Commodity cycles: What has changed during the last decade?

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Resumen

- The cyclical behavior of commodities has undergone a deep transformation in recent years. The data analyzed confirm that between 1960 and 1999 commodity-price cycles showed negative asymmetry. Or in other words, recessive periods tended to last longer and their absolute change in price was higher than in the expansions. However, when the analysis includes the recent years (up to 2010) this negative asymmetry practically disappears due to the strong positive asymmetry registered in the last years.

- Besides the change occurred in the behavior of individual cycles, this note investigates the degree of correlation or synchronization (co-movement) among the evolution of different commodity-price cycles. The results indicate that the level of co-movement is statistically significant and not constant over time

- Even though the objective of this study is far from exploring which variables underpinned these changes, the factors that presumably have led to the reconfiguration of the commodity cycles are numerous. Among them we can mention the strong reduction in the volatility of key economic variables, the emergence of China in world trade, the greater integration and extensive development of international capital markets, the high financial innovation, automation and standardization of operations and the use of raw materials as an asset class. All these issues help to explain the new cyclical behavior.

The change in cyclical behavior

The cyclical behavior of commodities has undergone a deep transformation in recent years. A proper understanding and assessment of these changes is important for different types of agents. Policy makers need a reliable estimate of the cycle to design successful strategies for counter-cyclical stabilization, especially if the country depends critically on the exports of these products. At the level of private sector companies that sell or buy commodities that knowledge can be used to improve the risk management and, thus, to reduce losses that could arise from unexpected fluctuations. Given that commodities have come to occupy a significant place in many portfolios, any information related to their cyclical patterns is of great importance for investment managers.

The factors that presumably have led to the reconfiguration of the commodity cycles are numerous. First, over the last decade there have been important changes in international macroeconomic dynamics: strong reduction in the volatility of key economic variables, the emergence of China in world trade, etc. The same has occurred in the field of financial markets: greater integration and extensive development of international capital markets, high financial innovation, automation and standardization of operations, use of raw materials as an asset class, brokerage and source of speculation. The behavior of commodity prices has not been immune to this new global scenario, a situation that has manifested itself through significant changes in the duration of the different cyclical phases, as well as the magnitude of price changes (amplitude) in periods of expansion and contraction.

This note aims to analyze the characteristics of the commodity-price cycles, with particular emphasis on the changes occurred over the last decade. Techniques commonly used for the study of business cycles are implemented. Specifically, we use the algorithm developed by Bry and Boschan (1971), which allows an objective dating of the turning points present in a series. Once established the turning points, it is possible to provide descriptive statistics that summarize important characteristics related to the different cyclical stages of a variable.

Although, in terms of cycles, a decade is a relatively short period to make a definitive judgment, the empirical evidence found indicates that the change in the cyclical patterns documented in this note may be permanent. However, there are other elements that are clearly temporary and, therefore, will gradually lose ground.

The note also analyzes the relationships between the cycles of the different materials.

The popular perception is that prices of commodities fluctuate in a coordinated manner. The evidence documented here points precisely in that direction. However, fluctuations in the prices of agricultural raw materials related to a severe drought should not significantly impact on, for example, the evolution of metal prices. Cashin, McDermott and Scott (1999) point out that finding a joint movement over and above that explainable by economic variables opens the possibility to interpret these movements as irrational ("herd" or "fad" behavior) and therefore to reject the hypothesis that these markets are competitive. We analyze the co-movement between the raw materials. To measure the degree of co-movement, two techniques are used. The first is the linear correlation between the cycles of raw materials (binary series). The second, called concordance measures, helps to assess the degree of synchronization between two series.

Dating peaks and valleys

The official dating of business cycles has a long tradition in America since this country has the Business Cycle Dating Committee of the National Bureau of Economic Research (NBER), a government agency responsible for determining business cycles. The procedure used by the NBER relies heavily on the work of Burns and Mitchell (1946). These authors identified the cycles of a variable through the turnings points found in the data.

One of the algorithms used to locate the turning points was developed by Bry and Boschan (1971), which replicates very well the

results of the NBER. Bry and Boschan algorithm is basically a process to recognize patterns in a given data set. The algorithm of Bry and Boschan consists of three key steps:

(i) Find an initial set of turning points in the smoothed version of a seasonally adjusted series (moving average of 12 months).
(ii) Verify alternation of peaks and troughs.
(iii) Eliminate certain turnings points in order to ensure that both phases and the cycle exceeds the minimum duration.

The procedure used in this paper is a variant of Bry and Boschan (1971), developed by Harding and Pagan (2002) but retaining the three principles of pattern recognition.

✓ The main difference is that it skip the step that smoothes the series.

Harding and Pagan argue that the process of smoothing the data eliminates certain movements that can be very relevant in the prices of commodities.

The arbitrariness to choose the length of the phases and the cycle is a methodological aspect that can be criticized. In this note, the minimal cycle length is five quarters. The duration of each phase is restricted to be at least two quarters. While it is possible to argue that it would be wise to set different durations for phases and cycles of certain commodities, we considered more appropriate to use a homogeneous rule for all series.

The procedure developed by Bry and Boschan (1971) and the variant of Harding and Pagan (2002) share two technical advantages. The first derives from the nature of the method, which implies that the dating of the turning points in the series is relatively independent of the sample used. The last peak or valley may be revised if new observations are added at the end of the series, but the rest of the points will remain unchanged.

The second arises from the definition adopted in this paper known as classical cycle which is in line with the work of Watson (1994), Cashin, McDermott and Scott (1999) and Cashin and McDermott (2002). The classic cycle describes a period of expansion (contraction) as a period of increase (decrease) held in the series and not as a period of growth above (below) the trend.

An alternative approach is to compute the cycle in terms of deviation of the original series from its trend, a method known as "growth cycle". However, the advantage of using the classic cycle is that it allows working with the series in levels and therefore avoids the subjective choice of a method for extracting the trend.

Characteristics of the commodity-price cycles

The analysis was performed using monthly data for 12 individual commodities and 4 aggregate indices of raw materials, obtained from the database of the International Monetary Fund (IMF). The sample covers the period from January 1960 to December 2010.

To calculate the real commodity prices, each nominal price was deflated by a unit value index (in U.S. dollars) of manufactures exported by 11 countries, weighted by the share of GDP in PPP (purchasing power parity).

In order to verify if the results documented in this study were in line with those documented in previous studies, we performed the analysis for different sub-periods. By this reason, the results are presented for three periods: 1960:1-2010:1, 1960:1-1999:8 and 1999:1-2010:1.

Figure 1 shows the estimated cycles for some commodities during the period 1960:1-2010:1. Booms are shaded in gray and slumps are in white. The trough of a recession is at the beginning of the gray area and the peak of the expansion at the end. At first glance, one can see that not all movements of the series are identified as peaks or valleys.

Table 1 exhibits the major characteristics associated with the turning points in the different commodities, differentiating the boom periods from the recessive ones. For each phase of the cycle, we show the results for the average duration (in months), the aggregate average amplitude (in percentage change) and

the average monthly amplitude (geometric mean based on duration). The last column of the table reports the percentage of time that each commodity has remained in recession.

January 1960 to December 2010

Table 1.A presents the results obtained for the full sample. The first important finding is that while you can see some negative asymmetry (in the sense that the recessive periods last longer and their absolute change in price is higher), it is not as strong as it was documented in previous studies. It is important to note that the durations are not homogeneous, a fact which supports the argument that raw materials do not rise or fall together.

As one can observe, the behavior of metals is mixed. On one hand, there are metals that show a clear positive asymmetry (nickel, gold and silver), since the magnitude of the duration and the amplitude is higher during the expansions. In the case of silver, the average duration of the booms is 29 months and the price amplitude averages 73%. The typical duration for slumps is around 23 months and the aggregate fall in price is almost 67%. With respect to gold, although the duration of booms and slumps is virtually the same, the percentage price change in the expansions in absolute terms is 13% higher than in recessions. On the other hand, we have the aluminum and copper, both displaying a negative asymmetry.

Oil shows a singular behavior because recessions tend to be longer, but in absolute terms the price changes in expansions is 8% higher than those registered during recessive periods. The commodities related to agriculture also display a negative asymmetry.

Another important aspect is the speed with which commodity prices change along each of the phases. The rate of change can be determined by the relative monthly amplitude (geometric mean between the total amplitude and duration). In the 51 years comprising the full sample, the average monthly decline in prices during slumps has been 2.7%, while the average monthly increase during the booms has been slightly less than 1.8%. In some commodities, the difference between the speed of price rises and the price falls is of an important magnitude. In particular, in table 1.A the nickel and silver stand out.

January 1960 to August 1999

Table 1.B documents the results obtained for the period January 1960 August 1999. That is, excluding the most recent decade.

The overall conclusion is that the results obtained are consistent with those documented in previous studies by international institutions like the IMF or the Reserve Bank of New Zealand. However, it is worth to remark that the results differ significantly with those presented in the previous section, which includes the most recent years.

First, the asymmetry is clearly negative. That is, the recessive periods are longer than the expansive phases and the fall in prices during recessions is greater than the increase that occurs during booms periods. The negative asymmetry referred to can be seen in Figure 2, which orders the duration of contractions in descending order.

The measurement of amplitude (percentage change) reveals that during this period the average drop in prices during recessions is greater than the average increase during the expansion phases. The difference in amplitude between the two phases can be seen in Figure 2.B, which orders the amplitudes of contractions in descending order.

It is interesting to note the different behavior of silver in this shorter period. Note from table 1.B that the asymmetry is negligible, since both the duration and the amplitude at the different phases of the cycle are almost equal. The oil is a special case, since the length of recessions is significantly greater than that of expansions, while the amplitude is marginally higher during recessions.

Regarding the rate of change in prices during this period, the average monthly price decline in recessions is around 2.6%, while the average monthly increase during expansions is roughly 1.8%. As in the previous section, commodities like the silver display an

important difference between the speed of price rises and the price falls. The average monthly decline in the price of silver during recessions is 5.5% while the average increase over the expansions is 2.3%.

January 1999 to December 2010

The huge difference between the two periods analyzed in the previous paragraphs and the one covering the last twelve years is remarkable. The results presented in table 1.C show that the last years have been largely dominated by the boom phases, both at duration and amplitude level (10 columns and 11). Second, it is interesting to note the stellar behavior displayed by the commodities during 1999-2010 has turned the negative asymmetry existing in the previous periods to positive.

The average length of expansions in recent cycles has increased by 25% to 25 months, compared with 20 months in the period 1960-1999. Besides that, the persistence of recessive periods has fallen from 25 months to 16 (-36%). Something similar has happened with the amplitude. During the booms phases of the last cycles, prices have risen on average by 58% (42% in the previous period), while the average correction in prices was 40% (47%).

When analyzing each commodity individually, we can observe a significant heterogeneity. The metals case is really striking, because they went from of negative asymmetry to a situation of strongly positive asymmetry in which the duration and amplitude of expansions double the figures recorded during recessions. The behavior displayed by the gold and silver is similar, while the nickel is more moderate. The evolution of aluminum is a clear exception in the group of metals.

The asymmetry in the oil also has become positive. However, as shown in table 1.C, the change is due to a combination of a very substantial fall in the length of recessions and a sharp increase in the average amplitude of the expansions.

Regarding the speed of change in prices, columns 5 and 8 of table 1.C glimpse a very interesting pattern. Overall, the asymmetry of the commodities analyzed has become very positive, the speed with which commodity prices falls has practically doubled, while the speed at which prices climb is largely unchanged. On average, the monthly decline in the price of raw materials is 5%, while for the increments is 2%.

Correlation and degree of synchronization

The correlation and synchronization measures presented in this paper have been computed using the cycles (binary series). This allows taking into account the observation of Cashin, McDermott and Scott (1999). The authors state that given that correlation as a measure of co-movement is based on the covariance between prices, it includes both the frequency and amplitude.

Why is important to know whether the correlation or synchronization between raw materials is low or high? Because confirming the existence of little or no synchronization would imply that we could not reject the hypothesis that these markets are competitive.

Table 2 shows the correlation matrix for all pairs of commodities cycles. Correlations with magnitudes higher than 0.0792 are statistically significant at the 5% level. For the period 1960-2010, only 40 out of the 120 correlations are below the critical value. In general, higher correlations exist between commodities of the same family (metals-copper, copper-gold, corn, food, etc.). The index of metals shows a high correlation with aluminum, copper, nickel and silver, while the index related to the agro displays its highest coefficients with wool, food, corn and soybeans. A similar situation can be observed for the period 1960-1999 (using the appropriate critical value).

Overall, the impression that there is some correlation between the different commodities studied, dominates a situation that prevents the rejection of the hypothesis that these markets are competitive. One possible explanation for this high correlation is that, during the period 1960-1999, the dominant cyclical context, both at the level of duration and amplitude, was the downturn. There are

numerous studies documenting that, during negative periods, the relationship between assets, although not belonging to the same class, tends to be higher.

In the most recent period, a decrease in the magnitude of the correlations can be seen, as well as an increase of insignificant coefficients (54 out of 120). During this period, the expansion has been the dominant phase and, possibly due to this, we observe a decrease in the co-movement between the commodities analyzed.

Besides the correlation, another simple way to assess the degree of synchronization between raw materials is through a concordance index. The concordance measure determines the proportion of time that two series remain in the same phase. Following the methodology used by Cashin, McDermott and Scott (1999), the degree of concordance between two cycles is calculated by the following expression:

$$C_{ij} = T^{-1}\left\{\sum_{t=1}^{T}\left(S_{i,t}S_{j,t}\right) + \left(1 - S_{i,t}\right)\left(1 - S_{j,t}\right)\right\}$$

where T is the number of observations, $S_{i,t}$ ($S_{j,t}$) is a dummy variable that takes the value 1 when the series x_i (x_j) is in an expansionary phase and 0 when the variable goes through a downturn. C_{ij} is the proportion of time that the two series remain in the same state.

Table 3.A shows the percentage of months in which two commodities coincide during the boom or recession phase. The figure to bear in mind is the distance from 50%. The information in this table allows us to reach the same conclusions that have been reached with the correlation analysis. In general, we can say that for the total sample there is an acceptable degree of synchronization (30 out of 120 pairs are not significant). As in table 2.C, table 3.C reflects a fall in the level of synchronization between the years 1999 and 2010, a period where the booms have been the dominant phase. During this period, the pairs of concordance that are not significant almost doubled (50 out of 120).

Diversification benefits

From the point of view of a portfolio manager, the change in the cyclical patterns of raw materials documented in above has several important implications. Figure 3 shows the three efficient frontiers (mean-variance) obtained for the different periods studied.

The first thing one can notice is the notable shift that the efficient frontier has when we include the most recent period. Second, the strong dominance that the efficient frontier computed for the period 1999-2010 has, over the other two periods, is remarkable. This situation is largely explained by the reduction in the degree of synchronization between the cycles of the raw material that has been documented. This fact is consistent with an increase of diversification gains, i.e., for a same level of risk it is possible to obtain a greater portfolio return. In addition, the change that has occurred in the asymmetry induced by the increase in the amplitude and duration of expansion, together with a drop in the amplitude and duration of recessions favors a lower risk environment.

Conclusions

This note analyzes the properties of the cycles present in commodity prices, identifying interesting results. First, the data analyzed confirm that between 1960 and 1999 commodity-price cycles showed negative asymmetry because recessions used to last longer than expansions. Secondly, it is documented that at the latest period, 1999-2010, the asymmetry is very positive, showing that cycle properties are not constant but, instead, they change over time. Third, unlike other studies, the evidence documented suggests that prices of commodities tend to move together. This implies that the hypothesis that markets are competitive raw materials could be rejected. However, for the period 1999-2010 the evidence is not as strong as for the other sub-periods. In recent years, a clear decrease of the pairs of correlations is observed, as well as the significance of the concordance measures.

These changes in the cyclical patterns are associated with important macroeconomic and financial changes that have occurred globally in the last decade. In terms of economics, we can highlight the growing influence of emerging countries in the international macroeconomic order, with special prominence of China. In the financial arena, the tighter integration of capital markets, the high financial innovation and the fact that raw materials have become a financial asset, are factors that have been accelerating and deepening the points identified.

Regular analysis of business cycles by governments or companies is important for various reasons. First, it enables them to assess the state of the economy. Second, it helps to identify the next turning point. In the case of public authorities, the information obtained can be of great help to design effective counter-cyclical stabilization policies. For the private sector, especially for those companies related to the commodity export sector, a detailed knowledge of the commodity-price cycles could be useful in at least two aspects. On one hand, knowing the cyclical phase of a certain commodity, and the approximate length that it can have, is of great help in the decision process related to a long term investment (increase in the capacity of extraction of metals, gas or oil). On the other hand, this knowledge can be used to improve the risk management and to reduce the potential losses. For example, a company or government expecting the end of an upward trend in oil prices can sell futures to hedge against the fall. Furthermore, this information can be exploited to optimize the cost of coverage.

Annex A: Steps to date cycles using the algorithm developed by Harding y Pagan (2002)

Step 1: Initial selection

- Perform an initial selection of peaks and troughs. Each peak (trough) is located at the highest (minimum) local point of the series using a window of two months at either side of the selected point.

Step 2: Enforce alternation of peak and troughs

- Check alternation of peaks and troughs. The algorithm verifies that none of the peak dates and troughs dates are shared.

Step 3: Enforcement of additional restrictions

- Elimination of some turnings points to restrict phases (peak-troughs and trough-peak) to be at least two quarters long.
- The algorithm verifies that cycles (peak-peak and trough-trough) have a minimum duration of at least five quarters.

Step 4: Final turning points

- The algorithm selects the final peak and through dates.

Table 1: Average amplitude and duration of booms and slumps in commodity price cycles

	Complete cycles	Booms			Slumps				Larger dur.	Larger ampl.	D_b - D_s col 3 - 6 in months	A_b - A_s col. 4 - 7 in %
		Duration[1]	Amplitude[2] total	Amplitude[2] monthly[4]	Duration	Amplitude total	Amplitude monthly[4]	Time[3]				
1 A: 1960:1-2010:12												
Metals	13	19	41	1,8	22	-40	-2,3	56	S	B	-2	1
Aluminium	10	27	46	1,4	31	-53	-2,4	52	S	S	-4	-7
Cooper	13	15	49	2,7	19	-49	-3,5	54	S	B	-4	0
Nickel	10	34	73	1,6	23	-70	-5,1	40	B	B	10	3
Gold	11	22	44	1,7	21	-31	-1,8	53	B	B	1	13
Silver	9	29	73	1,9	23	-67	-4,8	53	B	B	6	6
Oil	13	21	59	2,2	23	-51	-3,0	51	S	B	-2	8
Agro	13	19	25	1,2	21	-27	-1,5	52	S	S	-2	-2
Maize	13	20	44	1,9	24	-45	-2,4	55	S	S	-5	-1
Wheat	12	16	44	2,3	31	-46	-1,9	67	S	S	-15	-2
Soybean	12	17	50	2,4	25	-50	-2,8	52	S	S	-8	0
Cotton	13	17	39	2,0	18	-43	-3,1	50	S	S	-1	-4
Wool	13	20	43	1,8	24	-44	-2,4	55	S	S	-4	-1
Food	13	19	21	1,0	21	-24	-1,3	51	S	S	-2	-3
Beef	12	27	34	1,1	21	-33	-1,9	47	B	B	6	1
Beverages	11	26	49	1,6	25	-49	-2,7	49	B	B	1	0
1 B: 1960:1-1999:8												
Metals	11	15	33	1,9	23	-40	-2,2	71	S	S	-7	-7
Aluminium	9	21	43	1,7	31	-50	-2,2	68	S	S	-9	-7
Cooper	11	14	46	2,7	21	-51	-3,3	69	S	S	-7	-5
Nickel	8	32	54	1,4	26	-62	-3,7	57	B	S	6	-8
Gold	7	23	48	1,7	27	-44	-2,1	70	S	B	-5	4
Silver	7	25	75	2,3	24	-74	-5,5	69	B	B	1	1
Oil	9	22	47	1,8	30	-49	-2,2	66	S	S	-8	-2
Agro	11	18	27	1,3	22	-27	-1,4	65	S	B	-4	0
Maize	10	18	41	2,0	26	-47	-2,4	68	S	S	-8	-6
Wheat	9	15	39	2,2	33	-41	-1,6	77	S	S	-18	-2
Soybean	8	16	50	2,6	33	-56	-2,5	69	S	S	-17	-6
Cotton	11	15	37	2,1	19	-41	-2,8	64	S	S	-4	-4
Wool	11	18	33	1,6	21	-44	-2,7	63	S	S	-3	-11
Food	10	19	20	1,0	27	-27	-1,2	68	S	S	-8	-7
Beef	9	30	33	1,0	18	-38	-2,6	54	B	S	12	-5
Beverages	9	24	49	1,7	25	-53	-3,0	63	S	S	-1	-4
1 C: 1999:1-2010:12												
Metals	2	42	94	1,6	16	-43	-3,5	28	B	B	26	51
Aluminium	1	14	49	2,9	33	-77	-4,4	28	S	S	-19	-28
Cooper	4	19	59	2,4	10	-42	-5,3	30	B	B	9	17
Nickel	2	17	115	4,6	13	-98	-26,9	23	B	B	5	17
Gold	2	29	42	1,2	12	-8	-0,7	24	B	B	17	34
Silver	2	41	63	1,2	17	-37	-2,8	26	B	B	25	26
Oil	4	20	72	2,8	9	-55	-9,0	29	B	B	11	17
Agro	2	19	19	0,9	19	-27	-1,6	40	B	S	0	-8
Maize	3	29	51	1,4	11	-37	-4,2	29	B	B	18	14
Wheat	3	21	60	2,3	21	-50	-3,2	53	S	B	-1	10
Soybean	3	23	57	2,0	9	-36	-5,0	24	B	B	14	21
Cotton	3	25	47	1,5	11	-42	-5,1	29	B	B	15	5
Wool	2	28	87	2,3	27	-32	-1,4	56	B	B	1	55
Food	4	21	24	1,0	8	-16	-2,3	26	B	B	13	8
Beef	2	19	41	1,8	29	-17	-0,6	60	S	B	-10	24
Beverages	2	34	49	1,2	11	-17	-1,8	38	B	B	24	32

1. In months. 2. In percentage change.
3. Is the percentage of time spent in a slump or recession.
4. Is the geometric average.

Table 2: Correlation matrix between commodity-price cycles

2 A: 1960:1-2010:12

	Metals	Aluminium	Cooper	Nickel	Gold	Silver	Oil	Agro	Maize	Wheat	Soybean	Cotton	Wool	Food	Beef
Aluminium	0,45														
Cooper	0,65	0,32													
Nickel	0,36	0,19	0,22												
Gold	0,03	0,10	0,21	0,00											
Silver	0,33	0,17	0,34	-0,03	0,29										
Oil	0,26	0,27	0,30	0,17	0,05	0,26									
Agro	0,24	0,22	0,14	0,01	0,07	0,19	0,16								
Maize	0,01	-0,08	0,06	0,06	0,20	0,26	-0,03	0,16							
Wheat	-0,07	-0,23	0,02	0,06	0,11	0,01	0,02	0,11	0,56						
Soybean	0,04	0,12	0,08	0,06	0,34	0,41	0,05	0,15	0,31	0,09					
Cotton	0,23	0,13	0,21	0,06	0,05	0,32	0,17	0,26	0,23	0,11	0,25				
Wool	0,16	0,21	0,12	0,17	0,09	0,03	-0,08	0,35	0,09	0,03	0,09	0,21			
Food	0,10	0,12	0,17	-0,01	0,25	0,33	0,00	0,29	0,56	0,34	0,47	0,22	0,16		
Beef	0,03	-0,15	0,05	0,00	0,20	-0,04	-0,01	0,12	0,01	-0,04	0,06	0,09	0,18	0,03	
Beverages	0,19	-0,14	0,19	0,10	0,06	0,21	0,17	0,25	0,09	0,06	0,07	0,13	0,07	-0,04	0,00

2 B: 1960:1-1999:8

	Metals	Aluminium	Cooper	Nickel	Gold	Silver	Oil	Agro	Maize	Wheat	Soybean	Cotton	Wool	Food	Beef
Aluminium	0,38														
Cooper	0,69	0,31													
Nickel	0,25	0,05	0,24												
Gold	-0,03	0,01	0,13	-0,02											
Silver	0,23	0,19	0,27	-0,13	0,26										
Oil	0,16	0,21	0,21	0,14	-0,01	0,21									
Agro	0,20	0,19	0,12	-0,05	0,14	0,23	0,14								
Maize	0,00	-0,13	0,00	0,09	0,19	0,26	-0,07	0,15							
Wheat	-0,08	-0,37	-0,02	0,09	0,12	0,02	-0,01	0,01	0,54						
Soybean	-0,08	0,07	-0,05	0,03	0,27	0,37	-0,04	0,15	0,25	0,08					
Cotton	0,19	0,14	0,16	0,06	0,00	0,28	0,14	0,22	0,15	-0,02	0,15				
Wool	0,22	0,16	0,19	0,15	0,11	0,17	-0,08	0,39	0,16	-0,04	0,07	0,23			
Food	0,01	0,08	0,06	-0,08	0,30	0,32	-0,15	0,23	0,50	0,33	0,47	0,11	0,20		
Beef	0,15	-0,17	0,15	0,03	0,27	0,15	0,10	0,15	0,18	0,02	0,11	0,28	0,10	0,15	
Beverages	0,16	-0,17	0,13	0,14	0,00	0,07	0,09	0,25	-0,06	0,03	0,00	0,00	0,12	-0,13	0,10

2 C: 1999:1-2010:12

	Metals	Aluminium	Cooper	Nickel	Gold	Silver	Oil	Agro	Maize	Wheat	Soybean	Cotton	Wool	Food	Beef
Aluminium	0,54														
Cooper	0,31	0,16													
Nickel	0,66	0,64	-0,07												
Gold	-0,13	0,11	0,13	-0,27											
Silver	0,38	-0,09	0,42	-0,02	0,26										
Oil	0,45	0,34	0,42	0,16	-0,04	0,22									
Agro	0,29	0,24	0,09	0,20	-0,29	-0,02	0,14								
Maize	-0,19	-0,13	0,12	-0,13	-0,36	-0,06	0,03	0,26							
Wheat	-0,31	-0,05	-0,05	-0,21	-0,15	-0,18	-0,07	0,31	0,58						
Soybean	0,12	0,00	0,23	-0,08	0,25	0,26	0,10	0,00	0,10	-0,11					
Cotton	0,25	-0,03	0,18	-0,02	-0,19	0,32	0,19	0,45	0,29	0,30	0,28				
Wool	0,02	0,37	-0,19	0,35	-0,02	-0,41	-0,02	0,31	-0,02	0,20	0,11	0,07			
Food	-0,05	-0,16	0,24	-0,09	-0,33	0,13	0,18	0,30	0,60	0,27	0,11	0,22	-0,06		
Beef	-0,10	0,13	-0,09	0,10	0,19	-0,43	-0,14	0,16	-0,26	-0,17	0,16	-0,32	0,52	-0,21	
Beverages	0,06	-0,27	0,22	-0,25	0,10	0,56	0,26	0,14	0,23	0,13	0,10	0,36	-0,21	0,20	-0,31

Statisticaly significant at 1%.
Statisticaly significant at 5%.

Table 3: Concordance matrix between commodity-price cycles

3 A: 1960:1-2010:12

	Metals	Aluminium	Cooper	Nickel	Gold	Silver	Oil	Agro	Maize	Wheat	Soybean	Cotton	Wool	Food	Beef
Aluminium	**74**														
Cooper	**78**	**65**													
Nickel	**65**	**64**	**71**												
Gold	53	49	**62**	**60**											
Silver	**60**	**59**	**56**	49	**70**										
Oil	**67**	**66**	**67**	**64**	**58**	53									
Agro	**65**	**56**	**70**	**70**	**65**	54	**57**				30 not significant				
Maize	**55**	50	**57**	**67**	**68**	**62**	53	**64**							
Wheat	49	42	53	**55**	**62**	**57**	51	52	**62**						
Soybean	**56**	53	**57**	**61**	**66**	**58**	**61**	**56**	**82**	**61**					
Cotton	51	**55**	**60**	**57**	**61**	**59**	**57**	**58**	**61**	**58**	**60**				
Wool	50	47	**62**	53	**65**	53	49	**67**	**56**	**57**	**59**	**67**			
Food	48	50	**56**	**60**	**64**	**66**	53	52	**62**	**75**	**59**	**61**	**56**		
Beef	**70**	**61**	**58**	43	**69**	**66**	**55**	**57**	**58**	47	**61**	46	50	46	
Beverages	**64**	52	**63**	**55**	**61**	**68**	**64**	**55**	**65**	53	**61**	**58**	49	**61**	**67**

3 B: 1960:1-1999:8

	Metals	Aluminium	Cooper	Nickel	Gold	Silver	Oil	Agro	Maize	Wheat	Soybean	Cotton	Wool	Food	Beef
Aluminium	**75**														
Cooper	**75**	**62**													
Nickel	**57**	**61**	**67**												
Gold	47	51	**60**	**57**											
Silver	**59**	**65**	**56**	44	**70**										
Oil	**62**	**68**	**65**	**60**	49	46									
Agro	**60**	**56**	**68**	**68**	**60**	**54**	51				26 not significant				
Maize	**57**	50	**62**	**72**	**68**	**59**	50	**65**							
Wheat	50	47	**58**	**60**	**64**	**60**	51	51	**64**						
Soybean	**59**	**61**	**60**	**67**	**66**	**60**	**61**	**55**	**78**	**59**					
Cotton	51	**55**	**59**	**57**	**70**	**58**	**61**	**60**	**61**	**63**	**62**				
Wool	50	50	**63**	**57**	**69**	**58**	51	**69**	**57**	**57**	**58**	**66**			
Food	48	50	**61**	**64**	**71**	**67**	52	**56**	**63**	**79**	**65**	**65**	**63**		
Beef	**70**	**56**	**56**	35	**61**	**66**	48	52	**57**	46	**62**	51	52	49	
Beverages	**61**	51	**63**	49	**56**	**62**	**60**	**54**	**66**	**57**	**66**	**60**	**54**	**61**	**64**

3 C: 1999:1-2010:12

	Metals	Aluminium	Cooper	Nickel	Gold	Silver	Oil	Agro	Maize	Wheat	Soybean	Cotton	Wool	Food	Beef
Aluminium	**69**														
Cooper	**89**	**75**													
Nickel	**94**	**76**	**83**												
Gold	**70**	40	**65**	**64**											
Silver	**60**	40	**54**	**59**	**72**										
Oil	**85**	**60**	**75**	**79**	**80**	**80**									
Agro	**85**	**61**	**79**	**79**	**77**	**77**	**79**				51 not significant				
Maize	47	26	42	44	**69**	**69**	**60**	**58**							
Wheat	43	24	38	37	**58**	**58**	49	51	**69**						
Soybean	45	23	45	39	**65**	**65**	**58**	53	**81**	**67**					
Cotton	52	51	**63**	51	38	38	44	49	**60**	41	**56**				
Wool	46	35	**57**	40	51	51	38	**57**	**56**	**58**	**63**	**74**			
Food	42	49	37	42	46	46	**55**	35	**60**	**65**	42	49	35		
Beef	**74**	51	**63**	**75**	**89**	**89**	**80**	**77**	**58**	49	**56**	26	40	35	
Beverages	**67**	52	**62**	**72**	**79**	**79**	**74**	**56**	**63**	42	44	53	33	**61**	**74**

Values in the shadow cells are ststistically significant.
Is the percentage of months in which two commodities coincide during the boom or recession phase.

Figure 1: Dates for peaks and troughs

Logarithm of real price indices

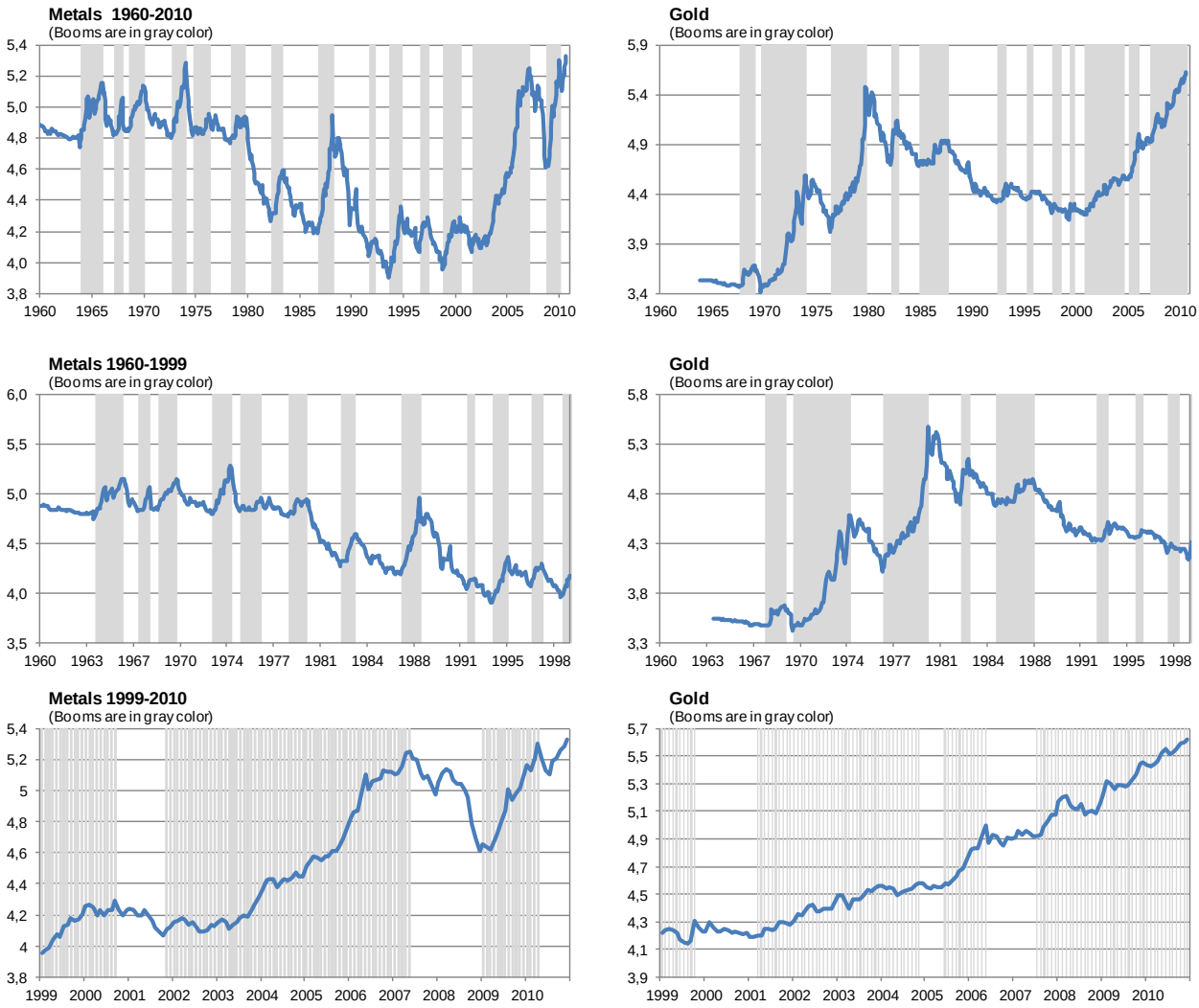


Figure 2: Average amplitude and duration of booms and slumps in commodity price cycles

Logarithm of real price indices

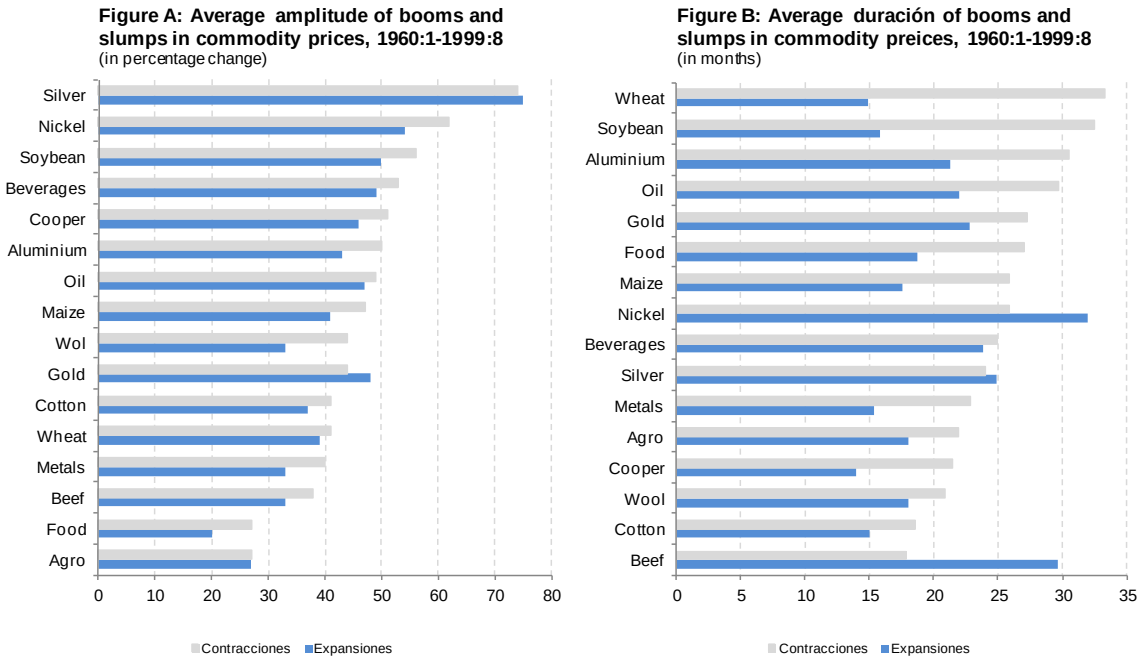
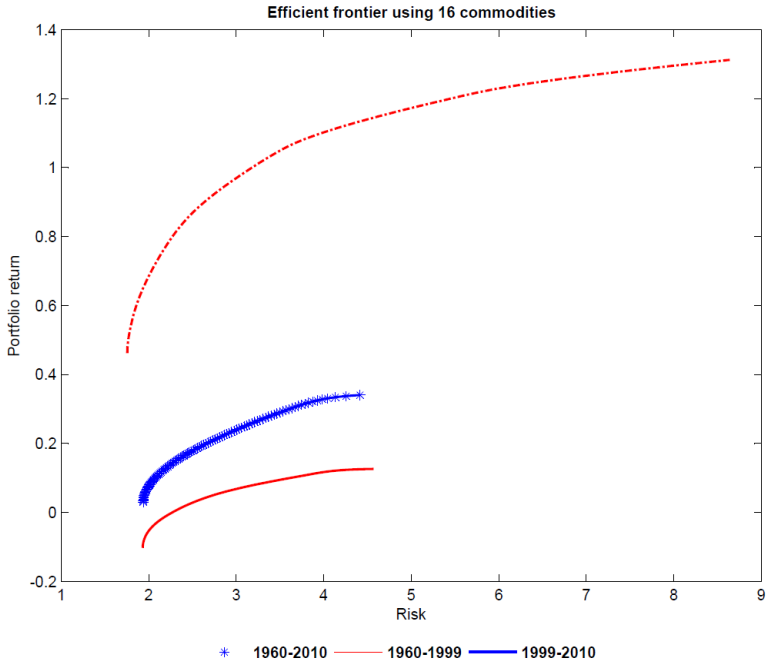


Figure 3: Efficient frontier for different periods

Mean-variance optimization, 100 portfolios.



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