Trends, Fluctuations, and Determinants of Commodity Prices

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Abstract

A threefold analysis of commodity prices is carried out to observe their long-run behaviour, their short-run properties and the main determinants. According to the evidence, the Prebisch-Singer hypothesis does not seem to be a property of most prices. The cycles of commodity prices are asymmetric but contrary to the case of economic activity, the longer phase corresponds to slumps. Interest rates seem to maintain a negative relationship with commodity prices.

JEL classification: E3, E32, F4, O13, O47, Q11.
Key words: commodity prices, real interest rates, Prebisch-Singer hypothesis, short-run behaviour.

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> *The thesis which I humbly submit to criticism is this. If, other things remaining the same, the leading banks of the world were to lower their rate of interest, say 1 per cent. below its ordinary level, and keep it so for some years, then the prices of all commodities would rise and rise and rise without any limit whatever; on the contrary, if the leading banks were to raise their rate of interest, say 1 per cent. above its normal level, and keep it so for some years, then all prices would fall and fall and fall without any limit except zero* (Wicksell, 1970).

I. Introduction

From time to time commodity prices come into play. This is the case of the recent boom of oil, gas, gold, cooper, coal, raw materials and food prices (see for example, Blanchard and Galí, 2007; Cheung and Morin, 2007; IMF, 2006 and 2008, amongst many others). Most agents are interested in commodity prices; that is the case of governments, monetary authorities, firms, investors, hedge funds, speculators and consumers of both supplier and buyer commodity countries. All these participants track not only the short-run behaviour of prices but also their movement in a more prolonged lapse. Having information about the behaviour of commodity prices is crucial for economic authorities to be able to design and implement economic policies since it could affect prices as well as national income, the exchange rate, the current account and the fiscal balance[1]. For the rest of participants, the behaviour of commodity prices determines portfolio, investment and consumption decisions.

Most analysts link the boom of commodity prices to the high rate of consumption growth in China and other emerging economies [see Barclays Capital (2006) cited in IMF (2006); Cheung and Morin (2007) and Gilbert (2006)]. In particular, it has been stated that Chinese demand for energy and raw material commodities is growing at a rate higher than supply[2] (Gilbert, 2006). However, the hypothesis of a commodity price boom related to China and other emerging economies has been accompanied by other explanations. Firstly, geopolitical stress has been an argument used by Jaramillo (2006) and Di Placido (2007) amongst others to justify why prices are persistently high. Secondly, the dramatic rise in trade of futures over the past decade and increased volatility over the same period are cited as evidence for the claim that speculation has also driven commodity prices (Gilbert, 2006). A third explanation is the presence in the market of institutional investors, which nowadays are responsible for abundant resources from pension and severance payment funds. Fourthly, 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, 29 February, 2008)[3].

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[1] Cashin, Liang and McDermott (2000) recommend different stabilization schemes depending on the time series properties of commodity prices. For example, they suggest the design of a domestic or international stabilization scheme to lessen the effects of price shocks if these are short-lived.

[2] New oil wells and mines take between 7 and 10 years to come on stream. This might suggest that commodity prices may remain persistently high.

[3] Ocampo and Parra (2008) add some other factors "…that influence recent prices, including the demand for biofuels, subsidies and protection measures, droughts (particularly in Australia) and a few export restrictions (particularly for rice) or taxes (such as in Argentina)". However, these explanations will not be considered here explicitly regardless of their notable importance.

Along these lines is the idea presented by Frankel (2005, 2006) who states that high real commodity prices can be a sign that monetary policy is loose. Frankel suggests that higher (short-term) interest rates expand the supply of commodities and reduce the demand for storable commodities that, in combination, reduce their prices. This result is obtained due to the higher incentive for extraction in the present rather than in the future, the lower incentive of firms to carry inventories, and the desire of speculators to move to treasury bills from commodity contracts.

With respect to the relationship between real interest rates and oil prices, Obstfeld and Rogoff (1996, pages 51-54) present a different view. According to them, countries benefiting from the oil shock, mainly OPEC countries, could not increase their spending at the same speed of the increase in their wealth given their lower marginal propensity to spend that transitory income. These countries experienced an increase of savings and current account surpluses; as a result, the real interest rate declined. At the same time the investment outside OPEC countries reduced, thereby pushing the interest further down. This story applies to the first OPEC shock. However, for the second shock that took place at the end of the seventies, the situation was rather different, since the increase of oil prices was followed by a rise of the real interest rate. One explanation was that on this occasion, OPEC countries could spend all that transitory income more quickly.

This study is aimed at making a marginal contribution, not only by estimating some of the determinants of commodity prices within a panel approach, but also by analysing some of the properties of commodity prices, both in the long-run and over the cycle. Apart from economic activity and real interest rates as the main determinants, this paper addresses three major features of commodity prices: the downward trend implied by the Prebisch-Singer hypothesis (henceforth PSH), the excess co-movement and persistence.

Analysis of the long-run behaviour is tackled by looking at the permanent component of commodity prices in relation to the manufacturing price. This provides an insight into the PSH, according to which the long-run component of primary good prices relative to manufactured good prices has a downwards tendency. Such behaviour might be explained by different market structures, because the market of primary goods is competitive whilst the market of manufactured goods is far more imperfect. Apart from this impaired structure, income elasticity has also been an argument underlying the PSH. In this sense, the demand for primary goods will fall when the income moves upwards because these commodities are regarded as less than normal. Literature devoted to verify the PSH is plentiful. Some works have found evidence in favour of such hypotheses [e.g. Spraos (1980), Sapsford (1985), Grilli and Yang (1988), Bloch and Sapsford (1997), amongst others] whereas others have rejected it [e.g. Powell (1991), Cuddington (1992), Cuddington and Urzúa (1989), Kellard and Wohar (2006)]. In this work, the long-run component of relative commodity prices is estimated through the Phase Average Trend, *PAT*, an approach developed by Boschan and Ebanks (1978) which has been used recently by Zarnowitz and Ozyildirim (2006) in the context of growth cycles. This approach is used for seventeen commodities (coffee, maize, sugar, palm oil, cotton, aluminium, iron, nickel, gold, silver, rubber, coal, natural gas, gas, oil and wheat), manufactured good prices and the industrial production index of developed countries.

With regard to the cyclical behaviour of relative commodity prices, we present some summarised statistics to describe the salient characteristics of that dimension. However, instead of breaking down commodity prices between permanent and cyclical components, we use the technique of Bry and Boschan (1971) which is also sometimes used to estimate the chronology of recessions and expansions of some economies. Notably, during the sample period, the industrial production index of developed countries (IPI-DC) had only five cycles whilst raw material, metals and foods had about ten cycles on average. Long and short-run properties are calculated by using monthly data between 1957 and 2007, from the International Monetary Fund (IMF). Interestingly, most of the cycles of commodity prices occurred whilst the IPI-DC experienced expansion episodes.

However, this work goes beyond the PSH or the derivation of short-run properties in the sense that, as mentioned previously, it also establishes a structural model to estimate some feasible determinants of commodity prices. From a supply-demand framework, we arrive at an expression for the unconditional demand where real prices depend on their own historical tendencies, the traded quantities of commodities, real interest rates, total factor productivity and price of goods.

The supply of commodities is determined by previous prices, previous traded quantities of commodities and previous real interest rate. We believe that this approach encompasses Frankel's idea (1985, 2006) according to which the prices of commodities respond to monetary policy: the more relaxed the monetary policy, the lower the interest rate and the higher the commodity prices. To that end, annual information between 1960 and 2006 from the IMF for approximately 50 different commodity prices and some other variables and sources is used.

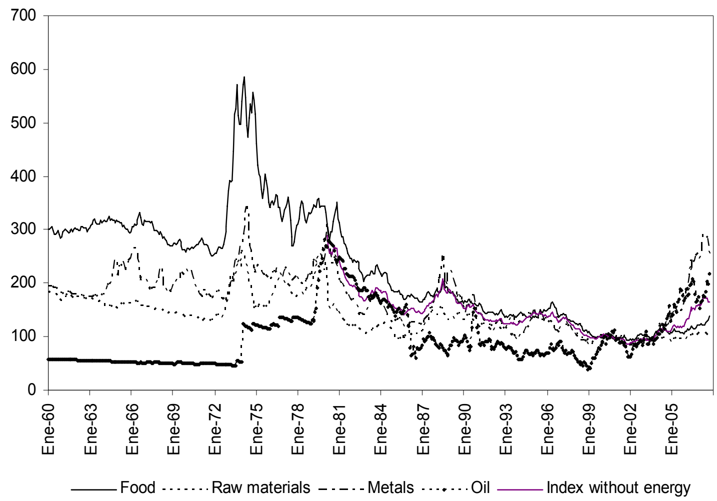
The paper evolves as follows. The second section is devoted to showing some facts concerned with the overall commodity prices and to making a point related to the hypothesis about the evolution of commodity prices: the relationship between them and the interest rates. The third section deals with the long-run behaviour of the aforementioned selected commodity prices. The fourth section discusses the short-run properties of those groups of commodity prices according to monthly frequency. The analysis of the latter two sections is carried out by using commodity prices relating to manufactured good prices on a monthly basis, from 1954:04 to 2007:04. The fifth section presents a simple model from which a demand function for commodities is established as the basis for an empirical panel econometrics approach. This estimation is accomplished for twenty-eight commodities that can be combined with capital to produce the world output. This section also discusses the results. Finally, the sixth section provides a brief discussion.

II. Commodity price behaviour

During the first decade of this century agents were surprised with a price boom of commodities such as crude oil, coal, copper, iron ore, coffee, maize, soybeans, sugar, wheat, rice, etc. Figure 1 shows the evolution of four commodity indexes (foods, raw materials, metals and an index not including energy) and oil. From Figure 1 we can observe an upsurge of prices from the beginning of 2002 up to the present date, metals and oil being the most affected. However, between the eighties and the end of last decade the indexes showed a persistent decline. One important message of Figure 1 is that regardless of price increases, the real indexes have not yet reached their historical maximum. Nonetheless, the case of foods is noteworthy[4].

We also mentioned in section I that the boom of commodity prices has been linked to the economic activity of some emerging economies including the astonishing case of China. For example, the IMF (2006, chapter 5, page 1) states that “some observers have suggested that the rise in the Chinese 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 in the case of metals”. However, apart from economic dynamics, the geopolitical stress, intervention of speculators, hedged funds[5] and institutional investors, in the commodity markets, the behaviour of monetary policy and the weakness of dollar have also been brought into play to explain the recent behaviour of commodity prices (see also Ocampo and Parra, 2008).

Figure 1. Real index commodity prices



Source: IMF, deflated by US-CPI Index.

In particular, with regard to monetary policy, Frankel (2006) uses an overshooting model to suggest that higher (short-term) interest rates expand the supply of commodities and reduce the demand for storable commodities, all of which reduce their prices[6]. Frankel presents, as part of the evidence about the negative relationship, a picture of real interest rates and a real commodity price index (Commodity Resources Board, CRB) in annual frequency between 1950 and 2005 (see Frankel 2005). Figure 2 illustrates the relationship amongst those variables between 1962 and 2007. However, we can observe that, apart from the negative relationship outlined by Frankel (2005, 2006), there seems to be another positive-sloped relationship represented by the dotted line. This positive relationship starts in about 1983 and is still occurring, according to Figure 3. This fact, which shall be considered further on, could suggest that the real

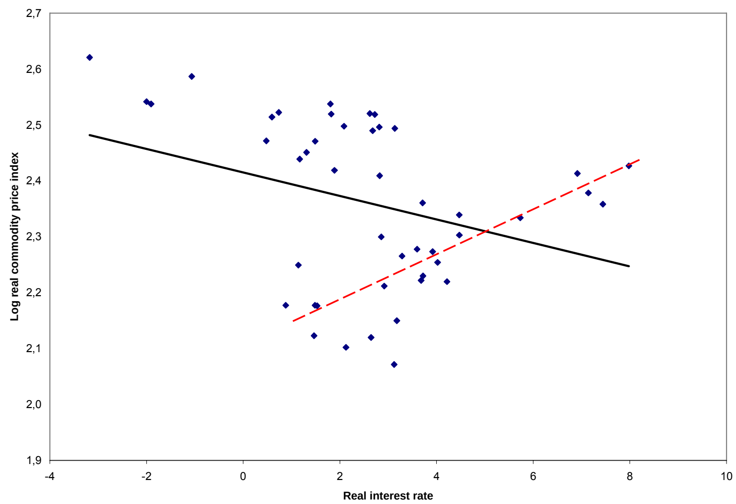
[4] However, the more recent statistics of oil prices would be over their historical maximum.

[5] In this case prices are viewed as a bubble, driven by hedge funds and other speculators characterized as having extrapolative expectations. Société Générale (2006) [cited by IMF (2006)] states that “…speculative forces have largely decoupled metal prices from market fundamentals”.

[6] However, Frankel maintains that real interest rate is not the only determinant (Frankel, 2006, pages 5 and 9).

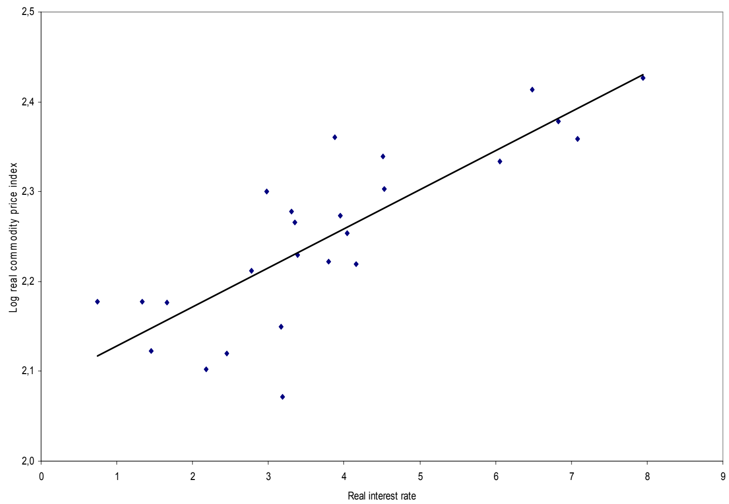
interest rate is not indeed the only one determinant of commodity price behaviour, or that the influence is not only contemporaneous but more dynamic or that there is room for arguments such as that of Obstfeld and Rogoff (1996) presented earlier.

Figure 2. Real interest rates and real commodity price index (CRB) 1962-2007



Source: Datastream and own calculations

Figure 3. Real interest rates and real commodity price index (CRB) 1983-2007



Source: Datastream and own calculations

III. Long-run behaviour of price commodities

According to the PSH, the relative price of commodities has a downward tendency. This behaviour mirrors a worsening of the developing countries' terms of trade, since many of the commodities are produced by countries that have a narrow industrial base. As stated by Cuddington (1992), plausible candidates for justifying the PSH are: *i*) that foods are regarded as less than normal goods, in the sense that the demand for them exhibits a low income elasticity; *ii*) different rates of technological progress between commodities and manufactured goods favouring the production of the latter; and *iii*) different degrees of competition in commodity and manufactured good markets, the former being more competitive.

Different approaches have been applied to test the PSH and the evidence is mixed[7]. Spraos (1980) used different series of terms of trade, from 1876 to 1975, to conclude that his results support the PSH, but when the post World War II period is included in the sample such evidence is weaker. Cuddington and Urzúa (1989), using the Grilli-Yang index, conclude that, with the exception of the drop occurred in the period 1920-21, there is no decline in the relative price of primary goods. Powell (1991) tested the PSH by using an equilibrium relationship approach between commodity and manufactured goods prices. Taking into account three negative jumps, he concluded that non-oil commodity prices and manufactured goods prices are co-integrated. The terms of trade commodity is stationary but has three negative shifts that occurred after periods of relatively sharply rising commodity prices. Thus, Powell ends by saying that the “stable declining of terms of trade” may not be a good representation of the behaviour of commodity prices.

Cuddington (1992) analysed the long-run trend for 26 primary commodity prices from 1900 to 1983, finding that there are no trends for 17 commodity prices, five have statistically significant negative trends and the remaining four have positive trends. By contrast, Ardeni and Wright (1992), by using a structural time series approach to study the Grilli-Yang primary commodity price index (1900-1988), deflated by the United Nations Manufacturing Unit Value (UNMUV), found a negative trend in the net barter terms of trade supporting the PSH (see also Reinhart and Wickham, 1994). The evaluation of the ratio of prices of primary commodities to manufactures, using the Grilli-Yang data from 1900 to 1991, carried out by Bleaney and Greenaway (1993) allowed them to conclude that there is a statistically significant long-run downward trend in commodity prices. However, the magnitude and statistical significance of the trend varies according to the span of data, since the behaviour of different categories of primary commodities is very different. For that reason, it is difficult to draw any conclusions about the long-term trends of the relative price of primary products as a group. Up to that date, Sapsford and Balasubramanyan (1994) argued that, regardless of the variety of statistical techniques employed, the evidence supported the PSH.

Bloch and Sapsford (1997) estimated the coefficients of a structural model of commodity price determination in the world economy relative to manufactured product prices. They evaluated the contribution of various effects to the movement in the relative prices of primary goods by using a generalised instrumental variable method. The sample consisted of annual data from 1948 up to 1986. Bloch and Sapsford, focusing on prices of 24 commodities, found a net trend in the terms of trade of minus 1.5% per year, explained by wages and manufacturing mark-up in line with the PSH. Kellard and Wohar (2006) tested the PSH on the original series of Grilli and Yang (1988) extended up to

[7] A number of articles have used the data constructed by Grilli and Yang (1988) at the World Bank.

1998, for 24 commodities prices, and deflated by the UNMUV. According to them, the PSH does not hold.

In this study, in order to deal with the long-run behaviour of commodity prices, rather than applying a particular technique to break down the series of prices, we estimate their permanent components by using the phase average trend[8] (*PAT*) put forth by Bry and Ebanks (1978). The idea is to decide whether it has had a downward tendency or not by means of simple visual inspection. Some of the pictures in Figure 4 also include a trend derived from the Hodrick-Prescott filter; this is identified by a dashed line.

Figure 4 shows the long-run behaviour of a selected group of commodity prices relative to the Unit Value Index of Exports, UVIE (used as a proxy of manufactured good prices), from 20 industrial countries. Such a commodity group is composed of coffee, maize, sugar, soybeans, palm oil, cotton, aluminium, iron, gold, silver, rubber, coal, natural gas, gas, oil and wheat. Figure 5 present the UVIE and the industrial production index for developed countries. The commodities included in Figure 4a, coffee, maize, sugar, soybeans, palm oil and cotton show a decline, a behaviour that would match with the PSH. A different kind of evolution is shown by the group of metals in Figure 4b and the energy commodities of Figure 4c, which, perhaps with the exception of iron, would not support the PSH. Therefore, according to these pictures and from simple visual inspection, the PSH may hold for a few sets of commodities but not for all of them, an observation that is in line with the results of Cuddington (1992).

According to these results, the PSH could not be rejected for prices of some foods because of the break down of international agreements during eighties and nineties that involved more competitive market structures. This is the case for coffee and sugar (Cashin, Liang and McDermott, 2000). In the case of cotton, the situation could be explained in the light of a high price elasticity of substitutes that are now produced under very different technological conditions. In the case of metals and some energy commodities the low investment in technology during the last 10 years may be a response to a long duration of low prices (IMF, 2008).

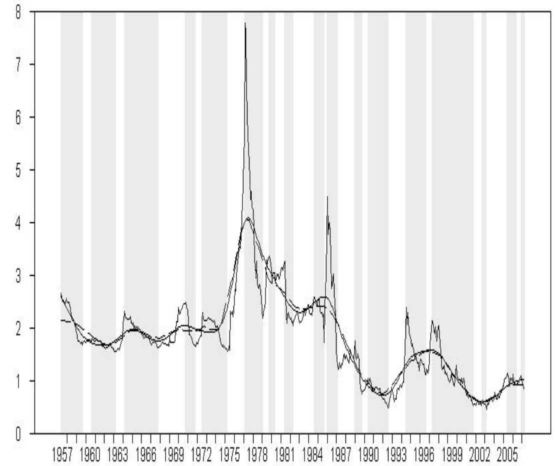
IV. Commodity Price Fluctuations

Fluctuations of commodity prices have been the subject of profuse analysis. Some research has focused on the cyclical properties of commodity prices themselves whilst others have focused on the co-movements between them and economic activity.

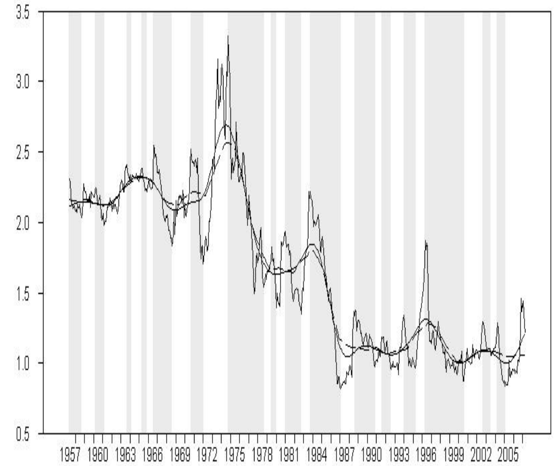
Pindyck and Rotemberg (1990) studied the co-movements of prices of seven apparently unrelated commodities (wheat, cotton, copper, gold, crude oil, lumber and cocoa), from 1960 to 1985. However, they did not reach a satisfactory explanation of such common movements by using current and expected future values of macroeconomic variables. Cashin, McDermott and Scott (1999) also focused on the (excess) co-movement of commodity prices by using the concept of concordance, a measure of the extent to which cycles of two price series are co-ordinated. Their findings enable them to reject the notion of excess co-movement along with the evidence of irrational behaviour on the part of commodity traders.

[8] This method is employed for all the series with the exception of natural gas and gas.

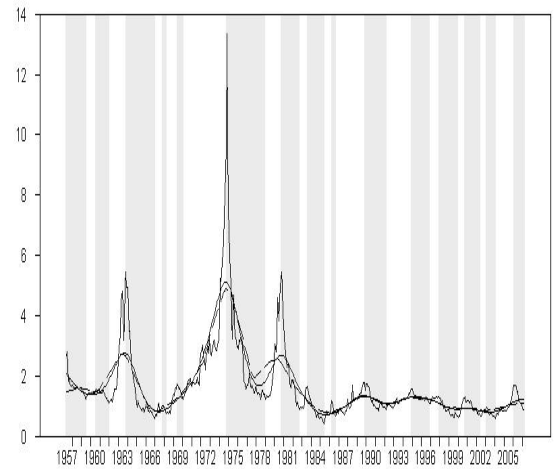
Figure 4a. Behavior of some commodity prices and the long-run component



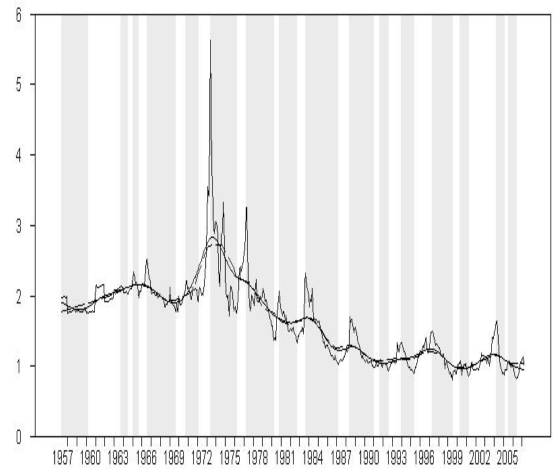
Coffee (May 1957 – April 2007)



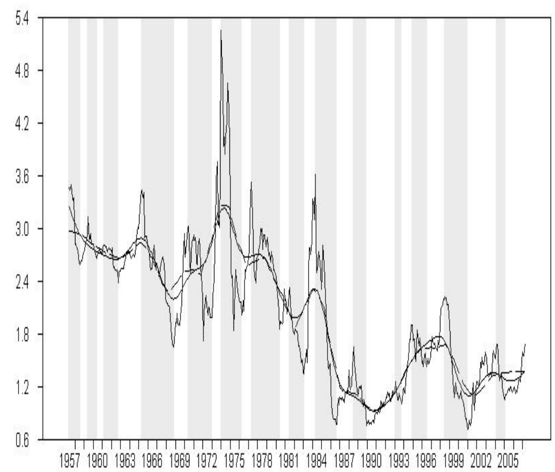
Maize (May 1957 – April 2007)



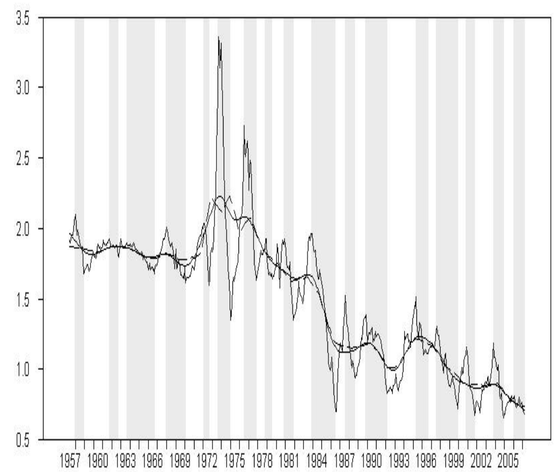
Sugar (May 1957 – April 2007)



Soybeans (May 1957 – April 2007)



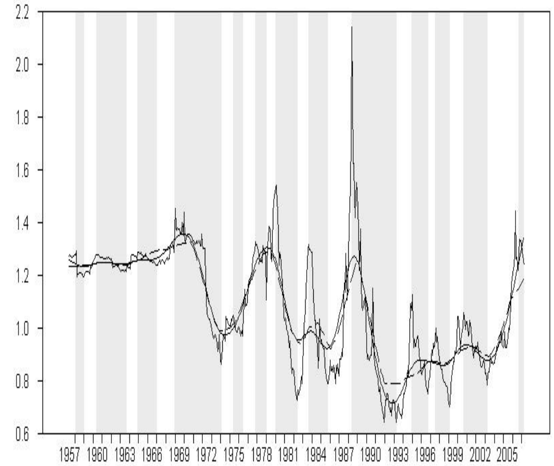
Palm Oil (May 1957 – April 2007)



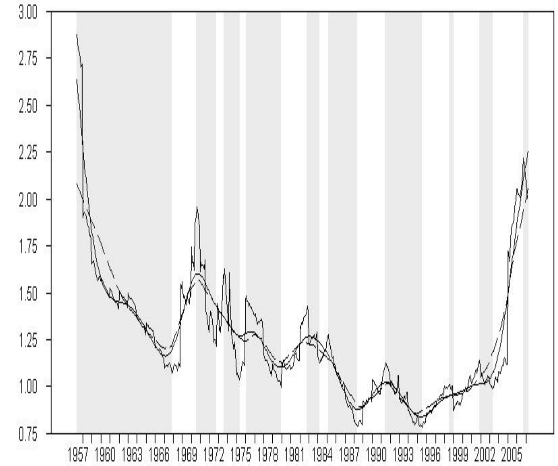
Cotton (May 1957 – April 2007)

Source: IMF Statistics and own estimates

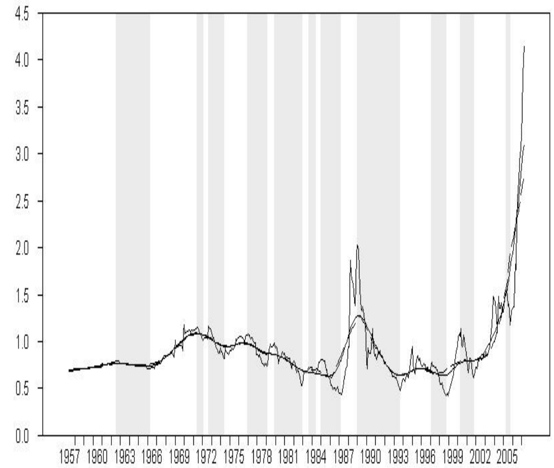
Figure 4b. Behavior of some commodity prices and the long-run component



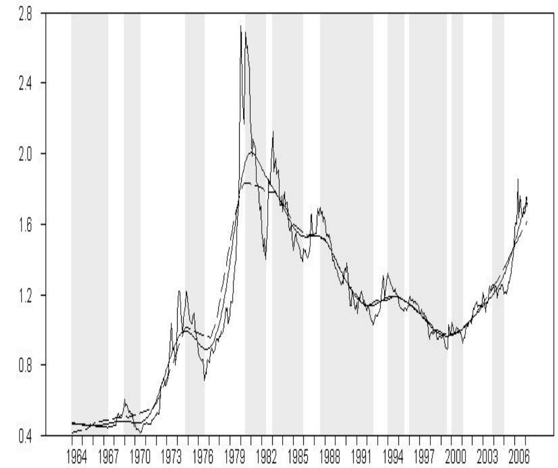
Aluminium (May 1957 – April 2007)



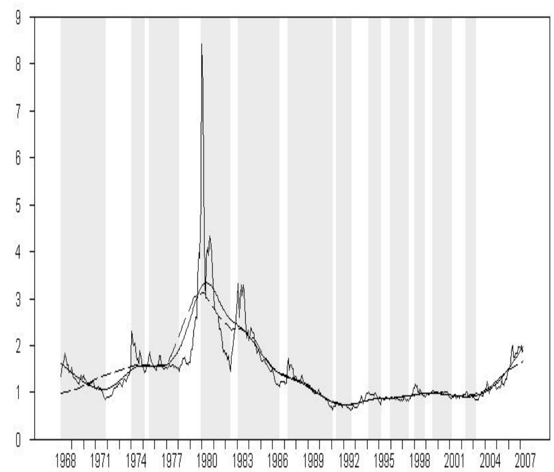
Iron (May 1957 – April 2007)



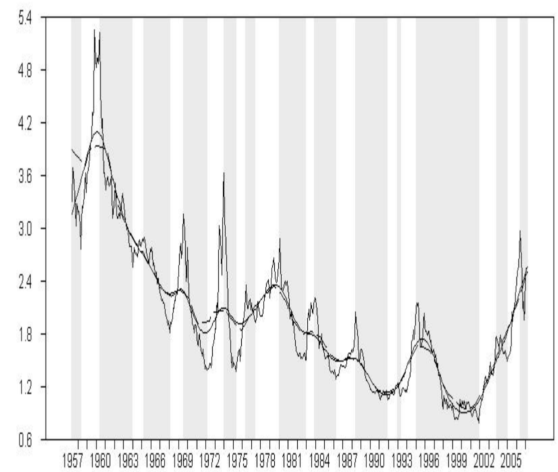
Nickel (May 1957 – April 2007)



Gold (Jan 1964 – April 2007)



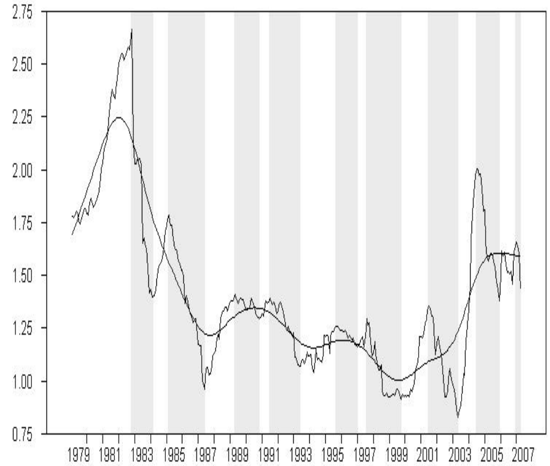
Silver (Feb 1968 – April 2007)



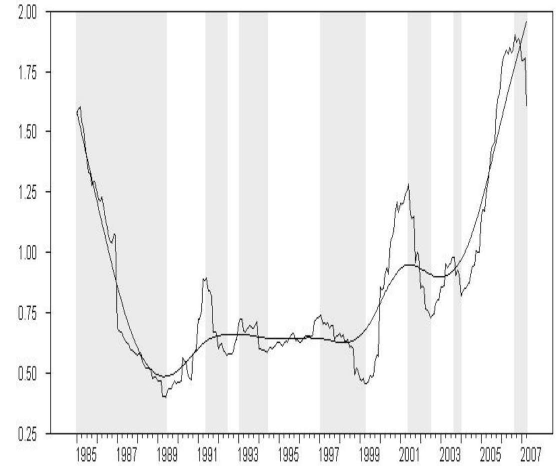
Rubber (May 1957 – April 2007)

Source: IMF Statistics and own estimates

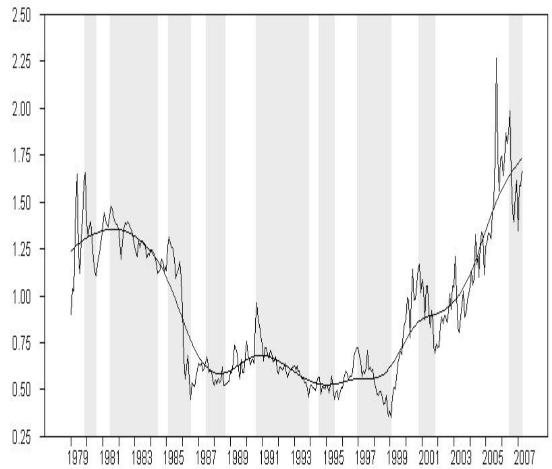
Figure 4c. Behavior of some commodity prices and the long-run component



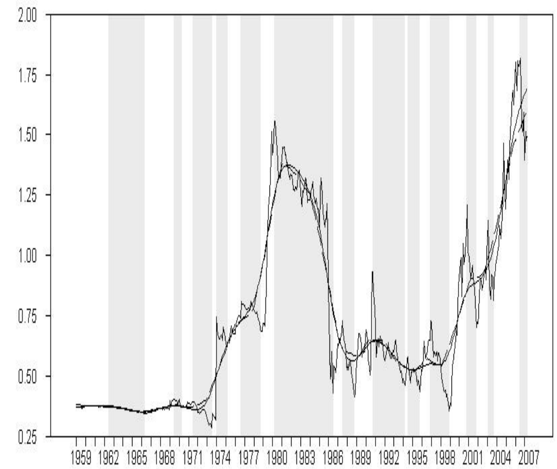
Coal (Feb 1979 – April 2007)



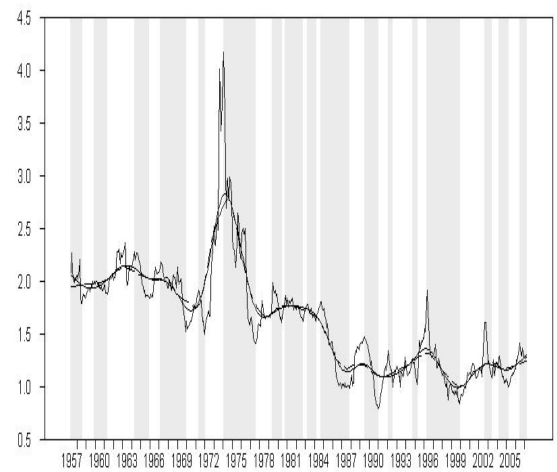
Natural Gas (Jan 1985- Apr 2007)



Gas (Jan 1979 – Apr 2007)



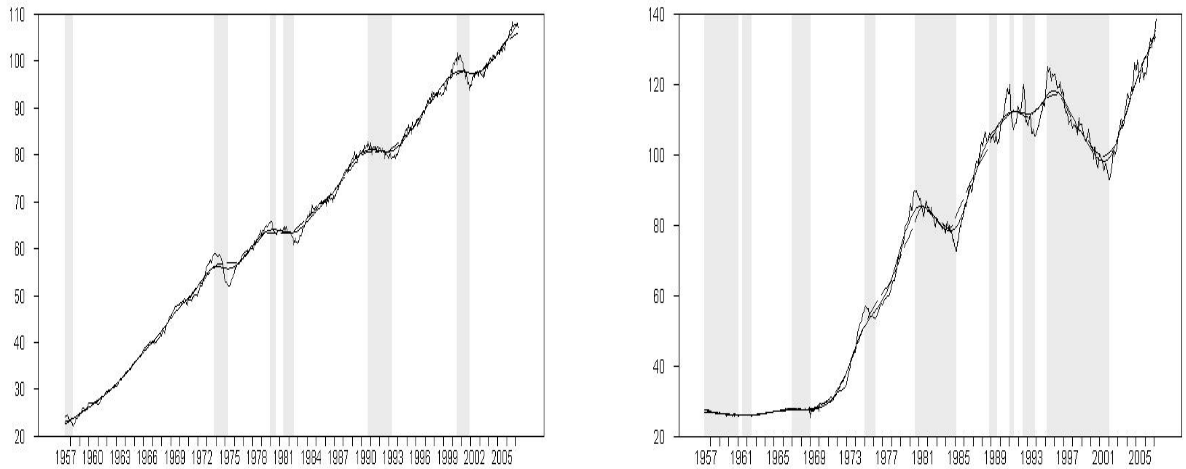
Oil (Jan 1959 – April 2007)



Wheat (May 1957 – April 2007)

Source: IMF Statistics and own estimates

Figure 5. Behavior of industrial production index and manufactured good prices



Industrial Production Index of Developed Countries (Jun 1957 – April 2007)

Manufactured Good Prices (May 1957 – April 2007)

Source: IMF Statistics and own estimates

Cashin and McDermott (2002) analysed the long-run behaviour of real commodity prices as well as the volatility and duration of price booms and slumps. By using *The Economist*'s index of industrial commodity prices from 1862 to 1999 (annual frequency), they found that during that period there was a downward trend in real commodity prices of about 1 percent per year, eighteen cycles of 4.2 years of average duration during slumps and 3.6 years during booms. Additionally, they found evidence of a change in the volatility of prices.

Cashin, McDermott and Scott (2002), studied the magnitude and duration of commodity price cycles, using the methodology of Bry and Boschan (1971). Their data spans from January 1957 up to August 1999 for 36 commodity prices. They found that the phase of slumps (39 months) is longer than the phase of booms (29 months).

In similarity to Cashin, McDermott and Scott (2002), we also used the algorithm of Bry and Boschan (1971) to calculate the salient features of a selected group of commodity prices (see Tables 1a, 1b, and 1c). At this stage, it is important to take two aspects into account. Firstly, not all sample periods of each commodity prices are equal. Secondly, we did not modify the procedure of Bry and Boschan (1971) in order to provide a chronology for the commodity price cycles[9]. The primary output of this methodology is to estimate the phases of the fluctuations of a series. As it is customary, the grey areas of Figure 4 identify periods in which the relative commodity price went through a slump. By contrast, the white areas correspond to periods during which the relative commodity price experienced a boom.

[9] Cashin, McDermott and Scott (2002) used a modified version of this algorithm by defining a commodity price boom as a period of at least 12 months during which the spot prices increased in real terms. By contrast, we consider that, in order to compare the cycles of economic activity (business cycles) and commodity prices, the algorithm should not be modified in any sense to estimate a chronology of the fluctuations. King and Plosser (1994) provide a description of the algorithm (see also Zarnowitz and Ozyildirim, 2006).

Table 1a. Some facts associated with commodity price fluctuations

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
Duration of phases and 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

Table 1b. Some facts associated with commodity price fluctuations

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
Number 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
Duration of phases and 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

The main findings are the following. In first place cycles are generally asymmetric but, contrary to the case of economic activity[10], the longer phase corresponds to slumps[11]. This fact makes us sceptical about the relationship between economic activity

[10] The dynamics of economic activity is different for boom and slump phases. For example, we can think of asymmetries as fluctuations with different time distance from peak to trough than from trough to peak, so that contractions are much shorter and steeper than expansions (Teräsvirta and Anderson, 1992; Zarnowitz, 1992; Granger, Teräsvirta, and Anderson, 1993; Peel and Speight, 1998; Arango and Melo, 2006).

[11] An exception is natural gas for which booms are more prolonged than slumps.

and commodity price behaviour. In other words, what is the frequency in which world economic activity and commodity prices have common fluctuations? Or can two variables with different kinds of asymmetry be correlated along the business cycle? The answer at this stage is maybe. However, it is possible that other factors could be affecting that relationship. Secondly, the behaviour of cotton, iron, nickel and gas prices are symmetric or almost symmetric. Thirdly, the fluctuations of manufactured good prices as well as IPI-DC during booms last longer than during slumps[12]. Again, the exclusive link between the cyclical behaviour of commodity prices and the dynamics of world economic activity is not straightforward. It is possible that some other determinants of the level and changes of commodity prices are also affecting the economic activity. This observation is the building block of our structural approach in the fifth section. Fourthly, amongst commodity prices, the most prolonged cycles, measured from peak to peak, correspond 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 months), maize (38), wheat (37) and soybeans (36). However, the cases of silver (34 months) and coal (36) are remarkable. Fifthly, the cycles of manufactured goods and IPI-DC, from peak to peak last for approximately 58 and 80 months, respectively. Finally, all commodity prices exhibit an erratic behaviour. However, during booms the more abrupt changes corresponded to sugar (see also Deaton and Laroque, 1992), silver, coffee, and nickel. During slumps, the sharper changes occurred in sugar, silver, palm oil, nickel and coffee. Therefore, there are commodities that have had higher volatility due to their rapid increases as well as to their hasty decreases. This is the case of sugar, silver, nickel and coffee.

Table 1c. Some facts associated with commodity price fluctuations

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
Duration of phases and 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

Source: IMF Statistics and own estimations

[12] The booms of manufactured good prices and IPI-DC last about 35 and 88 months, respectively, whilst during slumps they take about 27 and 17 months, respectively.

Table 2 shows the number of peaks and troughs that, according to the algorithm of Bry and Boschan (1971), of each commodity price during each phase (from trough to peak and from peak to trough) of the IPI-DC. Given that the latter variable has a lower number of cycles than any of the considered commodity prices, this table aims to illustrate the phase of the IPI-DC that contains most movements in commodity prices.

Table 2. Distribution of peaks and troughs of commodity prices within the phases of IPI-DC

		Troughs (T) to peaks (P) of IPI-DC occurred between:						Peaks (P) to troughs (T) of IPI-DC occurred between:						Proportion of T or P occurred in phase of trough to peak of IPI-DC
		58:04–73:11	75:05–80:01	80:08-81:07	82:08-90:10	93:05-00:08	Total	73:11-75:05	80:01–80:08	81:07–82:08	90:10-93:05	00:08–01:12	Total	
Coffee	T	4	1	0	3	1	9	1	1	1	1	1	5	64,3
	P	4	2	1	4	2	13	0	0	0	0	0	0	100,0
Maize	T	6	2	0	2	2	12	0	1	0	2	1	4	75,0
	P	5	1	1	2	2	11	1	0	0	1	0	2	84,6
Sugar	T	5	1	0	3	2	11	0	0	0	1	0	1	91,7
	P	4	0	1	3	2	10	1	0	0	0	1	2	83,3
Soybeans	T	5	1	0	2	2	10	0	1	0	2	1	4	71,4
	P	5	1	1	2	3	12	0	0	0	1	0	1	92,3
Palm oil	T	5	1	0	3	2	11	0	1	0	0	1	2	84,6
	P	4	1	1	2	2	10	1	0	1	1	0	3	76,9
Cotton	T	5	2	0	2	2	11	1	0	1	1	1	4	73,3
	P	5	2	1	3	2	13	0	0	0	0	1	1	92,9
Aluminium	T	3	2	0	1	2	8	1	0	1	1	0	3	72,7
	P	3	2	0	2	2	9	0	1	0	0	1	2	81,8
Iron	T	2	2	0	2	2	8	1	0	0	0	0	1	88,9
	P	2	1	0	2	1	6	0	0	0	1	1	2	75,0
Nickel	T	2	1	0	3	2	8	1	0	0	0	1	2	80,0
	P	2	2	0	3	2	9	0	0	0	0	0	0	100,0
Gold	T	2	1	0	1	2	6	0	0	1	1	1	3	66,7
	P	1	0	0	2	3	6	1	1	0	0	0	2	75,0
Silver	T	1	1	0	1	3	6	1	0	1	2	1	5	54,5
	P	0	2	0	2	4	8	1	1	0	1	0	3	72,7
Rubber	T	4	2	0	2	1	9	1	0	0	2	1	4	69,2
	P	3	1	0	2	1	7	1	1	0	1	0	3	70,0
Coal	T	0	0	0	2	3	5	0	0	0	1	0	1	83,3
	P	0	0	0	2	2	4	0	0	0	1	1	2	66,7
Natural gas	T	0	0	0	1	2	3	0	0	0	1	0	1	75,0
	P	0	0	0	0	1	1	0	0	0	2	1	3	25,0
Gas	T	0	0	1	3	3	7	0	1	0	0	1	2	77,8
	P	0	0	1	3	2	6	0	0	1	0	1	2	75,0
Oil	T	3	1	0	2	3	9	1	0	0	0	1	2	81,8
	P	2	1	0	2	2	7	1	1	0	1	1	4	63,6
Wheat	T	5	1	0	3	2	11	0	1	0	2	0	3	78,6
	P	4	1	1	3	2	11	1	0	0	1	0	2	84,6
Manufactured goods	T	3	1	0	2	1	7	0	0	0	1	0	1	87,5
	P	2	0	1	1	1	5	1	0	0	2	0	3	62,5

A number of useful insights come into play here. Firstly, about 77 percent of the peaks and troughs of commodity prices took place during boom phases of IPI-DC. This would seem to suggest that commodity prices are much more unstable when the world economy is experiencing expansion episodes. Secondly, the higher number of peaks and troughs of commodity prices corresponding to recessions of IPI-DC are allocated in the slump phase that occurred between October 1990 and May 1993. Thirdly, within each phase of IPI-DC it is feasible to find several cycles of commodity prices. Finally, by controlling according to the number of months, the highest number of peaks and troughs of commodity prices took place during the boom of world economic activity that occurred between May 1975 and January 1980. In summary, the evidence provided by the short-run analysis is not clear cut as regards any relationship between economic activity and commodity prices, which is the reason for carrying out the structural analysis in the next section.

V. Structural approach

A third aim of this work is to test some of the key commodity prices determinants. Previously, that task was undertaken by others who provided important evidence and insights (see, for example, Frankel, 1985; Reinhart, 1991; Borensztein, Khan, Reinhart and Wickham, 1994; Borensztein and Reinhart[13], 1994; Bloch and Sapsford, 1997; and IMF, 2006) where the real interest rate, real exchange rate, economic activity, fiscal balances, the impact of former Soviet Union and commodity market forces (demand and supply) appear as key determinants of commodity prices. Our approach differs from the previous studies in the sense that we only focus on a supply-demand framework and do not consider some of the other variables. Our model only retains the real interest rate and economic activity form the previous list. For this purpose, commodities are considered as an input which, combined with capital, is used to produce a final good (the world output) under a Cobb-Douglas-type technology. That is:

$$Q_t = (A_{Q,t} X_t^d)^\alpha K_t^\beta \qquad \alpha > 0, \quad \beta > 0 \tag{1}$$

where Q is the world output, X^d is the commodity, K is capital, A_Q is total factor productivity, and α, and β are parameters. This technology is Harrod-neutral, or commodity-saving, as in Bloch and Sapsford (1997). The unconditional demand for commodity *i* in time *t* is given by:

$$X_{i,t}^d = \left(\alpha / P_{Xi,t}\right)^{\frac{1-\beta}{1-\alpha-\beta}} \left(\beta / r_t\right)^{\frac{\beta}{1-\alpha-\beta}} P_{Q,t}^{\frac{1}{1-\alpha-\beta}} A_{Q,t}^{\frac{\alpha}{1-\alpha-\beta}} \tag{2}$$

where P_{Xi} is the price of commodity X_i, P_Q the price of good Q, and r the interest rate. We assume that commodities are supplied, $X_{i,t}^s$, according to:

$$X_{i,t}^s = P_{Xi,t-1}^\lambda \; X_{i,t-1}^\theta \; r_{t-1}^\gamma \qquad \lambda > 0, \quad \theta > 0, \quad \gamma > 0 \tag{3}$$

where $X_{i,t-1}$ corresponds to the equilibrium values of commodity markets in *t*-1 and λ, θ, and γ are parameters.

Apart from the influence of lagged commodity *i* price and traded quantities, equation (3) includes the previous value of the real interest rate. This is done by taking into consideration to Jeffrey Frankel´s intuition about the relationship between real interest

[13] They suggest that the slowdown in commodity prices observed from 1984 up to the beginning of nineties was not determined by the dynamics of economic activity and the real exchange rate of the US dollar. Instead, the boom of exports of primary products and the change in the net international demand for commodities of the former Soviet Union appeared as plausible determinants of commodity prices.

rates and commodity prices[14]. In equilibrium, supply is equal to demand so that we can write: $X^d = X^s = X$. In log terms, the equation of commodity prices relative to good prices, derived from the implicit unconditional demand for commodity *i* and the supply equation is given by:

$$\begin{aligned} ln\left(P_{Xi,t}/P_{Q,t}\right) = c - \frac{\lambda(1-\alpha-\beta)}{1-\beta} ln\left(P_{Xi,t-1}/P_{Q,t-1}\right) - \frac{(\lambda+\gamma)(1-\alpha-\beta)}{1-\beta} ln\, P_{Q,t-1} - \\ \frac{\theta(1-\alpha-\beta)}{1-\beta} ln\, X_{i,t-1} - \frac{\beta}{1-\beta} ln\left(r_t/P_{Q,t}\right) - \\ \frac{\gamma(1-\alpha-\beta)}{(1-\beta)} ln\left(r_{t-1}/P_{Q,t-1}\right) + \frac{\alpha}{1-\beta} ln\, A_t \end{aligned} \quad (4)$$

Notice that the contemporary effect of world demand, given our specification, is represented by the output price, P_Q, which we use to deflate commodity prices, P_{Xi}. Thus, the estimates we obtain below should be interpreted as being subsequent to controlling for contemporary world demand, although out work in the previous sections does not enable us to observe any clear cut relationship between world economic activity and commodity prices over the business cycle.

The dynamic expression in (4) is estimated within a panel framework following the approach of Arellano and Bond (1991), a procedure aimed at estimating panel data models, where the lagged endogenous variable appears as an explanatory variable. This methodology captures the dynamics that frequently arise in economic relationships and, at the same time, enables the estimation of consistent and efficient coefficients even in the presence of endogenous regressors.

The model to estimate is: $y_{i,t} = \alpha y_{i,t-1} + x_{i,t}\beta + \varepsilon_{i,t}$, where *y* is the vector of endogenous variables, and *x* the matrix of exogenous variables, with $\varepsilon_{i,t} = \mu_i + \upsilon_{i,t}$ and $E[\mu_i] = E[\upsilon_{i,t}] = E[\mu_i \upsilon_{i,t}]$, where μ_i are the fixed effects and $\upsilon_{i,t}$ the errors. The previous model can be rewritten as:

$$\Delta y_{i,t} = (\alpha - 1) y_{i,t-1} + x'_{i,t}\,\beta + \varepsilon_{i,t} \quad (5)$$

which, premultiplied by $I_N \otimes M$, allows us to obtain the model to estimate[15]:

$$\Delta y_{i,t} = \alpha \Delta y_{i,t-1} + \Delta x'_{i,t}\,\beta + \Delta \upsilon_{i,t} \quad (6)$$

The objective of such a transformation is the elimination of the fixed effects that cause the failure of the orthogonal condition. The *GMM* estimator of β is:

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[14] In the sense that, as we stated in the Introduction, higher interest rates will expand the supply of commodities since the incentive for extraction in the present, rather than in the future, is higher.
[15] Where *I* is the identity matrix and *M* is a matrix with ones in the diagonal and ones just at the right side of the diagonal.

$$\hat{\beta} = (x'zAz'x)^{-1} x'zAz'y$$

where *z* is the instruments matrix and *A* is the correction matrix. The instruments used for the current estimation are lags of the variables included in the original model as exogenous components. The standard restriction for the use of these instruments is that their lags cannot be correlated with the residuals.

The Sargan and Hansen tests are used to verify whether the set of instruments is valid or not. The null hypothesis of both tests is that the joint system is correctly specified. The tests have a Wald structure such as:

$$W = \left(\frac{1}{n} z'\hat{\xi}\right)' var\left[\frac{1}{n} z'\hat{\xi}\right]^{-1} \frac{1}{n} z'\hat{\xi} = \frac{1}{n}\left(z'\hat{\xi}\right)' A_{EGMM} z'\hat{\xi}$$

where *n* is the sample size, ξ are the empirical errors, and $A_{EGMM} = (z'z)^{-1}$. The difference between the two is that the Sargan test assumes that a structure of errors theoretically well-behaved whilst the Hansen test uses errors robust to possible problems of heteroscedasticity.

Apart from the overidentification problem, the correlation in the disturbance term u_{it} is another issue to deal with. When there is any sign of serial correlation of the residuals (without the fixed effects) of the original model, is possible that some lags of the variables could not be useful as instruments.

Thus, to test for autocorrelation without the influence of the fixed effects, the Arellano-Bond test is applied to the residuals in differences, as appears in equation (6). To check whether there is some *first-order serial correlation in levels*, it is ecessary to apply this test to *the second-order serial correlation in differences*. If we check this fact by the simple use of Δu_{it} and $\Delta u_{i,t-1}$, we found that this terms are always related via the subterm $u_{t,t-1}$ belonging to two of them. For this reason, *the Arellano-Bond test for AR(1) in first differences* [AB-AR(1) in the tables of the next subsection] must be rejected in all the cases. Hence, in order to correctly identify the serial correlation, we must use the terms $\Delta u_{i,t}$ and $\Delta u_{i,t-2}$.

The relevant results of this test appear in row AB-AR(2) in the tables of next subsection, for the *Arellano-Bond test for AR(2) in first differences*. Rejection of this test means that there is not evidence at usual standards that the residuals in levels do not have first-order correlation.

A. Results

The third component of the empirical analysis carried out in this paper estimates equation (4) within a panel approach based on equation (6). From the fifty commodities considered in this study[16], we regard twenty-eight of them as being suitable for mixture

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[16] The list is as follows: aluminium, bananas, barley, beef, coal, cocoa beans, coconut oil, coffee, copper, copra, cotton, fish meal, gasoline, gold, groundnuts, groundnut oil, iron ore, jute, lamb, lead, linseed oil, maize, natural gas, nickel, olive oil, oranges, palm kernels, palm oil, pepper, petroleum, plywood, phosphate rock, potash, poultry, rice, rubber, shrimp, silver, sisal, sorghum, soybeans, soybean oil, sugar, sunflower oil, swine, tea, tin, tobacco, wheat, and zinc.

with capital in order to produce the world output, *Q*. Such commodities are: aluminium, barley, coal, copper, cotton, gasoline, gold, iron ore, jute, lead, maize, natural gas, nickel, palm oil, petroleum, plywood, phosphate rock, potash, rubber, silver, sisal, sugar, soybean oil, sorghum, tin, tobacco, wheat, and zinc. The rest of the commodities are treated as foods that are more suitable for direct consumption.

The estimation results can be found in Table 3, which has the following structure. Firstly, each column corresponds to an equation; the head of the column shows the name of the dependent variable. Commodity prices are measured in two ways: deflated by US-CPI index without foods and relative to manufactured goods price index. Each equation includes two lags of the dependant variable, as well as the lagged prices of goods, proxied by the US-CPI without foods, and supply[17], the contemporary and twice lagged real interest rate and productivity. The real interest rate has been obtained by deflating either the ten years treasury rate or the three-month Libor with the US-CPI without foods. Also two measures of productivity were used: non-farm productivity and the total productivity for the US economy. According to the results in the tables, we have sufficient statistical evidence that the models do not exhibit first-order serial correlation and that the set of instruments seem accurate, based on the Sargan and Hansen tests.

Reading across the columns, the results of Table 3 show that commodity prices exhibit a moderated degree of persistence after controlling for the other factors. Lagged good prices are significant except in two cases. However, the associated coefficients do not always have the negative sign predicted by our model; in any case they are rather close to zero. The variable associated to traded quantities, $X_{i,t}$, is negative in all cases but one. When that is the case, the estimate is not significant [column (4)]. With respect to the contemporary interest rates, the coefficient is always negative as suggested by our model. Noticeable, the coefficients corresponding to lags one and two are positive and negative, respectively. But, when we move on to relative prices (in columns 6 and 8) the interest rate is not significant.

Both the sign and significance of the coefficients seem to lend support to the theoretical model in the sense that the hypothesis that the interest rate is negatively correlated to the real price of commodities once other factors such as price persistence, the previous traded quantities and productivity have been taken into account.

The coefficient associated to the dummy variable that represents the break in the slope of the relationship between interest rates and real commodity prices after 1983 is positive and significant in all cases except one, according to the results of Table 4. Thus, the slope of interest rates in net terms is positive (see Figures 2 and 3) which might be a symptom that the higher the contemporary interest rate the higher the real commodity prices, evidence that goes against the hypothesis we are testing. A possible interpretation of this result is that real interest rate moves in a different direction to real commodity prices but such an effect is not contemporaneous. It comes into effect after two years of movement in the interest rates. Moreover, the current state of the world economy seems to suggest that the abrupt movement of prices is the result of monetary decisions of the authorities made a few years ago. In the meantime, it is also possible that after 1983, given the lag of interest rates to have an effect on commodity prices, the

[17] Which is equal to the demand for commodity *i* under the assumption that the commodities market clears.

countries benefiting from the high prices have raised consumption quite rapidly, according to the interpretation of Obstfeld and Rogoff (1996).

Table 3. Estimation of equation (4)
Interest rate deflated by US-CPI not including food. 28 commodities.

Dependent variable	Price-cpi (1)	Price-cpi (2)	Price-cpi (3)	Price-cpi (4)	Relative price (5)	Relative price (6)	Relative price (7)	Relative price (8)
				Coefficient				
t-1	0.567 (4.51)	0.749 (5.55)	0.458 (2.76)	0.517 (2.67)	0.654 (13.11)	0.395 (2.25)	0.657 (13.29)	0.448 (3.11)
t-2	-0.300 (-7.66)	-0.236 (-5.63)	-0.367 (-7.12)	-0.659 (-2.78)	-0.281 (-3.03)	-0.667 (-2.66)	-0.285 (-3.10)	-0.653 (-2.83)
US-CPI t-1	0.002 (2.34)	-0.003 (-3.21)	0.006 (2.29)	-0.003 (-3.84)	0.003 (2.00)	0.009 (1.00)	0.003 (1.89)	0.009 (0.96)
Traded quantities t-1	-0.359 (-3.14)	-0.148 (-1.71)	-0.377 (-2.14)	0.135 (0.65)	-0.337 (-3.12)	-0.464 (-1.39)	-0.305 (-2.97)	-0.475 (-1.45)
Treasury 10 years	-3.928 (-5.39)		-5.488 (-4.01)		-3.143 (-3.88)		-3.111 (-3.84)	
t-1	1.365 (3.40)		1.662 (2.60)		1.003 (3.30)		1.024 (3.37)	
t-2	-3.337 (-7.23)		-4.904 (-4.26)		-2.996 (-4.72)		-2.982 (-4.69)	
Libor 3 months		-2.255 (-4.44)		-1.923 (-3.72)		2.240 (0.72)		1.580 (0.57)
t-1		2.097 (4.37)		2.409 (4.07)		0.247 (0.12)		0.820 (0.42)
t-2		-3.256 (-5.80)		-3.887 (-5.86)		-2.503 (-1.31)		-3.223 (-1.73)
Non farm Productivity	0.225 (1.28)	1.306 (4.01)			0.266 (1.50)	-3.401 (-1.23)		
t-1	-0.375 (-2.74)	-0.998 (-4.22)			-0.418 (-3.03)	2.604 (1.36)		
Total Productivity			-0.023 (-0.11)	1.419 (3.58)			0.392 (2.33)	-3.298 (-1.17)
t-1			-0.518 (-2.95)	-1.406 (-3.99)			-0.546 (-3.69)	2.477 (1.29)
AB-AR(1) (*p*)	0.001	0.000	0.021	0.001	0.000	0.000	0.000	0.000
AB-AR(2) (*p*)	0.623	0.125	0.110	0.334	0.503	0.505	0.508	0.536
Sargan test	0.022	0.001	0.288	0.181	0.149	0.108	0.131	0.109
Hansen test	0.137	0.147	0.255	0.215	0.408	0.140	0.393	0.131

The PSH is mainly focused on commodities that are more linked to food and beverages. However, we also estimate the model only for foods as if they were an input into a production process. In this case, they are combined with capital to produce a final good. This can only said to be true recently since some commodities are being used to produce energy. Table 5 shows the results of the model estimated for the twenty-two remaining commodities; that is, those that may be assimilated to foods and beverages. It could be argued that this is not the proper framework to analyse the behaviour of their prices[18] because there are some omitted variables. However, we wanted to observe them under this approach anyway.

Persistence continues to be a property of the behaviour of food prices whilst the coefficient associated to the previous traded quantities is not always significant but when

[18] A cobweb-type model might be a more appropriate alternative.

that is the case, the sign is negative, although the coefficients are very low. With respect to the real interest rate, the ten year Treasury rate seems to render the results predicted by the model. The Libor, on the other hand, has mixed results since sometimes the coefficient is not significant whilst in other cases it has a positive sign.

Table 4. Estimation of equation (4) with structural change in 1983
Interest rate deflated by US-CPI not including food. 28 commodities.

Dependent variable	Price-cpi (1)	Price-cpi (2)	Price-cpi (3)	Price-cpi (4)	Relative price (5)	Relative price (6)	Relative price (7)	Relative price (8)
				Coefficient				
t-1	0.563 (4.16)	0.552 (2.91)	0.560 (4.29)	0.544 (2.88)	0.618 (7.27)	0.572 (5.00)	0.423 (2.72)	0.566 (4.91)
t-2	-0.284 (-4.70)	-0.665 (-3.38)	-0.283 (-4.69)	-0.678 (-3.35)	-0.199 (-2.24)	-0.647 (-3.92)	-0.831 (-3.04)	-0.654 (-3.82)
US-CPI t-1	0.003 (0.51)	-0.003 (-3.25)	0.003 (0.55)	-0.003 (-3.13)	0.001 (0.29)	-0.000 (-0.38)	-0.002 (-1.65)	-0.000 (-0.38)
Traded quantities t-1	-0.220 (-1.89)	0.184 (0.85)	-0.239 (-2.09)	0.199 (0.91)	-0.331 (-1.69)	0.140 (0.75)	0.221 (0.79)	0.159 (0.83)
Treasury 10 years	-4.683 (-2.19)		-4.694 (-2.19)		-6.811 (-2.25)		4.056 (2.10)	
t-1	0.071 (0.06)		0.115 (0.09)		-0.783 (-0.44)		-1.405 (-1.54)	
t-2	-4.679 (-2.63)		-4.746 (-2.67)		-6.362 (-2.73)		1.850 (1.55)	
Libor 3 months		-2.358 (-3.80)		-2.385 (-3.59)		-2.294 (-3.81)		-2.351 (-3.71)
t-1		0.675 (0.76)		0.812 (0.96)		0.818 (1.05)		0.959 (1.25)
t-2		-4.732 (-5.68)		-4.774 (-5.58)		-3.541 (-4.01)		-3.590 (-3.94)
Non-farm Productivity	-0.120 (-0.09)	0.376 (0.63)			1.191 (0.89)	0.499 (0.92)		
t-1	-0.151 (-0.16)	-0.432 (-0.85)			-1.304 (-1.00)	-0.652 (-1.71)		
Total Productivity			-0.279 (-0.18)	0.486 (0.82)			-0.113 (-0.19)	0.620 (1.13)
t-1			-0.026 (-0.02)	-0.559 (-1.13)			0.445 (0.61)	-0.795 (-2.09)
Interaction	4.878 (2.75)	3.926 (3.26)	5.014 (3.00)	3.868 (3.33)	6.091 (2.83)	2.865 (2.42)	-1.437 (-1.28)	2.834 (2.45)
AB-AR(1) (*p*)	0.022	0.001	0.021	0.000	0.023	0.000	0.000	0.000
AB-AR(2) (*p*)	0.135	0.438	0.163	0.418	0.103	0.362	0.452	0.343
Sargan test	0.007	0.170	0.008	0.174	0.001	0.137	0.213	0.126
Hansen test	0.180	0.185	0.174	0.188	0.132	0.167	0.113	0.172

When the price of these twenty-two commodities is predicted by using the same model as before (including now not only the structural change of 1983 but also a trend to account for the PSH), the results show that when the trend is significant, the coefficient is positive (Table 6). At least this is the case when the dependant variable is the commodity prices deflated by the US-CPI without foods because when it is the commodity prices relative to manufactured goods, the trend is not significant at all. The interaction variable (the dummy times the interest rate after 1983) is significant for all the cases.

In summary, the evidence provided in this section suggests that commodity prices exhibit persistence; that previous traded quantities are not always significant but when it happens the associated coefficient is negative; and that the results concerning productivity are mixed while those related to real interest rate show that the associated coefficients are, contemporaneous and twice lagged, negative. However, when the change in the relationship between interest rates and real commodity prices, occurred since the beginning of eighties, is taken in account and modelled by means of an interaction between a dummy (that takes the value of 1 after 1983 and zero otherwise) and the proper interest rate, the contemporary coefficient turns to be positive. The negative effect of the interest rates appears only after two lags. Thus, while the supply of financial resources, including loose monetary policy is above the long-run average, the real commodity prices will be persistently high.

Table 5. Estimation of equation (4)
Interest rate deflated by US-CPI not including food. 22 commodities.

Dependent variable	Price-cpi (1)	Price-cpi (2)	Price-cpi (3)	Price-cpi (4)	Relative price (5)	Relative price (6)	Relative price (7)	Relative price (8)
t-1	0.479 (2.91)	0.750 (3.64)	0.469 (2.94)	0.749 (3.61)	0.611 (4.80)	0.677 (4.89)	0.603 (4.77)	0.542 (3.08)
t-2	-0.348 (-7.68)	-0.458 (-3.59)	-0.355 (-8.00)	-0.452 (-3.52)	-0.380 (-3.26)	-0.384 (-2.71)	-0.388 (-3.29)	-0.536 (-2.70)
US-CPI t-1	0.003 (0.47)	-0.005 (-4.03)	0.002 (0.33)	-0.005 (-4.23)	-0.001 (-0.65)	-0.003 (-2.32)		-0.003 (-2.51)
Traded quantities t-1	-0.603 (-2.16)	0.064 (0.39)	-0.551 (-2.14)	0.079 (0.47)	-0.071 (-0.39)	-0.007 (-0.05)	-0.042 (-0.23)	0.064 (0.35)
Treasury 10 years	-4.934 (-1.82)		-4.883 (-1.84)		-0.606 (-0.59)		-0.656 (-0.63)	
t-1	2.037 (0.98)		1.821 (0.94)		0.481 (1.54)		0.563 (1.82)	
t-2	-4.953 (-2.49)		-4.935 (-2.51)		-1.685 (-2.21)		-1.719 (-2.19)	
Libor 3 months		0.338 (0.65)		0.441 (0.80)		0.344 (0.66)		0.036 (0.07)
t-1		0.948 (2.86)		0.974 (2.92)		0.758 (2.45)		0.902 (3.14)
t-2		-1.370 (-2.24)		-1.285 (-1.96)		-0.675 (-1.29)		-1.017 (-1.82)
Non farm Productivity	-0.104 (-0.10)	1.549 (4.50)			0.875 (3.42)	1.325 (4.49)		
t-1	0.018 (0.02)	-1.145 (-4.64)			-0.598 (-4.79)	-1.011 (-5.57)		
Total Productivity			0.205 (0.17)	1.628 (4.85)			0.967 (4.00)	1.362 (4.44)
t-1			-0.227 (-0.21)	-1.201 (-5.06)			-0.698 (-4.58)	-1.134 (-6.04)
AB-AR(1) (*p*)	0.019	0.002	0.020	0.002	0.000	0.000	0.000	0.000
AB-AR(2) (*p*)	0.830	0.268	0.687	0.239	0.264	0.296	0.286	0.947
Sargan test	0.066	0.257	0.057	0.265	0.059	0.423	0.059	0.296
Hansen test	0.248	0.100	0.236	0.103	0.109	0.203	0.099	0.145

VI. Discussion

The current decade has seen a strong increase of commodity prices for which multiple explanations have been provided amongst which are the dynamics of world economic activity, mainly that of China and other emerging economies, geopolitical stress, climate factors, participation of speculators, hedgers and other investors in the markets, monetary policy, etc. To offer some insights into the behaviour of commodity prices, this study examined them in different frequencies of data, sample periods, approaches and techniques and generated an analysis in three dimensions: over the long-run, over the cycle and provided estimates of some determinants.

In the first dimension, by using the phase average trend (*PAT*) of Boschan and Ebanks (1978) for seventeen commodity prices relative to manufactured good prices for the sample period 1957:1-2007:4, monthly dated, we found that coffee, maize, sugar, soybeans, palm oil and cotton prices show a decline in the long-run, a behaviour that is close to the Prebisch-Singer hypothesis. The evolution of the metals and energy commodities (aluminium, iron, gold, silver, rubber, coal, natural gas, gas, and oil) is different and does not concur with the PSH. According to our visual inspection, we conclude that the PSH may hold for a few sets of commodities but not for all of them. We regard this result as note worthy in the sense that, other things being equal, substitution of production might not necessarily be in the top of the agenda of countries that are metal and energy commodities producers.

Table 6. Estimation of equation (4) with structural change in 1983 and trend Models with US-CPI not including foods. 22 commodities.

Dependent variable	Price-cpi (1)	Price-cpi (2)	Price-cpi (3)	Price-cpi (4)	Relative price (5)	Relative price (6)	Relative price (7)	Relative price (8)
Coefficient								
t-1	0.230 (0.95)	0.807 (5.11)	0.220 (0.91)	0.797 (4.74)	0.515 (2.06)	0.918 (7.25)	0.513 (2.06)	0.912 (7.32)
t-2	-0.265 (-0.58)	-0.395 (-2.32)	-0.224 (-0.49)	-0.422 (-2.53)	-0.099 (-0.25)	-0.191 (-3.19)	-0.043 (-0.10)	-0.169 (-2.78)
US-CPI t-1	-0.032 (-1.60)	-0.002 (-0.37)	-0.031 (-1.66)	-0.000 (-0.13)	-0.048 (-1.52)	-0.011 (-2.13)	-0.048 (-1.46)	-0.008 (-1.48)
Traded quantities t-1	-0.561 (-0.87)	-0.146 (-0.98)	-0.594 (-0.93)	-0.125 (-0.88)	-1.013 (-1.25)	-0.205 (-0.93)	-1.067 (-1.25)	-0.161 (-0.73)
Treasury 10 years	-9.827 (-3.43)		-9.356 (-3.48)		-9.727 (-1.99)		-9.509 (-1.93)	
t-1	0.462 (0.53)		0.215 (0.23)		-1.399 (-1.20)		-1.701 (-1.28)	
t-2	-8.452 (-4.78)		-8.282 (-4.89)		-7.988 (-2.49)		-8.195 (-2.39)	
Libor 3 months		-1.701 (-0.88)		-1.224 (-0.74)		-8.858 (-3.00)		-8.968 (-2.94)
t-1		1.344 (0.89)		1.023 (0.76)		6.416 (2.25)		6.937 (2.27)
t-2		-4.242 (-2.12)		-3.814 (-2.25)		-10.121 (-3.24)		-10.134 (-3.23)
Non-farm Productivity	-2.200 (-1.89)	1.480 (1.96)			-2.186 (-1.13)	5.270 (2.37)		
t-1	-4.560 (-1.89)	-0.234 (-0.22)			-6.381 (-1.70)	-3.620 (-2.51)		
Total Productivity			-1.982 (-1.83)	1.336 (1.77)			-1.864 (-0.99)	6.322 (2.32)
t-1			-4.823 (-1.95)	0.078 (0.08)			-6.788 (-1.63)	-3.568 (-2.50)
Trend	0.368 (1.74)	-0.044 (-0.93)	0.367 (1.79)	-0.054 (-1.21)	0.513 (1.52)	-0.032 (-0.49)	0.513 (1.46)	-0.086 (-1.01)
Interaction	8.399 (4.87)	3.223 (2.97)	7.777 (5.22)	3.188 (3.32)	8.341 (2.61)	4.762 (3.83)	7.975 (2.65)	4.791 (3.83)
AB-AR(1) (*p*)	0.019	0.001	0.048	0.000	0.008	0.001	0.020	0.001
AB-AR(2) (*p*)	0.279	0.262	0.319	0.275	0.219	0.849	0.270	0.250
Sargan test	0.358	0.194	0.347	0.249	0.347	0.592	0.335	0.575
Hansen test	0.320	0.079	0.321	0.127	0.258	0.140	0.253	0.132

The second dimension consisted of analysing the short-run behaviour of commodity prices. This was carried out by using the Bry and Boschan (1971) algorithm, which assigns dates to boom and slump phases. According to the estimated chronology we found that commodity prices relative to manufactured prices are asymmetric but this asymmetry is contrary to that of economic activity, since the longer phase corresponds to slumps. This fact questions the straightforward relationship that is sometimes established between world economic activity and commodity prices. Some other factors must be brought into play in order to obtain a more complete spectrum of commodity price determinants. In addition, not all prices behave in an asymmetric way. Exceptions, in the selected set that we studied, are cotton, iron, nickel and gas prices.

The most prolonged cycles, measured from peak to peak, corresponded to metals such as iron, gold, aluminium and nickel while the shorter fluctuations corresponded to foods. In the meantime the cycles of manufactured goods and IPI-DC, from peak to peak, last for about 58 and 80 months. Finally, all commodity prices exhibit an erratic behaviour. However, the higher volatility could be attributed to sugar, silver, nickel and coffee.

The third dimension of our analysis tested some determinants of real commodity prices. That is the case of their own history, the traded quantities in the previous period, the real interest rates and total factor productivity. The panel approach was applied, firstly, to a sample of twenty eight commodity prices deflated using the US-IPC without foods, on an annual basis, from 1960 until 2006. The initial results provide evidence that persistence of prices is a property that occurs after controlling for other factors. Secondly, the previous traded quantities reduce commodity prices as well as the interest rates, both contemporaneous and after two periods. Finally, there is no strong evidence to show that productivity determines commodities prices. One reason for that result may be that while higher total factor productivity in the production of the world output might push commodity prices upwards, the reduced necessity of commodities in order to produce such world output, taking for granted that the production process is commodity saving, the commodity prices should move downwards.

One fact that we could trace from the insights of Frankel (2005, 2006) is that the interest rate is inversely related to commodity prices irrespective of the variable used (the ten years Treasury or three-month Libor). Such a relationship seems to break in the early eighties when a positive-sloped fit line is obtained. After that period, there seems to be a lag in the action of interest rates. Thus, we believe that any explanation for the excess co-movement of commodity prices should take into account the behaviour of real interest rates.

The same estimation was performed for the remaining twenty-two commodities that are more closely linked to foods. In this case, the interest rate was not as significant as in the previous set of commodities. In this case, a trend, when significant, happened to be a positive result that enabled us to dismiss the PSH.

Is it a negative event that commodity prices are high? Not necessarily, as long as they do not contribute to a generalised and deep recession. If it were negative, is there a policy measure that can be recommended based upon our results? The answer is yes. One way of reducing the growth rate of commodity prices is tightening the monetary policy of the largest economies in a co-ordinated manner. Whilst real interest rates remain low, the commodity prices will remain high.

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Appendix. Sources of annual Data from 1960-2006:

1. Index commodity prices from International Monetary Fund.

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

2. Price index of manufactured goods (Unit Value Index of Exports, UVIE, from 20 industrial countries) from IMF.

3. Traded quantities: for each price we used the supplied quantities: FAO (Food and Agriculture Organization of the United Nations), and USGS (United States Geological Survey). The direct links to each page are: http://faostat.fao.org/site/506/default.aspx http://minerals.er.usgs.gov/minerals/pubs/commodity/myb/

4. CPI US -Consumer price index and PPI US -Producer price index from IMF, and Consumer price index not including food, from Datastream.

5. Nominal interest rate (Federal Funds, 3-month LIBOR US, Treasury to 1, 2, 10, 20 years): Datastream.

6. Productivity (Non-farm productivity US and total productivity US) from Bureau of Labor Statistics.

7. Industrial production developed countries from IMF.