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Oil Spills on Other Commodities

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Abstract

This paper examines the effect of crude oil prices on the prices of 35 internationally traded primary commodities for the 1960-2005 period. It finds that the pass-through of crude oil price changes to the overall non-energy commodity index is 0.16. At a more disaggregated level, the fertilizer index had the highest pass-through (0.33), followed by agriculture (0.17), and metals (0.11). The prices of precious metals also exhibited a strong response to the crude oil price. In terms of individual commodities, the estimates of the food group exhibited remarkable similarity while those of raw materials and metals gave a mixed picture. The implication is that if crude oil prices remain high for some time, as most analysts expect, then the recent commodity price boom is likely to last much longer than earlier booms, at least for food commodities. The other commodities, however, are likely to follow diverging paths. On the methodological side, the results show that price indices, while providing useful summary statistics, need to be supplemented by individual commodity analysis.

This paper—a product of the Development Prospects Group—is part of a larger effort in the department to gain a better understanding of commodity price movements. 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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OIL SPILLS ON OTHER COMMODITIES

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Introduction

Crude oil prices have been sufficiently low for most of the past two decades, or at least low enough not to upset policy makers and consumers in oil importing countries. Between 1983 and 2002 they averaged US$20 per barrel in nominal terms or US$22 per barrel in real (1990) terms (see Figure 1). That changed in 2004. Between January 2004 and August 2005 crude oil prices doubled (from $31 to $62 per barrel). The *Economist* concluded that "… the basic fact is that the equilibrium price of oil has risen …" (August 27, 2005, p. 56). Given strong demand, especially by large emerging economies such as China and India, and capacity constraints on the supply side, analysts agree that oil prices in the range of $55 to $65 per barrel will be the norm for the next five to ten years. [1] The World Bank (2007) forecasts oil prices to fluctuate from $50 to $60 per barrel between 2007 and 2010. The IMF's (2007) range is even higher: $60 to $65 per barrel.

Oil price changes affect, to various degrees, most sectors of most economies. Moreover, the channels through which such effects take place are numerous.[2] This paper focuses on one such channel: the pass-through of crude oil price changes to the prices of 35 internationally traded primary commodities.

Crude oil prices affect the prices of other commodities in a number of ways. On the supply side, crude oil enters the aggregate production function of most primary commodities through the use of various energy-intensive inputs (e.g., fertilizer and fuel for agricultural commodities) and, often, transportation over long distances, an equally energy demanding process. Some commodities have to go through an energy-intensive primary processing stage (e.g., some metals such as aluminum). Other commodities can be used to produce substitutes for crude oil (e.g., maize and sugar for ethanol production or rapeseed and other oils for biodiesel production). In other cases, the main input may be a close substitute for crude oil, such as nitrogen fertilizer, which is made directly from natural gas. On the demand side, some commodities are competing with synthetic products, which are produced from crude oil (e.g., cotton with manmade fibers, natural rubber with synthetic rubber). The prices of commodities such as gas and coal are affected because of their substitutability with crude oil as sources of energy. On the other hand, increases in crude oil prices increase the disposable income of oil exporting countries and hence the demand for some commodities (two examples are tea and gold, which are characterized by high consumption levels in Middle Eastern oil producing countries). Lastly, because crude oil price spikes are often associated with inflationary pressures, the demand (and hence the price) of precious metals is expected to increase, since investors and households view these metals as more secure ways for storing wealth.

Crude oil price increases reduce disposable income, which, in turn, may slow industrial production. In principle, lower disposable income should have a negative impact on the consumption of food commodities; however, because the income elasticity for food has been estimated to be generally small, such effect may not be detectable.[3] On the other hand, lower industrial production is expected to negatively affect the demand for raw materials and metals thereby putting downward pressure on their prices. Therefore, the positive impact of crude oil price increases on the prices of food commodities—through increased production/transportation costs—is expected to overshadow the negative impact of reduced global consumption. However, this may not necessarily be the case for raw materials and metals where both impacts (i.e. increased production/transportation costs and weak demand) are expected to be large and thus may offset each other.

The objective of this paper is to estimate the pass-through of crude oil price changes to the prices of most other primary commodities. A reduced-form econometric framework is used, i.e., an OLS regression of the individual commodity price on the crude oil price by explicitly taking into account inflation and technological change. The rest of this paper proceeds as follows. The next section describes the methodological framework and the data; the penultimate section discusses empirical results for indices and individual commodities; and the last section concludes and points to some directions for future research.

Methodology and data

The estimation is based on the following specification:

$$(1) \qquad log(p_t) = \mu + \beta_1 log(POIL_t) + \beta_2 log(MUV_t) + \beta_3 t + \varepsilon_t,$$

where p_t denotes the price of a specific primary commodity at time t, $POIL_t$ denotes the price of crude oil, MUV_t denotes the price deflator, t is time trend, and ε_t denotes the error term, the of properties which will be subject to empirical investigation; β_1, β_2, and β_3 denote parameters to be estimated. The model is expressed in logarithms in order to facilitate interpreting the estimated parameters as elasticities. The estimates of β_1 and β_2 are expected to be positive while β_3 is expected to be negative in most cases—consistent with the long term impact of technological progress on commodity prices.

An alternative specification would have been to deflate both p_t and $POIL_t$ by the MUV_t and instead run the following regression:

$$(2) \qquad log(p_t/MUV_t) = \mu + \beta_1 log(POIL_t/MUV_t) + \beta_3 t + \varepsilon_t.$$

Since (2) can be rewritten as,

$$(3) \qquad log(p_t) = \mu + \beta_1 log(POIL_t) + (1-\beta_1) log(MUV_t) + \beta_3 t + \varepsilon_t,$$

regressing real commodity prices on real oil prices effectively restricts the sum of the oil price and inflation coefficients to unity (i.e. $\beta_1 + \beta_2 = 1$). The advantage of estimating (1) instead of (2) is that the homogeneity restriction is relaxed and a direct estimate the effect of inflation can be obtained (Houthakker 1975).

The dataset consists of annual observations for 35 internationally-traded primary commodities, including food, raw materials, and metals, and spans the 1960-2005 period (46 observations). The analysis is supplemented with 10 price indices—a common level of aggregation used in the literature on commodity price behavior. A brief description of the indicator price of the 35 commodities along with the price indices is given in the statistical appendix.

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 five industrial countries—France, Germany, Japan, the United Kingdom, and the United States—weighted proportionally to the countries' exports to developing countries.[4]

Admittedly, such a simplified modeling framework cannot capture the complex interplay and diverse nature of primary commodity markets. However, its simplicity along with the fact that all types of internationally-traded commodities are included in the analysis not only gives us a rough idea of the nature of the pass-through but will also guide us as to what shape future research should take.

The use of low frequency data was motivated by the desire to identify and compare the effect of crude oil prices on the prices of all primary commodity groups. Because most agricultural commodities (as opposed to other commodities such as metals) are subject to crop cycles, only annual frequency is 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 extremely volatile nature of commodity prices allows even annual observations to have large information content.[5]

Empirical results

The first step was to examine the stationarity properties of the series under consideration using the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) testing procedures. (In order to conserve space, unit roots results are not reported here.)

Almost all commodity prices and indices were found to be non-stationary, 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—exceptions were coconut oil (ADF, 5 percent and PP, 1 percent), rice and sugar (ADF, 5 percent). Therefore, validating the model would require examination of the stationarity properties of the error term of (1), in addition to conventional statistics such as R^2s and t-ratios.

On the other hand, the existence of a stationary error term ensures that the long-run nature of (1) is always accompanied by an error-correction representation with, at least, unidirectional causality—this follows the Engle-Granger representation theorem (Engle and Granger 1987). Furthermore, because crude oil either enters the aggregate production function of the other primary commodities or it works through the various substitutability conditions, the causality can be interpreted as an economic relationship rather than a simple statistical relationship.

The next two sections discuss results based on price indices along with results based on individual commodity prices.

Price indices

Results for commodity price indices are reported in Table 1. Specifically, the first three columns report parameter estimates of crude oil, inflation, and the time trend (as a proxy for technical change), followed by the adjusted-R^2, while the last two columns report the ADF and PP unit root statistics. The results—reflected in the signs of the estimated parameters as well as the conventional and stationarity statistics—indicate that crude oil prices, inflation, and technological progress explain a considerable part of commodity price variability. For example, the adjusted R^2 for the 10 index regressions averaged 0.85. Moreover, with two exceptions (PP for metals and ADF for fats & oils), unit root statistics indicate that the error term of the respective regressions is stationary, at least at the 5 percent level, further confirming the validity of the model.

The crude oil price pass-through coefficient of the non-energy index is 0.16, implying that a 10 percent increase in the price of crude oil will induce a 1.6 percent increase in the non-fuel commodity price index in the long run. Two earlier studies—Gilbert (1989) and Borensztein and Reinhart (1994)—reported elasticities of 0.12 and 0.11, respectively (see Table 2). Note that both studies include the 1973 and 1980 crude oil price spikes. When the sample of this study is adjusted to match Gilbert's and Borensztein & Reinhart's period, the respective coefficients become 0.13 and 0.12.

The estimate of pass-through to the non-fuel commodity price index, however, masks large variations among its components. The pass-through coefficient of the fertilizer index is 0.33 while for agriculture it is half of that (0.17). For metals, on the other hand, the pass-through is 0.11 and only marginally significant. Hence, the 0.16 estimate for the non-energy index reflects an average of quite diverse estimates. The picture is more blurred when one considers that the pass-through to the agriculture index reflects an average of two highly significant estimates—beverage (0.26) and food (0.18)—and one insignificant estimate—raw materials (0.04). The elasticity estimate of food, however, can be considered a firm average of its components: cereals (0.18), fats & oils (0.19), and other food (0.17), all significantly different from zero at the 5 percent level.

Three key conclusions emerge from the above regressions. First, the non-energy pass-through coefficient appears to be insensitive to the model structure as can be inferred by its remarkable similarity with the earlier studies and the fact that it did not change dramatically when different sample sizes were considered (see rows B and C in Figure 2, which consider shorter samples).[6] Second, the similarity of the results of this study with the earlier ones which used higher frequency data indicates that frequency may not be a matter of great concern at least when the objective is to derive estimates of long run elasticities. Third, the estimates of some sub-indices were quite diverse, implying that any policy-related conclusions should be based on a more disaggregated level of analysis, as the next section highlights.

The trend coefficient of the non-energy index implies an almost 1.5 percent decline per annum, after accounting for the effect of crude oil price and inflation. Again, this estimate masks considerable variation among sub-indices. The metals and fertilizer sub-indices have small and insignificant trend coefficients while agriculture has an almost 2 percent implied annual decline.[7]

Individual commodity prices

The results for indices, while informative, suggest that a proper and accurate assessment of the pass-through requires examination at a more disaggregated level. To that end, Table 3a reports results of four beverage commodities (upper panel) and 14 food commodities (lower panel) while Table 3b reports results of seven raw material & fertilizer commodities (upper panel) and 10 energy & metal commodities (lower panel).

The estimates with the least variability are those belonging to the food and fertilizer groups and hence the estimated elasticities of 0.33 and 0.18 can be safely interpreted as 'average' elasticities. The similarity of the estimates among the food commodities most likely reflects the strong substitutability conditions on both the input and output side of food crops. On the input side, growers can shift land among crops from one season to the next. Similarly, on the output side end-users of most of these commodities can shift from one commodity to another (e.g., from soybean meal to maize—used as animal feed—and from soybean oil to palm oil—used for human consumption—and *vice-versa*).

The elasticity on beverages, 0.25, is mainly cocoa-driven, which yielded a surprisingly high value of 0.49. Tea yielded a significant estimate of 0.16 but the similar estimates for coffee were not significant at the 5 percent level. It should be noted that all three beverage commodities are tree crops and thus substitutability on the input side is very limited. Substitutability on the output side is also limited since cocoa is used as an input to confectionary and chocolate products while coffee and tea are consumed as beverages in quite distinct markets (developing countries for the former and high income countries for the latter).

The elasticities of raw materials were quite diverse. Cotton and rubber estimates (0.14 and 0.17) are in the same range as those of food commodities. Note that both cotton and natural rubber compete with synthetic products (manmade fibers and synthetic rubber, respectively) whose main input is crude oil. The remaining elasticities, however, were either negative (-0.05 for logs and -0.13 for sawnwood) or close to zero (0.04 for tobacco).

Natural gas exhibited the highest elasticity (0.64 with the highest *t*-ratio and the second highest R^2), not surprisingly given its use as a key source of energy. The precious metals also exhibited high elasticities (0.34 for gold and 0.58 for silver) implying that high crude oil prices are indeed associated with inflationary pressures by households and investors.

The picture for metals was as mixed as that of raw materials, with elasticities ranging from a negative and insignificant estimate for copper to almost zero for aluminum and zinc and a highly significant estimate for tin. Of the seven metal commodities examined, only two were highly significant—iron ore (0.18) and tin (0.56)—and one was significant at the 5 percent level—lead (0.21).[8] The different performance between the food and metals equations was also evident in the unit root statistics. With the exception of beef and soybean oil, both ADF and PP statistics were significant either at the 1 or 5 percent level, which indicates that the respective equations form strong cointegrating relationships. However, this was not the case with the metals equations, of which for three (copper, iron ore, and lead) the PP statistic was not significant while for zinc it was significant only at the 10 percent level.

Aluminum's near-zero elasticity (0.04) is quite surprising, considering that its energy costs are larger than for any other metal examined in this study. Aluminum requires large amounts of electricity, which is typically generated either through hydroelectric power or from stranded natural gas, located close to production site. The implication is that the electricity and natural gas markets to which aluminum production is subjected are local, thus not responding to global energy demand and supply conditions.

A number of facts may also explain the unresponsiveness of copper, nickel, and zinc prices to the price of crude oil. First, there may be negotiated prices between extraction companies and the respective governments with concessions which effectively weaken the link between prices paid by the companies and world energy prices. Similarily, the energy sectors of the metal producing countries may be subject to policy distortions with a number of metal companies state-owned, implying that energy prices may not reflect marginal cost pricing. The lower pass-through to metals may reflect their high price, which makes transportation costs (a key component of energy use) very low compared to more bulky and lower value per ton agricultural commodities: For example, the average price of the four cereals (maize, rice, sorghum, and wheat) during 2004-05 was a little over $150/ton while the price of the seven metals examined was almost 30 times as much ($4,200/ton or $4,900/ton when iron ore is excluded). Lastly, it should be noted that substitutability on the input side is non-existent in metals since mines are metal-specific. Substitutability on the output side is also restricted as it only takes place through the use of alloys (i.e. changing the mix of metals for a specific purpose).[9]

On the other hand, the highly significant estimate for iron ore may reflect the fact that its price is based on negotiated contracts which presumably take into account cost factors such as the price of energy. Furthermore, among the seven metals, iron ore is the "bulkiest" commodity (apart from crude oil and phosphate fertilizer) with a price of $50/ton, making its transportation costs a considerable component of its price.

The more interesting metal result is for tin, which gave one of the highest estimates among all commodities (0.54, the third highest after natural gas and silver). Between 1956 and 1985, the tin market was subjected to export controls through successive International Tin Agreements (Anderson and Gilbert 1988). Therefore, the comovement between the price of crude oil (which is subject to a cartel as well, OPEC), at least for 1972-85, may not be a market-based outcome but rather a result of the actions by the Tin Agreement and OPEC; i.e., the conditions that allowed OPEC to be in a position to exert power were the same as those of the Tin Agreement, hence forcing prices to move in the same direction (note that following the collapse of the Tin Agreement, tin prices fell by more than 40 percent.)[10]

Concluding remarks

Based on annual data from 1960 to 2005 and a simple econometric model, this paper estimates the degree of pass-through of crude oil price changes to the prices of 35 other internationally-traded primary commodities. The elasticity for the non-energy commodity index was estimated at 0.16. At a more disaggregated level, the fertilizer index exhibited the largest pass-through, followed by the index for food commodities. Precious metals (not part of the non-energy index) had a very high pass-through, while beverages, raw materials, and metals gave a mixed picture. The implications are that if crude oil prices remain high, as most analysts believe will happen, then the recent commodity price boom is likely to last much longer than earlier booms, at least for the food commodities, fertilizers, and precious metals.[11] The other commodities however, especially metals and raw materials, are likely to follow diverging paths. On the methodological side, the results showed that price indices, while providing useful summary statistics, ought to be supplemented by individual commodity analysis.

Among the various ways of extending the current model (which may include the use of higher frequency data or the incorporation of dynamics through an error-correction mechanism), a useful extension would be to include additional explanatory variables (such as industrial production, exchange rates, and interest rates). A second extension may be to use of a time-varying parameter model, which would give a more precise assessment of the pass-through by allowing the elasticity to change over time.

ENDNOTES

[1] The International Energy Agency's July 2007 outlook noted that (p. 10) "Oil and gas price pressures set to remain in the coming years." Not that long ago, however, the energy outlook was different. In its March 6, 1999 issue, the *Economist*'s leader article entitled "Drowning in Oil" concluded (p. 19) that "$10 [per barrel] might actually be too optimistic. We may be heading for $5 [per barrel]. 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 $5-10 range. Factor in the current slow growth of the world economy and the normal price drops to the bottom of that range."

[2] A literature review on the oil price shocks and the macroeconomy can be found in Jones, Leiby, and Paik (2004). For an example of the effects of crude oil price changes to the various sectors of the Australian economy see Valadkhani and Mitchell (2002).

[3] Ai, Chatrath, and Song (2006), who examined whether there is excess comovement in commodity prices as argued by Pindyck and Rotemberg (1990), found that agricultural commodities respond very little to macroeconomic variables, including income.

[4] The nominal commodity price deflated by the MUV can be viewed as the terms of trade of commodity-dependent developing countries since their economies are characterized by exports of primary commodities and imports of manufactured goods.

[5] In a comparison of US and Venezuelan income growth, Campos and Ericsson (1999) showed that 16 years of annual Venezuelan data carry almost twice the information content of that in over four decades of quarterly US data (162 observations).

[6] Most studies use either World Bank or IMF commodity prices data, which are almost identical. There are some minor differences in the weight structure of price indices. The World Bank uses weights based on exports form developing countries while the IMF uses weights based on world trade.

[7] A trend regression of the real agricultural index (i.e., nominal divided by the MUV) gives an annual decline of about 1.8 percent, very similar to the trend estimate reported in Table 2. Although the simple trend regression produced a non-stationary residual, one may conclude that technological change induces a 1.5 to 2 percent annual decline in agricultural commodity prices, which is a common view in the literature and consistent with the so-called 'Prebisch-Singer' hypothesis—Prebisch (1950) and Singer (1950) argued that the net barter terms of trade between primary commodities and manufactures had been deteriorating throughout the first half of the 20th century.

[8] The results for metals in this paper echo those of Evans and Lewis (2005) who estimated a dynamic liner metals demand function and concluded that there is no common metals demand function.

[9] Aluminum and tin are substitutes. It is believed that the large market share of aluminum reflects the Tin Agreement's ability to keep tin prices high thus making aluminum an inexpensive alternative.

[10] A similar argument may be applied to coffee, cocoa, and rubber, which have also been subjected to UN-backed commodity agreements (see Gilbert 1987 for a discussion on these agreements).

[11] Radetzki (2006) examined the anatomy of the three post-WWII commodity booms (Korean war, 1970s, and the post-2004) and concluded (p. 63): "The third boom, in contrast, perseveres in mid-2006 without any end in sight." As of June 2007, the 2007 non-energy index was 12 percent higher than the 2006 average!

TABLE 1: PARAMETER ESTIMATES: PRICE INDICES

INDEX [weight]	*log(POIL$_t$)*	*log(MUV$_t$)*	*100*trend*	*Adj-R^2*	*ADF*	*PP*
Non-Energy [100.00]	0.16@	0.65@	-1.47@	0.93	-3.40**	-3.60***
	(4.32)	(5.19)	(-4.09)			
Metals [28.15]	0.11@	0.52@	-0.10	0.91	-4.36***	-2.27
	(2.28)	(3.39)	(-0.23)			
Fertilizers [2.71]	0.33@	0.24	-0.52	0.84	-4.27***	-3.01**
	(4.51)	(0.99)	(-0.75)			
Agriculture [69.08]	0.17@	0.72@	-1.98@	0.91	-3.39**	-3.38**
	(3.97)	(5.07)	(-4.81)			
Beverages [16.87]	0.26@	0.90@	-3.65@	0.73	-4.26***	-3.26**
	(2.82)	(2.97)	(-4.21)			
Raw materials [22.82]	0.04	0.81@	-0.88@	0.93	-4.21***	-4.15***
	(0.99)	(6.64)	(-2.50)			
Food [29.44]	0.18@	0.52@	-1.34@	0.85	-3.96***	-3.11**
	(3.44)	(3.03)	(-2.71)			
Cereals [6.94]	0.18@	0.52@	-1.75@	0.76	-4.25***	-3.24**
	(2.90)	(2.57)	(-3.01)			
Fats and oils [10.13]	0.19@	0.42	-1.39@	0.76	-2.88*	-3.68**
	(3.15)	(2.11)	(-2.44)			
Other food [12.36]	0.17@	0.68@	-0.99	0.86	-3.70***	-3.49**
	(2.53)	(3.16)	(-1.60)			

Notes: ADF and PP denote the Augmented Dickey-Fuller (Dickey and Fuller 1979) and Phillips-Perron (Phillips and Perron 1988) statistics. One (*), two (**), and three (***) asterisks indicate stationary error term at the 10, 5, and 1 percent levels of significance. The @ sign denotes parameter estimate significant at the 5 percent level. The estimate of the constant term is not reported here. The coefficient of time trend has been multiplied by 100 in order to be interpreted as annual price change due to technical change. The numbers in square brackets denote weights (they add to 100). The structure of the indices is illustrated in Figure 2 while their commodity composition is discussed in the statistical appendix.

TABLE 2: COMPARING ESTIMATES OF LONG-RUN ELASTICITIES FOR PRICE INDICES

	Holtham (1988) 1967:II-1984:II	*Gilbert (1989) 1965:I-1986:II*	*Borensztein & Reinhart (1994) 1970:I-1992:III*	*Present Study 1960-2005*
Non-energy	—	0.12	0.11	0.16
Food	—	0.25	—	0.18
Non-food	—	0.12	—	0.33/0.04
Raw materials	0.08	—	—	0.04
Metals	0.17	0.11	—	0.11

Notes: Holtham uses semiannual data, Gilbert and Borensztein & Reinhart quarterly, and 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. The two non-food figures of the present study correspond to fertilizers and raw materials. '—' means not available.

Source: Holtham (1988), Gilbert (1989), Borensztein & Reinhart (1994), and author's estimates.

Table 3a: Parameter Estimates: Beverages and Food

	log(POIL$_t$)	*log(MUV$_t$)*	*100*t*	*Adj-R^2*	*ADF*	*PP*
BEVERAGES						
Cocoa	0.47@	0.32	-2.71@	0.70	-2.89*	-2.81*
	(4.42)	(0.90)	(-2.28)			
Coffee, arabica	0.19	1.44@	-3.94@	0.69	-3.55**	-3.64***
	(1.80)	(3.34)	(-4.04)			
Coffee, robusta	0.19	1.63@	-6.92@	0.60	-4.51***	-2.83*
	(1.41)	(3.69)	(-5.45)			
Tea	0.14@	0.32	-0.51	0.78	-3.84***	-3.82***
	(2.64)	(1.79)	(-1.01)			
FOOD						
Bananas	0.05	0.62@	0.52	0.93	-4.22***	-4.15***
	(1.10)	(4.33)	(1.24)			
Beef	0.11	0.61@	-0.97	0.79	-2.72*	-2.73*
	(1.66)	(2.85)	(1.58)			
Oranges	0.13@	0.17	1.93@	0.90	-3.63**	-3.71**
	(2.36)	(0.95)	(3.71)			
Sugar	0.20	1.06@	-3.70@	0.48	-3.25**	-3.13**
	(1.30)	(2.04)	(-2.47)			
Maize	0.19@	0.40@	-1.31@	0.79	-3.80***	-3.64***
	(3.41)	(2.23)	(-2.53)			
Rice	0.14	0.70@	-2.55@	0.59	-4.60***	-3.09**
	(1.66)	(2.51)	(-3.16)			
Sorghum	0.20@	0.36@	-1.03@	0.82	-3.61***	-3.67***
	(3.73)	(2.10)	(-2.07)			
Wheat	0.20@	0.45@	-1.25@	0.84	-4.59***	-3.15**
	(3.71)	(2.51)	(-2.41)			
Coconut oil	0.22@	0.11	-0.84	0.41	-5.91***	-4.42***
	(2.26)	(0.35)	(-0.90)			
Groundnut oil	0.28@	0.12	0.03	0.77	-3.77***	-3.67**
	(3.59)	(0.48)	(0.04)			
Palm oil	0.25@	0.29	-1.58	0.60	-2.97**	-3.68***
	(2.96)	(1.04)	(-1.98)			
Soybean meal	0.13	0.61@	-1.46@	0.75	-4.65***	-4.53***
	(1.91)	(2.81)	(-2.34)			
Soybean oil	0.25@	0.24	-1.11	0.66	-2.64*	-3.51**
	(3.23)	(0.93)	(-1.52)			
Soybeans	0.18@	0.50@	-1.33@	0.81	-4.08***	-3.98***
	(3.09)	(2.67)	(-2.48)			

Notes: See notes in Table 1.

TABLE 3b: PARAMETER ESTIMATES: RAW MATERIALS AND METALS

	log(POIL$_t$)	*log(MUV$_t$)*	*100*trend*	*Adj-R^2*	*ADF*	*PP*
RAW MATERIALS & FERTILIZERS						
Cotton	0.14@	0.89@	-2.75@	0.86	-4.65***	-4.65***
	(2.59)	(5.21)	(-5.61)			
Rubber	0.17@	0.58@	-1.85@	0.67	-4.18***	-3.27**
	(2.14)	(2.26)	(-2.51)			
Timber, logs	-0.05	1.57@	-1.04@	0.96	-6.07***	-6.08***
	(-1.03)	(9.89)	(-2.27)			
Timber, sawnwood	-0.13@	0.94@	1.01@	0.95	-3.31**	-4.07***
	(-3.13)	(6.69)	(2.63)			
Tobacco	0.04	0.57@	-0.34	0.83	-3.23**	-3.22**
	(0.83)	(3.28)	(-0.68)			
Phosphate rock	0.37@	0.26	-0.70	0.87	-4.61***	-3.19**
	(5.24)	(1.12)	(-1.06)			
TSP	0.31@	0.23	-0.43	0.79	-4.45***	-2.79*
	(3.80)	(0.87)	(-0.55)			
ENERGY & METALS						
Gas, US	0.64@	-0.37	0.74@	0.97	-3.03**	-3.00**
	(8.18)	(-1.45)	(7.44)			
Gold	0.34@	1.49@	-2.42@	0.98	-3.78***	-3.76***
	(7.04)	(9.30)	(-5.25)			
Silver	0.58@	0.38	-2.42@	0.87	-3.76***	-3.70**
	(6.50)	(1.29)	(-2.85)			
Aluminum	0.04	0.80@	-0.25	0.92	-4.82***	-3.33**
	(0.73)	(4.95)	(-0.53)			
Copper	-0.07	0.63@	0.82	0.60	-4.04***	-2.48
	(-0.82)	(2.21)	(0.30)			
Iron ore	0.24@	0.18	0.80	0.93	-3.74***	-2.03
	(5.28)	(1.20)	(1.88)			
Lead	0.21@	0.46	-1.03	0.71	-2.91*	-2.37
	(2.41)	(1.60)	(-1.24)			
Nickel	0.12	0.47	1.20	0.83	-4.11***	-3.12**
	(1.35)	(1.65)	(1.46)			
Tin	0.56@	0.20	-3.65@	0.81	-3.85***	-3.80**
	(7.15)	(0.76)	(-4.94)			
Zinc	0.06	0.93@	-0.46	0.84	-4.37***	-2.84*
	(0.70)	(3.41)	(-0.58)			

Notes: See notes in Table 1.

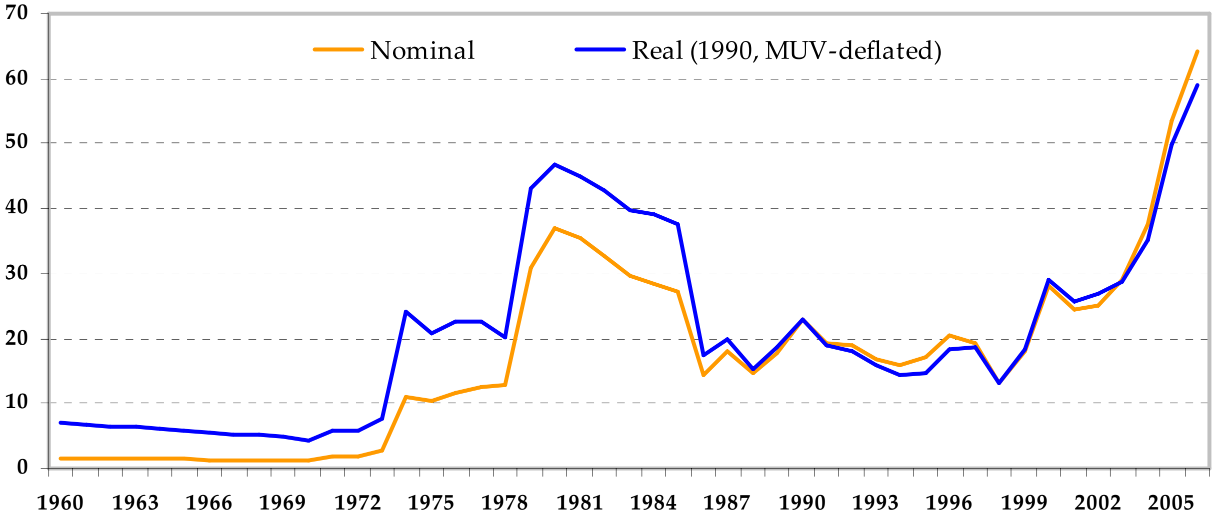
TABLE 4: COMPARING ESTIMATES OF LONG-RUN ELASTICITIES FOR METALS

	Baffes (1997) *1971:IV-1988:IV*	*Chaudhri (2001)* *1973:1-1996:5*	*Present Study* *1960-2005*
Aluminum	-0.04	0.11	0.04
Copper	0.25	-0.19	-0.07
Iron ore	0.17	—	0.24
Lead	0.22	0.09	0.21
Nickel	—	-0.05	0.12
Tin	0.30	0.55	0.56
Zinc	—	-0.17	0.06

Notes: Baffes uses quarterly data, Chaudhri monthly, and the present study annual. '—' means not available.

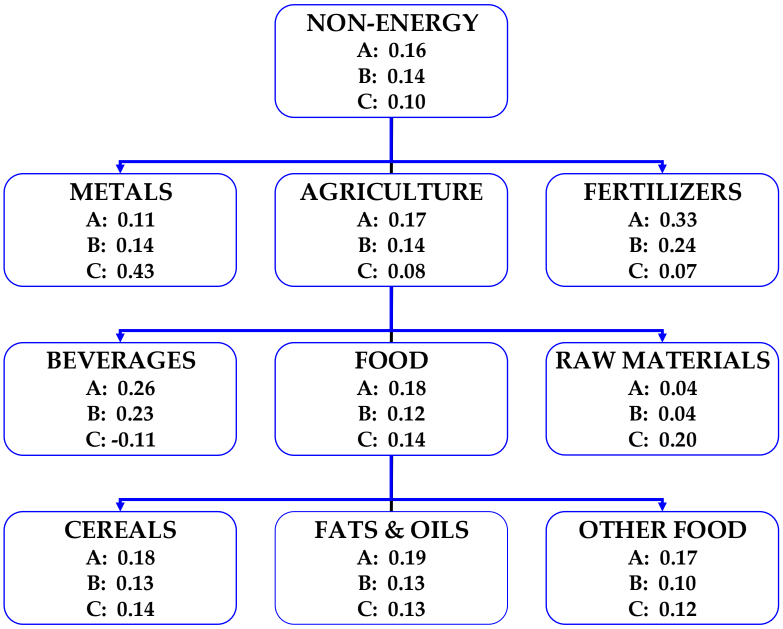
Source: Baffes (1997), Chaudhri (2001), and author's estimates.

FIGURE 1: CRUDE OIL PRICES (US$ per barrel)



Source: World Bank

FIGURE 2: COMMODITY PRICE INDICES AND CRUDE OIL PRICE PASS-THROUGH



Notes: The numbers following the letters A, B, and C refer to elasticities for the 1960-2005, 1972-2005, and 1984-2005 periods, respectively. The numbers in row A are the same as the ones reported in Table 1.

Source: Author's estimates

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STATISTICAL APPENDIX

The dataset consists of the prices of 35 internationally traded primary commodities covering the 1960-2005 period (46 annual observations). The analysis was supplemented with 10 price indices—a common level of aggregation used in the literature of commodity price behavior. A description of the price indicators along with average price for 2003-04 is given in Table A1. The numbers in the square brackets correspond to the percentage weights used for the construction of the non-fuel price index. The precious metals, gold and silver, are not part of the non-fuel commodity price index (thus appearing in Table A1 without weights.) The weights used for the construction of indices are constant and are based on the export value shares of the respective commodities from developing countries for the 1987-89 period—the choice of the specific period was motivated by the desire to be approximately in the middle of the sample.

Data on commodity prices are collected and reported by the World Bank. The structure of the indices can be seen in Figure 2; the specific commodity-composition of the indices is as follows:

- **Beverages**: cocoa, coffee arabica, coffee robusta, tea;
- **Cereals**: maize, rice, sorghum, wheat;
- **Fats & oils**: coconut oil, groundnut oil, palm oil, soybean meal, soybean oil, soybeans;
- **Other food**: bananas, beef, oranges, sugar;
- **Raw materials**: cotton, rubber, timber (logs), timber (sawnwood), tobacco;
- **Fertilizers**: phosphate, TSP;
- **Metals**: aluminum, copper, iron ore, lead, nickel, tin, zinc.

More details regarding the construction and behavior of the World Bank commodity price indices reported here can be found in Grilli and Yang (1988) and Pfaffenzeller, Newbold, and Rayner (2007).

TABLE A1: DATA DESCRIPTION (PRICES DENOTE 2004/05 AVERAGES)

Commodity [weight]	*Price*	*Description*
Crude Oil	337	Average spot of Brent, Dubai, West Texas, equally weighted ($/ton)
Natural gas, US	7.4	Spot, Henry Hub, Louisiana ($/million British thermal units)
Cocoa [3.92]	1,544	ICCO indicator, average of the first 3 positions of New York and London ($/ton)
Coffee, arabica [7.00]	2,153	ICO indicator, average New York and Bremen/Hamburg, ex-dock ($/ton)
Coffee, robusta [3.81]	954	ICO indicator, average New York and Le Havre/Marseilles, ex-dock ($/ton)
Tea [2.14]	1,666	Weekly average of 3 auctions (Mombasa, Colombo, Kolkata) ($/ton)
Bananas [2.31]	564	Central and South American, US import prices f.o.t. US Gulf ($/ton)
Beef [1.79]	2,565	Australian/New Zealand c.i.f. US ports ($/ton)
Oranges [0.82]	887	Mediterranean exporters, EEC indicative import price, c.i.f. Paris ($/ton)
Sugar [7.45]	188	World, ISA daily price, raw, f.o.b. Caribbean ports ($/ton)
Maize [1.68]	105	US, no. 2 yellow, f.o.b. US Gulf ports ($/ton)
Rice [2.91]	262	Thai, 5% broken, based on surveys of export transactions, f.o.b. Bangkok ($/ton)
Sorghum [0.38]	103	US, no. 2 yellow, f.o.b. US Gulf ports ($/ton)
Wheat [1.97]	155	US, hard red winter, export US Gulf ports ($/ton)
Coconut oil [0.66]	639	Philippines/Indonesia, bulk, c.i.f. Rotterdam ($/ton)
Groundnut oil [0.20]	1,111	Any origin, c.i.f. Rotterdam ($/ton)
Palm oil [2.29]	447	Malaysian, 5% bulk, c.i.f. N.W. Europe ($/ton)
Soybean meal [4.12]	228	Argentina, c.i.f. Rotterdam ($/ton)
Soybean oil [0.84]	581	Dutch, crude, f.o.b. ex-mill ($/ton)
Soybeans [2.02]	291	US, c.i.f. Rotterdam ($/ton)
Cotton [5.86]	1,291	'A Index' average of the cheapest 5 of 15 styles traded in N. Europe, c.i.f. ($/ton)
Rubber [4.85]	1,403	Asian, RSS 1, Singapore Commodity Exchange, 30 days forward ($/ton)
Timber, logs [2.88]	200	Malaysian, meranti, sale price charged by importers, Tokyo ($/cubic meter)
Timber, sawnwood [6.38]	620	Malaysian, meranti, UK ports ($/cubic meter)
Tobacco [2.85]	2,765	US import unit value ($/ton)
Phosphate rock [1.77]	44	Moroccan, contract, f.a.s. Casablanca ($/ton)
TSP [0.94]	194	Bulk, spot, f.o.b. US Gulf ($/ton)
Gold	427	UK, London afternoon fixing, average of daily rates ($/troy oz)
Silver	7.0	Refined grade (Handy & Harman), New York ($/troy oz)
Aluminum [7.93]	1,807	LME, settlement price ($/ton)
Copper [9.30]	3,272	LME, settlement price ($/ton)
Iron ore [5.36]	51	Brazilian, CVRD, contract price to Europe, f.o.b. Porta de Madeira ($/ton)
Lead [0.50]	931	LME, settlement price ($/ton)
Nickel [2.19]	14,284	LME, settlement price ($/ton)
Tin [1.60]	7,946	LME, settlement price ($/ton)
Zinc [1.27]	1,215	LME, settlement price ($/ton)

Source: World Bank, Commodity Price Data (shaded rows indicate prices not measured in $/ton).