WPS5371

Policy Research Working Paper 5371

Placing the 2006/08 Commodity Price Boom into Perspective

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The World Bank
Development Prospects Group
July 2010

Abstract

The 2006-08 commodity price boom was one of the longest and broadest of the post-World War II period. Apart from strong and sustained economic growth, the recent boom was fueled by numerous factors, including low past investment in extractive commodities, weak dollar, fiscal expansion, and lax monetary policy in many countries, and investment fund activity. At the same time, the combination of adverse weather conditions, the diversion of some food commodities to the production of biofuels, and government policies (including export bans and prohibitive taxes) brought global stocks of many food commodities down to levels not seen since the early 1970s. This in turn accelerated the price increases that eventually led to the 2008 rally. The weakening and/or reversal of these factors coupled with the financial crisis that erupted in September 2008 and the subsequent global economic downturn, induced sharp price declines across most commodity sectors. Yet, the main price indices are still twice as high compared to their 2000 real levels, begging once more the question about the real factors affecting them. This paper concludes that a stronger link between energy and non-energy commodity prices is likely to be the dominant influence on developments in commodity, and especially food, markets. Demand by emerging economies is unlikely to put additional pressure on the prices of food commodities. The paper also argues that the effect of biofuels on food prices has not been as large as originally thought, but that the use of commodities by financial investors (the so-called "financialization of commodities") may have been partly responsible for the 2007/08 spike. Finally, econometric analysis of the long-term evolution of commodity prices supports the thesis that price variability overwhelms price trends.

This paper—a product of the Development Prospects Group—is part of a larger effort in the department to gain a better understanding of the causes and consequences of the 2006–08 commodity price boom. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at jbaffes@worldbank.org.

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The views expressed in this paper are those of the authors and should not be attributed to their affiliated institutions. We would like to thank Ataman Aksoy, Julie Dana, Betty Dow, Chris Gilbert, Louis Goreux, Bernard Hoekman, and Gauresh Rajadhyaksha for comments and suggestions on preliminary drafts. Rachel Weaving provided excellent editing. The paper is a contribution to the World Bank-DFID Global Trade and Financial Architecture project.

1. Introduction

The 2006-08 commodity boom was one of the longest and broadest of the post-WWII period. The boom—and especially the 2008 rally, when crude oil prices peaked at US$ 133/barrel (up 94 percent from a year earlier) and rice prices doubled within just five months—has renewed interest in the long-term behavior and determinants of commodity prices, and raised questions about whether commodity prices have reversed the downward course that most of them followed during most of the past century.[1] It has also produced numerous calls for coordinated policy actions at the national and international level to address food availability and food security concerns.[2]

To put the recent commodity boom into perspective calls for a good understanding of the key characteristics and determinants of long-term commodity price movements—and an appreciation of how limited this understanding is, especially with respect to the conditions under which the recent boom unfolded. Such a perspective is important in order to avoid policy pitfalls that in the name of mitigating food security concerns or improving the functioning of the markets may, in fact, exacerbate existing problems.

This paper has two objectives. The first is to analyze the nature of the recent boom, especially in food commodities, by examining which key factors fueled it and whether such factors are likely to remain in place in the long term. The second objective is to place the boom into perspective by examining long-term trends and characteristics of commodity prices. The next section begins with a discussion of recent price trends, including the causes of the boom as well as a comparison with earlier episodes of high prices. Particular attention is paid to three key (real or perceived) causes of the boom: excess liquidity and speculation, food demand growth by emerging economies, and use of some food commodities to produce biofuels. Section 3 analyzes the long-term behavior of commodity prices, including stationarity, co-movement among prices of food commodities, and the price link between energy and non-energy commodities. The final section summarizes and discusses some policy issues, including the rationality and viability of proposals for dealing with price spikes.

We conclude that a stronger link between energy and non-energy commodity prices is likely to have been the dominant influence on developments in commodity, and especially food, markets. Demand by developing countries is unlikely to have put additional pressure on the prices of food commodities, although it may have created such pressure indirectly through energy prices. We also conclude that the effect of biofuels on food prices has not been as large as originally thought, but that the use of commodities by investment funds may have been partly responsible for the 2007/08 spike. Finally, econometric analysis of the long-term evolution of commodity prices supports the thesis that price variability overwhelms price trends.

2. The Nature and Causes of the Recent Commodity Boom

The recent commodity boom emerged in the mid-2000s after nearly three decades of low and declining commodity prices (Figure 1). The long-term decline in real prices had been especially marked in food and agriculture. Between 1975-76 and 2000-01, world food prices declined by 53 percent in real US-dollar terms. Such price declines raised concerns, especially with regard to the welfare of poor agricultural producers. In fact, one of the Doha Round's chief motives (and also one of its perceived main obstacles) was the reduction of agricultural support and trade barriers in high-income countries—a set of reforms that was expected to induce increases in commodity prices and hence improve the welfare of low-income commodity producers (Aksoy and Beghin 2005). Starting in the mid-2000s, however, most commodity prices reversed their downward course, eventually leading to an unprecedented commodity price boom.

Between 2003 and 2008, nominal prices of energy and metals increased by 230 percent, those of food and precious metals doubled, and those of fertilizers increased fourfold. The boom reached its zenith in July 2008, when crude oil prices averaged US$ 133/barrel, up 94 percent from a year earlier. Rice prices doubled within just five months of 2008, from US$ 375/ton in January to $757/ton in June.

The recent boom shares two similarities with the two earlier major commodity booms of the post-WWII period, during the Korean War and the early 1970s energy crisis (see Radetzki (2006) for a discussion of the three booms). Each of the three booms took place against a backdrop of high and sustained economic growth as well as an expansionary macroeconomic environment, and each was followed by a severe slowdown of economic activity. And all three triggered discussions on coordinated policy actions to address food and energy security concerns.

Yet the recent boom also shows some important differences from the previous ones. By most accounts, it was the longest-lasting and the broadest in the numbers of commodities involved. It was the only one that simultaneously involved all three main commodity groups—energy, metals, and agriculture—with its peak showing food and agriculture prices increasing less than all other commodity prices (World Bank 2009). It was not associated with high inflation, unlike the boom of the 1970s (although the increase in food prices had some notable, albeit short-lived, impact on inflation). Finally, it unfolded simultaneously with the development of two other booms—in real estate and in equity markets—whose end led most developed countries to their most severe post-WWII recession.

The recent boom took place in a period when most countries, especially developing ones, sustained strong economic growth. During 2003-07, growth in developing countries averaged 6.9 percent, the highest five-year average in recent history (Figure 2). Yet apart from broad and prolonged economic growth, the causes of the recent boom were numerous, including macro and long-term as well as sector-specific and short-term factors.

Fiscal expansion in many countries and lax monetary policy created an environment that favored high commodity prices.[3] The depreciation of the US dollar—the currency of choice for most international commodity transactions—strengthened demand (and limited supply) from non-US$ commodity consumers (and producers). Other important contributing factors include low past investment, especially in extractive commodities;[4] investment fund activity by financial institutions that chose to include commodities in their portfolios; and geopolitical concerns, especially in energy markets.

In the case of agricultural commodities, prices were affected by the combination of adverse weather conditions and the diversion of some food commodities to the production of biofuels (notably maize in the US and edible oils in Europe). That led to global stock-to-use ratios of several agricultural commodities down to levels not seen since the early 1970s, further accelerating the price increases (Figure 3). Policy responses including export bans and prohibitive taxes that were introduced in 2008 to offset the impact of increasing world food prices contributed to creating the conditions for the "perfect storm."

The weakening and/or reversal of these factors, coupled with the financial crisis that erupted in September 2008 and the subsequent global economic downturn, induced sharp price declines across most commodity sectors. But though commodity prices have declined sharply since their mid-2008 peak, they picked up again recently and the key commodity price indices are still twice as high as their early 2000s levels (Figure 4).

Thus the key question is whether at least some of the factors behind the recent boom are more permanent in nature, and likely to remain in place. Past experience reveals that food commodity price spikes were mainly driven by negative supply shocks, with high prices often acting as the best incentive for mitigating the shocks that generated them. Yet the pertinence of such experience for future developments has been questioned, and in attempts to explain the current boom, some factors have received considerably more attention (or even subjected to a considerable amount of misinformation) than others. With this in mind, the rest of this section examines the contributions made by three such factors, namely, excess liquidity and speculation, income growth and dietary changes in emerging economies, and the diversion of some food commodities to biofuel production.

Excess liquidity and speculation

During the course of the recent boom, it has been argued often that fundamentals do not tell the whole story and commodity prices have been driven, in part, by factors that go beyond demand and supply considerations. Excess liquidity, which is often placed within the broader context of speculation, is often argued to have fueled a commodity bubble.

To gauge the importance of the issue, consider the following. Between the second half of 2007 and the first half of 2008 production of petroleum increased from 85.8 million barrels per day (mb/d) to 86.8 mb/d. Consumption fell from 86.5 mb/d to 86.3 mb/d. Prices should have fallen. In December 2007, crude oil averaged US$ 90/barrel while in June 2008 it averaged US$ 132/barrel, almost 50% up. Recent figures on spare capacity give an equally perplexing picture. During 2009, OPEC spare capacity stood at 6.3 mb/d while petroleum prices averaged $62/barrel. However, similar capacity levels during the early 2000s were associated with $20/barrel. Stocks of key food commodities are 20% higher in 2009/10 compared to 2007/08; yet the nominal food price index averaged 23% higher in December 2009 compared to a year ago, rather surprising given that an often cited reason for the food price spike of 2008 was low inventories. Admittedly, the apparent "divergence" between commodity prices and fundamentals deserves (and has received) attention.

While fundamentals have played a key role in commodity price movements, observations such as the above have led many researchers and analysts to argue that the commodity price boom reflected, in part, excess liquidity and speculation. In other words, a lot of "new" money (a result of excess liquidity) chased too few assets and eventually found its way into commodity markets, in turn causing a speculative bubble.

Various concepts related to speculation have been discussed often interchangeably and have been analyzed in isolation from each other, or they are presented in an oversimplified manner, especially in various editorials and blogs. These concepts include: excess liquidity (one of the three sources of "new" money); index fund activity (the chief investment vehicle for the "new" money); speculation (an activity not well-defined but necessary for the functioning of futures exchanges and sometimes the source of market manipulation); the role of commodity futures exchanges (the nerve centers of commodity price discovery mechanisms); inventories (which matter most for non-perishable agricultural commodities, mostly grains); and speculative bubble (a very broad and difficult to quantify issue). Not surprisingly, such complexity has led to different views and mixed empirical evidence. The remaining of this section elaborates on these concepts (see Appendix A for a discussion on speculation in commodity markets).

Broadly speaking, the "new" money—which is not associated with physical commodity transactions—can be linked to three sources:

- ***Diversification of investment vehicles.*** During the past decade or so, investment fund managers noticed that existing asset classes were becoming increasingly correlated. In their search for new (uncorrelated) assets they broadened their portfolios by including assets from emerging economies. When these assets became themselves correlated (because of the systemic effect of all funds invested in the same assets) fund managers began investing in commodities, thus setting the stage for the so-called 'financialization of commodities'—a role typically reserved for gold, after 1973. To the extent that commodities are viewed as another asset class, diversification may have a permanent character.
- ***Rebalancing of investment portfolios.*** The rebalancing of investment portfolios by shifting funds from US$-denominated (and other) holdings to commodities added further inflows into commodity markets. The strong inverse relationship between the US$ and commodity prices—especially crude oil—has been invoked often as evidence for such rebalancing (see Medlock and Jaffe 2009).[5] The effect of rebalancing is less permanent than diversification and depends largely on how long investors' risk attitudes will favor commodities or disfavor other assets.
- ***Excess liquidity.*** The low interest rate environment supported by many central banks resulted in excess liquidity, part of which found its way to commodity markets (on top of the price increase due to expansion of physical demand for commodities). It is believed that excess liquidity has been the key reason behind the boom in real estate markets. The effect of excess liquidity is likely to last for as long as interest rates remain low.

The key channel through which the "new" money found its way into commodity markets is index funds. The most widely used and closely watched indices are the Dow Jones-AIG and S&P Goldman Sachs Commodity Index (also known as DJ-AIG and S&P-GSCI). About 95 percent of funds indexed to commodities are replicated by these two indices. The funds take long positions in commodity futures exchanges by buying contracts and, prior to expiration, rolling them over. While there are no precise estimates on their size, a broadly accepted range as of mid-2008 was $250 to $300 billion (Masters 2008). A report by a major commercial bank estimated that an additional $60 billon went into commodities during 2009, placing the 2009 total estimate to $230-240 billion, marginally lower from 2008 due to weaker commodity prices. Although these amounts of money represent about one percent of the global value of pension and sovereign wealth fund holdings (both key contributors to index funds, with the global value of these two groups estimated at $20 and $4 trillion, respectively) they are large compared to the size of commodity markets.[6]

The effect of the "new" money on commodity prices has been associated with speculation that might have led to a price bubble. The views on the subject, however, have been, for the most part, extreme. For example, Krugman in a series of *New York Times* blogs and editorials, not only rejected the view that speculation fueled the boom but also dismissed the idea that commodity trading activity in futures exchanges may have affected commodity prices at all, arguing that "a futures contract is a bet about the future price. It has no, zero, nada direct effect on the spot price" (*New York Times*, June 23, 2008). Others too have argued that speculation played no role. Wolf is of the opinion that "if speculation were raising prices above the warranted level, one would expect to see inventories piling up rapidly, as supply exceeds the rate at which oil is burned. Yet there is no evidence of such a spike in inventories" (*Financial Times,* May 13, 2008). Frankel cited the Congressional testimony by the chief economist of the Commodities Futures Trading Commission (CFTC) on April 3, 2008 to support in his weblog (July 25, 2008) that "The evidence does not support the claim that speculation has been the source of, or has exacerbated the price increases." Verleger (2009), based on IEA (2009) analysis, concluded at his CFTC testimony that the increase in crude oil price between 2007 and 2008 was caused by the incompatibility of environmental regulations and speculation had nothing to do with the price rise.[7] The IOSCO Task Force (2009), formed at the request of G-8 to examine the issue of speculation in commodity markets, found that economic fundamentals, not speculative activity, are the possible explanation for recent price changes in commodities.[8] Wright (2009) echoed similar views by noting that if long futures positions were behind the grain price spike of 2008, stocks would have increased.

At the other end of the spectrum, Soros (2008) called commodity index trading at his US congressional testimony intellectually unsound, potentially destabilizing, and distinctly harmful in its economic consequences. Eckaus (2008) and Khan (2009) authored papers entitled "The Oil Price Is Really a Speculative Bubble" and "The 2008 Oil Price Bubble", respectively. Calvo (2008) noted that speculation and low inventories are not necessarily inconsistent with each other and concluded that "… [increases in] commodity prices are the result of portfolio shift against liquid assets by sovereign investors, sovereign wealth funds, partly triggered by lax monetary policy, especially in the US." Roubini (2009) said this on the early 2009 crude oil price increase: "… improving fundamentals … justify oil going from $30 to maybe $50. I think the other $30 is all speculative demand feeding on it—speculators and herding behavior." Similar views were echoed by others as well, including Medlock and Jaffe (2009) and Wray (2008).

The empirical evidence on the subject has been mixed. Two IMF studies (2006, 2008) found no evidence that speculation had systematically influenced commodity prices. A similar conclusion was reached by a series of studies undertaken by the US Commodities Futures Trading Commission, the agency that regulates US futures exchanges.[9] Sanders, Irwin, and Merrin (2008) expressed skepticism about the assertion that speculation has led to bubbles in agricultural futures prices.

Other authors share somewhat different views. Robles and others (2009) identified speculative activity in the futures market as a source of the 2007/08 agricultural commodity price increases. Plastina (2008) concluded that between January 2006 and February 2008, investment fund activity might have pushed cotton prices 14 percent higher than they would otherwise have been. In the non-ferrous metals market, Gilbert (2007) found no direct evidence of the impact of investor activity on the prices of metals, but found strong evidence that the futures positions of index providers had affected the prices of soybeans (though not of maize) in the US futures exchanges. Perhaps, the strongest evidence is a subsequent study by Gilbert (2010: 420) who concluded that "By investing across the entire range of commodity futures, index-based investors appear to have inflated food commodity prices."

Why is the empirical evidence mixed? Often it is argued that despite the fact that investment fund activity remained steady or even increased between mid- and end-2008, prices declined sharply during that period. Hence, the argument goes, investment funds did not affect commodity prices. However, that is based on the logic that if investment fund activity continued to increase, then prices would increase forever (or, at least they would not decline), an unlikely outcome. Supply and demand fundamentals will prevail, eventually. Thus, from an empirical perspective, the key question should be whether investment fund activity contributed to the recent boom (or any boom, for that matter), not whether it affects commodity prices in general. Consequently, examining the role of investment funds in commodity markets requires first, the identification of the boom period and second, either analyze that period in isolation–perhaps within a univariate modeling framework–or use of earlier periods (or some other prior) as counterfactuals.

Identifying the "suspect" period will contain a large element of subjectivity and hence will inevitably lead to differing opinions. However, there are at least three reasons why investment fund activity may have influenced commodity prices. First, investment in commodities is a relatively new phenomenon, and funds have to date flowed mostly in, not out, implying that some markets may have been subject to extrapolative price behavior; that is, high prices leading to more buying by investment funds, in turn leading to even higher prices, and so on. In fact, that may have been the case with the sovereign wealth funds, whose revenue comes from commodities, which in turn it is invested in commodities. Second, index funds invest on the basis of fixed weights or past performance criteria, and hence investment often behaves differently from what market fundamentals would dictate. Third, the large size of these funds compared to commodity markets may exacerbate price movements. Or, as Soros (2008: 3) characteristically put it "… the institutions are piling in on one side of the market and they have sufficient weight to unbalance it."

What conclusion can be derived from of all this in the context of excess liquidity and speculation? Was investment fund activity at least partly responsible for the recent commodity boom? Any commodity-related activity on the financial side is unlikely to alter long-term price trends, which will ultimately be determined by market fundamentals. But, such activities can induce higher price variability in the sense of exacerbating the length and the amplitude of price cycles, as they most likely did during the 'perfect storm' of 2007/08.

Dietary changes and income growth in middle-income countries

Typically agricultural price booms are linked to supply shocks such as weather events or animal diseases that disturb normal production patterns. Supply shocks were no exception in the recent boom. Droughts played a major role in the reduction of dairy exports from New Zealand. Australia's grain production was severely affected by the three droughts experienced during 2002/08 (a highly unusual weather pattern, often linked to global warming). The 2009 drought in South America affected the oilseeds market for more than a year. But the magnitude of these events, although cumulative and coming after a long period of normal weather patterns, falls short of explaining the extent of the food price spike.

Could a demand shock offer a more plausible explanation, as has often been suggested? For this to have been the case, such a shock should have taken place either unexpectedly and suddenly or through a rapid shift in long-term expectations about food demand patterns. It has often been argued that a structural shift has taken place in the demand for grain by emerging countries, including China and India, and especially during the past decade when these two countries experienced high income growth. The June 2009 issue of *National Geographic*, for example, noted that "… as countries like China and India prosper and their people move up the food ladder, demand for grains has increased." Similar arguments have been advanced by noted scholars as well. Krugman argued that "… there's the march of the meat-eating Chinese—that is, the growing number of people in emerging economies who are, for the first time, rich enough to start eating like Westerners" (*New York Times* editorial, April 7, 2008). Likewise, Wolf asked "So why have prices of food risen so strongly?" and then answered "… strong rises in incomes per head in China, India, and other emerging countries have raised demand for food, notably meat and the related animal feeds" (*Financial Times*, April 29, 2008). Indeed, the size of China and India, which together account for 27 percent of the world's population, implies that even a minor change in their pattern of demand growth has a major effect on world market prices.

But a closer look at the growth trends of population and income over the past decades, coupled with those of demand for food commodities, shows no evidence that food demand growth accelerated either in China and India or in the world as a whole. Table 1 summarizes demand growth patterns for a number of key food commodities since 1961 for four 12-year periods roughly corresponding to four price cycles: the period of the "green revolution" (1961-72); the aftermath of the two energy shocks (1973-84), the recovery of agricultural prices until their mid-1990s price spike (1985-96), and the last period until the recent price peak (1997-08). The data clearly show that demand growth has slowed for most grains—including those used for feed, reflecting a slowdown in the growth of demand for meat.

During the most recent decade, despite a clear acceleration of GDP growth since 2003, stronger demand for agricultural products both at world level and in China and India has been the exception—it occurred in maize and in soybeans (driven by demand for edible oils), and was rather mixed in grains, but certainly did not occur in meats or dairy products (see Table 2 with a breakdown of the 1997-2008 period for the world, China, and India). Similar findings on the role (or, the non-role) of China and India have been discussed in Alexandratos (2008: 673) who emphatically stated that "… their [China's and India's] combined average annual increment in consumption (both growth rates and absolute increments) was lower in the years of the price surges, 2002-08, than in the preceding period 1995-2001." FAO (2009) arrived at nearly identical conclusions.

These developments reflect the huge gap that existed during the price boom between the fundamentals of agricultural markets and the corresponding price levels. No other example demonstrates this better than the fact that the highest price increases took place in two commodities—wheat and rice—where food demand was stagnating and yet were widely explained as being driven by strong food demand. Thus, while supply shocks may explain some of the price pressures in certain food commodities, by contrast demand growth accelerated in recent years in commodities used for biofuels, such as maize and edible oils.

Biofuels

The increasing interaction between the price movements of energy and non-energy commodities during the boom focused attention on the impact of growing demand for biofuels, including for maize-based ethanol (mainly in the US) and oilseed-based biodiesel production (mainly in Europe). During the boom, maize and crude oil prices moved in tandem, pointing to an emerging new and fixed relationship between them. Obviously, maize and its use for ethanol moved into the picture as significant factors affecting price developments. But how much impact was there, and was there a similar one in oilseeds, resulting from their use for biodiesel?

The contribution of biofuels to the recent price boom, and especially the price spike of 2007/08, has been hotly debated. Mitchell (2009) argued that biofuel production from grains and oilseeds in the US and the EU was the most important factor behind the food price increase between 2002 and 2008, accounting, perhaps, for as much as two thirds of the price increase. Gilbert (2010), on the other hand, found little direct evidence that demand for grains and oilseeds as biofuel feedstocks was a cause of the price spike.

FAO (2008) compared a baseline scenario, which assumes that biofuel production will double by 2018, to an assumption that biofuel production will remain at its 2007 levels; it concluded that in the latter case grain prices would be 12 percent lower, wheat prices 7 percent lower, and vegetable oil prices 15 percent lower than in the baseline scenario. OECD (2008) arrived at similar conclusions for vegetable oils, finding that their prices would be 16 percent lower than the baseline if biofuel support policies were abolished; eliminating biofuel subsidies would have smaller impacts on the prices of coarse grains (-7 percent) and wheat (-5 percent). Rosegrant (2008), who simulated market developments between 2000 and 2007 (excluding the surge in biofuel production), concluded that biofuel growth accounted for 30 percent of the food price increases seen in that period, with the contribution varying from 39 percent for maize to 21 percent for rice. Looking ahead, Rosegrant found that if biofuel production were to remain at its 2007 levels, rather than reaching its mandated level, maize prices would be lower by 14 percent in 2015 and by 6 percent in 2020.[10]

Banse and others (2008) compared the impact of the EU's current mandate to (i) a no-mandate scenario and (ii) a mandate whereby the US, Japan, Brazil also adopt targets for biofuel consumption. They estimate that by 2020, in the baseline scenario (no mandate), cereal and oilseed prices will have decreased by 12 and 7 percent, respectively. In the EU-only scenario, the comparable changes are -7 percent for cereal and +2 percent for oilseeds. By contrast, under the "global" scenario (adding biofuel targets in US, Japan, and Brazil) oilseed prices will have risen by 19 percent and cereal prices by about 5 percent. The European Commission's own assessment of the long-term (2020) impacts of the 10 percent target for biofuels (i.e. that renewable energy for transport, including biofuels, will supply 10 percent of all EU fuel consumption by 2020) predicts fairly minor impacts from ethanol production, which would raise cereals prices 3-6 percent by 2020, but larger impacts from biodiesel production on oilseed prices; the greatest projected impact is on sunflower (+15 percent), whose global production potential is quite limited. Taheripour and others (2008) simulate the biofuel economy during 2001-06. By isolating the economic impact of biofuel drivers (such as the crude oil price and the US and EU biofuel subsidies) from other factors at a global scale, they estimate the impact of these factors on coarse grain prices in the US, EU, and Brazil at 14 percent, 16 percent, and 9.6 percent, respectively.

A joint US Department of Agriculture and Department of Energy assessment (USDA/USDE 2008) concluded that the recent increase in maize and soybean prices appears to have little to do with the run-up in prices of wheat and rice. It found that if the amounts of corn used for ethanol and edible oil used for biodiesel in the US had remained unchanged at their 2005/06 levels, prices in 2007/2008 would have been 15 percent lower for maize, 18 percent for soybean, and 13 percent for soybean oil. The assessment also concluded that the impact of biofuels production in 2007 was a 3-4 percent increase in retail food prices and a 0.1-0.15 percent increase in the all-food CPI.

Clearly US maize-based ethanol production, and (to a lesser extent) EU biodiesel production) affected the corresponding market balances and land use in both US maize and EU oilseeds. Yet, worldwide, biofuels account for only about 1.5 percent of the area under grains/oilseeds (Table 3). This raises serious doubts about claims that biofuels account for a big shift in global demand. Even though widespread perceptions about such a shift played a big role during the recent commodity price boom, it is striking that maize prices hardly moved during the first period of increase in US ethanol production, and oilseed prices dropped when the EU increased impressively its use of biodiesel. On the other hand, prices spiked while ethanol use was slowing down in the US and biodiesel use was stabilizing in the EU.

Yet while the debate has focused mostly on the amount of food crops that have been diverted to the production of biofuels, and the resulting effect on prices, less attention has been paid to a more important issue linked to this development—the level at which energy prices provide a floor to agricultural prices. Analytically, this is a very complex issue; in addition to the prices of the respective commodities (energy and feedstock for biofuels), it involves numerous other elements, including subsidies, mandates, trade restrictions, and sunk costs of the biofuel industry. Therefore, analysts often use various rules of thumb to express a perceived new relationship between agricultural and crude oil prices. One such rule is that the price of maize expressed in US$/ton is roughly double the price of crude oil in US$/barrel (thus a US$ 75/barrel price for crude oil would correspond to US$ 150/ton for maize). Other commentators (in the US) have argued that a price of US$ 3/gallon of gasoline at the pump is the level at which the maize price is determined by the crude oil price. The World Bank (2009) reported that crude oil prices above US$ 50/barrel effectively dictate maize prices; this conclusion was based on the strong correlation between the maize price and crude oil prices above US$ 50/barrel and the absence of correlation below that level. The US Government Accountability Office (2009: 101) while acknowledging that economists have disagreed about the circumstances that would make the 2009 US biofuel mandates non-binding (i.e. biofuels become profitable at current energy prices), it gave a range between $80 and $120 per barrel (the range was based on anecdotal evidence based on interviews). The empirical basis of such rules is linked to the issue discussed in the next section.

3. Commodity Prices: Longer-term Trends

This section focuses on three key characteristics of commodity price behavior: lack of trends, co-movement among prices, and a special case of the latter, i.e., the link between energy and non-energy commodity prices.

Trends, cycles, and everything in between

The long-term behavior of commodity prices was first examined systematically by Prebisch (1950) and Singer (1950), who noted that since the late 19th century the prices of primary commodities had been declining relative to the prices of manufactured goods (often referred to as the barter terms of trade). They warned of potential problems for producers of primary commodities, and in fact the notion of declining terms of trade formed the cornerstone of the industrialization policies that many developing countries pursued during the 1960s and 1970s.

The so-called Prebisch-Singer (PSH) hypothesis has been, perhaps, one of the most researched topics in commodity price behavior. Early research (e.g., Spraos 1980; Sapsford 1985; Grilli and Yang 1988), which focused mainly on identifying trends, supplied broad support for PSH. However, later authors found that prices did not simply move along a linear trend but instead contained strong stochastic elements, i.e., long and irregular cycles, thus producing more mixed results (e.g., Cuddington and Urzua 1989; Cuddington 1992). Studies using better econometric techniques and longer time series allowed for structural breaks (e.g., Leon and Soto 1997; Zanias 2005; Kellard and Wohar 2006). And very recent literature, focusing on non-linear or time-varying alternatives (e.g., Balagtas and Holt 2009), finds even less support for PSH.

All this research is perhaps best summarized by Cashin and McDermott (2002) who concluded that the downward trend in real commodity prices is of little policy relevance because it is small when compared to the variability of prices. Or as Deaton (1999: 27) succinctly put it, "what commodity prices lack in trend, they make up for in variance."

Commodity price variability is at the core of the current policy debate. The difficulty associated with describing past price behavior, and hence with making inferences regarding future trends, can be inferred from Figure 1; the conclusions reached depend on what time period is chosen for analysis. Statistically, this difficulty reflects the problem of nonstationarity, i.e. the fact that the average price does not exist in the statistical sense. Table 4 shows the results of an analysis of stationarity for prices of six food commodities (wheat, maize, rice, soybeans, soybean oil, and palm oil). For sensitivity purposes, we report results from two tests, with and without trend, both in nominal and real terms (we also used US CPI in addition to MUV and the results were remarkably similar). All lend strong support to non-stationarity, thus reaffirming the conclusions reached by Cashin and McDermott (2002) and Deaton (1999).

The fact that commodity price variability overwhelms trends has a number of key implications. On the methodological side, analysis involving prices needs to recognize that correlations may not be meaningful unless certain conditions are met (see next section), and also that because a mean or a trend of the price series cannot be properly defined, the variability in prices is difficult to calculate.

On the policy side, attempts to introduce mechanisms with price triggers (as has often been proposed recently) are likely to fail. In fact, the absence of trends (or simply put, the non-existence of an "average price") may be the key reason why earlier price stabilization (or other) mechanisms failed.[11] When prices stay low for long periods, stabilization funds run out of resources, and when prices stay high for long periods, stabilization funds tend to be misused. Consider, for example, that the agricultural commodity price index (shown in Figure 1) exceeded its period average (equal to 173) in all years during 1948-71 and fell below it in all years during 1981-2007.

Co-movement

Because some agricultural commodities can be substituted for one another (e.g. various edible oils), while resources on the input side (e.g., land, labor, and machinery) can be shifted from one crop to another, the changes in fundamentals or policy actions in one market will eventually be transmitted to other markets as well. Thus, assessing how the prices of various food commodities move with respect to each other is paramount in understanding the way and the degree to which market conditions and policies affect prices. Examining such relationships ultimately comes down to estimating the degree of price co-movement among various commodities.

While the general subject of price co-movement has been extensively studied in the literature, analysis of the co-movement among prices of different commodities is scarce. (For a brief literature review of price co-movement and the reasons why the issue has not been adequately researched see the Appendix B.)

Here we analyze the co-movement of prices using a simple econometric model. The degree of co-movement was analyzed among six food commodity prices, using ordinary least squares with annual data from 1960 to 2008: $P_t^i = \mu + \beta_1 P_t^j + \beta_2 MUV_t + \beta_3 t + \varepsilon_t$, where P_t^i and P_t^j denote the logarithm of commodity price i and j in year t (expressed in nominal dollar terms), MUV_t denotes the deflator, t is the time trend, and ε_t denotes the error term; μ, β_1, β_2, and β_3 are parameters to be estimated.

The results are reported in Table 5. Because prices are non-stationary (see previous section) examining the stationarity properties of the error term is a crucial step in establishing the validity of the model. All the regressions show strong performance, with an average R^2 of 0.84 and with unit root statistics that strongly confirm the stationarity of the error term. Moreover, in all cases the slope estimate of the price variable is significant at the 1 percent level.

The results imply that it is important not to analyze commodity markets in isolation from one another, because the impact of events that seemingly affect one market will eventually be equalized among most commodity sectors. Consider, for example, the palm oil/soybean oil parameter estimate of 0.97 and an R^2 of 0.93 (Table 5, bottom row). This suggests an almost synchronous movement of palm and soybean oil prices, despite the fact that soybean oil is an annual crop produced chiefly in North and South America and palm oil is a tree crop produced almost exclusively in East Asia. The implication is that, whether biofuel mandates are applied to one or the other edible oil market, the effect will be eventually diffused among all edible oil markets. Not surprisingly, policies favoring biofuel production in the name of environmental benefits may in fact lead to less desirable outcomes. That is, the environmental benefits from switching from fossil fuel use to, say, rapeseed-based biodiesel in Europe or soybean oil-based biodiesel in the US may be less than the environmental costs of expanding palm oil production in East Asia.[12] Similarly, prices of wheat, maize, and soybeans—key food crops, produced primarily in the US, EU, and South America—

show an equally large co-movement, as their R^2 averaged 0.93, much like that of palm and soybean oil.

For inflation, by contrast, the estimated coefficient is either not significantly different from zero or, in the few cases where it is significant, it is small. And the time trend parameter estimate is almost always zero—implying that there is either no trend or the same trend for all prices.

The energy/non-energy price link

It has become increasingly clear that the energy price increases of the last few years have a permanent character. In the 20 years between 1984 and 2004, the price of crude oil averaged a little more than US$ 20/barrel in real 2000 terms.[13] Now most analysts and researchers believe that the "new" equilibrium price of oil will be three to four times higher than this, with proportional changes taking place in all other types of energy, at least in the long term. If such assessment is correct, then high energy prices coupled with the high energy intensity of agricultural commodities imply that developments in non-energy (especially food) markets will depend strongly on the nature and degree of the price links between energy and non-energy commodities.

The channels through which energy prices affect other commodities are numerous (see for example FAO 2002; Baffes 2007; World Bank 2009). On the cost side, energy enters the aggregate production function of most primary commodities through the use of various energy-intensive inputs and, often, transport of outputs over long distances. Some commodities have to go through an energy-intensive primary processing stage. In other cases, the main input may be a close substitute to crude oil, as when nitrogen fertilizer is made directly from natural gas. And, to the extent that some commodities are used to produce biofuels (to some degree a response to high energy prices), another important dimension is added to the energy/non-energy price link (see earlier discussion on biofuels).

We examined the energy/non-energy price link by estimating a regression similar to the one used for the co-movement estimates above.[14] The results for eleven commodity price indices are presented in Table 6. They show that energy prices explain a considerable part of commodity price variability; the adjusted R^2 of all regressions averaged 0.85. Specifically, the parameter estimate of the non-energy index (top row of Table 6) is 0.28, implying that a 10 percent increase in energy prices is associated with a 2.8 percent increase in non-energy commodity prices, in the long run.

Three earlier studies—Gilbert (1989), Borensztein and Reinhart (1994), and Baffes (2007)—that estimated the elasticities of non-energy commodity prices with respect to energy prices reported these as 0.12, 0.11, and 0.16, respectively

(Table 7, top row).[15] When the sample underlying the current analysis is adjusted to match the samples used in these studies, the pass-through coefficient becomes remarkably similar, at 0.13, 0.12, and 0.18, respectively.

Underlying these aggregate pass-through coefficients for non-energy commodity prices are variations within sub-indices. Among the sub-indices, the highest pass-through elasticity is in fertilizer, at 0.55—not surprisingly, since nitrogen-based fertilizers are made directly from natural gas. Interestingly, the fertilizer and energy price increases during the recent boom were in line with those experienced during the first oil shock: from 1973 to 1974 phosphate rock and urea prices increased four-fold and three-fold, while the crude oil price increased from US$ 2.81/barrel to US$ 10.97/barrel.

The pass-through elasticity for agriculture, estimated at 0.27, reflects a wide range among the components of the agriculture index: beverages (0.38), food (0.27), and raw materials (0.11). For the components of the food price index, by contrast, the elasticity estimates fall within a very narrow range: cereals (0.28), edible oils (0.29), and other food (0.22). Based on the same regression, Table 8 reports parameter estimates for the six food commodities under consideration. The estimates for all six fall within a narrow range, from a low of 0.27 in maize to a high of 0.36 in soybean oil. This result contrasts sharply with estimates for metals, which show a high degree of diversity (see Chaudhri 2001; Baffes 2007).

A number of key conclusions emerge from these results. First, the prices of most commodities respond strongly to energy prices, with the response further strengthening in periods of high prices (the values of the estimated elasticities increase considerably when the recent boom is included in the analysis). More importantly, the difference between the last two estimates (last two columns of Table 7) indicates that the effect of energy prices on the prices of all commodities has increased considerably when the recent boom is taken into consideration—suggesting that the energy/non-energy price link has strengthened (see earlier discussion). Many observers have attributed such strengthening of the relationship to the use of biofuels, which also coincides (roughly) with the boom. Yet, it is important to note that the strengthening of the effect of energy on non-energy prices is more pronounced in non-food commodities (e.g. raw materials and metals) than in food. Thus, common factors appear to have played a more prominent role in the recent boom (see Vansteenkiste 2009; Gilbert 2010).

Second, food commodity prices respond to energy prices by moving in a very synchronous manner since the elasticities fall within a very narrow range (from 0.25 to 0.36). Such result not only emphasizes the interdependence of agricultural markets (as discussed earlier) but also indicates that since a key determinant of food commodity prices is energy prices, analyzing food markets requires an understanding of energy markets as well.

Third, though the transmission elasticities of energy prices to non-energy prices are broadly similar to one another, this is not the case with the inflation coefficient, estimates of which vary considerably in sign, magnitude, and level of significance. The inflation coefficient is positive and significantly different from zero only for agriculture and some of its sub-indices, and effectively zero for metals and fertilizers. This implies that the relationship between inflation and nominal commodity prices is much more complex and, perhaps, changing over time. This may not be surprising if one considers that during 1972-80 (a period that included both oil shocks) the MUV increased by 45 percent, and that during 2000-08 it increased by only half as much. The increases in the index of nominal non-energy prices during these two eight-year periods were identical, at 170 percent.

Lastly, the estimates of trend parameters are spread over a wider range than the estimates of energy price pass-through and inflation. For example, the aggregate index of non-energy prices shows no trend at all, while the index of metal prices shows an almost 2 percent positive annual trend and the index of agriculture prices shows a 1 percent negative annual trend. Further, the trend parameter estimates of the agriculture sub-indices vary considerably, from 0.08 for raw materials to -3.12 for beverages—confirming the point made earlier that commodity prices do not exhibit well-defined trends, even when one accounts for the effect of energy prices.

4. Concluding Remarks

Numerous factors have contributed to the recent commodity boom, and have been analyzed extensively in the literature. Yet their relative weight continues to be an area of contention. In this paper we examined three key factors whose role has been somewhat controversial: speculation, the growth of demand for food commodities by emerging economies and the role of biofuels. We conjecture that index fund activity (one type of "speculative" activity among the many that the literature refers to) played a key role during the 2008 price spike. Biofuels played some role too, but much less than initially thought. And we find no evidence that alleged stronger demand by emerging economies had any effect on world prices. Although tentative, these conclusions provide insights into the determinants of the future path of commodity prices, which is still uncertain.

Central among the uncertainties is the relationship between the prices of energy and of food commodities. Our examination of the key characteristics of longer-term commodity price behavior revealed a strong link between energy and non-energy prices, which increased considerably during the recent boom; it also revealed that co-movement among the prices of food commodities is very strong. The latter implies that events taking place in one sector (e.g., increased demand for maize for the production of ethanol) will affect other markets (e.g., for wheat) through reallocation of resources, especially land. It also implies that policy changes in one market may affect other markets. For example, expectations about the use of corn for biofuels could result in high wheat prices even in the presence of record levels of wheat stocks. Our results also show that agricultural commodity market fundamentals appear, in the short term, to be playing somewhat less of a role than in the past, tending to be overshadowed by the much stronger pull of energy prices.

Our conclusion about the long-term evolution of commodity prices is consistent with earlier literature, and supports the thesis that price variability overwhelms price trends. Variability is such that the average price does not exist in the statistical sense (i.e., prices exhibit non-stationary behavior), and the conclusions reached about trends depend on what time period is chosen for the analysis.

Despite its simplicity, this conclusion has important implications. Following the recent food price spike, there have been calls for policy actions, essentially aiming to alleviate the impacts of price spikes on developing countries, through reliance on some level of buffer stocks (whether physical or virtual). History has not been kind to collective measures designed to prevent the decline or reduce the variability of prices. What type of measures would be more pertinent to mitigate any undesired effects of price variability would depend on the better understanding of the factors that not only affect, but also potentially alter, long-term price trends.

Endnotes

[1] Numerous authors have analyzed the recent commodity boom. See, for example, Abbott, Hurt, and Tyner (2008), Timmer (2008), Gilbert (2009), Mitchell (2009), Piesse and Thirtle (2009), Sarris (2009), Trostle (2008), and Coady, Dorosh, and Minten (2009). *Agricultural Economics* devoted an entire issue to the subject (Masters and Shiverly 2008).

[2] See, for example, Von Braun and Torero (2009) on virtual reserves and Mendoza (2009) on rice insurance mechanisms. Today's discussions call to mind those in earlier booms (for example, Meadows and others 1972).

[3] Calvo (2008) and Frankel (2007) have argued that interest rates played a key role during the boom.

[4] Although underinvestment has been cited very often as the key factor in the boom, this assessment is essentially derived ex post. Certainly, any level of past investment will be considered low at high prices and high at low prices. Yet, research reported in World Bank (2009) shows that the level of investment was "right" at the time it was made. For example, during 1980-2007, R&D and investment expenditures by major multinational oil and gas companies track very closely output prices (as evidenced by their strong correlation with energy prices, R^2 = 0.95). Similarly, public R&D agricultural expenditures follow agricultural GDP.

[5] This inverse relationship is in addition to the effect of the US$ exchange rate against currencies of commodity producing and consuming countries mentioned earlier.

[6] Information on pension and, especially, sovereign wealth funds is not widely available. The recently published first annual report on sovereign wealth funds is an attempt to fill this gap (SWF 2009).

[7] Yet, Verleger (2009: 2) argued that "The collapse in oil prices from July 2008 to December 31, 2008 can be tied to … the possible liquidation of futures positions." Which begs the question: If the liquidation of futures positions were partly responsible for the collapse in oil prices, should not the taking of such positions be responsible for the corresponding increase in oil prices?

[8] The IOSCO (2009: 3) report's recommendations, which were based on reviewing other studies, were: (i) understand with greater clarity the role of speculative and commercial activity in commodity futures markets; (ii) gain a more comprehensive view of trading activities in, and the structure of, the underlying markets that may affect price formation on commodity futures markets; and (iii) detect, deter, and prosecute manipulation and other trading abuses involving commodity futures, and related commodity markets.

[9] See, for example, Büyükşahin, Haigh, and Robe (2008) and Commodity Futures Trading Commission (2008).

[10] The models used in the studies discussed in this section are the following: FAO (2008) and OECD (2008) used AGLINK; Rosegrant (2008) used IMPACT; Banse and others (2008) used GTAP-E; EU (2008) used ESIM-PE; Mitchell (2009) used simple statistical analysis; and Gilbert (2009) used a CAPM-type econometric model.

[11] Such failed arrangements include the 1962 International Coffee Agreement (and a subsequent series of agreements) to restrict exports and boost coffee prices, the 1972 International Cocoa Agreement, and similar efforts by producers of cotton and grains; the International Tin Agreement; and the International Natural Rubber Organization. For a discussion of such agreement see Gilbert (1996) and Radetzki (2009).

[12] A large body of literature discusses this issue; see for example, Searchinger and others (2008) and Fargione and others (2008).

[13] The low energy prices between mid-1980s and early 2000s prompted most analysts to argue that the high prices of the 1970s were an aberration and that the pre-1973 levels were the norm. For example in its March 6, 1999 edition, the *Economist*'s leader article entitled "Drowning in Oil" concluded that (p. 19): "$10 might actually be too optimistic. We may be heading for US$ 5. Thanks to new technology and productivity gains, you might expect the price of oil, like that of most other commodities, to fall slowly over the years. Judging by the oil market in the pre-OPEC era, a 'normal' market price might now be in the US$ 5-10 range. Factor in the current slow growth of the world economy and the normal price drops to the bottom of that range." Indeed, most energy analysts were forecasting real prices to average between US$ 15/barrel and US$ 20/barrel in the long run. For example, the World Bank's nominal crude oil price forecast in 1999 was US$ 18/barrel for 2005 and US$ 19/barrel for 2010. The December 2008 WTI futures contract opened at US$ 18.88 in January 15, 2002, when it was first introduced. During 2008, crude oil prices averaged US$ 97/barrel, almost five times higher than the highest forecasts.

[14] Here the model is the same as the one used above for co-movement, except that P_t^i denotes the prices of food commodities and P_t^j denotes the energy price index. The rest of the coefficients and variables have the same interpretation. However, in contrast to the price co-movement regressions, regressing food prices on energy prices has a well-defined endogeneity pattern; energy affects food prices but not vice versa. Thus, we estimated only the regressions with the energy price index (along with deflator and time trend) as the explanatory variables. The estimates can be viewed as energy price transmission elasticities rather than just co-integration parameters. See Baffes (2009) for the structure of the indices.

[15] Table 7 indicates that the elasticities for food commodities are higher than those for raw materials and metals. This is consistent with the input-output table of the GTAP database, which shows that the direct energy component in the US agriculture and manufacturing sectors is 12 percent and 3 percent respectively.

TABLE 1
ANNUAL GROWTH (PERCENT) IN GLOBAL GDP, POPULATION, AND CONSUMPTION FOR SELECTED COMMODITIES

	1961-72	*1973-84*	*1985-96*	*1997-2008*
MACRO VARIABLES				
Population	2.0	1.8	1.6	1.3
GDP, real	5.5	3.4	2.8	3.0
CONSUMPTION				
Rice	3.3	2.7	1.9	1.2
Wheat	3.9	2.9	1.4	0.9
Maize	3.7	2.5	2.7	2.8
Soybeans	4.8	2.6	5.5	4.0
Palm Oil	8.4	10.2	7.7	8.8
Beef	3.2	1.8	1.1	1.0
Pork	3.7	4.9	2.7	2.2
Poultry	12.1	6.9	6.8	4.0

Source: Authors calculations based on FAO, FAPRI, World Bank, and UN data.

TABLE 2
ANNUAL GROWTH (PERCENT) IN CONSUMPTION OF SELECTED COMMODITIES

	------ WORLD -------		*-------- CHINA --------*		*--------- INDIA ---------*	
	1997-2002	*2003-08*	*1997-2002*	*2003-08*	*1997-2002*	*2003-08*
GDP	2.9	3.3	8.4	10.4	5.1	8.5
Wheat	1.3	2.7	-0.7	0.2	2.7	1.8
Rice	1.6	1.5	0.5	-0.6	1.0	1.9
Maize	1.8	3.6	2.8	3.4	1.9	5.5
Soybeans	5.8	3.3	16.1	8.7	-1.4	7.1
Palm Oil	10.5	7.5	22.1	8.2	21.4	7.2
Beef	0.8	1.6	3.8	2.8	-0.5	-2.2
Pork	2.7	1.3	2.8	1.2	1.0	0.4
Poultry	4.7	3.8	4.9	4.6	17.6	7.7

Source: Authors calculations based on FAO, FAPRI, World Bank, and UN data.

TABLE 3
KEY BIOFUEL STATISTICS

	2000-01	*2002-03*	*2004-05*	*2006-07*	*2008-09*
Biofuels as a share of global grain and oilseed area (percent)					
EU oilseeds	0.00	0.06	0.15	0.24	0.34
US maize	0.13	0.27	0.37	0.76	1.11
Land used for US ethanol from maize as a share of (percent)					
US Maize area	3.63	7.32	9.45	18.03	27.54
US Grain area	0.99	2.00	2.79	5.68	8.44
World grain area	0.16	0.32	0.43	0.85	1.26

Notes: The shares have been calculated based on average world yields.

TABLE 4
STATIONARITY STATISTICS FOR KEY FOOD COMMODITY PRICES, 1960-2008

	Without Trend		*With Trend*	
	ADF	*PP*	*ADF*	*PP*
REAL (MUV-Deflated) SERIES				
Wheat	-2.32	-1.70	-1.83	-1.47
Maize	-1.59	-1.49	-1.84	-1.83
Rice	-1.59	-1.71	-3.08	-1.92
Soybeans	-1.72	-1.59	-2.09	-1.96
Soybean oil	-1.34	-2.06	-0.96	-2.28
Palm oil	-1.41	-2.14	-1.31	-2.47
NOMINAL SERIES				
Wheat	-1.63	-0.84	-3.10	-2.02
Maize	-1.69	-1.22	-2.76	-2.21
Rice	-2.53	-1.62	-3.40*	-2.27
Soybeans	-1.32	-1.23	-2.11	-2.14
Soybean oil	-1.08	-1.17	-1.99	-2.56
Palm oil	-1.41	-2.14	-1.31	-2.47

Notes: ADF and PP denote the Augmented Dickey-Fuller (Dickey and Fuller 1979) and Phillips-Perron (Phillips and Perron, 1988) statistics for unit roots. Asterisks in this and the following tables denote significance at 10% (*), 5% (**), and 1% (***) levels. The corresponding *t-statistics* are -2.60, -2.93, and -3.58 for the tests without trend and -3.18, -3.50, and -4.16 for the tests with trend. The ADF statistic corresponds to the MacKinnon one-sided *p-value*. The lag length of the ADF equations was determined by minimizing the Schwarz-loss function while the bandwidth of the PP statistic was based on the Newey-West method.

TABLE 5

PARAMETER ESTIMATES: CO-MOVEMENT REGRESSIONS

	μ	β_1	β_2	$100^*\beta_3$	$Adj\text{-}R^2$	ADF
Maize-Wheat	0.29	0.85@	0.06	-0.33	0.94	-4.86***
	(1.37)	(14.40)	(0.77)	(1.35)		
Soybeans-Wheat	0.90@	0.78@	0.19@	-0.45	0.92	-5.20***
	(3.20)	(10.21)	(1.99)	(1.40)		
Wheat-Rice	0.34	0.60@	0.26@	0.41	0.90	-4.54***
	(1.01)	(8.31)	(2.36)	(1.02)		
Soy oil-Wheat	1.75@	0.97@	-0.08	0.03	0.81	-6.54***
	(3.90)	(7.83)	(0.51)	(0.05)		
Wheat-Palm oil	0.02	0.63@	0.39@	-0.04	0.87	-5.30***
	(0.02)	(6.64)	(3.26)	(0.10)		
Maize-Soybeans	-0.16	0.85@	0.04	-0.01	0.91	-6.18***
	(0.54)	(10.82)	(0.39)	(0.92)		
Rice-Maize	0.48	1.02@	0.13	-0.86	0.77	-5.60***
	(0.99)	(7.24)	(0.81)	(1.54)		
Palm oil-Maize	1.27@	1.09@	-0.04	-0.17	0.79	-5.64***
	(2.69)	(8.00)	(0.27)	(0.31)		
Soy oil-Maize	1.45@	1.12@	-0.13	0.39	0.86	-6.90***
	(3.64)	(9.72)	(0.98)	(0.86)		
Rice-Soybeans	0.00	1.01@	0.06	-0.79	0.76	-5.19***
	(0.01)	(7.13)	(0.32)	(1.41)		
Soybeans-Palm oil	0.54	0.53@	0.41	-0.35	0.89	-4.54***
	(1.48)	(7.75)	(3.96)	(0.91)		
Soy oil-Soybeans	0.89@	1.12@	-0.23	0.47	0.86	-7.73***
	(2.09)	(9.82)	(1.61)	(1.04)		
Palm oil-Rice	1.70@	0.64@	0.18	0.01	0.69	-5.15***
	(1.48)	(5.40)	(1.01)	(0.02)		
Soy oil-Rice	1.94@	0.64@	0.12	-0.71	0.74	-5.71***
	(3.71)	(5.80)	(0.53)	(0.86)		
Palm oil-Soy oil	-0.13	0.97@	0.08	-0.54@	0.93	-4.32***
	(0.44)	(16.83)	(1.03)	(1.79)		

Notes: All regressions were run in both directions. (@) denotes parameter estimate significant at the 5 percent level. We report the direction with the largest ADF statistic. The variances have been estimated using White's method for heteroskedasticity-consistent standard errors. For other notes see table 4.

TABLE 6

PARAMETER ESTIMATES: PRICE INDICES REGRESSED ON ENERGY PRICE INDEX

	μ	β_1	β_2	$100^*\beta_3$	Adj-R^2	ADF
Non-Energy	3.03@	0.28@	0.12	-0.01	0.90	-3.35**
	(6.54)	(5.24)	(0.68)	(0.02)		
Metals	3.77@	0.25@	-0.17	1.93@	0.82	-3.30**
	(4.80)	(3.14)	(0.60)	(2.31)		
Fertilizers	3.58@	0.55@	-0.30	0.39	0.81	-3.97***
	(4.12)	(4.79)	(0.95)	(0.48)		
Agriculture	2.51@	0.26@	0.33@	-0.99@	0.90	-3.81***
	(6.90)	(5.54)	(2.43)	(2.73)		
Beverages	1.83@	0.38@	0.55@	-3.12@	0.76	-4.95***
	(3.10)	(4.87)	(2.63)	(5.22)		
Raw materials	1.85@	0.11@	0.51@	0.08	0.91	-3.15**
	(4.16)	(2.15)	(3.15)	(0.19)		
Food	2.91@	0.27@	0.21	-0.71	0.85	-3.85***
	(7.11)	(4.93)	(1.39)	(1.80)		
Cereals	3.13@	0.28@	0.17	-0.87	0.78	-3.83***
	(5.94)	(4.23)	(0.89)	(1.76)		
Edible oils	3.33@	0.29@	0.12	-0.80	0.80	-2.82*
	(6.16)	(4.51)	(0.58)	(1.50)		
Other food	1.86@	0.22@	0.45@	-0.42	0.89	-3.60***
	(6.28)	(3.81)	(4.44)	(1.18)		
Precious metals	-1.40@	0.46@	1.05@	-1.75@	0.98	-3.91***
	(3.58)	(9.40)	(7.61)	(3.68)		

Notes: See Tables 4 and 5.

Source: Baffes (2009).

TABLE 7
COMPARING LONG-RUN TRANSMISSION ELASTICITIES

	Holtham (1988) 1967:S1-1984:S2	*Gilbert (1989) 1965:Q1-1986:Q2*	*Borensztein & Reinhart (1994) 1970:Q1-1992:Q3*	*Baffes (2007) 1960-2005*	*Baffes (2009) 1960-2008*
Non-energy	—	0.12	0.11	0.16	0.28
Food	—	0.25	—	0.18	0.27
Raw materials	0.08	—	—	0.04	0.11
Metals	0.17	0.11	—	0.11	0.25

Notes: Holtham uses semiannual data, Gilbert and Borensztein & Reinhart quarterly, and Baffes along with the present study annual. Gilbert's elasticities denote averages based of four specifications. Holtham's raw materials elasticity is an average of two elasticities based on two sets of weights. '—' indicates that the estimate is not available.

Source: Holtham (1988), Gilbert (1989), Borensztein and Reinhart (1994), Baffes (2007, 2009).

TABLE 8
PARAMETER ESTIMATES: INDIVIDUAL COMMODITIES ON ENERGY PRICE INDEX

	μ	β_1	β_2	$100*\beta_3$	*Adj-R^2*	*ADF*
Wheat	3.27[@]	0.30[@]	0.12	-0.49	0.84	-4.35[**]
	(6.50)	(5.02)	(1.49)	(1.07)		
Maize	3.15[@]	0.27[@]	0.13	-0.74	0.80	-3.49[**]
	(6.23)	(4.66)	(0.70)	(1.58)		
Soybeans	3.58[@]	0.26[@]	0.25	-0.82	0.82	-3.85[***]
	(8.11)	(4.92)	(1.51)	(1.83)		
Rice	3.57[@]	0.25[@]	0.32	-1.62[@]	0.58	-4.05[***]
	(5.14)	(2.67)	(0.26)	(2.78)		
Palm oil	4.94[@]	0.35[@]	-0.01	-0.95	0.63	-3.16[**]
	(6.44)	(3.72)	(0.02)	(1.38)		
Soybean oil	5.25[@]	0.36[@]	-0.09	-0.42	0.70	-2.56
	(7.83)	(4.13)	(0.39)	(0.53)		

Notes: See tables 4 and 5.

Figure 1
Commodity Price Indices (Real, MUV-deflated, 2000=100)

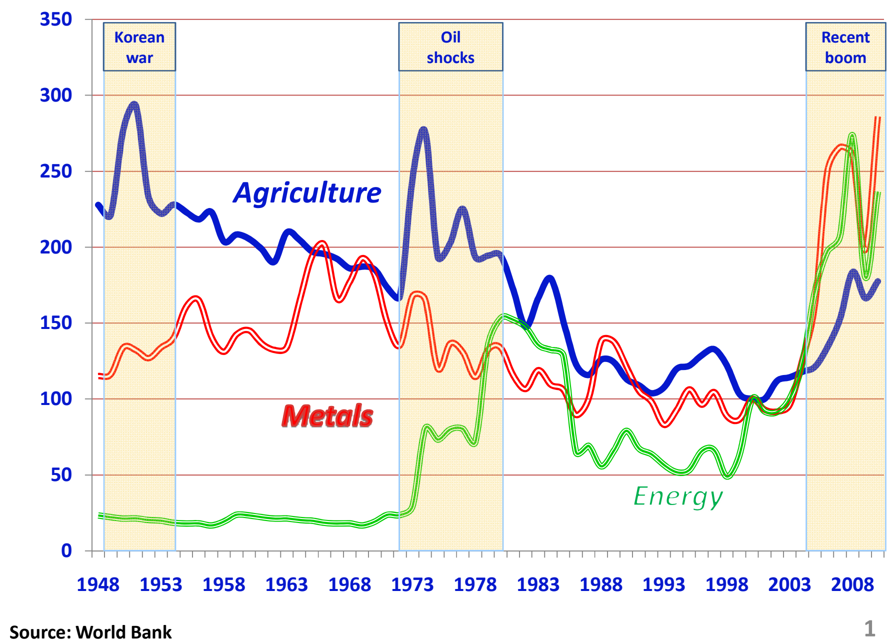
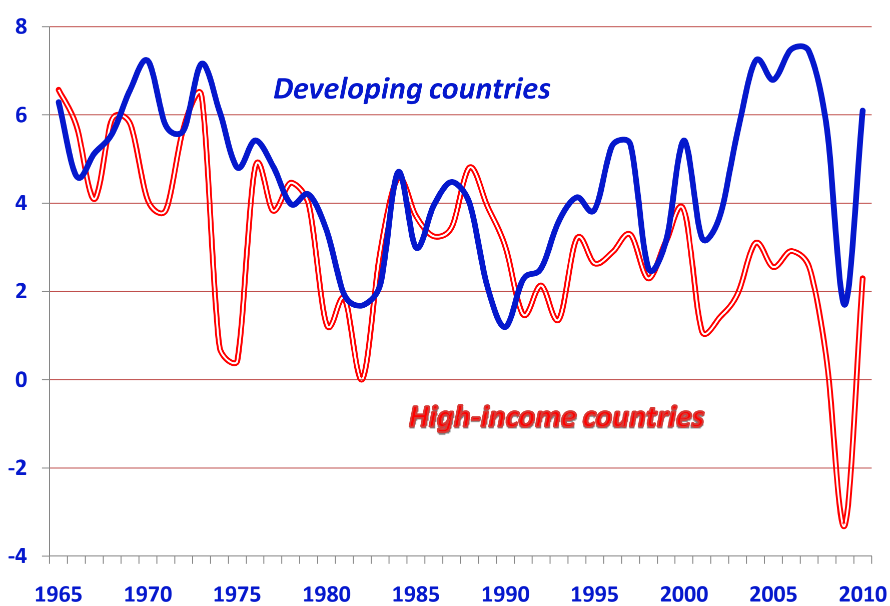


Figure 2
Real GDP Growth (Annual Percent Change)



Source: World Bank

Figure 3
Global Grain Stocks-to-Use Ration (Percent)

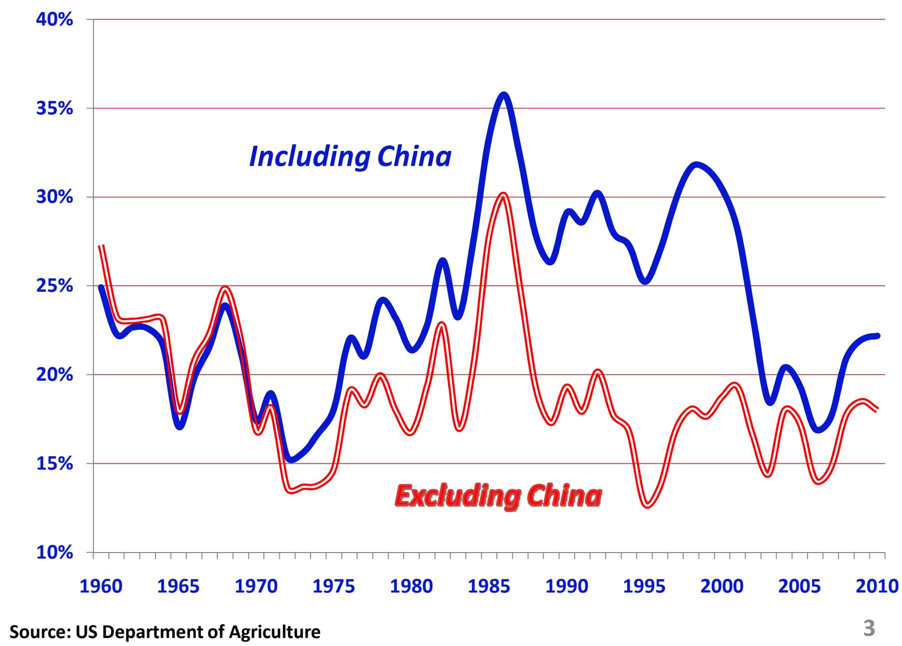
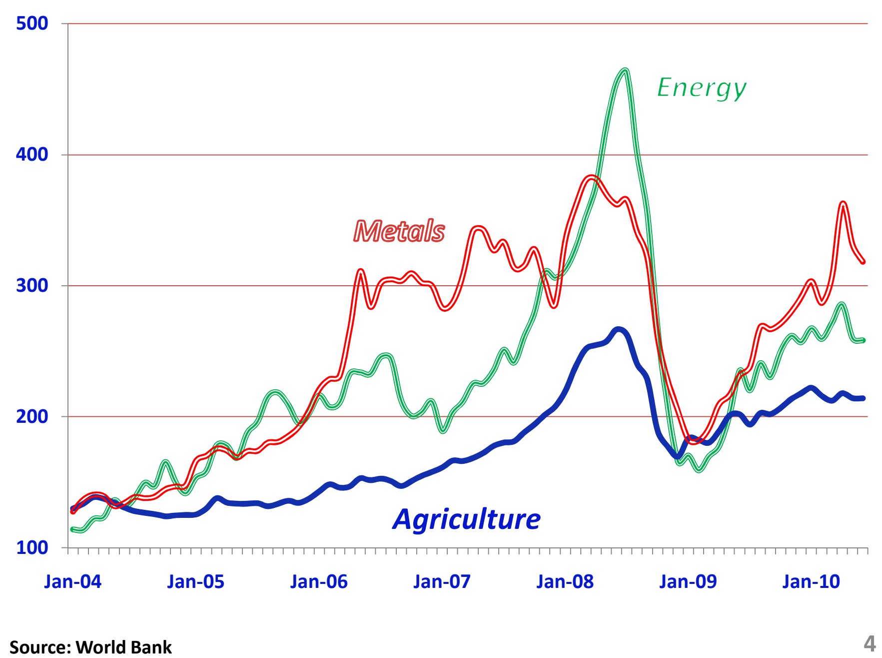


Figure 4
Commodity Price Indices (Nominal, 2000=100)



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Appendix A. What is Speculation?

Blaming speculative activity in periods of sharp price increases is not uncommon. Pushed by such a belief, numerous attempts have been made to restrict or even close the US futures markets. Markham (1987) reports that during 1907-09 (60th US Congress), 25 bills were introduced, designed to prohibit futures trading—for a comprehensive treatment of all attempts to regulate and/or prohibit futures trading see Cowing (1965). Baffes and Kaltsas (2004) describe how numerous cotton futures exchanges were shut down during the first half of the 20th century as the result of government intervention, again because of perceived speculative activity. Schaede (1989) documents similar attempts for the Dōjima rice market in Japan, often cited as the world's oldest futures exchange—it began operation in 1730.

What makes the recent debate on speculation interesting is that it has divided even noted scholars and analysts. Apart from the insufficient empirical evidence on the subject, such division partly reflects the different types of "speculative activity" that analysts and economists refer to. Indeed, the lines between hedgers and speculators, between physical and financial transactions, as well as between legal and illegal trading activities are complex, blurry, and go beyond text-book definitions. To gauge such complexities, consider the traditional separation of the place in which transactions take place (physical *versus* financial) and the actors involved (hedgers *versus* speculators), as depicted in table A1. The first column shows hedging transactions by producers, consumers, and traders (with the banks as intermediaries) that take place either in physical or financial markets (the latter in commodity futures exchanges). This is the typical text-book case. The picture becomes complicated, however, when speculators engage in physical transactions by holding inventories, keeping resources in the ground, or engaging in various types of market manipulation. A more complex picture emerges when speculators engage in financial transactions (often combined with physical transactions).

Hence, understanding the complexities and the controversial nature of speculation ultimately comes down to understanding the right-bottom cell of the Table A1. One way to analyze speculation is to map its sources and its effect on commodity markets to the place where transactions take place, the actors involved, and their motivation.

Place of transaction

Commodity transactions take place either in futures exchanges or physical markets. Speculation taking place in commodity exchanges forms the backbone of the functioning of the futures markets by injecting the necessary liquidity to complete the transactions. This is the type of speculative activity that was typically given as a reason for the closure of commodity futures exchanges mentioned above.

In the physical market, on the other hand, traders may buy and hold large quantities of commodities with the expectation that an upward movement in prices will generate profits (often called hoarding). This is the type of speculative activity that Paul Krugman and Martin Wolf (among others) have referred to. Unless such activity entails market manipulation (in which case it would be an illegal activity), it is the intertemporal equivalent of Adam Smith's "invisible hand:" traders buy at current prices to sell later when (in their opinion) the market will be tight, thereby balancing the market and hence reducing price variability. There is no evidence that hoarding took place during the recent boom, as known inventories in almost all commodities reached historical lows. However, in the case of extractive commodities—especially crude oil—one may well argue that "targeting" output to levels below what the market fundamentals dictate (as is the case with OPEC quotas) is a form of hoarding. The difference is that the commodity is kept in the ground, rather than in above-ground and therefore off the market storage facilities.

Actors involved

Apart from the hedgers (e.g., producers and consumers) with interest in the physical transaction of commodities, two other actors have been operating in the market during the last two or so decades with purely financial incentives and no transactions in the physical markets. They are hedge funds and commodity trading advisors (CTAs). During the past few years, investment funds (mostly pension funds and sovereign wealth funds) also entered the financial markets. It has been argued that these groups (mostly the latter) may have affected commodity prices.

- *Hedge funds*. These undertake investment and trading activities in a broad range of assets, including commodity markets. A hedge fund may trade and invest in commodity asset classes in order to "hedge" the diverse risks inherent in their portfolios. In such a case, taking a position in the futures market for a particular commodity or commodity class can represent an investment in a non-correlated asset that provides diversification benefits to the overall portfolio. Hedge funds have existed for decades and their effect on commodity markets is typically of short term nature (i.e., they affect short term price movements).
- *Commodity trading advisors* (CTAs) are asset managers that operate almost exclusively in commodity markets. They invest for portfolios under management and for clients with the objective of earning profits from market volatility. Perhaps, CTA activity reduces price volatility since they trade on the basis of market fundamentals and

technical analysis.

- *Investment funds*. They include sovereign wealth and pension funds which during the past few years began including commodities in their portfolio mix as another asset class. Their chief motivation has been asset diversification. In addition to the way these funds invest in futures markets (i.e., fixed weights and past performance criteria), it is their sheer size that matters most (see discussion in main text).

Motivation

Very often speculation takes place in the form of market manipulation. This refers to illegal activity typically isolated in one or a few commodity markets. It can take place in the physical or financial markets (often it involves both). Well publicized cases are the US onion market in the 1950s, where onion producers argued that traders in the Chicago Mercantile Exchange cornered the market (this resulted in the passage of the *Onions Futures Act* which prohibited futures contracts on onions); the Hunt brothers who attempted to corner the silver market in the late 1970s and early 1980s; Sumitomo's chief copper trader, Yasuo Hamanaka, who cornered the copper market in the 1990s; and the BP cornering of the propane market in 2006, which resulted in a US$ 300 million fine. Such activity is not known to have prevailed during the recent boom.

TABLE A1: "SPECULATION" IN COMMODITY MARKETS

ACTOR / PLACE	HEDGERS	SPECULATORS
PHYSICAL	• Producers/consumers • Traders • Banks	• Holding inventories (e.g., hoarding) • Keeping resources in the ground (e.g., OPEC) • Market manipulation (e.g., cornering the market)
FINANCIAL	• Producers/consumers • Traders • Banks	• Investment funds (e.g., pension funds, sovereign wealth funds) • Investment and diversification instruments (e.g., CTAs, hedge funds) • Market manipulation (e.g., cornering the market)

APPENDIX B. CO-MOVEMENT OF COMMODITY PRICES

The general subject of commodity price co-movement has been examined extensively and in various contexts. Yet some topics have received much more attention than others. The topics that have received less attention matter most in the current policy debate.

Overall, the research on commodity price co-movement falls largely within two strands. The first examines co-movement among prices of the same commodity in different locations within the market efficiency context, a phenomenon also known as spatial market integration or the law of one price. While most of these studies examine co-movement in a bivariate context, some use models capable of examining it within a multivariate setting. This topic has been studied extensively (see Fackler and Goodwin 2001 for a literature review). A less researched subject (though one more useful for policy analysis purposes) within that strand has been the co-movement between world and domestic commodity prices, a relationship that includes a policy dimension. Specifically, these studies examine whether world price signals have been fully transmitted to domestic markets or instead have been subjected to policy distortions (see, for example, Baffes and Gardner 2003; Mundlak and Larson 1992). Now, for agricultural products, a research project led by Kym Anderson has produced a consistent global database that includes prices received by farmers and paid by consumers in 75 countries (Anderson and others 2008). That database is expected to generate more research on the subject.

The second strand of literature examines price co-movement (or lack thereof) among different commodities. The genesis of this literature goes back to Granger (1986: 218), who wrote: "If x_t and y_t are a pair of prices from a jointly efficient, speculative market, they cannot be co-integrated … if the two prices were co-integrated, one can be used to help forecast the other and this would contradict the efficient market assumption. Thus, for example, gold and silver prices, if generated by an efficient market, cannot move closely together in the long run." Granger's assertion led to research in commodity markets (e.g., MacDonald and Taylor 1988) and other markets as well, notably exchange rates (see, among others, Baillie and Bollerslev 1989; Hakkio and Rush 1989). This research was later questioned on several grounds including the fact that co-movement reflects responses to common fundamentals rather than market inefficiencies. (See, for example, Agbeyebbe 1992; Baffes 1993; Dwyer and Wallace 1992; and Sephton and Larsen 1991.)

A similarly controversial subject has been the "excess co-movement" hypothesis first discussed by Pindyck and Rotemberg (1990) who, after analyzing price movements of seven seemingly unrelated commodities (cocoa, copper, cotton, crude oil, gold, lumber, and wheat), concluded that these prices co-moved in excess of what the macroeconomic variables could explain. A number of likely explanations were given, including an incomplete model, endogeneity of the macroeconomic variables, rejection of normality assumption, and bubbles or market psychology. Subsequent research, however, challenged the excess co-movement hypothesis on data and methodological grounds (see Ai, Chatrath, and Song 2006; Cashin, McDermott, and Scott 1999; Deb, Trivedi, and Varangis 1996; and LeyBourne, Lloyd, and Reed 1994). In a more recent paper, Vansteenkiste (2009) concluded that commodity price co-movement is driven mainly by exchange rates, interest rates, and the price of crude oil.

One may argue that the rejection of the efficient market hypothesis in the presence of co-movement argued by Granger (1986) corresponds to Pindyck and Rotemberg's (1990) bubbles or market psychology explanation for excess co-movement—provided that prices used in Granger's sense have been adjusted accordingly by the fundamentals. Perhaps, the fact that two leading articles on price co-movement among different commodities have been somewhat controversial may have led to a slowing down of research in that area as well.