Special Focus:

From energy prices to food prices: Moving in tandem?

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Energy prices declined 45 percent in 2015 and are projected to drop another 16 percent in 2016. Given the energy intensive nature of agriculture, lower energy prices will help reduce the cost of producing food commodities. They will also ease policy pressures to encourage production of biofuels, which have been a key factor behind the growth of food commodity demand over the past decade. During 2011-16, they are likely to account for up to one-third of the projected 32 percent price decline of grain commodities and soybeans.

Introduction

In 2016, food commodity prices are expected to average 26 percent below their 2011 highs (Figure F1). The decline in food prices has been due to a range of factors. Key among them have been falling energy prices, which are an important cost component of food production, and improved overall crop conditions, which are due to a robust supply response induced by large investment during the 2000s. Given the energy-intensive nature of agricultural production, the post-2014 weakness in energy prices is expected to continue to weigh on food prices.

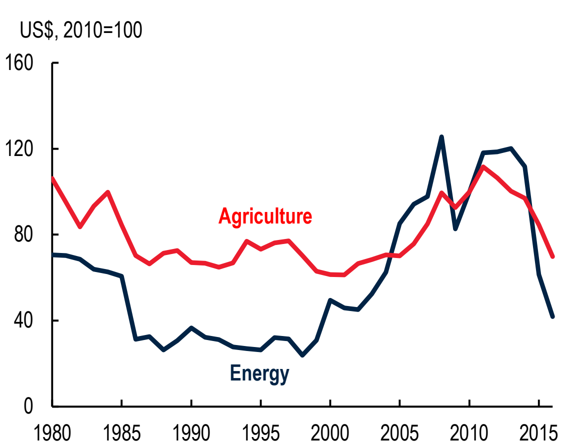
Against this background, this *Special Focus* discusses the following three questions: (1) Through which channels do energy prices affect food commodity prices? (2) What are the major factors driving food prices? (3) Which factors mattered most during the post-2000 price cycle?

Through which channels do energy prices affect food commodity prices?

Energy prices affect food commodity prices through two main channels (Figure F2). First, fuel is a key cost component of producing and transporting food commodities (link A). Energy constitutes more than 10 percent of the cost of agricultural production—four to five times the energy intensity of manufacturing production (Figure F3). Furthermore, some chemicals and fertilizers that are by-products of crude oil or made from natural gas are also another large cost component (link B/C in Figure 2).

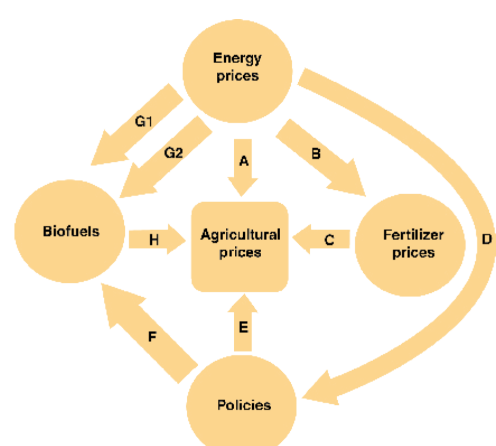
Second, energy price changes affect commercial incentives and policy support for biofuels use, which is partly driven by an objective to reduce dependence on imported crude oil. The diversion of some food commodities to the production of biofuels is an important driver of food commodity demand (link D/F in Figure F2).[1] During the past decade, biofuels constituted the largest source of growth in demand for grains and oilseeds. Currently, biofuels account for about three percent of global area allocated to grains and oilseeds and contribute the equivalent of 1.5 million barrels per day (1.6 percent) to global liquid energy consumption (Figure F4). Most biofuel production comes from maize-based ethanol in the United States and accounts for 49 percent of global biofuel production.[2] Sugar-based ethanol from Brazil accounts for 20 percent of the total, while edible oil-based biodiesel and ethanol in the European Union account for 15 percent (Brazil was the world's dominant biofuel producer until 2000). The remainder is produced by a

F1 Energy and agriculture price indexes



Source: World Bank.
Note: Definitions and compositions of price indexes can be found in Appendix A and C. Last observation is 2016 and represents forecast as of July 2016.

F2 The energy-biofuel-food price link



Source: Baffes (2013).
Notes: A—fuel channel; B/C—Fertilizer channel; D/F—policy-induced biofuel channel; E—other energy policies; G1—profitable biofuel channel due to high oil prices; G2—profitable biofuel channel due to induced innovation in biofuel technology.

number of smaller contributors, including Canada, China, and Thailand.

Based on data prior to the rise of biofuels, numerous studies have estimated the transmission elasticity of energy to non-energy prices, including food prices. The elasticities have been estimated to range from 0.11 to 0.16 (Borensztein and Reinhart 1994; Gilbert 1989; Baffes 2007). Food commodity prices (and agricultural prices more broadly) are more sensitive to energy prices than other non-energy prices, with average elasticity estimates ranging from 0.18 to 0.25 (Baffes 2007; Chaudhuri 2001; Gilbert 1989). For the United States, several authors have documented a sizable pass-through of oil price changes to agricultural producer prices as well (Hanson et al. 1993; Moss et al. 2010).

The more recent literature, which examines the energy/non-energy price link by also taking into account the biofuel channel, finds more tenuous links between energy and non-energy commodity prices (Saghaian 2010; Gilbert 2010; Zhang et al. 2010; Reboredo 2012). The mixed evidence could reflect different data frequencies (Zilberman et al. 2013) or the mandated nature of biofuels (De Gorter and Just 2008). For example, a technology-driven decline in oil prices would increase demand for oil and, because of the mandated nature of biofuel policies, would also increase demand (and hence the price) of ethanol.

What are the major factors driving food prices?

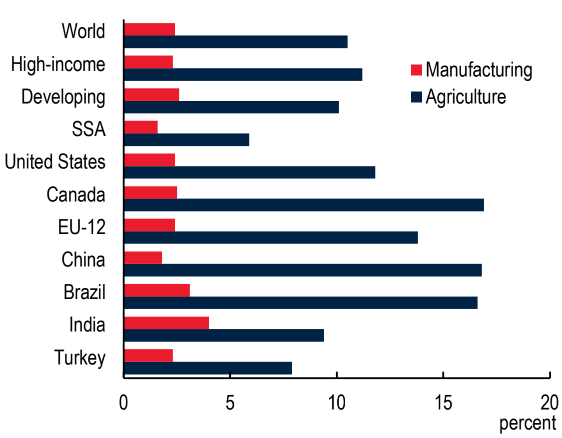
A reduced-form econometric model is estimated to identify the major drivers of the prices of agricultural commodities that, together, account for the largest part of world arable land: maize, soybeans, wheat, rice, palm oil, and cotton. The model incorporates the five main drivers of real agricultural prices (deflated by manufacturing prices): oil prices and exchange rates as cost components; GDP and interest rates as proxies for demand and monetary conditions; and stock-to-use ratios as proxies of crop conditions and biofuel policies. Implicitly, the stock-to-use ratio accounts for the diversion of food commodities to the production of biofuels (see Technical Appendix for model description and elasticity estimates).

Impact of oil prices. The estimated elasticities on oil prices are significantly different from zero for all food prices with an average (panel regression) estimate of 0.19. That is, a 10 percent increase in oil prices is associated with almost 2 percent increase in food prices. These elasticities are consistent with the literature which examined the effect of energy prices on the prices of food commodities based on data before the biofuel boom.

Impact of crop conditions and biofuel policies. The stock-to-use ratio, a measure of how well-supplied food markets are relative to demand (including biofuels), is also an important contributor to food price variability (Figure F5). Typically, low stocks-to-use ratios exert upward pressure on the prices of storable commodities, as was the case in the early stages of the price boom (conversely, the relatively high stocks of the past few years reduced such pressure.) The elasticity of real food prices to the stock-to-use ratio is estimated at -0.33. That is, a 10 percentage point increase in the stock-to-use ratio is associated with a 3.3 percent decline in food prices, similar to findings reported elsewhere (Bobenrieth et al. 2012, FAO 2008).

Impact of monetary conditions. The estimated impact of interest rates on food prices is either statistically insignificant (maize) or small (wheat, rice, soybeans, palm oil, cotton). This weak evidence is a common

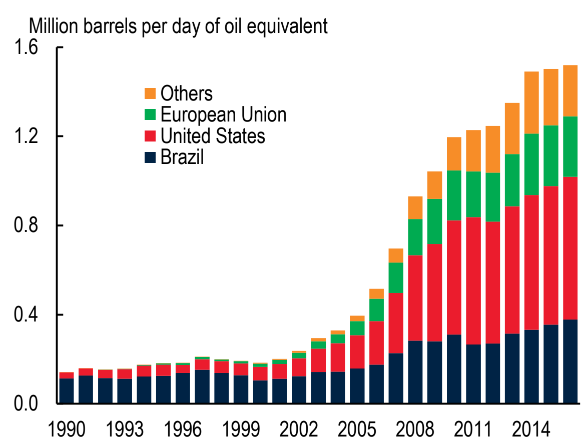
F3 Cost of energy component



Source: World Bank calculations based on the GTAP database.

Note: SSA = Sub-Saharan Africa. The energy intensity reflects the energy cost component of agriculture and manufacturing industries and accounts for both direct and indirect use of energy.

F4 Global biofuels production



Sources: BP Statistical Review and World Bank.

Note: Last observation is 2016.

finding in the empirical literature (Frankel and Rose 2010; Frankel 2014; Anzuini et al. 2010, Akram 2009).[3]

Impact of dollar appreciation. When the U.S. dollar appreciates (as it did over the past two years), the value of other assets that are evaluated against the U.S. dollar—including commodities—tends to decline. Over the medium-term, U.S. dollar appreciation raises commodity prices in domestic currency terms and leads to supply increases from non-U.S. dollar exporters and demand cuts from non-U.S. dollar importers (Radetzki 1985). On average, a 10 percent appreciation of the U.S. dollar is associated with a 5 percent decline in food commodity prices. The inverse relationship between the U.S. dollar and commodity prices is empirically well-established (Lamm 1980; Gardner 1981; Baffes and Dennis 2015 for agriculture; Gilbert 1989; Akram 2009 for metals).

Impact of GDP. As GDP rises, food consumption grows more slowly than consumption of other goods and services (Engel's Law, Engel 1857). This results in declining food prices relative to manufactured goods prices (the Prebisch-Singer hypothesis; Prebisch 1950; Singer 1950). A 10 percent increase in real GDP is associated with a 6 percent decline in real food prices.[4]

Which factors mattered most during the post-2000 price cycle?

The above elasticities combined with actual movements of the fundamental drivers of food prices provide a guide to the main reasons for the post-2011 weakness in food prices. Real prices of the three key grains—maize, wheat, and rice—and soybeans are expected to average 43, 42, 25, and 23 percent, respectively, lower in 2016 compared to their 2011 highs.[5] About one-third of this decline can be explained by the real oil price drop.[6] The steady increase in incomes is estimated to shave another one-sixth off real grain prices during 2011-16 (Figure F6, right panel).

These developments are a reversal of trends during the boom part of the post-2000 commodity price cycle. During 2000-08, oil prices increased from $35/bbl to $94/bbl in real (2010) terms. The stock-to-use ratio for wheat, maize, and rice declined, on average, from 0.34 to 0.22 percent during this period (but was broadly constant for soybeans). While the decline in the stock-to-use ratio contributed up to 13 percentage points to the average grain and soybean price drop between 2000 and 2008, oil prices contributed about 16-18 percent (Figure F6, left panel).

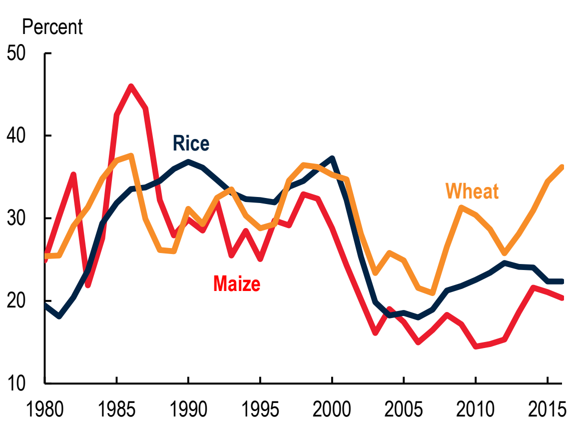
Conclusion

Given the energy-intensive nature of agriculture, lower energy prices are expected to reduce the costs of producing food commodities. They should also ease policy pressures to encourage biofuels production, which has been a key source of growth in food commodity demand over the past decade. Energy prices declined 45 percent in 2015 and are projected to drop another 16 percent in 2016. Based on elasticity estimates from a reduced-form econometric model, it is shown that the impact of lower energy prices on food commodities was about twice as much compared to the impact of crop conditions.

Endnotes

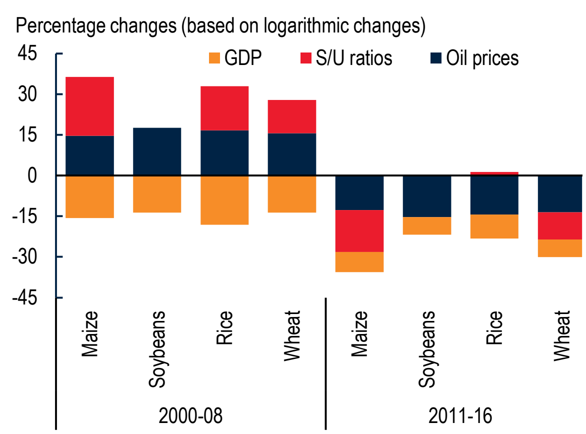
1. Links G1 and G2 represent the cases when biofuels become profitable. These scenarios are mostly relevant under high oil prices. For example, if biofuels are profitable (link G1) the price of oil acts as a floor to agricultural prices. Technological improvements under an induced innovation scenario could increase the energy

F5 Global stock-to-use ratios



Source: U.S. Department of Agriculture.
Note: The last observation refers to the 2016/17 crop year (July 2016 USDA update).

F6 Contribution to explained price variation



Source: World Bank.
Note: Predicted contributions (of the three most important drivers) are defined as the parameter estimates times the logarithmic changes during 2000-08 and 2011-16.

content of biofuels crops thereby rendering biofuels profitable even under a low oil price scenario (link G2), in which case, again, oil prices set a floor for agricultural prices (see Baffes 2013).

2. About 38 percent of U.S. maize goes to the production of ethanol—yet because one-third of maize returns to the feed industry in the form of byproducts, the actual share is 25 percent.

3. The literature typically assumes that when interest rates are low, increased consumption and larger stock holding will increase demand. Baffes and Savescu (2014) conjectured that the low cost of capital may have induced parallel (and similar) rightward shifts in both demand and supply schedules, thus explaining the muted impact of interest rate on commodity prices.

4. It has often been argued that changing consumption patterns by emerging economies, especially China and India, were key drivers of the boom (e.g., Krugman 2008, Wolf 2008, and Bourne 2009). However the evidence is to the contrary (see Alexandratos 2008; FAO 2008; Alexandratos and Bruinsma 2012; Sarris 2010; Baffes and Haniotis 2010; FAO 2009; and Lustig 2008). Deaton and Drèze (2008), noted that despite growing incomes, the caloric intake in India has followed a downward trend since the early 1990s.

5. To ensure consistency with the model described in the Technical Appendix, the decomposition has been applied to logarithmic changes, not percentage changes.

6. Although crude oil price remained high during 2011-13, low natural gas prices in the U. S. not only kept in check the costs of producing food commodities in the U.S. but also reduced the price pressure on fertilizer prices. For example, following their all time high of almost $9/mmbtu in 2008, U.S. natural gas prices have been declining steadily to $2.60/mmbtu. And, unlike other commodity prices, U.S. natural gas prices did not rebound after the Great Recession because of the large expansion of shale gas.

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Technical Appendix: Modeling food price trends

To identify the long-term impact of the various sectoral and macroeconomic fundamentals on real commodity prices, this appendix presents estimates from a reduced-form econometric model reported in Baffes and Haniotis (2016). The model takes the following form:

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

P_t is the real price of the commodity. 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 denotes the stock-to-use ratio, P_t^E is the real price of crude oil, the $\beta_j s$ are parameters to be estimated and ε_t is the error term. Because the variables (except the interest rate) are expressed in logarithmic levels, the estimated parameters can be interpreted as elasticities.

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 (pink sheet data. All commodity prices have been deflated by the Manufacturing Unit Value index (MUV). 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). 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 basket of 26 currencies. Interest rate, exchange rate and CPI are taken from the Board of Governors of the Federal Reserve System. Income is proxied by the real global GDP, taken from the World Bank's World Development Indicators.

Before estimating the model, the unit root properties of all the variables under consideration were examined by using the modified Dickey-Fuller and Phillips-Perron 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, and the error terms of all regressions were stationary (stationarity test results are not reported here).

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) and also to have a sense of the average effects across all commodities (panel estimates, reported in the last column of Table). 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).

TABLE F1 Parameter estimates

	Maize	Soybeans	Wheat	Rice	Palm oil	Cotton	Panel
Constant	13.90*** (6.71)	12.30** (4.77)	11.30** (4.82)	20.70*** (7.31)	15.40*** (4.68)	15.10*** (6.01)	4.32*** (12.31)
Real GDP	-0.62*** (-7.86)	-0.54*** (-5.48)	-0.54*** (-6.10)	-0.72*** (-6.05)	-0.74*** (-5.92)	-0.71*** (-7.33)	-0.62*** (14.15)
Real interest rate	-0.02 (0.98)	-0.05*** (-3.25)	-0.05*** (-3.42)	-0.03** (-1.72)	-0.05*** (-2.41)	-0.03*** (-2.23)	-0.03*** (-4.94)
Real exchange rate	-0.41 (1.16)	-0.34 (-0.93)	-0.056 (-0.16)	-1.39*** (-3.45)	-0.22 (-0.47)	-0.22 (-0.61)	-0.45*** (2.58)
Stock-to-Use ratio (lag)	-0.48*** (6.90)	-0.18*** (-3.38)	-0.43*** (-4.58)	-0.29*** (-3.39)	-0.34*** (-3.15)	-0.40*** (-4.64)	-0.33*** (8.22)
Real oil price	0.15*** (2.99)	0.18*** (3.62)	0.16*** (3.38)	0.17*** (3.11)	0.32*** (4.58)	0.13*** (2.66)	0.19*** (8.12)
R-square	0.76	0.63	0.63	0.73	0.61	0.73	0.64
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 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. Absolute t-statistics in parentheses, * = 10 percent, ** = 5 percent, *** = 1 percent.