Trends, fluctuations, and determinants of commodity prices

Luis Eduardo Arango, Fernando Arias and Luz Adriana Flórez

(Work in progress)

The first decade of the new century has been surprising in the sense it has witnessed a commodity price boom – including the prices of many commodities important in Latin America, such as crude oil, coal, copper iron ore, Arabica coffee, maize, soybeans and sugar.

Most commentators link the boom to rapid Chinese consumption growth. This is probably correct but makes it difficult to project how long prices will remain high.

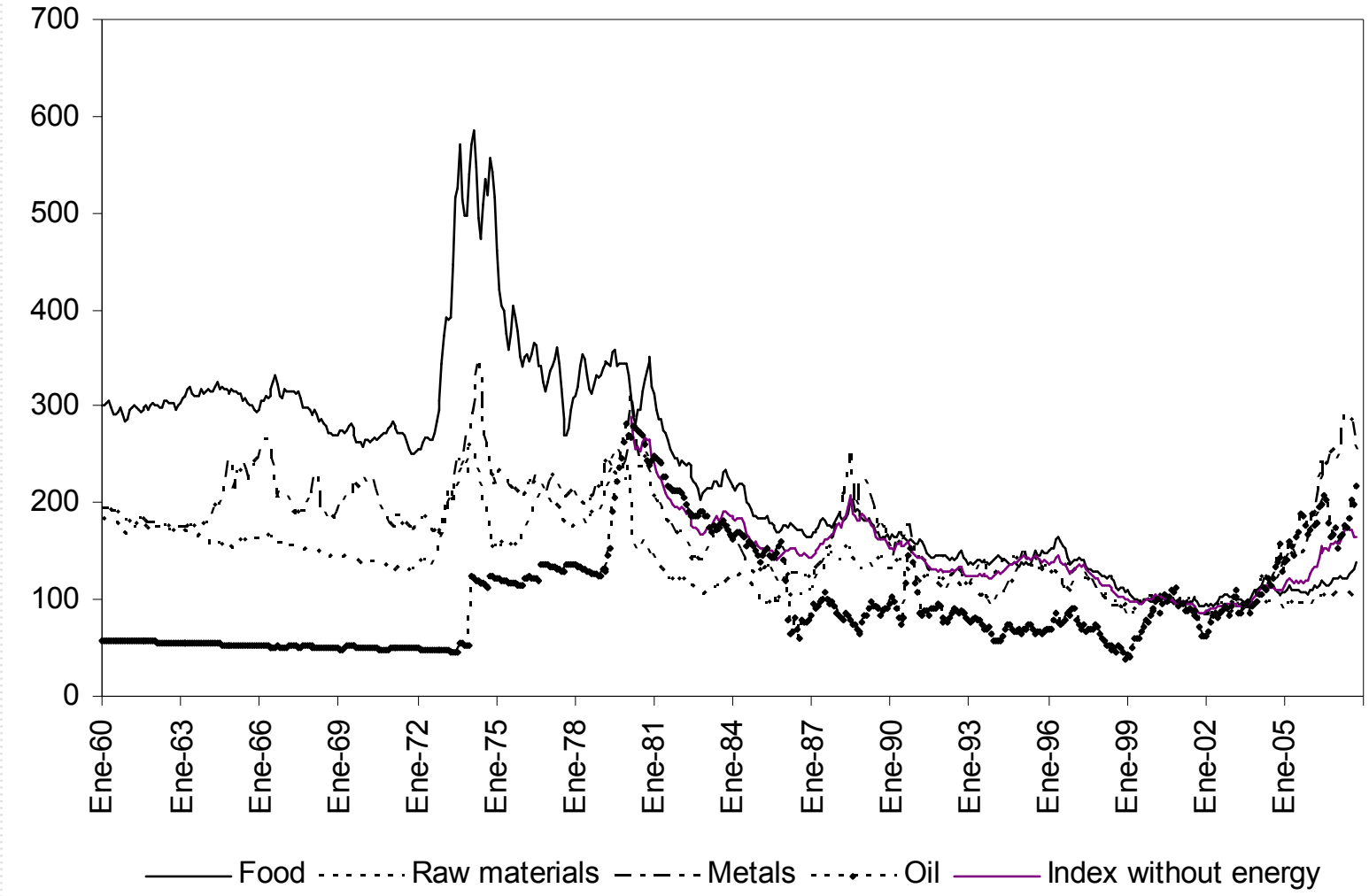
However, as we will see, the above hypothesis has been accompanied by other explanations.

Plan

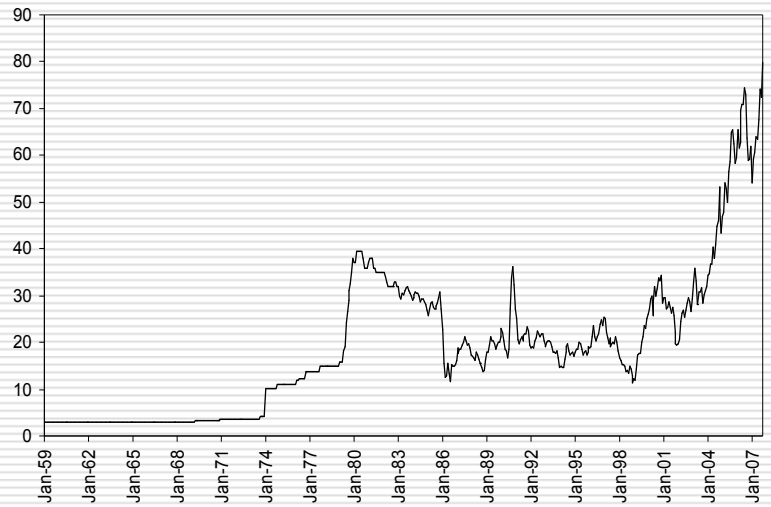
1. Motivation
2. Stylized facts: long run behavior
3. Stylized facts: short run properties
4. A structural approach
5. Temporary conclusions

1. Motivation

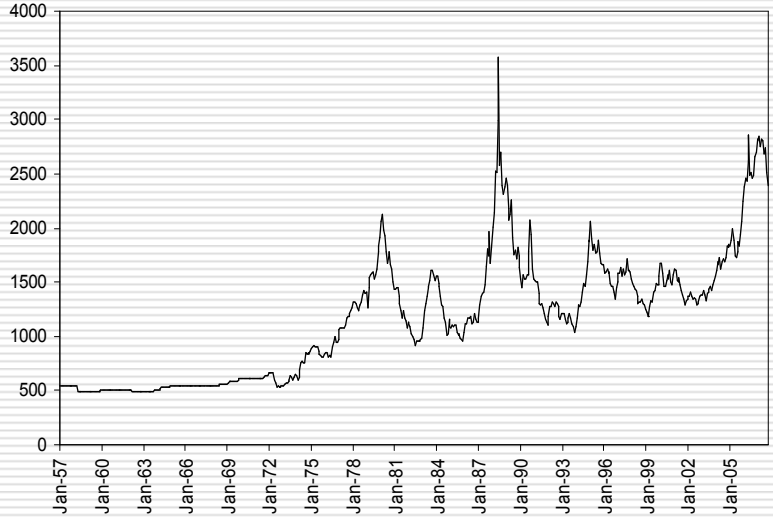
Real index commodity prices (CPI US)



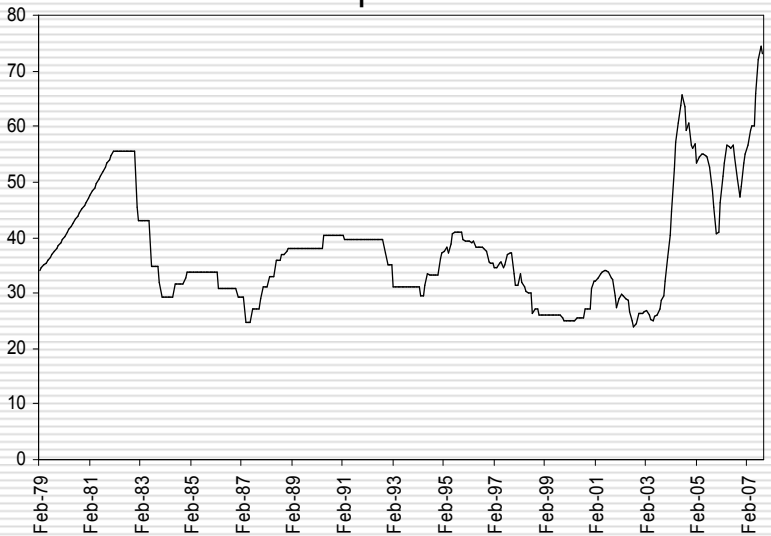
Petroleum. West Texas Intermediate
US Dollars per barrel



Aluminium
US Dollars per metric ton



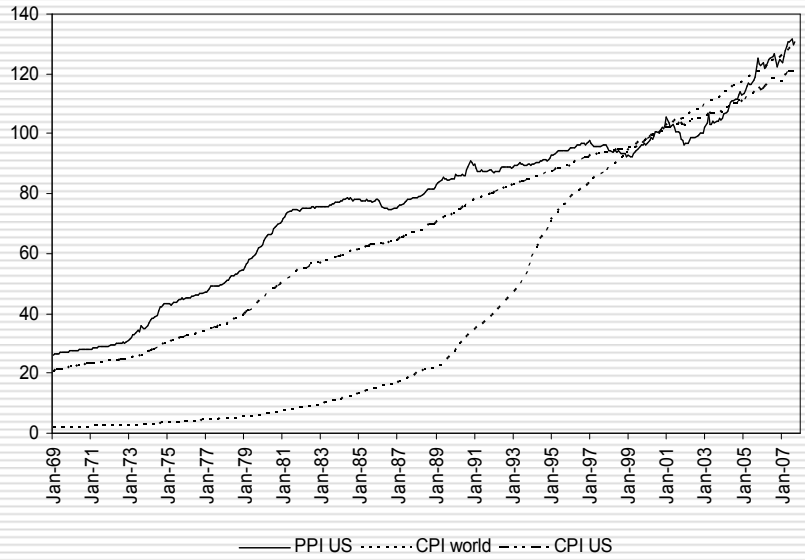
Coal. Australia
US Dollars per metric ton



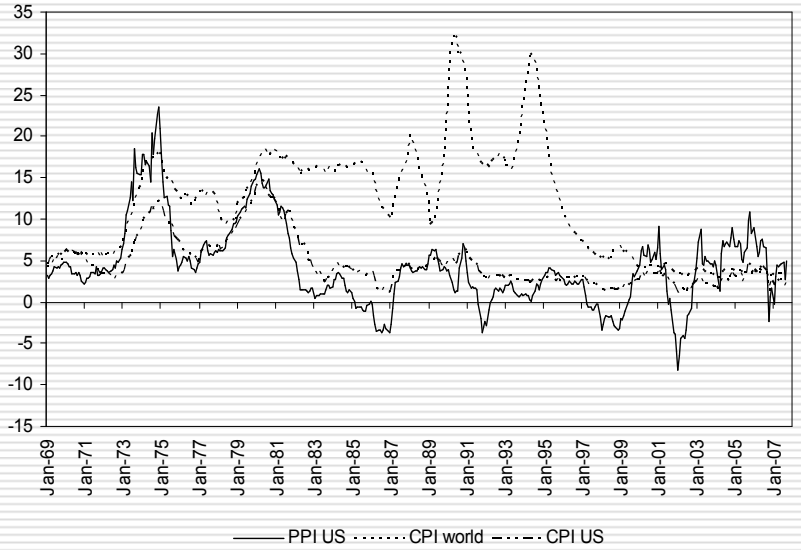
Gold. United Kingdom

Wheat. US Gulf
US Dollars per metric ton

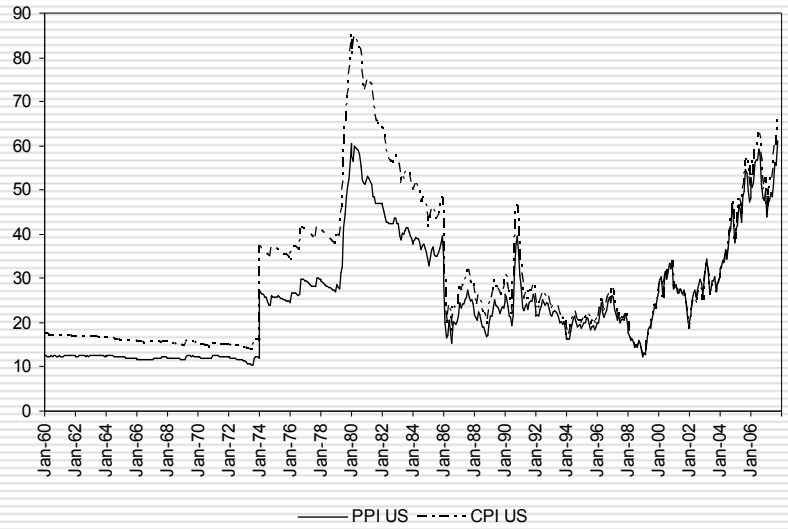
Price indexes



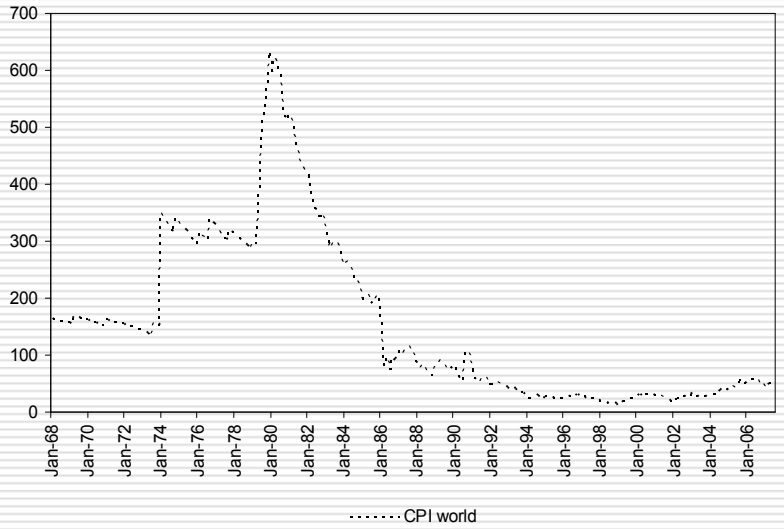
Inflation indicators



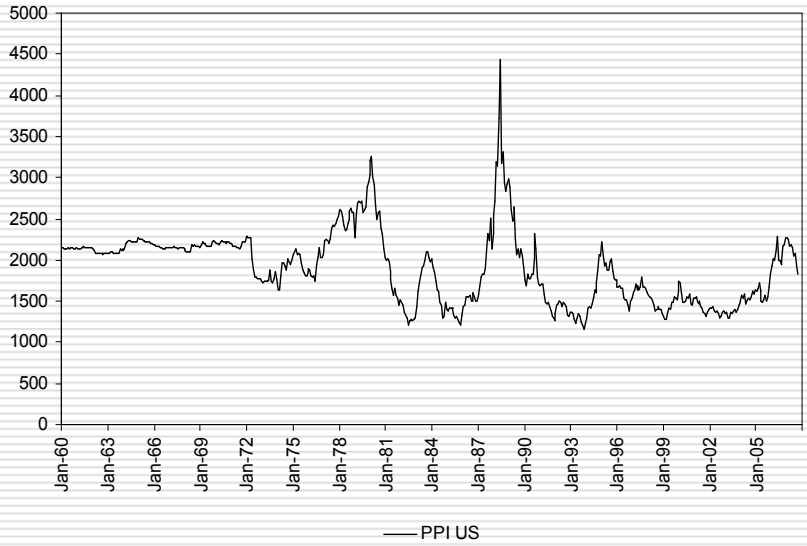
Petroleum. West Texas Intermediate
US Dollars per barrel. Real terms



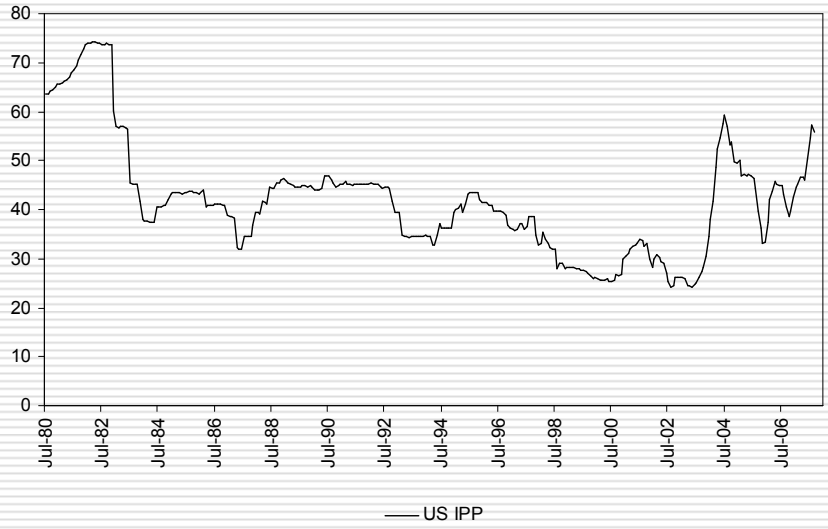
Petroleum. West Texas Intermediate
US Dollars per barrel. Real terms



Aluminium
US Dollars per metric ton. Real terms



Coal. Australia
US Dollars per metric ton. Real terms



Gold. United Kingdom
Real terms

Wheat. US Gulf
US Dollars per metric ton. Real terms

Reasons for the recent behavior of commodity prices

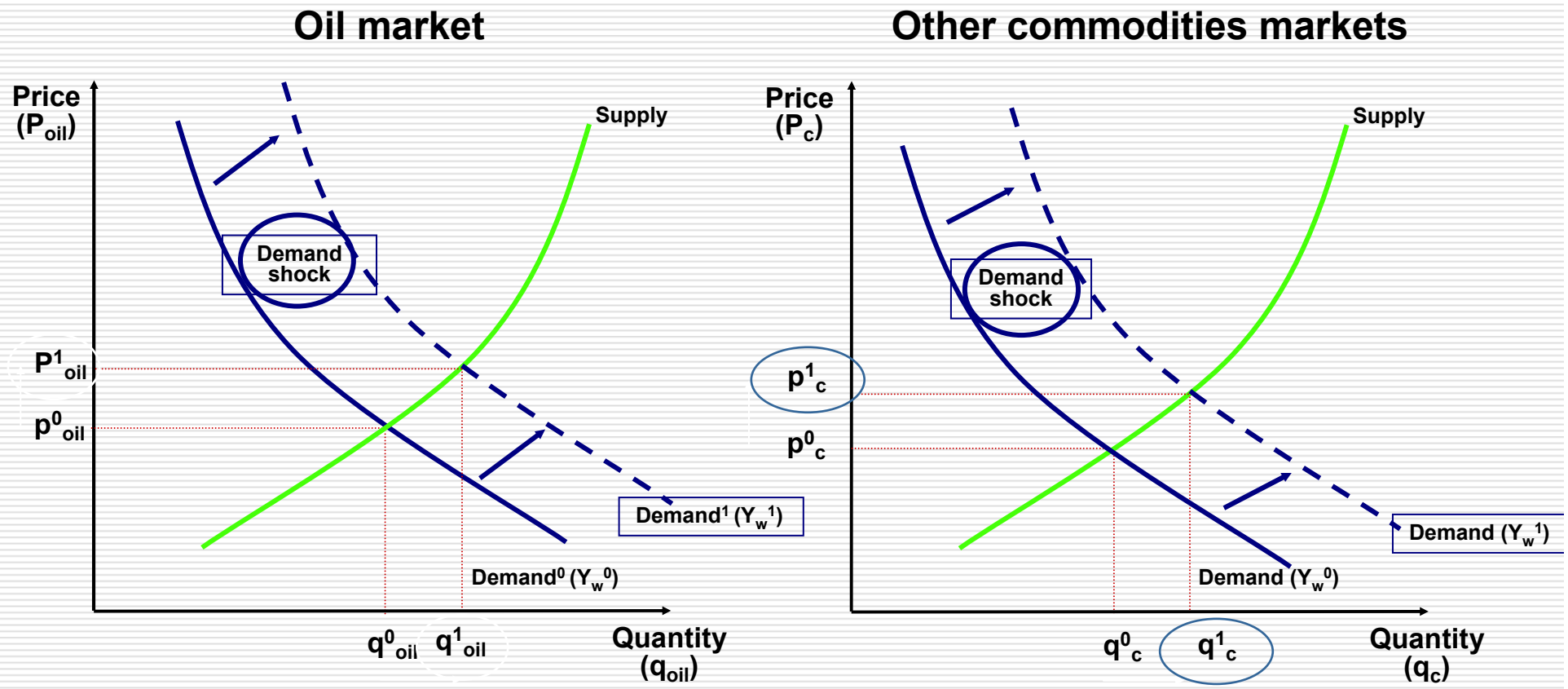
i) Geopolitical stress … [Jaramillo (2006), Di Placido (2007)].

ii) "…the rise of China and other large emerging markets may have led to a fundamental change in long-term price trends, and the world has now entered a period of sustained high prices, particularly of metals, [Barclays Capital (2006) cited in WEO (2006); Cheung and Morin (2007), Gilbert (2006)].

It is important to distinguish between final form intermediate consumption of commodities in China since only the former can be understood as net new demand (Gilbert, 2006).

In particular, Chinese demand for energy and raw material commodities is growing at a rate higher than supply. New oil wells and mines and take 7-10 years to come on stream. This might suggest that commodity prices may remain persistently high.

Oil and other commodities demand shocks: a simple graphical analysis



Y_w = World output

Source: Latin Macro Watch, 2006. Borrowed from a presentation of Fidel Jaramillo, IDB, 2006.

iii) "…speculative forces have largely decoupled metals prices from market fundamentals [Societe General (2006) cited by WOE (2006)].

In this case prices are viewed as a bubble, driven by hedge funds and other speculators characterized as having extrapolative expectations. The dramatic rise in futures trading over the past decade and increased volatility over the same period are cited as evidence for the claim that speculation drives prices (Gilbert, 2006).

iv) "An avalanche of cash and simpler forms of buying and selling are triggering the price of commodities including oil, platinum, and wheat to very high levels , regardless of the decline of economic activity" (El Tiempo, 2008, 29 February).

Why Are Oil and Metal Prices High? Don´t forget Low Interest Rates. Jeffrey A. Frankel. Financial Times, 4/15/05

"…Commodity prices are back, with vengeance", "The central argument of this paper is that real commodity prices can be a signal that monetary policy is loose" (Frankel, 2006).

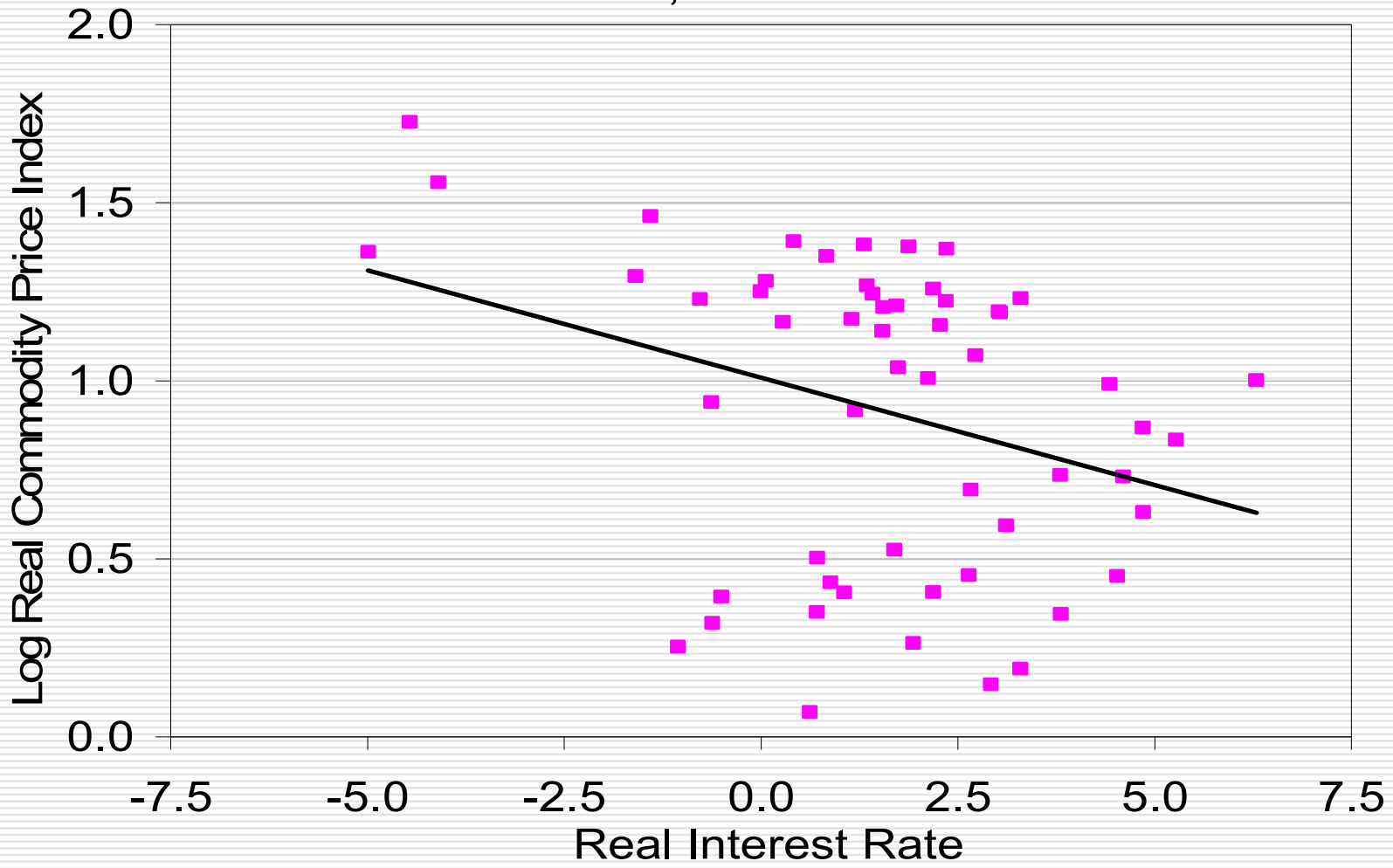
"High (short term) interest rates reduce the demand for storable commodities, or increase the supply, through a variety of channels:

a) by increasing the incentive for extraction today rather than tomorrow.
b) by decreasing firms' desire to carry inventories.
c) by encouraging speculators to shift out commodity contracts and into treasury bills".

All this within an *overshooting* model in which the real commodity prices in excess of the long run value is explained by the real interest rate.

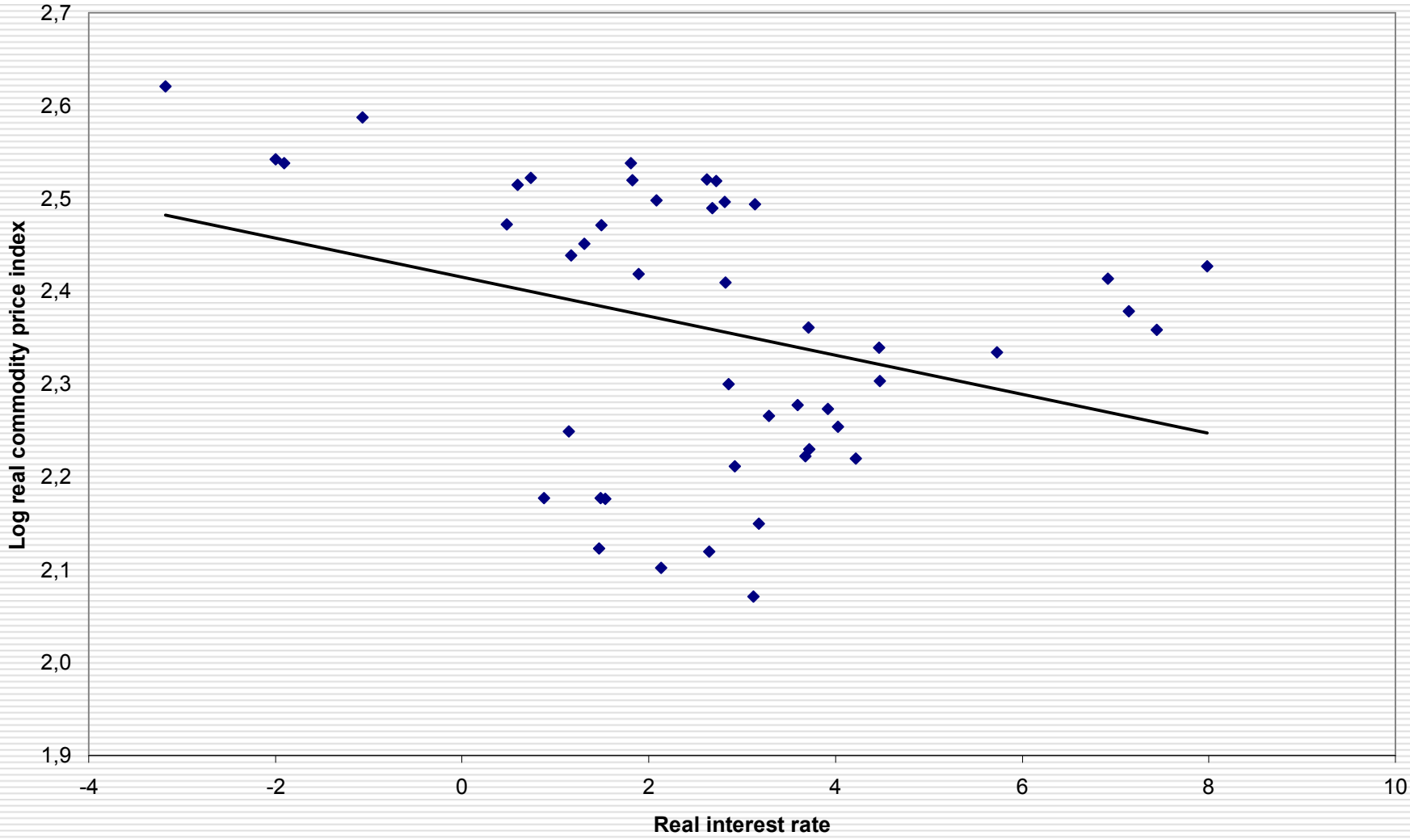
CRB Commodity Price Index vs. Real Interest Rate

Annual, 1950-2005



Source: Global Financial Data Inc.

Real interest rate and Real commodity price index (CRB)
1962-2007



In the movements of commodity prices are interested governments, monetary authorities, firms, investors, hedge funds, speculators and consumers.

All these participants follow not only the short run behavior of prices but also their movements in the long run.

This paper is aimed to make a marginal contribution on the properties of commodity prices both in the long run and over the business cycle and, mainly, on their determinants.

This work deals with different facets of commodity prices:

i) The Prebisch-Singer hypothesis, PSH: the long run component of primary good prices relative to manufactured good prices tends downwards.

ii) Properties of fluctuations (such as asymmetries, relationship with economic activity, etc.)

iii) Determinants of price behavior. From a supply-demand framework, we derive an expression in which prices depend on its own history, the supply of commodities, total factor productivity, real interest rate, and the price of goods.

This approach encompasses Frankel's (1986, 2005, 2006) according to which prices of commodities respond to monetary policy: the more relaxed the monetary policy, the lower the real interest rate and the higher the real commodity prices.

There are four features of commodity prices: long periods of tranquil times followed by some sudden spikes; a downward trend; excess comovement; and high persistence. Here we (believe that) address some of them.

2. Stylized facts: long run behavior

The Prebisch-Singer hypothesis: the long run component of primary good prices relative to manufactured good prices tends downwards.

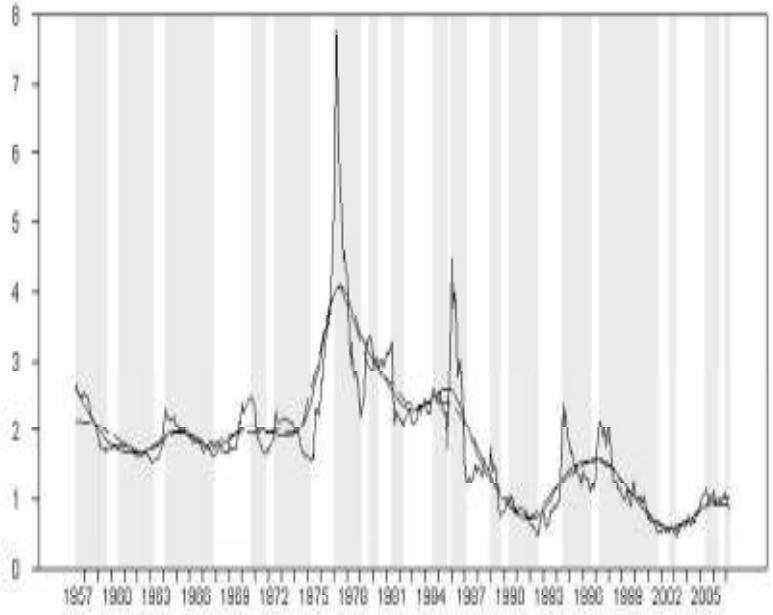
In favor of PSH: Spraos (1980), Sapsford (1985), Grilli and Yang (1988), Bloch and Sapsford (1997), among many others].

Against PSH: Perron (1990), Powell (1991), Cuddington (1992), Kellard and Wohar (2006).

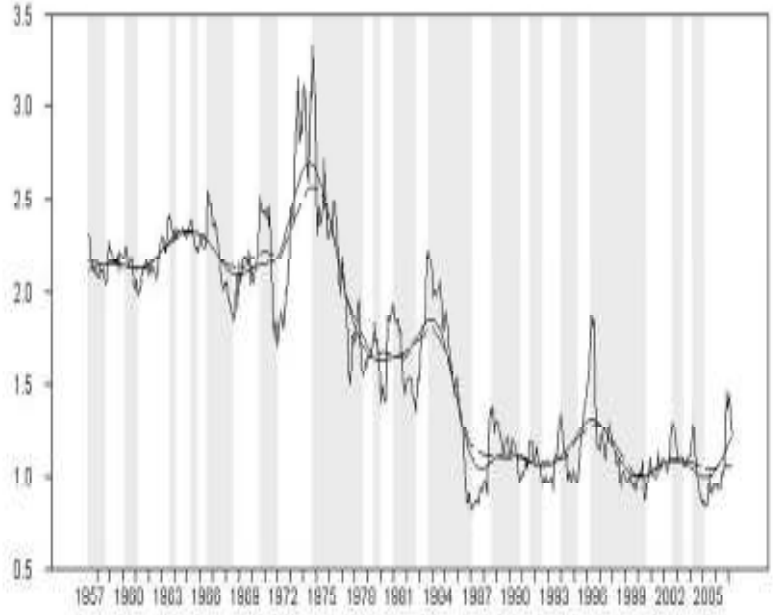
We estimate the long run component of relative commodity prices through the Phase Average Trend, *PAT* (Boschan and Ebanks, 1978).

Such a technique is used here for seventeen commodities (coffee, maize, sugar, palm oil, cotton, aluminium, iron, nickel, gold, silver, rubber, coal, natural gas, gas, oil and wheat).

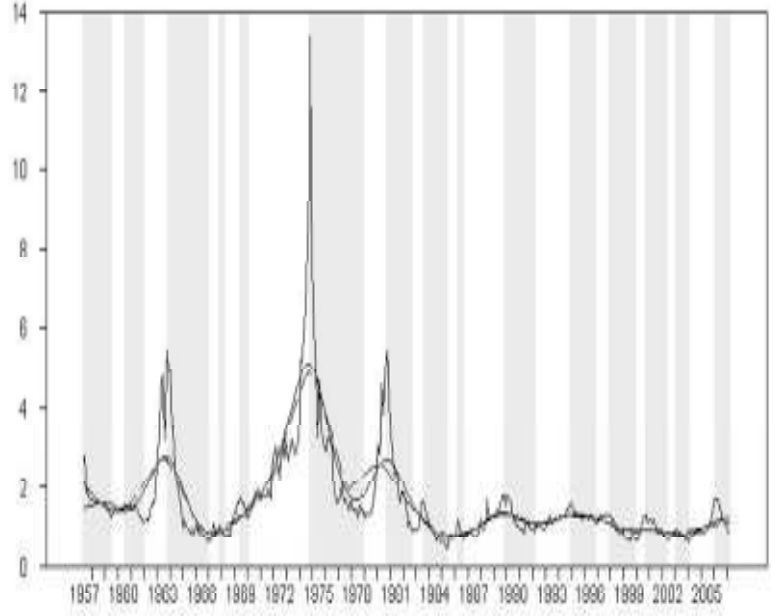
The PAT method is also used for tracking the manufactured good prices and the Industrial Production Index of developed countries.



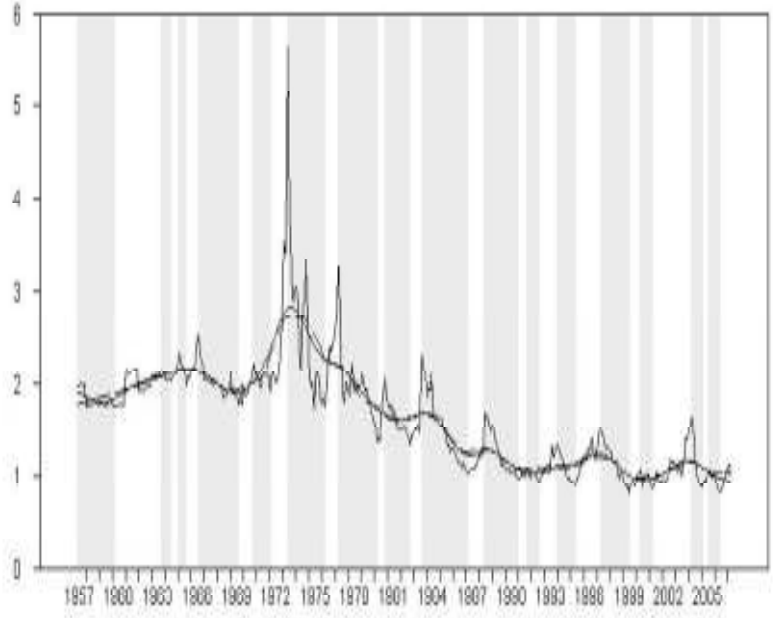
Coffee (May 1957 – April 2007)



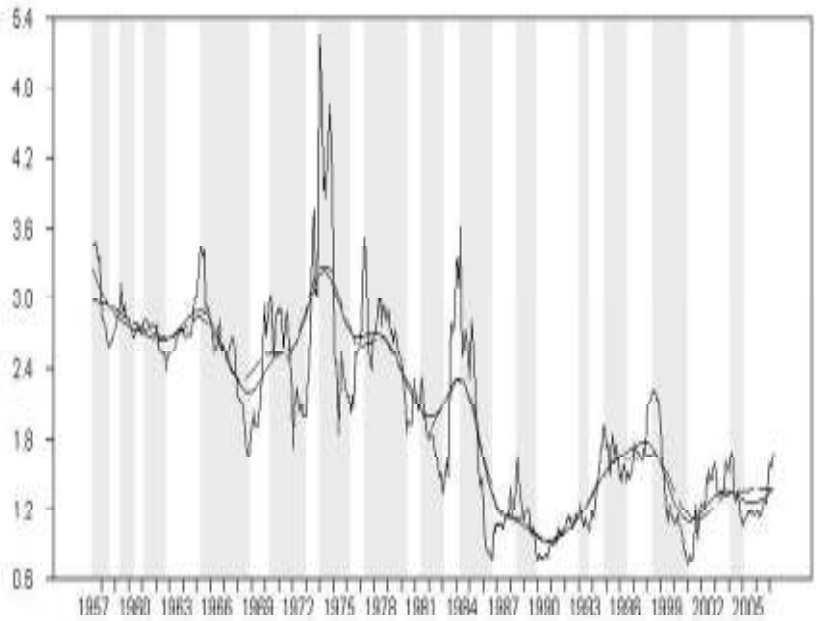
Maize (May 1957 – April 2007)



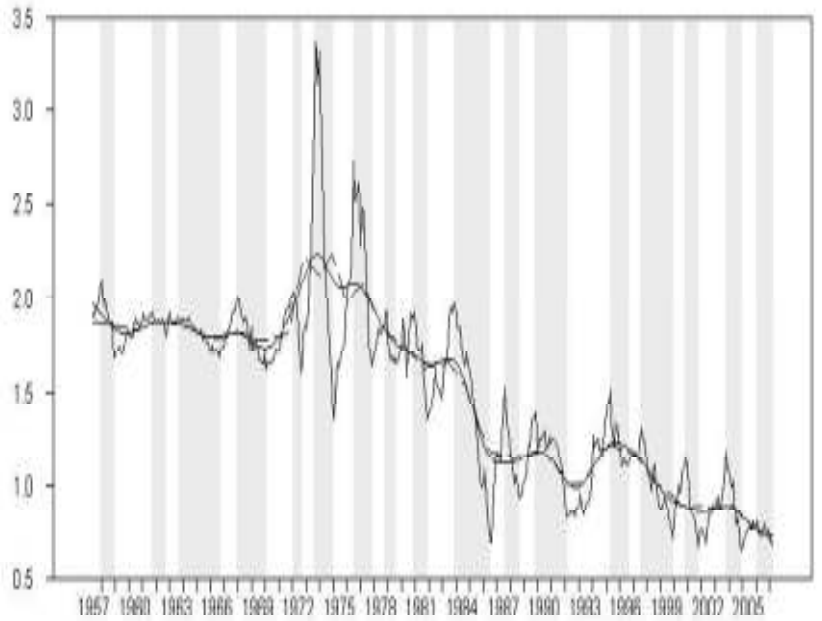
Sugar (May 1957 – April 2007)



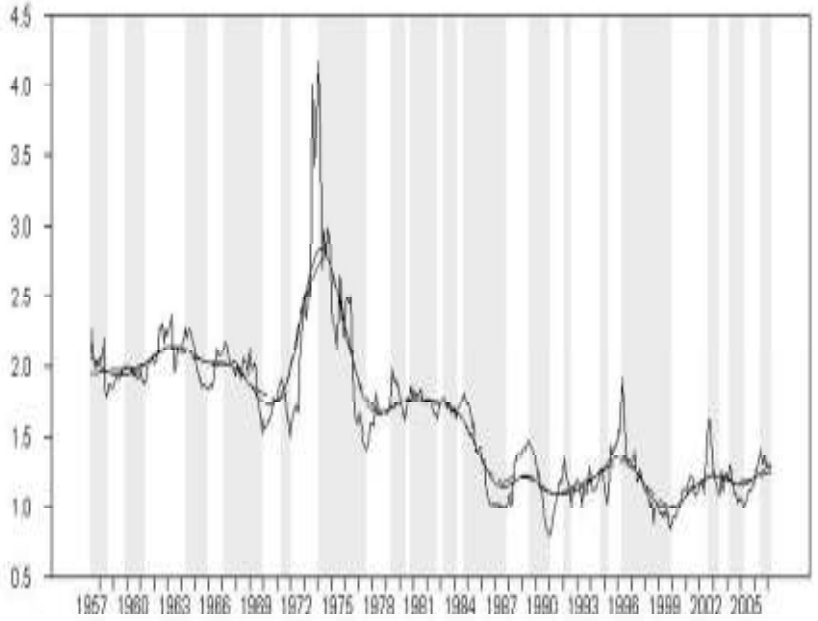
Soybeans (May 1957 – April 2007)



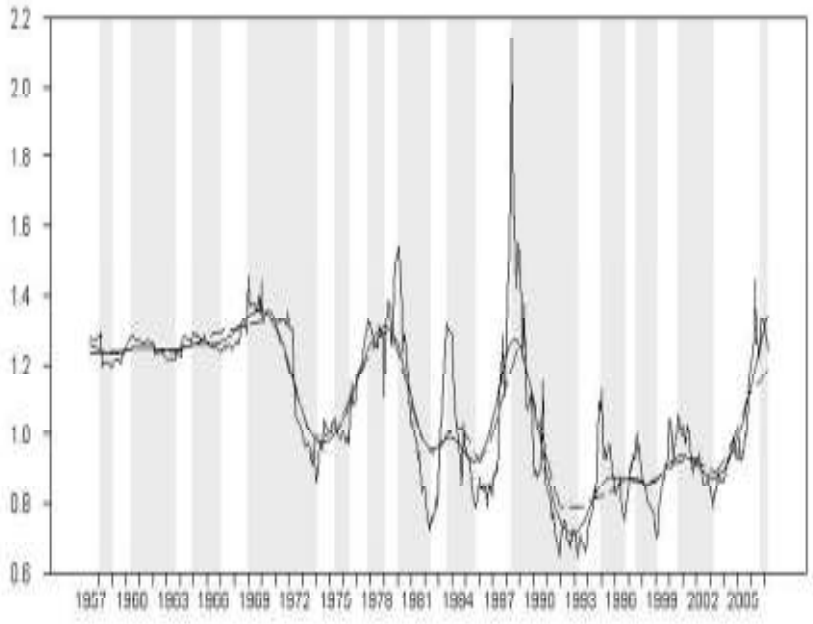
Palm Oil (May 1957 – April 2007)



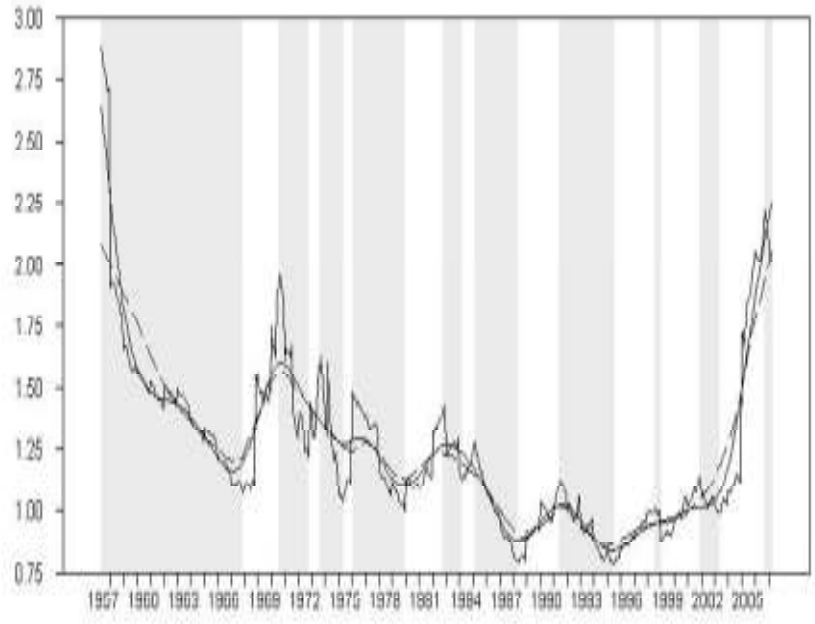
Cotton (May 1957 – April 2007)



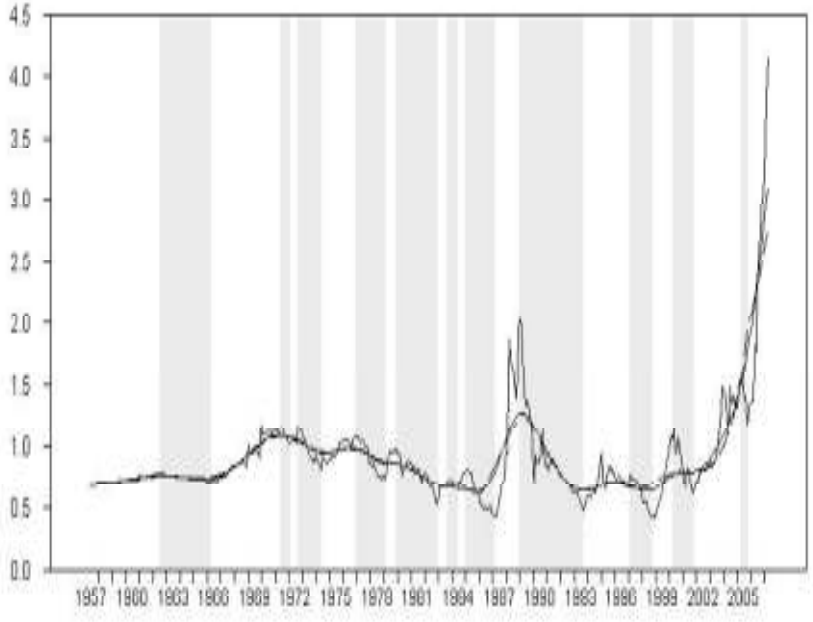
Wheat (May 1957 – April 2007)



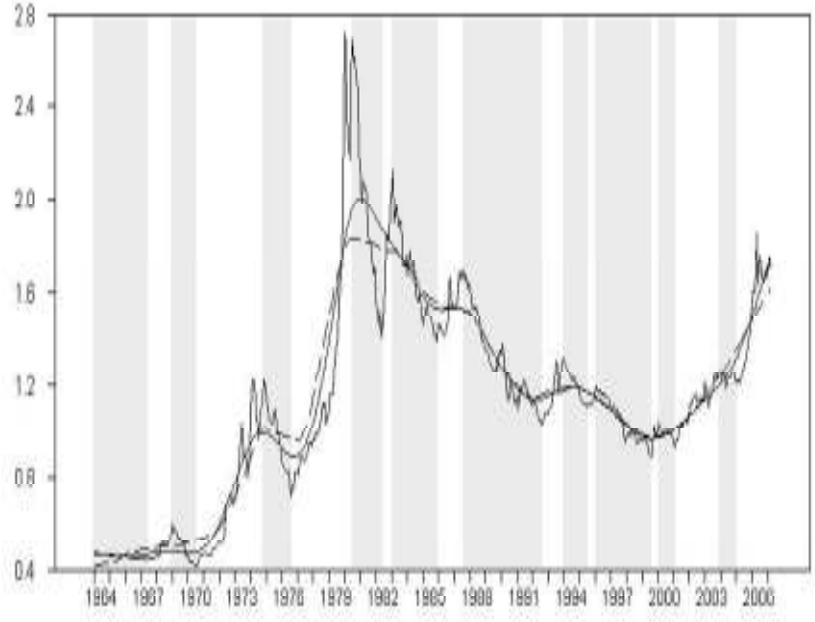
Aluminium (May 1957 – April 2007)



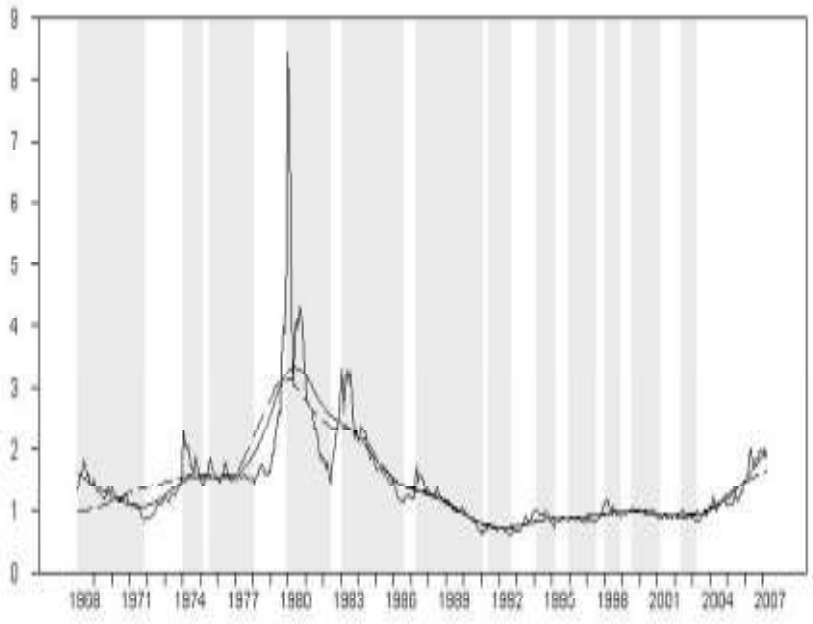
Iron (May 1957 – April 2007)



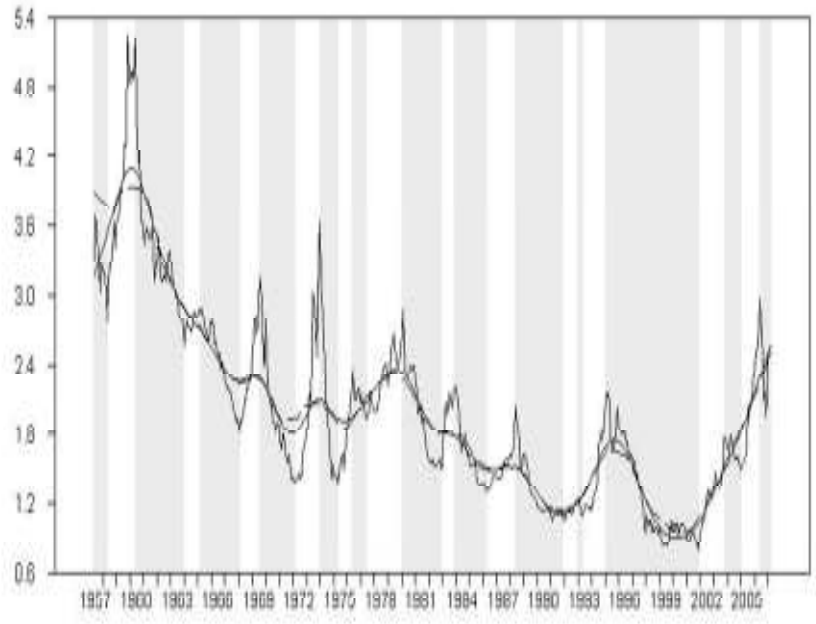
Nickel (May 1957 – April 2007)



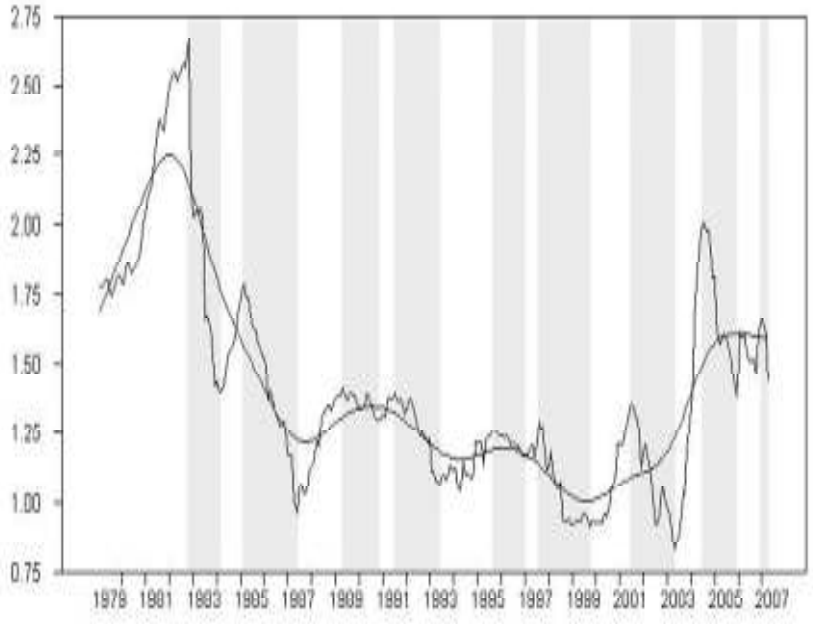
Gold (Jan 1964 – April 2007)



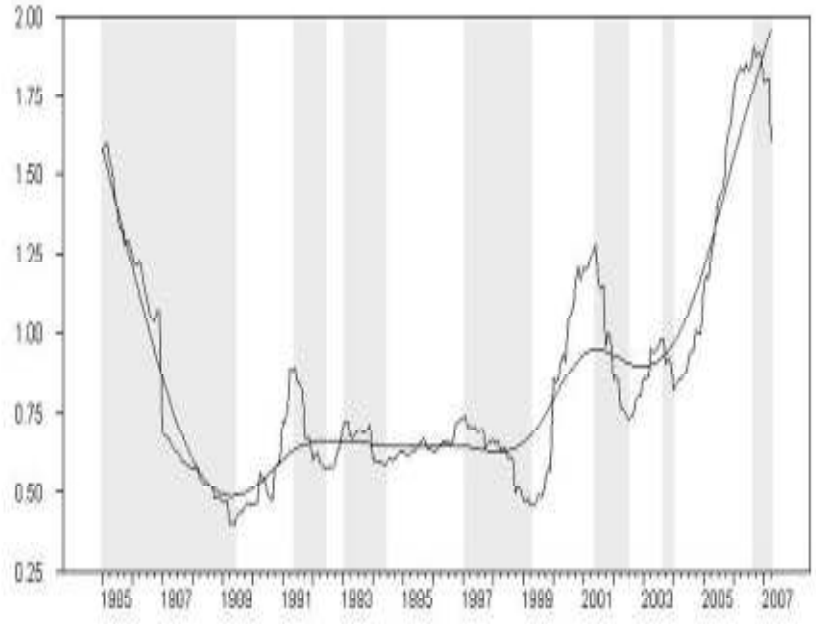
Silver (Feb 1968 – April 2007)



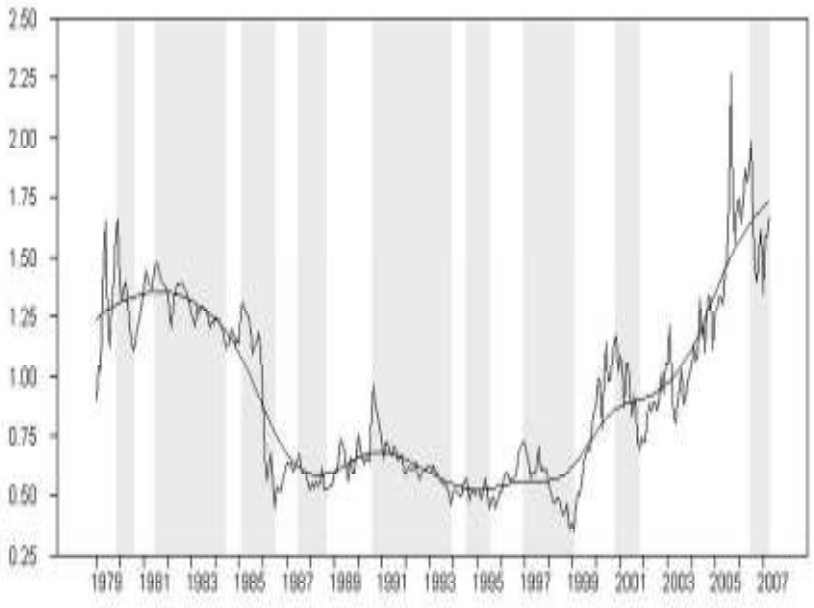
Rubber (May 1957 – April 2007)



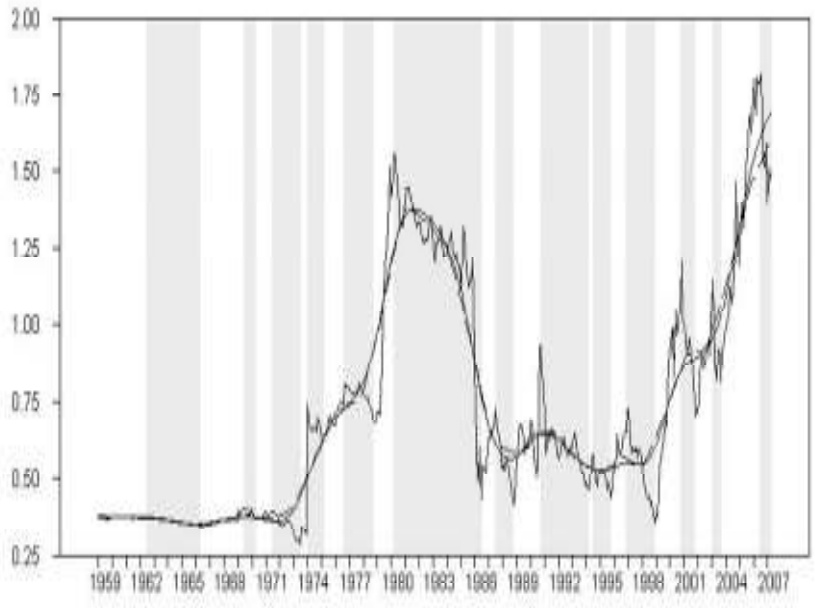
Coal (Feb 1979 – April 2007)



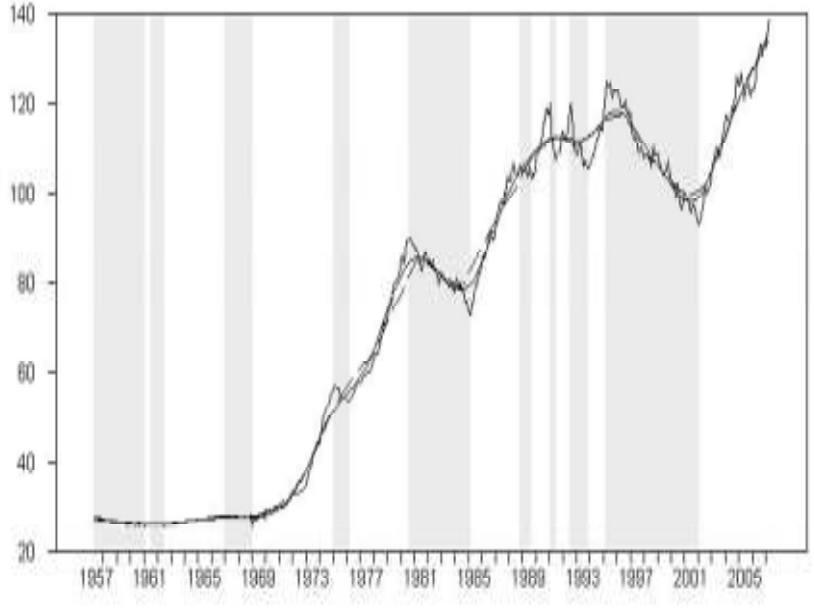
Natural Gas (Jan 1985- Apr 2007)



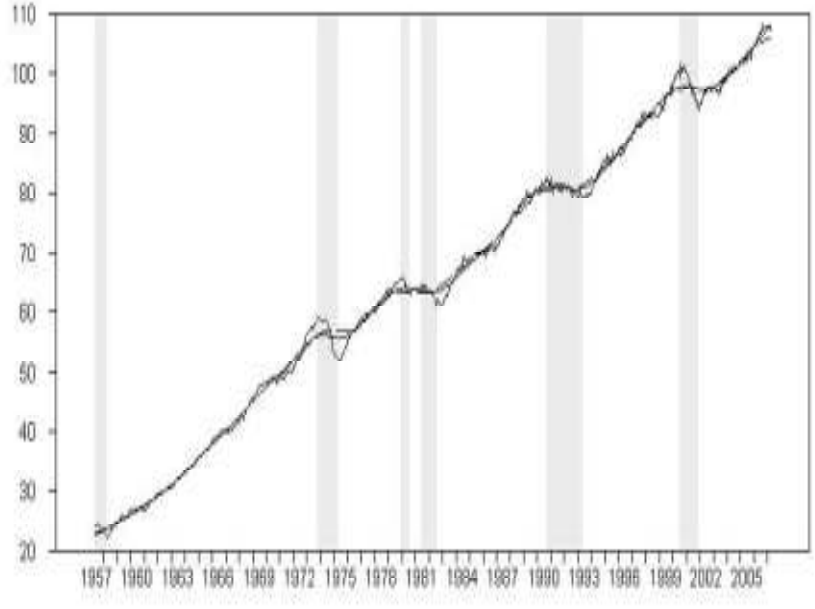
Gas (Jan 1979 – Apr 2007)



Oil(Jan 1959 – April 2007)



Manufactured Good Prices (May 1957 – April 2007)



Industrial Production of Developed Countries (Jun 1957 – April 2007

3. Stylized facts: short run properties

Pindyck and Rotemberg (1990); Cashin, McDermott and Scott (2002); Cashin and McDermott (2002).

Since we want to describe some “stylized facts” in words of Cuddington and Urzúa (1989), instead of decomposing commodity prices between permanent and cyclical components, we use the algorithm of Bry and Boschan (1971), also used to estimate the chronology of recessions and expansions in some economies, to compute a number of salient features of a selected group of commodity prices.

It is important to have into account that:

i) Not all sample periods are equal.

ii) We do not modify the procedure of Bry and Boschan (1971) to provide a chronology of the commodity price cycles.

Noticeably, the Industrial Production Index of developed countries has had only five cycles while raw material, metals and foods more than double that figure.

Some facts of commodity prices over the business cycle

Fact \ Commodity	Coffee	Maize	Sugar	Soybeans	Palm oil	Cotton
Number of booms	16	15	14	15	13	16
Number of slumps	15	15	13	15	13	16
Number of cycles measured from trough to trough	15	15	13	15	13	15
Number of cycles measured from peak to peak	15	14	13	14	12	15
Durations of phases and business cycles (number of months in average)						
During booms	15	17	20	16	20	18
During slumps	21	20	21	21	23	18
During a cycle measured from peak to peak	37	38	42	36	45	35
During a cycle measured from trough to trough	37	37	41	37	43	37
Summary statistics of growth rate between trough and peak (%)						
Maximum	395	95	970	193	168	118
Minimum	7	4	23	11	6	5
Average	97	40	199	55	80	49
Standard deviation	124	29	247	46	53	38
Summary statistics of growth rate between peak and trough (%)						
Maximum	-13	-5	-28	-5	-15	-6
Minimum	-75	-63	-91	-69	-79	-64
Average	-42	-29	-53	-34	-42	-33
Standard deviation	21	17	24	19	20	17
Sample						
Period	1957:05 2007:04	1957:05 2007:04	1957:05 2007:04	1957:05 2007:04	1957:05 2007:04	1957:05 2007:04
Number of months	600	600	600	600	600	600

Some facts of commodity prices over the business cycle

Fact \ Commodity	Aluminium	Iron	Nickel	Gold	Silver	Rubber
Number of booms	12	9	10	9	11	12
Number of slumps	11	8	11	9	11	11
lumber of cycles measured from trough to trough	11	8	10	9	11	11
Number of cycles measured from peak to peak	11	8	10	8	10	11
Durations of phases and business cycles (number of months in average)						
During booms	20	28	25	23	12	20
During slumps	30	27	24	27	22	31
During a cycle measured from peak to peak	51	54	51	52	34	50
During a cycle measured from trough to trough	48	53	47	50	34	51
Summary statistics of growth rate between trough and peak (%)						
Maximum	172	124	371	275	477	162
Minimum	6	13	14	7	14	13
Average	51	49	95	74	94	75
Standard deviation	46	34	110	94	136	42
Summary statistics of growth rate between peak and trough (%)						
Maximum	-4	-14	-10	-4	-9	-12
Minimum	-70	-38	-76	-48	-83	-63
Average	-28	-28	-34	-28	-35	-41
Standard deviation	21	10	20	15	25	18
Sample						
Period	1957:05 2007:04	1957:05 2007:04	1957:05 2007:04	1964:01 2007:04	1968:02 2007:04	1957:05 2007:04
Number of months	600	600	600	520	471	600

Some facts of commodity prices over the business cycle

Fact \ Commodity	Coal	Natural gas	Gas	Oil	Wheat	Manufactured good prices	IPI-DC
Number of booms	8	6	8	12	16	8	5
Number of slumps	8	5	8	12	15	8	5
Number of cycles measured from trough to trough	7	5	7	11	15	8	5
Number of cycles measured from peak to peak	8	5	8	12	15	7	4
Durations of phases and business cycles (number of months in average)							
During booms	16	23	20	18	17	35	88
During slumps	21	14	20	26	20	27	17
During a cycle measured from peak to peak	36	37	40	44	37	58	80
During a cycle measured from trough to trough	37	35	36	41	37	62	105
Summary statistics of growth rate between trough and peak (%)							
Maximum	142	180	231	238	179	124	166
Minimum	8	26	17	6	10	1	3
Average	40	87	86	87	45	37	52
Standard deviation	44	67	79	69	44	42	65
Summary statistics of growth rate between peak and trough (%)							
Maximum	-8	-16	-21	-8	-6	-1	-4
Minimum	-48	-43	-66	-72	-66	-26	-12
Average	-29	-30	-39	-32	-29	-11	-7
Standard deviation	15	12	16	20	-17	8	3
Sample							
Period	1979:02 2007:04	1985:01 2007:04	1979:01 2007:04	1959:01 2007:04	1957:05 2007:04	1957:05 2007:04	1957:06 2007:05
Number of months	339	268	340	580	600	600	600

Findings:

i) Cycles are in general asymmetric but, contrary to what happens to economic activity, for commodity prices, the longer phase corresponds to slumps. An exception is natural gas for which booms are more prolonged than slumps.

ii) Symmetric or almost symmetric is the behavior of cotton, iron, nickel, and gas prices.

iii) Fluctuations of manufactured good prices as well as IPI-DC last more during booms than during slumps.

Thus, the exclusive link between the cyclical behavior of commodity prices and the dynamics of world economic activity is not straightforward. There must be some other determinants of the level and changes of commodity prices. This observation is the building block of our structural approach.

iv) Among commodity prices, the most prolonged cycles, measured from peak to peak, corresponds to metals: iron (54 months), gold (52), aluminium (51) and nickel (51).

On the other hand, the shorter cycles correspond, in average, to foods such as coffee (37), maize (38), wheat (37), and soybeans (36). However, the cases of silver (34) and coal (36) are also remarkable.

v) All commodity prices exhibit an erratic behavior. However, during booms the more abrupt changes were given by sugar (see also Deaton and Laroque, 1992), silver, coffee, and nickel.

During slumps, the sharper changes were given by sugar, silver, palm oil, nickel and coffee. So, there are commodities that have had the higher volatility since they have had not only rapid increases but also the faster decreases.

4. Structural analysis

Reinhart (1991); Borensztein and Reinhart (1994);

We assume that world´s output is generated with a production function such as:

$$Q = \left[\lambda(AX^d)^{\rho} + (1-\lambda)K^{\rho}\right]^{j/\rho}$$

$$0 < j;\ -\infty < \rho < 1;\ 0 < \lambda < 1$$

$$X^d - (P_X)^{\frac{1}{j-1}}\left(jA^j P_Q\right)^{\frac{1}{1-j}}\left[\lambda + (1-\lambda)\left(\lambda Ar/(1-\lambda)P_X\right)^{\frac{\rho}{\rho-1}}\right]^{\frac{j(1+\rho-j)}{\rho(j-1)}} = 0$$

$$\partial P_X/\partial X < 0 \qquad \partial P_X/\partial r < 0 \qquad \partial P_X/\partial P_Q > 0 \qquad \partial P_X/\partial A > 0$$

$$P_{X\,i,t} = F\left[X_{i,t}, P_{Q\,t}, A_t, r_t\right]$$

The previous equation is highly nonlinear which is not convenient for our empirical approach. Thus, we also consider a Cobb-Douglas technology-type production function, that has the virtue of allowing a log-linear representation which is the one we implement in the empirical part:

$$Q = (AX^d)^{\alpha} K^{\beta}$$

$$\ln(P_X/P_Q) = \frac{1}{1-\beta}(\ln\alpha + \beta\ln\beta) - \frac{1-\alpha-\beta}{1-\beta}\ln X + \frac{\alpha}{1-\beta}\ln A - \frac{\beta}{1-\beta}(r/P_Q)$$

Since we attempt a production function approach, we consider that not all of the commodities are appropriate as a production factor.

Aluminium	Cotton	Linseed oil	Phosphate rock	Soybean oil
Bananas	Fish meal	Maize	Plywood	Soybeans
Barley	Gasoline	Natural gas	Potash	Sugar
Beef	Gold	Nickel	Poultry	Sunflower oil
Coal	Groundnuts	Olive oil	Rice	Swine
Cocoa beans	Grounnut oil	Oranges	Rubber	Tea
Coconut oil	Iron ore	Palm kernels	Shrimp	Tin
Coffee	Jute	Palm oil	Silver	Tobacco
Copper	Lamb	Pepper	Sisal	Wheat
Copra	Lead	Petroleum	Sorghum	Zinc

Annual data 1960 – 2006. We use a dynamic panel since commodity prices have memory.

Dependent variable	Price-cpi	Price-cpi	Price-cpi	Relative price	Relative price	Relative price	Price-ppi	Price-ppi
	Coefficient							
t-1	0.648	0.429	0.643	0.367	0.378	0.640	0.701	0.499
	(3.33)	(2.34)	(3.41)	(2.84)	(3.53)	(6.76)	(4.55)	(2.76)
t-2	-0.346	-0.110	-0.360	-0.135	-0.301	-0.341	-0.327	-0.131
	(-2.82)	(-0.96)	(-2.80)	(-1.35)	(-2.96)	(-2.01)	(-5.76)	(-1.35)
US-CPI					-0.044			
					(-0.88)			
t-1					0.107			
					(1.28)			
t-2					-0.050			
					(1.11)			
US-PPI						-0.026		
						(-0.55)		
t-1						0.029		
						(0.63)		
t-2						0.010		
						(0.33)		
Supply	-0.359	2.778	-0.478	1.297	-0.681	-0.629	-1.063	2.085
	-(0.16)	(1.91)	(-0.21)	(0.89)	(-0.51)	(-0.42)	(-0.85)	(1.53)
t-1	0.004	-3.265	0.120	-2.234	-0.341	-0.115	0.527	-2.637
	(0.00)	(-2.60)	(0.06)	(-1.76)	(-0.28)	(-0.08)	(0.53)	(-2.24)
t-2	0.281	-0.151	0.288	0.062	0.180	0.265	0.256	-0.54
	(1.02)	(-0.64)	(1.04)	(0.35)	(0.81)	(1.85)	(1.31)	(-0.25)
Treasury 10 years	-3.72		-4.008	-3.813	-10.066	-8.724	-2.594	
	(-6.10)		(-5.78)	(-3.37)	(-3.26)	(-3.11)	(-5.16)	
t-1	1.313		1.497	-0.663	1.677	-0.736	1.287	
	(3.34)		(3.55)	(-1.08)	(2.43)	(-0.20)	(3.87)	
t-2	-3.985		-4.206	-1.346	-3.715	-4.665	-2.784	
	(-4.90)		(-4.71)	(-1.52)	(-1.83)	(-2.95)	(-5.99)	
Libor 3 months		-2.466						-2.344
		(-2.64)						(-2.75)
t-1		0.706						0.790
		(1.00)						(1.28)
t-2		-3.470						-3.266
		(-2.93)						(-3.19)
Nonfarm Productivity	0.823	-0.761		-2.633	1.223	1.240	-0.416	-0.431
	(1.17)	(-1.32)		(-2.78)	(0.87)	(0.89)	(1.12)	(-0.84)
t-1	-0.459	-0.077		-0.042	-0.262	-0.029	-0.399	-0.262
	(-2.01)	(-0.17)		(-0.13)	(-0.25)	(-0.04)	(-2.21)	(-0.63)
t-2	-0.314	1.053		-1.562	-2.300	-2.229	0.225	0.943
	(-0.48)	(1.98)		(-1.97)	(-1.33)	(-2.28)	(0.66)	(2.05)
Productivity			0.972					
			(1.28)					
t-1			-0.690					
			(-2.08)					
t-2			-0.246					
			(-0.40)					
Tendency				0.164				
				(3.26)				
AB-AR(1) (p)	0.006	0.005	0.012	0.009	0.008	0.037	0.008	0.003
AB-AR(2)	0.870	0.625	0.841	0.965	0.981	0.084	0.220	0.633
Sargan test	0.096	0.081	0.127	0.014	0.180	0.311	0.119	0.058

Dependent variable	Relative price	Relative price	Relative price
t-1	0.826	0.730	0.784
	(4.48)	(3.57)	(3.37)
t-2	-0.215	-0.210	-0.157
	(-2.69)	(-3.37)	(2.09)
US-CPI	0.001		
	(0.02))		
t-1	-0.074		
	(-0.35)		
t-2	0.063		
	(0.46)		
US-PPI		-0.028	-0.009
		(-3.05))	(-0.89)
t-1		-0.053	-0.038
		(2.71)	(1.47)
t-2		-0.037	-0.049
		(-1.19)	(-1.24)
Supply	-2.281	-1.864	-2.804
	(-1.77)	(-2.98)	(-2.48)
t-1	1.079	0.943	1.611
	(1.41)	(2.38)	(2.43)
t-2	0.705	0.699	1.015
	(2.10)	(3.29)	(2.75)
Treasury 10 years	2.533	-3.874	
	(0.38)	(-1.18)	
t-1	-0.567	2.493	
	(0.40)	(1.59)	
t-2	4.258	-1.243	
	(-0.70)	(-0.58)	
Libor 3 months			-0.897
			(-0.30))
t-1			3.199
			(1.73)
t-2			0.355
			(0.15)
Nonfarm Productivity	-1.474	2.456	3.016
	(-0.42)	(1.62)	(1.26)
t-1	0.227	-1.119	-2.367
	(0.30)	(-2.27)	(-2.07)
t-2	2.298	-2.418	-2.422
	(0.44)	(-1.78)	(-0.90)
Tendency	0.015	0.071	0.118
	(0.12)	(0.54)	(0.73)
AB-AR(1) (ρ)	0.014	0.000	0.003
AB-AR(2) (ρ)	0.176	0.083	0.198
Sargan test	0.051	0.080	0.116

5. Temporary conclusions

The empirical evidence obtained so far suggests that:

i) Some food prices exhibit a downward trend such as that predicted by PSH. However, a trend component is not significant for the prices.

ii) Most of selected commodities have an asymmetric cycle. Moreover, the asymmetry is contrary to that of economic activity.

iii) From the panel estimates we can conclude that interest rate is inversely related to commodity prices as predicted by Frankel. However, our explanations could be very different: inputs might be complementary rather than substitutes.

Thus, high interest rates leads to less demand for capital and, given the gross complementary between commodities and capital, the demand for commodities goes down and so the price of commodities.

iv) Commodity prices exhibit some persistence which is captured by our specification.

v) The PSH is not validated by the empirical approach adopted here.