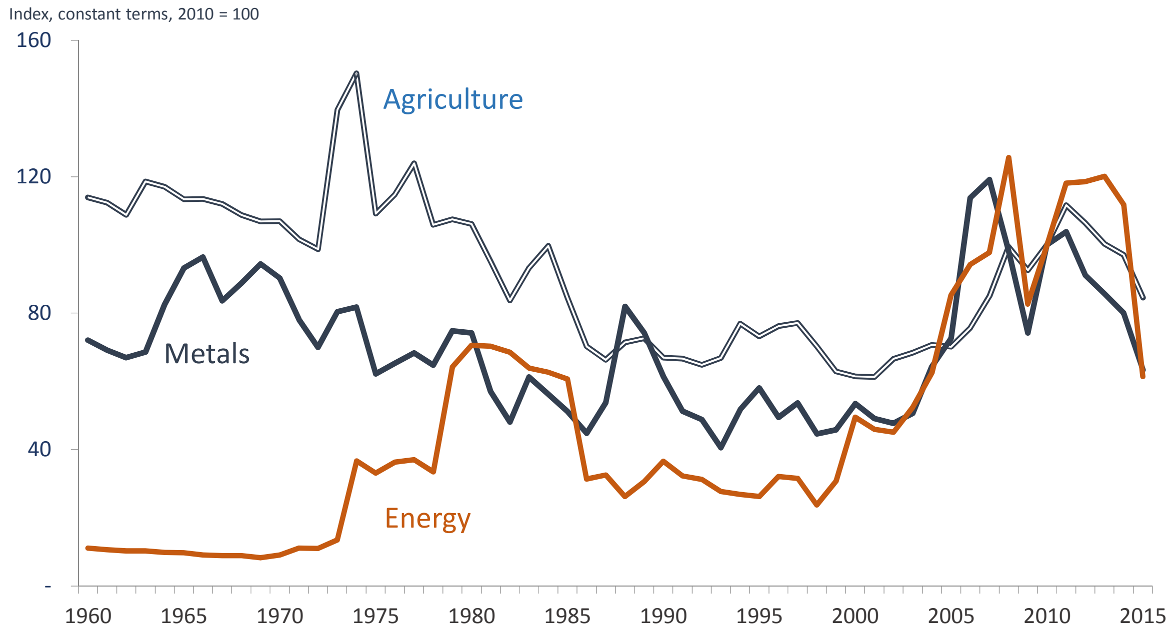
**Source**: BarclayHedge, Center for Research for the Epidemiology of Disasters (www.cred.be), Federal Reserve Bank of St. Louis, International Energy Agency, International Monetary Fund, Organization of Economic Co-operation and Development, United Nations, U.S. Department of Agriculture, World Bank, and authors' calculations.

## Table 2: Parameter estimates

| | Maize | Soybeans | Wheat | Rice | Palm oil | Cotton | Panel |
|---|---|---|---|---|---|---|---|
| *Constant* | 7.91***<br>(4.02) | 5.85**<br>(2.47) | 5.41**<br>(2.45) | 14.20***<br>(6.07) | 7.83***<br>(2.70) | 8.08***<br>(3.21) | 7.50***<br>(4.89) |
| *Income* | -0.60***<br>(5.28) | -0.44***<br>(3.10) | -0.49***<br>(3.73) | -0.71***<br>(4.98) | -0.71***<br>(4.17) | -0.71***<br>(4.50) | -0.48***<br>(4.59) |
| *Real interest rate* | -0.02<br>(0.98) | -0.06***<br>(3.53) | -0.06***<br>(3.76) | -0.04**<br>(2.00) | -0.06***<br>(2.86) | -0.05***<br>(2.80) | -0.01<br>(1.25) |
| *Real exchange rate* | -0.41<br>(1.16) | -0.21<br>(0.50) | 0.05<br>(0.13) | -1.44***<br>(3.41) | -0.13<br>(0.26) | -0.16<br>(0.36) | -0.46**<br>(1.81) |
| *Stock-to-Use ratio (lag)* | -0.48***<br>(6.90) | -0.21***<br>(3.72) | -0.46***<br>(4.62) | -0.49***<br>(5.10) | -0.42***<br>(3.80) | -0.40***<br>(3.80) | -0.37***<br>(8.05) |
| *Real oil price* | 0.15***<br>(2.99) | 0.13**<br>(2.06) | 0.11*<br>(1.93) | 0.15**<br>(2.54) | 0.30***<br>(3.58) | 0.10<br>(1.45) | 0.15***<br>(3.22) |
| *R-square* | 0.67 | 0.50 | 0.50 | 0.70 | 0.53 | 0.60 | 0.59 |
| *No of observations* | 55 | 50 | 55 | 55 | 50 | 55 | 310 |

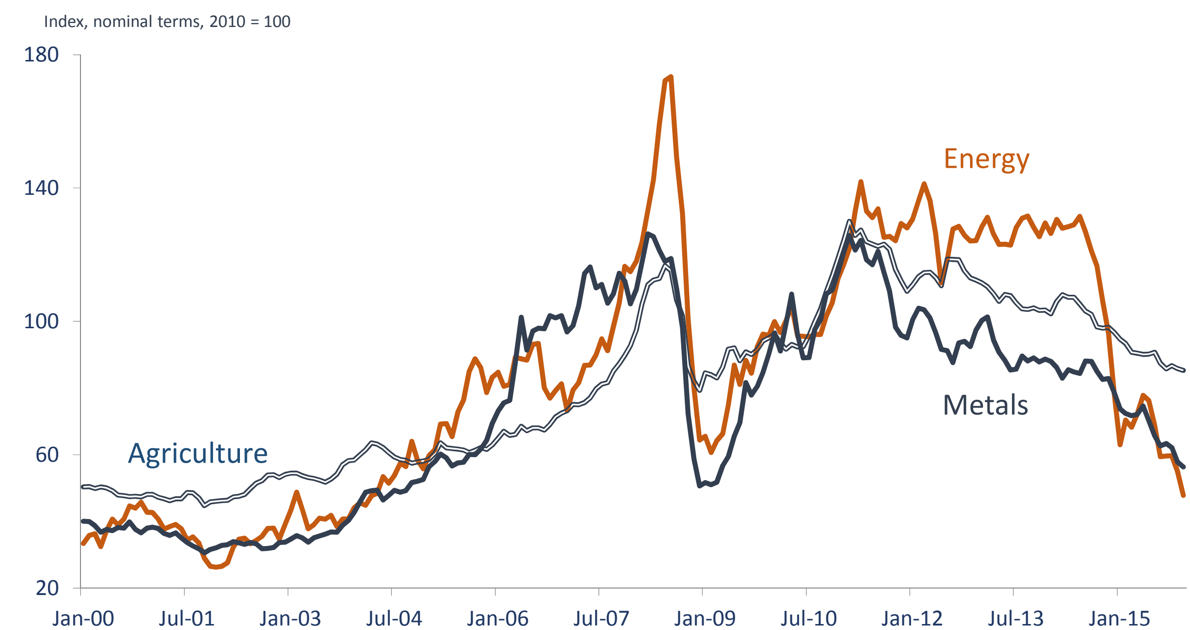
**Notes:** All variables (except interest rate) are expressed in logarithmic terms. The dependent variable is the logarithm of the nominal price divided by the price of manufacture goods. Because of data unavailability, the regressions for soybeans and palm oil begin in 1965 (the rest span in 1960-2014). The last row, Panel, reports estimates from a random effects model. The *R-square* for the Panel refers to the overall *R-square* (the within and between *R-squares* are 0.51 and 0.69, respectively). Absolute *t*-statistics in parentheses, * = 10 percent, ** = 5 percent, *** = 1 percent.

## Figure 1: Real Commodity Price Indices




**Source**: World Bank
**Note**: Prices have been deflated by the Manufacture Unit Value index.

## Figure 2: Nominal Commodity Price Indices




**Source**: World Bank
**Note**: Last observation is December 2015.

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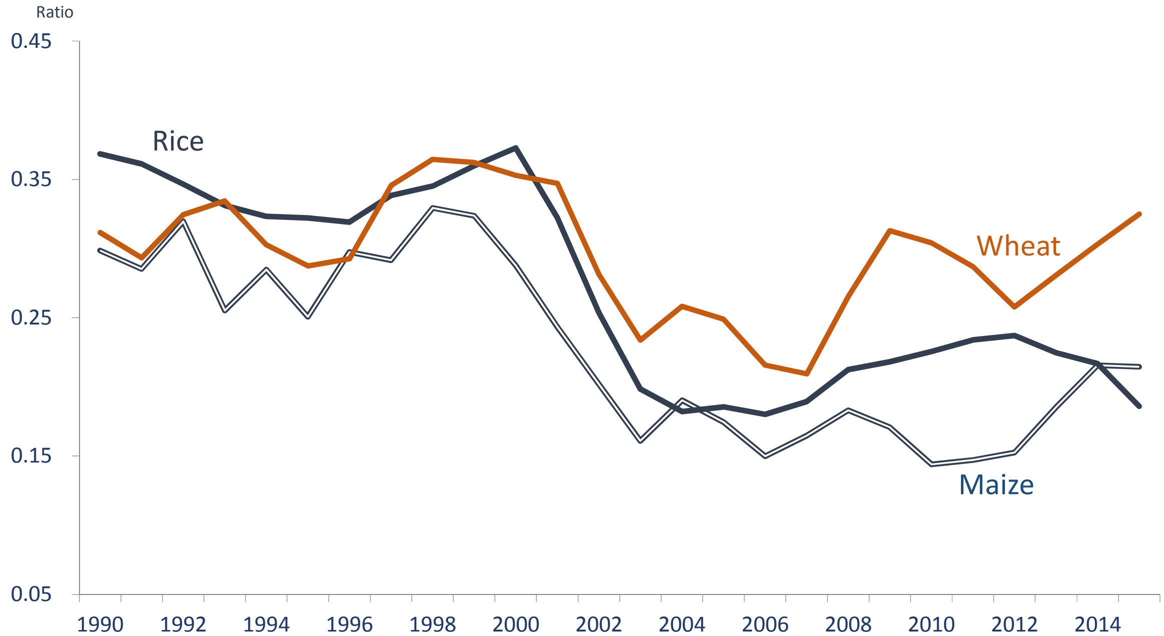
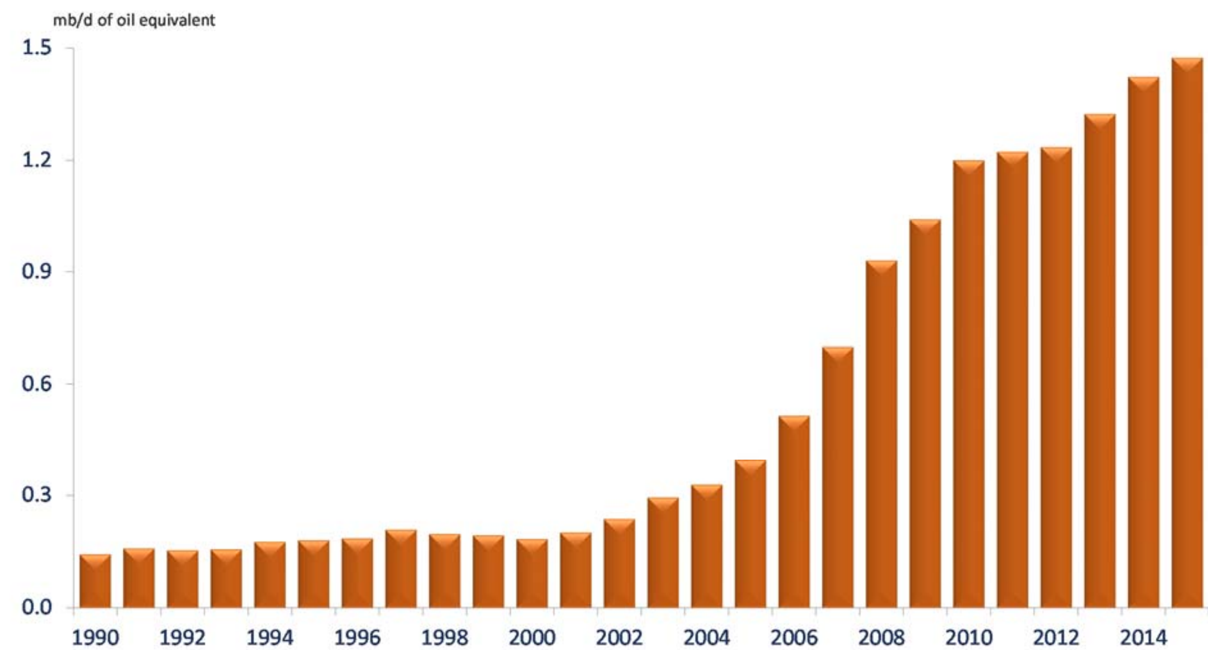
# APPENDIX A: SECTORAL FUNDAMENTALS

## Figure A1: Stock-to-Use ratios



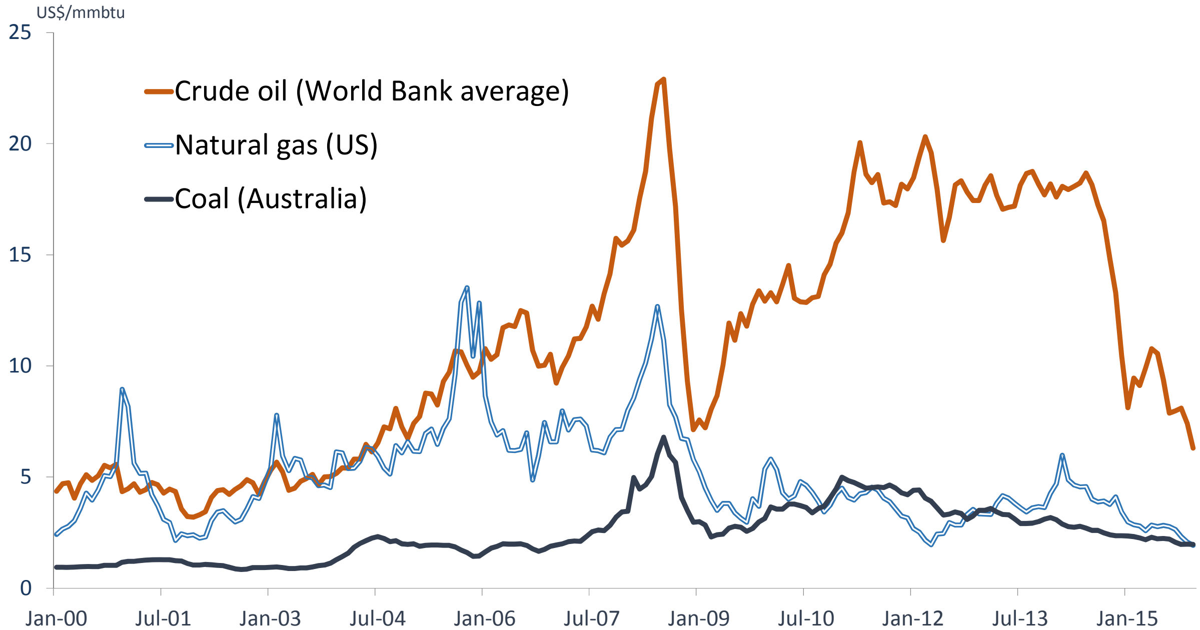

**Source**: U.S. Department of Agriculture
**Note**: Data based on the January 2016 update.

## Figure A2: Production of biofuels



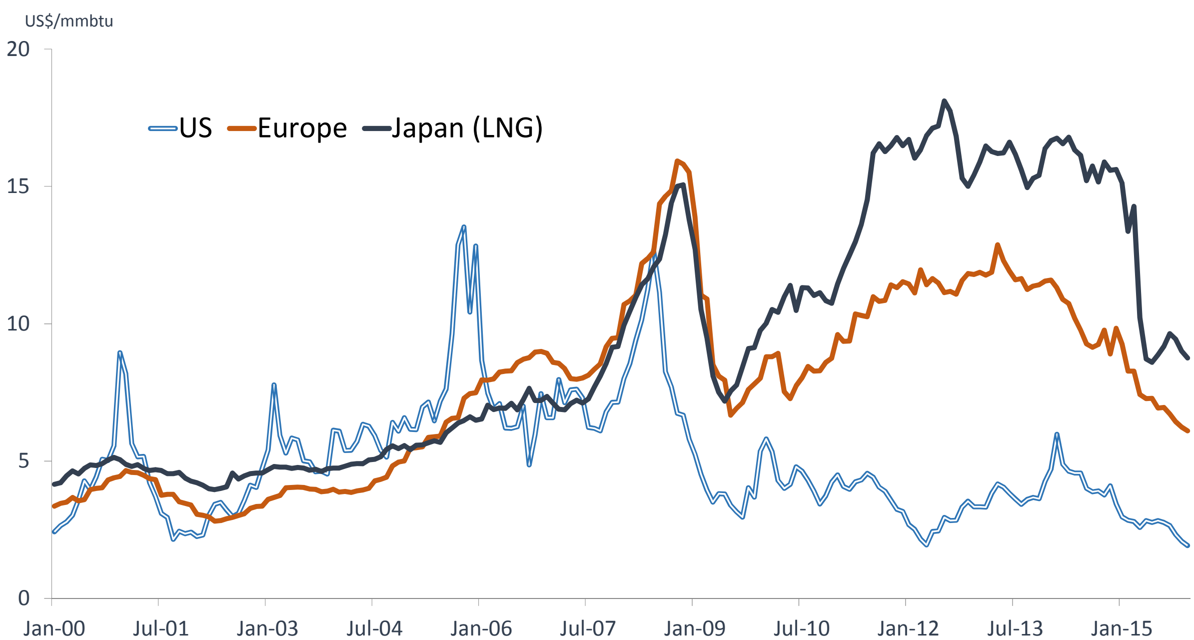

**Source:** BP Statistical Review

## Figure A3: Energy prices



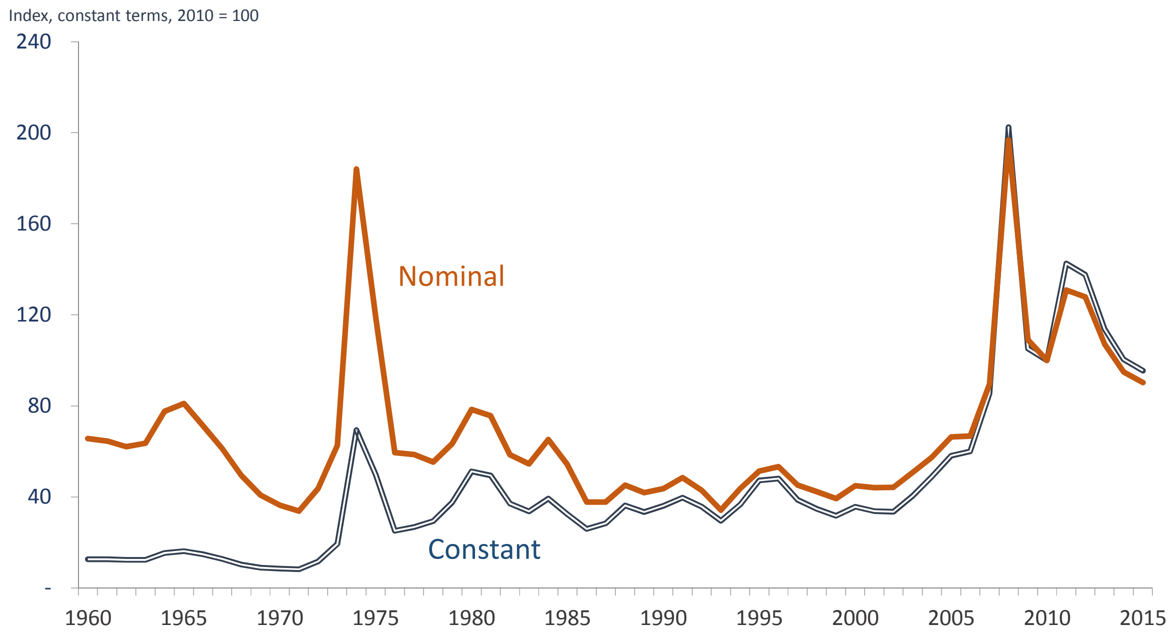

**Source**: World Bank
**Note**: Last observation is December 2015.

## Figure A4: Natural gas prices



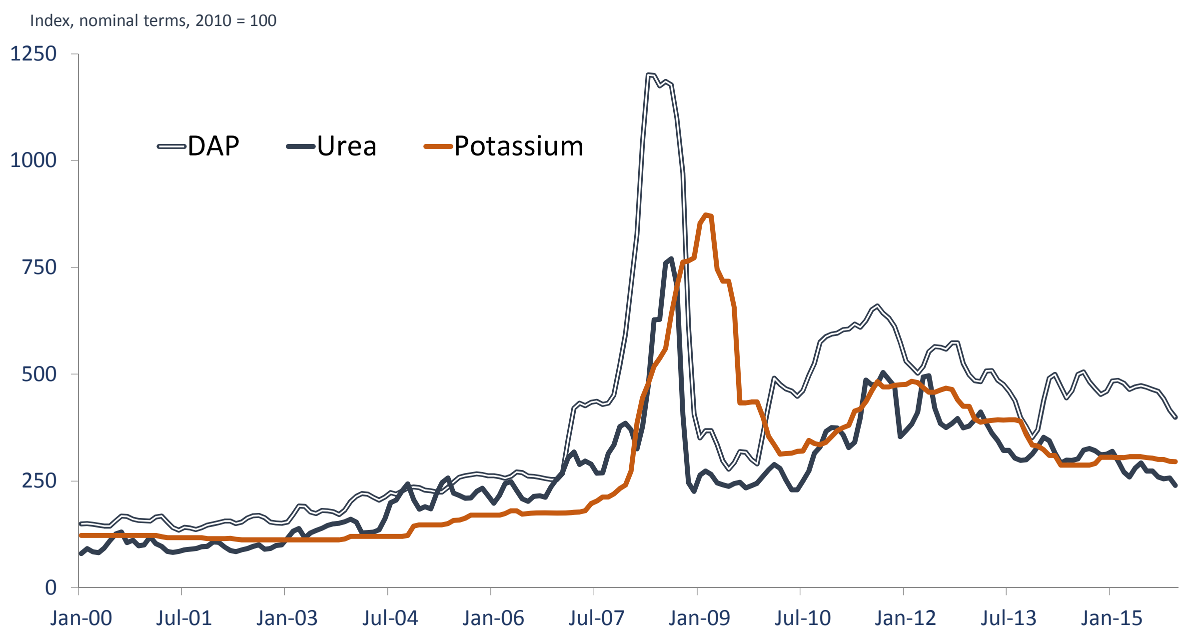

**Source**: World Bank
**Note**: Last observation is December 2015.

## Figure A5: Fertilizer price index




**Source**: World Bank
**Note**: Prices have been deflated by the Manufacture Unit Value index.

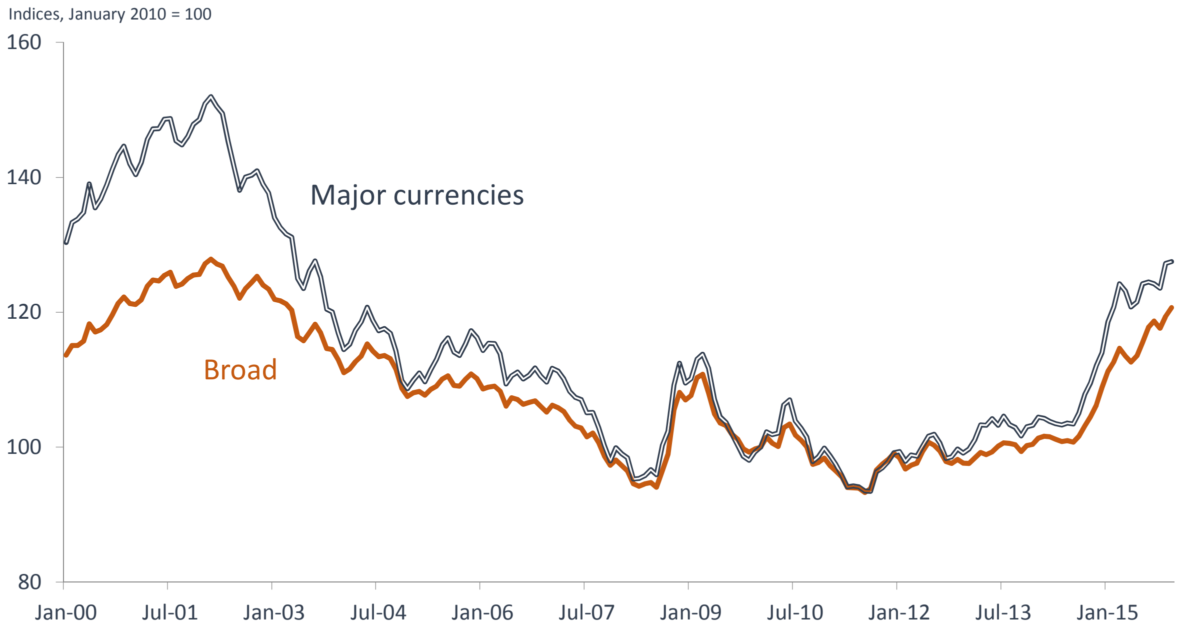
## Figure A6: Fertilizer prices




**Source**: World Bank
**Note**: Last observation is December 2015.

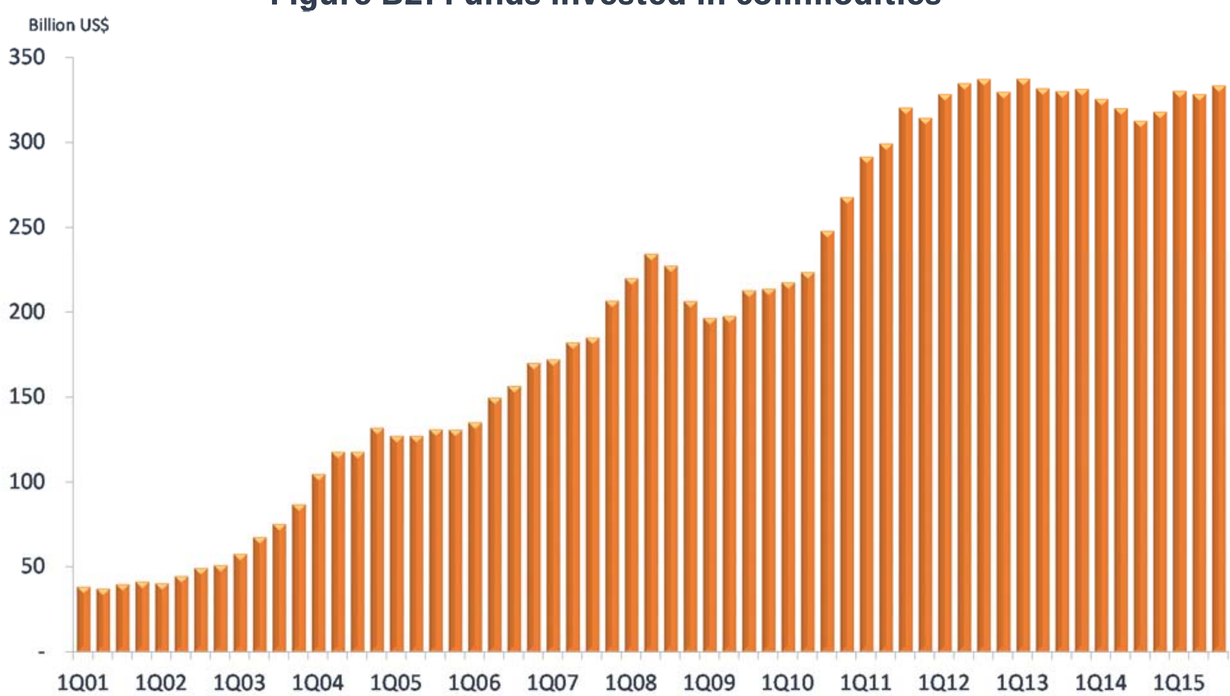
# APPENDIX B: MACROECONOMIC FUNDAMENTALS

## Figure B1: US$ movements, trade-weighted indices



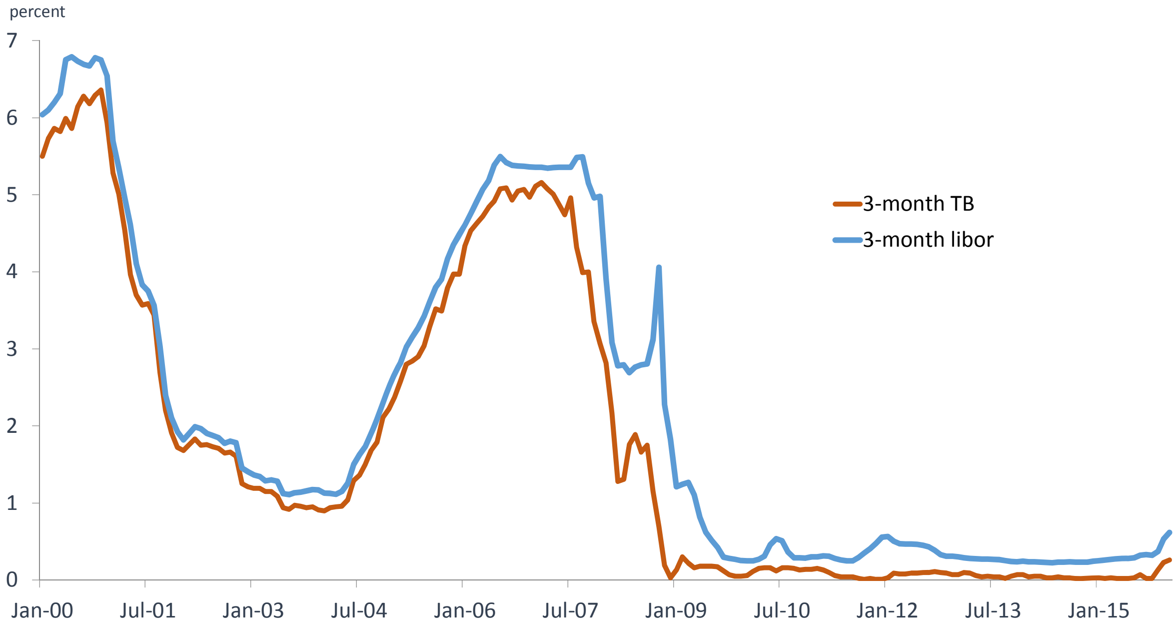

**Source**: Federal Reserve Bank of St. Louis
**Note**: Last observation is December 2015.

## Figure B2: Funds invested in commodities



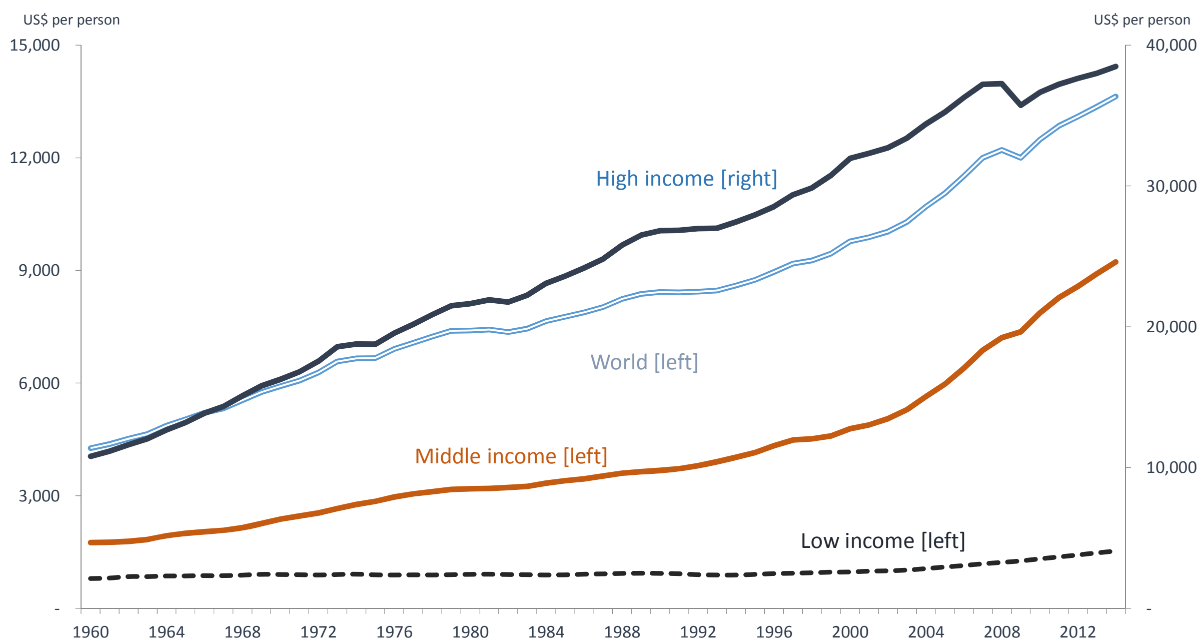

Source: BarclayHedge, December 2015 update.

## Figure B3: US Treasuries and Libor rates, 3-month




**Source**: Federal Reserve Bank of St. Louis and Bloomberg
**Note**: Last observation is December 2015

## Figure B4: Per capita GDP, PPP 2010 terms




**Source**: World Bank