The Energy/Non-Energy Commodity Price Link: What Relevance for Agriculture?

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Paper presented at the
International Agricultural Trade Research Consortium
Analytic Symposium
"Confronting Food Price Inflation: Implications for Agricultural Trade and Policies"

June 22-23, 2009
Seattle, Washington

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June 2009

ABSTRACT: *This paper examines the energy/non-energy commodity price link, based on a reduced form econometric model and using annual data from 1960 to 2008. It finds that the transmission from energy to the non-energy commodity price index has almost doubled in the aftermath of the recent commodity price boom, to reach 0.28. At a more disaggregated level, fertilizers exhibited the largest transmission (0.55), followed by precious metals (0.46), food (0.27), metals & minerals (0.25), and raw materials (0.11). On the other hand, only a few price indices respond strongly to inflation while the trend parameter estimate (often viewed as a proxy to technological progress) is negative for agriculture and positive for metals. A key implication of the transmission results is that for as long as energy prices remain elevated, most non-energy commodity prices are expected to be high.*

JEL: O13, Q33

KEY WORDS: energy prices, non-energy prices, transmission elasticities

* The views of the authors (with the World Bank and the European Commission, respectively) are personal and do not necessarily reflect views of their institutions.

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I. Introduction

By most accounts, the recent commodity boom was the longest, largest, and broadest (in terms of commodities involved) of the post-WWII period (World Bank 2009). Between 2003 and 2008, nominal energy and metal prices increased by 230%, food and precious metals doubled, while fertilizer prices increased four-fold. Although prices (except precious metals) have declined sharply since their mid-2008 peak, as of early 2009 they are still considerably higher than their lows reached in early 2000s. The breadth of the recent boom did not only generate renewed interest on the nature and degree of commodity price links, but also concerns about the long-term impact of such links for agriculture and food supply and demand prospects.

Shedding some light on recent price developments, this paper examines the price transmission from energy to non-energy commodity prices and the price linkages among agricultural commodities, and attempts to draw some tentative conclusions with respect to suggested potential policy responses to the perceived "food crisis" price. Specifically, 11 non-energy commodity price indices are regressed on an energy price index, a measure of inflation, and a time trend (considered as a proxy to technological change). The paper expands earlier work (Baffes 2007) by broadening the definition of energy (i.e., use of an energy index which includes natural gas and coal in addition to crude oil) and by extending the sample to 2008. The rest of the paper begins with a brief discussion of the methodology and description of the data. The results are discussed next while the last section concludes.

II. Modeling framework

Although the literature on the energy/non-energy commodity price links is relatively thin, the broader subject of price comovement has been examined extensively and in various contexts with the research falling largely within two strands. The first strand examines comovement among prices of the same commodity in different locations within the market efficiency context, also known as spatial market integration or law of one price (see Fackler and Goodwin (2001) for a literature review). A more important but less researched subject within that strand has been the comovement between world and domestic commodity prices. This relationship adds the policy dimension by analyzing whether world price signals have been fully transmitted to domestic markets or such signals have been subjected to policy distortions (see Baffes and Gardner (2003) and Mundlak and Larson (1992)).[1]

The second strand of literature, following Granger (1986)[2], examines price comovement (or lack thereof) of different commodities (e.g., MacDonald and Taylor 1988) and other markets as well, notably exchange rates (see, among others, Baillie and Bollerslev (1989) and Hakkio and Rush (1989)).[3] So-called 'excess comovement' hypothesis was first highlighted by Pindyck and Rotemberg (1990), who concluded that the prices of seven seemingly unrelated commodities (cocoa, copper, cotton, crude oil, gold, lumber, and wheat) comoved in excess of what the macroeconomic variables could explain.[4] Subsequent research, however, challenged the excess comovement hypothesis on data and methodological grounds.[5]

The present paper examines the transmission from energy to non-energy commodity prices by estimating the following relationship for 11 non-energy price indices:

$$log(NON\_ENERGY_t) = \mu + \beta_1 log(ENERGY_t) + \beta_2 log(MUV_t) + \beta_3 TIME + \varepsilon_t,$$

where NON_ENERGY_t denotes the various non-energy US dollar-based commodity price indices at time t, $ENERGY_t$ denotes the energy price index, MUV_t denotes the deflator, $TIME$ is time trend, and ε_t denotes the error term, the properties of which will be subject to empirical investigation; μ, β_1, β_2, and β_3 denote parameters to be estimated. Because the model is expressed in logarithms, the parameter estimates can be interpreted as elasticities.

Although the signs and magnitudes of the coefficients are not dictated by economic theory, β_1 and β_2 are expected to be positive because energy as well as other goods and services (as reflected by the measure of inflation) constitute key inputs to the production process of all commodities.[6] (See Baffes (2007), FAO (2002), and World Bank (2009) for the various transmission channels of prices between energy and non-energy markets; Kilian (2008) on the transmission channels to the broader economy; and Schmidhuber (2006) on the impact of biofuels on agricultural markets.) On the other hand, β_3 is expected to be negative, at least for agriculture—consistent with the long term impact of technological progress on production costs as well as the low income elasticity of most food commodities, especially cereals.[7]

Annual data for 11 non-energy indices covering the period from 1960 to 2008 are used in the analysis, giving a total of 49 observations. The Manufacture Unit Value (MUV) is used as an inflation proxy. The MUV, often considered as a developed country deflator indicator, represents the unit value index in dollar terms of manufactures exported from industrial countries weighted proportionally to the countries' exports to the developing countries.

Data on all indices are collected and reported by the World Bank (World Bank, various issues) and are defined as follows. **Energy** [world trade-based weights in square brackets] consists of crude oil [84.6%], natural gas [10.8%], and coal [4.6%]. **Non-energy** consists of metals [31.6%], fertilizers [3.6%], and agriculture [64.8%]. **Agriculture** consists of beverages [8.4%], raw materials [16.5%], and food [39.9%] while **Food** consists of cereals [11.3%], edible oils [16.3%], and other food [12.3%]. The commodity-composition of the sub-indices is as follows: **Beverages**: cocoa, coffee (arabica and robusta), tea; **Cereals**: maize, rice, sorghum, wheat; **Edible oils**: coconut oil, groundnut oil, palm oil, soybean meal, soybean oil, soybeans; **Other food**: bananas, meat (beef and chicken), oranges, shrimp, sugar; **Raw materials**: cotton, rubber, timber (logs and sawnwood); **Fertilizers**: DAP, phosphate rock, potassium chloride, TSP, urea; **Metals**: aluminum, copper, iron ore, lead, nickel, tin, zinc. Finally, a **Precious metal** index was included in the analysis—not part of the non-energy index—consisting of gold [89.7%] and silver [10.3%].

The use of low frequency (annual) data was motivated by the desire to avoid the noise typically embedded in high frequency data and also compare the effect of energy prices on the prices of all primary commodity groups. Because most agricultural commodities are subject to crop cycles, annual frequency is, perhaps, more relevant. For example, the decision of how much land to allocate to each commodity and how much inputs to use is taken once a year, typically prior to planting. On the other hand, although a higher frequency would add more observations, the high variability characterizing commodity prices implies that even annual observations contain a large amount of information (Campos and Ericsson 1999).

III. Results

First, the stationarity properties of all the series in log-level form using the augmented Dickey-Fuller (ADF) testing procedure were examined (these statistics are not reported here). With the exception of the cereals index (ADF = -1.76, significant at 10%), the remaining AFD statistics ranged from -0.15 (metals) to -1.53 (other food). Appending a time trend to the ADF regressions did not alter the statistics in any significant way thus confirming the existence of a unit root. Differencing the series once, however, induced stationarity in all cases, implying that validating the model would require examination of the stationarity properties of its error term, in addition to conventional indicators such as R^2s and *t*-ratios. Recall that non-stationarity of price series is not a surprising result considering the long period along with the low frequency of the data and the fact that the series were expressed in nominal terms.

Results from OLS regressions are presented in table 1. Specifically, the first four columns report parameter estimates of the constant term, energy, inflation, and the time trend, followed by the adjusted-R^2 and the ADF statistic. The estimates—reflected in the positive sign of the energy price coefficient as well as the conventional and stationarity statistics—indicate that energy prices and to a lesser extent inflation and technological change explain a considerable part of commodity price variability (the adjusted R^2 of all regressions averaged 0.85). Moreover, the ADF statistics were in all but one case (edible oils) far below -3.00 (they averaged -3.77), fully consistent with a stationary error term.

The parameter estimate of the non-energy index (top row of table 1) is 0.28, implying that a 10% increase in energy prices is associated with a 2.8% increase in non-energy commodity prices, in the long run. This estimate is roughly double the level of three earlier studies, Gilbert (1989), Borensztein and Reinhart (1994), and Baffes (2007), which reported elasticities of 0.12, 0.11, and 0.16, respectively (see table 2). When the sample of the current analysis is adjusted to match the samples of these studies, the transmission coefficient becomes remarkably similar (0.13 and 0.12, and 0.18, respectively).

This result, clearly a reflection of the impact of energy in the recent commodity-price boom, raises the issue of whether it is also indicative of a significant long-term shift with potential implications. The transmission elasticity of the non-energy index, however, masks some variations. The highest elasticity among the sub-indices was in fertilizer, estimated at 0.55, not surprisingly since nitrogen-based fertilizers are made directly from natural gas. Fertilizer and energy price increases during the recent boom were in line with the ones experienced during the first oil shock: from 1973 to 1974 phosphate rock and urea prices increased four-fold and three-fold n nominal terms, very similar to the crude oil nominal price increase during that period, from $2.81/barrel to $10.97/barrel.

The metals elasticity was estimated at 0.25; yet its components presented considerable variation (individual commodity elasticity estimates are not reported here). Note that highly diverse estimates in the transmission elasticities of metal prices were the key findings of Baffes (1997, 2007) and Chaudhri (2001). The precious metals elasticity was estimated at 0.46—the second largest elasticity among the 11 sub-indices studied here. Its large value reflects the association of high energy prices with inflationary pressures, slower economic growth, and resource scarcity, all of which prompt households and investors to view precious metals (especially gold) as safe investment alternatives, therefore increasing their demand and hence their prices. Not surprisingly, the two post-Bretton Woods peaks of gold prices, $750/toz in 1980 and $687/toz in 2008, correspond to the two crude oil price peaks, $45/barrel and $76/barrel, respectively (all prices are expressed in 2000 real US dollars).

The agriculture transmission, estimated at 0.27, reflects an average of wide ranging parameter estimates: beverages (0.38), food (0.27) and raw materials (0.11). The elasticity estimates of the food price index components, however, fall within a very narrow range: cereals (0.28), edible oils (0.29), and other food (0.22), all significantly different from zero at the 1% level.[8]

To disaggregate further the analysis of agricultural prices, table 3 presents results of the energy price link to individual agricultural commodities. Again the range of estimated price transmission elasticities is rather narrow, with values between 0.25 (rice) to 0.30 (wheat) for crops and between 0.35 and 0.36 for the two examined edible oils (palm oil and soybean oil, respectively).

IV. Result implications

Three important conclusions emerge from the analysis. First, the results show that the prices of most commodities, and especially those of fertilizers and precious metals, respond firmly to energy prices. Furthermore, such response appears to be strengthening in periods of high commodity prices as confirmed by the fact that the values of the estimated elasticities increase considerably when the recent boom is included in the analysis (in some cases the elasticities double; see difference between the last two columns of table 2). Price transmission values for agricultural commodities in particular, was estimated to narrowly range between 0.25 and O.35, whether estimated at the aggregate or the individual commodity level.

The implication of the above results is clear: for as long as energy prices remain elevated, analysis of non-energy commodity markets requires understanding of the energy markets as well. On the other hand, the non-energy elasticity is insensitive to the model structure and frequency of the data as can be inferred by its remarkable similarity with the earlier studies (when adjusted for sample size).

Second, while the transmission elasticities were broadly similar, this was not the case with the inflation coefficient, b_2, the estimates of which varied considerably in terms of sign, magnitude, and level of significance. It was positive and significantly different from zero only for agriculture (and some of its sub-indices) while it was effectively zero for metals and fertilizers. All this implies that the relationship between inflation (at least as measured by the MUV) 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 which includes both oil shocks) the MUV increased by 45% while during 2000-08, it increased by half as much. The nominal non-energy price index increase during these two 8-year periods was identical at 170%.

Third, the trend parameter estimates, b_3, are spread over an even wider range compared to energy transmission and inflation parameter estimates. The non-energy price index, for example, shows no trend at all. Yet, the metal price index exhibited an almost 2% positive annual trend while the agriculture index showed a 1% negative annual trend. Furthermore, the trend parameter estimates of the agriculture sub-indices vary considerably, from 0.08 (*t-value* = 0.19) for raw materials to -3.12 (*t-value* = 5.22) for beverages, a result which confirms Deaton's (1999, p. 27) observation that what commodity prices lack in trend, they make up in variability.[9]

The sign of trend parameter estimates at the individual agricultural commodity level is consistently negative, implying annual rates of decline between 0.5% and 1.5%.

However, none of the estimated parameters is statistically significant.

IV. Concluding remarks

Based on 1960-2008 annual data and a simple econometric model, I estimated the degree of price transmission from energy to 11 non-energy commodity groups. The long run elasticity for the non-energy index was estimated at 0.28. At a disaggregated level, the fertilizer index exhibited the largest transmission, followed by precious metals, food, and metals & minerals.

The key implication of these findings is that, for as long as energy prices remain elevated, most non-energy commodity prices are expected to remain high. Moreover, any analysis of non-energy commodity markets should take into consideration developments in energy markets. On the methodological side, the fact that the estimates of the current study (which included the recent commodity boom) are larger than earlier ones (not accounting for the recent boom) implies that, perhaps, time-varying parameter or switching-regime models may be more appropriate in analyzing the energy/non-energy price links. Such models could shed more light on the relationship between inflation and commodity prices; they may also enhance our understanding on the (well-researched but not yet settled) subject of the secular decline of primary commodity prices. Another avenue to pursue in terms of further research is, naturally, the use of higher frequency data within an error-correction framework.

Finally, several crucial issues with respect to policy considerations are pertinent. If previous energy prices booms have any relevance for the future, then oil prices could stabilize at a higher level than their previous trough. This possibility raises expectations about a new band within which grain prices could fluctuate in the future. The consequent impacts on not just market revenues but also production costs already influence domestic and international policy considerations in several countries.

ENDNOTES

[1] The thinly researched subject of world/domestic price comovement reflects, perhaps, the unavailability of data. That, however, changed recently for agricultural products following the research project led by Kym Anderson whose methodology (Anderson et al. 2008) resulted in a consistent global database which includes prices received by farmers and paid by consumers in 75 countries (www.worldbank.org/agdistortions).

[2] "If x_t and y_t are a pair of prices from a jointly efficient, speculative market, they cannot be cointegrated … if the two prices were cointegrated, 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 (1986, p. 218).

[3] This research was later questioned on several grounds including the fact that comovement reflects response to common fundamentals rather than market inefficiencies. See, for example, Agbeyebbe (1992), Baffes (1993), Dwyer and Wallace (1992), and Sephton and Larsen (1991).

[4] A number of likely explanations were given for such comovement, such as incomplete model, endogeneity of the macroeconomic variables, rejection of normality assumption, and bubbles or market psychology. It can be argued that the rejection of the efficient market hypothesis in the presence of comovement argued by Granger (1986) corresponds to Pindyck and Rotemberg's (1990) 'bubbles' or 'market psychology' explanation for excess comovement—provided that prices used in Granger's sense have been adjusted accordingly by the fundamentals.

[5] See Ai, Chatrath, and Song (2006), Cashin, McDermott, and Scott (1999), Deb, Trivedi, and Varangis (1996), and LeyBourne, Lloyd, and Reed (1994)).

[6] The exogeneity of energy prices assumed here reflects the large size of energy markets compared to the size of other commodity markets as well as the fact that energy is a key input in the production process of most commodities. Hence, b_1 is interpreted as a transmission elasticity rather than just a cointegration parameter, similar to the cases of domestic/world price links where domestic prices are typically assumed to be a function of world prices.

[7] As an alternative to this specification, one could deflate both indices by di-viding NON_ENERGYt and ENERGYt with MUVt, effectively restricting the sum of the en-ergy index and inflation coefficients to unity (i.e., $\beta1 + \beta2 = 1$). Estimating nominal indices, however, relaxes the homogeneity restriction so that a direct estimate of the impact of inflation can be obtained (Houthakker 1975).

[8] Commodity-specific regressions show that the high elasticity estimate of beverages is driven by cocoa (b_1 = 0.52, *t-value* = 5.35), a result with no obvious explanation. On the other hand, the similarity among food sub-indices extends to most individual commodities, especially for the components of grain and edible oil indices.

[9] The large variation among the trend parameter estimates could imply that the validity of the Prebisch-Singer hypothesis, often discussed in the context of the secular decline of primary commodity prices, may require rethinking (see Spraos 1980, among others).

TABLE 1: PARAMETER ESTIMATES

INDEX	μ	b_1	b_2	$100*b_3$	$Adj\text{-}R^2$	*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: The @ sign denotes parameter estimate significant at the 5% level while the numbers in parentheses are absolute *t-values* (the corresponding variances have been estimated using White's method for heteroskedasticity-consistent standard errors.) ADF denote the MacKinnon one-sided *p-values* based on the Augmented Dickey-Fuller equation (Dickey and Fuller 1979). One (*), two (**), and three (***) asterisks indicate rejection of the existence of one unit root at the 10%, 5%, and 1% levels of significance (the respective *t-statistics* are -2.60, -2.93, and -3.58). The lag length of the ADF equations was determined by minimizing the Schwarz-loss function.

Source: Author's estimates.

TABLE 2: 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*	*This Study 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), and author's estimates.

TABLE 3: PARAMETER ESTIMATES, INDIVIDUAL COMMODITIES

COMMODITY	*μ*	b_1	b_2	$100*b_3$	$Adj\text{-}R^2$	*ADF*
Deflator is MUV						
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 table 1

TABLE 4: PARAMETER ESTIMATES, CROSS- COMMODITY REGRESSIONS

	Wheat	*Maize*	*Soybeans*	*Rice*	*Palm Oil*
Wheat	—	0.85	0.78	1.01	0.94
Maize	0.97	—	0.85	1.02	1.09
Soybeans	0.89	0.85	—	0.76	1.08
Rice	0.60	0.53	0.53	—	0.64
Palm oil	0.53	0.54	0.53	0.61	—

Notes: See table 1.

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