

# Informational Content of Commodity Prices

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## Abstract

The informational content of commodity indices as predictors of inflation in industrial economies remains a subject of debate in the literature and among practitioners. In this paper we study within the framework of cointegration, the relationship among four commodity indices without considering the “target” price level, which in our case is measured by either US CPI or WPI. Two stochastic common trends summarize the secular common movements among the commodity indices and are cointegrated with each price variable. On the other hand the cyclical components can be synthesized into a single common stationary combination of the variables. These cyclical movements are strongly related to inflation and present the interesting feature of Granger causing inflation but not being caused by it.

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# 1 Introduction

Two issues regarding commodity prices have attracted attention of economists over a long period. The first concerns the long- and short-term relationships between commodity prices and general price indices such as the consumer price index (CPI) and the wholesale price index (WPI). The second concerns the trend in the long-term *real* price of commodities, as exemplified in the literature on the so-called Prebisch-Singer hypothesis which predicts a long-term decline in real commodity prices. This article is primarily concerned with the first of these two issues, but will comment on the implications of our analysis for the second.

Since commodities are inputs into many widely consumed or produced outputs, nominal prices of the latter are expected to move in line with the former. Furthermore, the assumption that commodity prices are determined in “auction markets” is widely accepted as a first approximation. Hence, they tend to respond relatively more quickly and sensitively to monetary or real shocks than do industrial prices. These considerations are at the center of the search for a synthesis of commodity prices (an index) able to characterize these transmission mechanisms on inflation.<sup>1</sup> Some commodity index producers (e.g., Crimmins, 1993) claim that this is one of the considerations underlying the choice of the weights of the index and of changing them as the structure of the world demand for commodities changes. Theoretical support for a relationship between nominal commodity prices and the general price level is provided by Frankel (1986), Boughton and Branson (1991), and Pecchenino (1992) among others. In what follows we will sketch a simple model which highlights how supply and demand shocks in the economy can impact on commodity prices and then on the general price level. We will provide a possible explanation of why the empirical evidence on a long-term relation between commodity prices and a general price index (such as CPI or WPI) has proved to be elusive (e.g., Baillie, 1989) by suggesting that any single index does not fully summarize the various general price components, but several indices may have information in common which is relevant for the general price.

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<sup>1</sup>See “Tapping the Inflation Barometer”, the *Economist*, March 5th 1994, which reminds us that “.. In 1987 James Baker, then America’s treasury secretary, proposed that the G7 countries should adopt a commodity-price index as an early warning indicator”. See also Durand and Blondal (1991) and Kugler (1991).

There are a number of commodity price indices that have wide currency (Reed, 1995), and several of these have been used in previous econometric investigations: here we will use four of these indices, namely the Commodity Research Bureau Index, the Goldman Sachs Commodity Index, the World Bank Commodity Index and The Economist Dollar based Commodity Index. Most previous authors have adopted cointegration analysis (justified by the nonstationarity of the indices used), although limited to a bivariate framework between a commodity index and a general price index. For example, Baillie (1989) could not find bivariate cointegration between some commodity price indices and the consumer price index for the U.S.A., France, Italy, U.K., or West Germany. Similarly, Garner (1985) and Durand and Blondal (1991) found no relationship between commodity price *levels* and the consumer price index level, though they found a stronger indication of a relationship between the *changes* in these variables.

Two are the main empirical questions which are addressed in this paper:

1. How much information is shared by different (US dollar based) commodity price indices?
2. How much of the common information is related to a US price index or to inflation?

We show that two common trends drive the permanent components of the indices (in spite of the different individual commodity weights), and a single common factor explains most of the variability of the cyclical components. Although there do exist several methods to achieve a permanent/cyclical decomposition, our empirical results suggest that there is little practical difference from following one or the other.

For the second question we show that there exists an equilibrium relationship between commodity indices (summarized by the common trends) and a general price index. Moreover, the common cyclical component of the commodity indices is shown to Granger-cause inflation while the reverse is not true.

The plan of the remainder of the paper is as follows. Section 2 outlines a simple model where commodity prices and a general price level are related to supply and demand shocks whose characteristics generate the dynamic properties of price behavior and can justify the cointegration framework.

In Section 3 we describe in more detail the commodity indices used in the analysis. In Section 4 we study the properties of the four indices, deriving an estimate of their common permanent and transitory components. In Section 5 these components are compared to two general US price indices (CPI and WPI), and to the related measures of inflation. Section 6 concludes.

## 2 A Simple Theoretical Framework

The model that we propose to relate commodity prices to the general price level is similar to that by Pecchenino (1992), modified to consider two commodities or bundles of them, and the existence of a futures commodity market. Further extensions such as the introduction of more commodities or of price stickiness are feasible, but we prefer to adopt the simplest model to highlight the main point that we wish to make, namely, that the price indices can be expected to be integrated, while cointegration among themselves and with the general price index may or may not hold. By so doing we set the stage for the empirical questions of the paper.

Consider an economy with three types of agents, consumer good producers, commodities producers, and traders. The representative producer of consumer good has a Cobb-Douglas production function:

$$y_t = \alpha c_t + (1 - \alpha)d_t + \mu_t,$$

where  $y$  is the (log of the) product,  $c$  and  $d$  are (the logs of) two commodities,  $\alpha \in [0, 1]$  is the elasticity of substitution,  $\mu$  is a productivity shock, and, for simplicity, we assume that a fixed amount of labor and capital are used, one unit of each of them (so that their logs are zero). For technological reasons, e.g., transportation time, the amount of  $c$  and  $d$  to be used in period  $t$  must be decided one period in advance, in  $t - 1$ .

The representative trader is committed in period  $t - 1$  to deliver to the producer of the good the required quantity of  $c$  and  $d$  in period  $t$  at unit prices  $p_{ct}$  and  $p_{dt}$ , by buying it from a commodity producer at unit prices  $g_t$  and  $h_t$ . Thus the trader fixes the prices  $p_{ct}$  and  $p_{dt}$  in period  $t - 1$ , so that the demand of each commodity is equal to the expected supply,  $c_t^d = c_{t|t-1}^d = c_{t|t-1}^s$  and  $d_t^d = d_{t|t-1}^d = d_{t|t-1}^s$ , where  $x_{t|t-1}$  indicates the expected value of  $x_t$  in period  $t - 1$ .<sup>2</sup>

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<sup>2</sup>To add realism to the model, one may want to consider the presence of a risk premium

The supply functions of the representative commodity producer are:

$$\begin{aligned}c_t^s &= s(g_t - p_t) + \varepsilon_t, \\d_t^s &= r(h_t - p_t) + \eta_t,\end{aligned}$$

where  $p_t$  is the general price level, that coincides with the price of  $y_t$ , and  $\varepsilon_t$  and  $\eta_t$  are supply shocks. In equilibrium  $g_t$  and  $h_t$  are such that  $c_t^d = c_t^s$  and  $d_t^d = d_t^s$ .

The price level is established by a money demand equation, facing a fixed money supply, namely:

$$\begin{aligned}m_t^d - p_t &= y_t + \zeta_t, \\m_t^s &= \bar{m}_t,\end{aligned}$$

where  $\zeta_t$  is a demand shock.

We will now solve the model to determine the equilibrium quantities  $c_t$  and  $d_t$ , the prices  $g_t$ ,  $h_t$ ,  $p_{ct}$ , and  $p_{dt}$ , and the general price level  $p_t$ .

The first order conditions for the good producer are:

$$\begin{aligned}p_{ct} - p_{t|t-1} &= \ln \alpha + (1 - \alpha)d_t^d - (1 - \alpha)c_t^d, \\p_{dt} - p_{t|t-1} &= \ln(1 - \alpha) - \alpha d_t^d + \alpha c_t^d,\end{aligned}$$

namely, the expected real price of commodities equals their expected marginal product. Given that in equilibrium  $c_t^d = c_{t|t-1}^s$  and  $d_t^d = d_{t|t-1}^s$ , we get

$$\begin{aligned}p_{ct} - p_{t|t-1} &= \ln \alpha + (1 - \alpha)r(p_{dt} - p_{t|t-1}) \\&\quad + (1 - \alpha)\eta_{t|t-1} - (1 - \alpha)s(p_{ct} - p_{t|t-1}) - (1 - \alpha)\varepsilon_{t|t-1}, \\p_{dt} - p_{t|t-1} &= \ln(1 - \alpha) - \alpha r(p_{dt} - p_{t|t-1}) - \alpha\eta_{t|t-1} \\&\quad + \alpha s(p_{ct} - p_{t|t-1}) + \alpha\varepsilon_{t|t-1}.\end{aligned}$$

Solving for  $p_{ct} - p_{t|t-1}$  and  $p_{dt} - p_{t|t-1}$  yields

$$p_{ct} - p_{t|t-1} = \frac{(1 + \alpha r) \ln \alpha + (1 - \alpha)r \ln(1 - \alpha) + (1 - \alpha)\eta_{t|t-1} - (1 - \alpha)\varepsilon_{t|t-1}}{1 + \alpha r + (1 - \alpha)s}$$

demanded by the trader. We prefer not to do so because it would mainly burden the notation impeding the derivation of a closed-form solution.

$$\begin{aligned}
&\equiv k_c, \\
p_{dt} - p_{t|t-1} &= \frac{(1 + (1 - \alpha)s) \ln(1 - \alpha) + \alpha s \ln \alpha + \alpha \varepsilon_{t|t-1} - \alpha \eta_{t|t-1}}{1 + \alpha r + (1 - \alpha)s} \\
&\equiv k_d.
\end{aligned}$$

and

$$\begin{aligned}
c_t^d &= sk_c + \varepsilon_{t|t-1}, \\
d_t^d &= rk_d + \eta_{t|t-1}.
\end{aligned}$$

Notice that if  $\varepsilon_{t|t-1}$  is positive, i.e., a positive shock to the supply of  $c$  is expected,  $p_{ct} - p_{t|t-1}$  decreases less than proportionally,  $p_{dt} - p_{t|t-1}$  increases, and both  $c_t^d$  and  $d_t^d$  increase.

The prices of  $c_t$  and  $d_t$ ,  $g_t$  and  $h_t$ , must be such that  $c_t^d = c_t^s$  and  $d_t^d = d_t^s$ . Hence,

$$\begin{aligned}
c_t^s &= s(g_t - p_t) + \varepsilon_t = s(p_{ct} - p_{t|t-1}) + \varepsilon_{t|t-1}, \\
d_t^s &= r(h_t - p_t) + \eta_t = r(p_{dt} - p_{t|t-1}) + \eta_{t|t-1},
\end{aligned}$$

and

$$\begin{aligned}
g_t &= p_t + (p_{ct} - p_{t|t-1}) - (\varepsilon_t - \varepsilon_{t|t-1})/s \\
&= p_{ct} + (p_t - p_{t|t-1}) - (\varepsilon_t - \varepsilon_{t|t-1})/s, \\
h_t &= p_t + (p_{dt} - p_{t|t-1}) - (\eta_t - \eta_{t|t-1})/r \\
&= p_{dt} + (p_t - p_{t|t-1}) - (\eta_t - \eta_{t|t-1})/r.
\end{aligned}$$

Therefore, the prices increase with the “future” prices and with unexpected shocks to the general price level, and decrease with unexpected supply shocks.

On average,  $g_t = p_{ct}$  and  $h_t = p_{dt}$ .

From the monetary sector,

$$\begin{aligned}
p_t &= \bar{m}_t - \alpha c_t - (1 - \alpha)d_t - \mu_t - \zeta_t \\
&= \bar{m}_t - \alpha s(p_{ct} - p_{t|t-1}) - (1 - \alpha)r(p_{dt} - p_{t|t-1}) \\
&\quad - \alpha \varepsilon_{t|t-1} - (1 - \alpha)\eta_{t|t-1} - \mu_t - \zeta_t \\
&= \bar{m}_t - \mu_t - \zeta_t - \frac{(1 - \alpha)(1 + s)\eta_{t|t-1} + \alpha(1 + r)\varepsilon_{t|t-1}}{1 + \alpha r + (1 - \alpha)s} + K,
\end{aligned}$$

$$p_{t|t-1} = \bar{m}_t - \mu_{t|t-1} - \zeta_{t|t-1} - \frac{(1-\alpha)(1+s)\eta_{t|t-1} + \alpha(1+r)\varepsilon_{t|t-1}}{1+\alpha r + (1-\alpha)s} + K,$$

where

$$K = -\frac{\alpha s[(1+\alpha r) \ln \alpha + (1-\alpha)r \ln(1-\alpha)] + (1-\alpha)r[(1+(1-\alpha)s) \ln(1-\alpha) + \alpha s \ln \alpha]}{1+\alpha r + (1-\alpha)s}.$$

Hence, the price level increases with negative shocks to aggregate supply ( $\mu_t < 0$ ), positive shocks to aggregate demand ( $\zeta_t < 0$ ), and negative expected shocks to the commodities supply ( $\varepsilon_{t|t-1} < 0$ ,  $\eta_{t|t-1} < 0$ ). Price surprises,  $p_t - p_{t|t-1}$ , are due to unexpected shocks to the aggregate demand and supply but not to the commodities supply.

The dynamic behavior of the general price level and of the commodity prices depends on the properties of the shocks. The demand shocks usually only have temporary effects, so that  $\zeta_t$  is assumed to be stationary, even if possibly correlated in time. According to the Real Business Cycle literature (e.g. Long and Plosser, 1983), the aggregate supply shocks have in general permanent effects, i.e., from the statistical point of view, they are integrated processes. The supply of commodities is affected by a mixture of permanent and transitory shocks, so that overall  $\varepsilon_t$  and  $\eta_t$  can be also expected to be integrated process. For example, Reinhart and Wickham (1994) include weak economic growth, the surge in commodities supply during the 1980s, and the breakdown of several international commodity agreements among permanent shocks in real commodity prices; weak economic performance in industrial countries, and negative demand and supply shocks from the former Soviet Union among the cyclical shocks.

In the presence of persistent shocks, both the commodity prices and the general price level are integrated. A natural question is under what conditions they are cointegrated, i.e., there exists a linear combination of them that is stationary. For our purposes, this is particularly interesting if we interpret  $c$  and  $d$  as two bundles of commodities instead of single commodities, and  $g_t$  and  $h_t$  as two different commodity price indices.

Several cases can be distinguished, according to the relationships among the three supply shocks  $\mu_t$ ,  $\varepsilon_t$  and  $\eta_t$ . Two of them are of particular interest.

1. If there is no cointegration among  $\mu_t$ ,  $\varepsilon_t$  and  $\eta_t$ , the commodity price indices  $g_t$  and  $h_t$  are not cointegrated. Each of them is also not cointegrated with the general price level,  $p_t$ . This is a common result in empirical analysis, see e.g., Baillie (1989), where usually no cointegra-

tion is found between a commodity price index and the general price level. Yet, the linear combination

$$\alpha g_t + (1 - \alpha)h_t - p_t$$

is stationary, i.e., there exists a cointegration relationships but it involves all the three price measures. This is because  $p_{ct} - p_{t|t-1}$  and  $p_{dt} - p_{t|t-1}$  are driven by the same shock,  $\varepsilon_t - \eta_t$ , and all surprises,  $x_t - x_{t|t-1}$ , are stationary.

2. If  $\varepsilon_t - \eta_t$  is stationary, i.e., the supply of the two commodities is affected by the same permanent shock,  $g_t - h_t$  is also stationary, i.e., the two commodity price indices are cointegrated. Moreover, each of them is cointegrated with the general price level.

Even if we increased the number of commodities in the production function, it would still be possible that their prices are driven by a limited number of permanent shocks, reflecting the interrelationships among commodity markets, and that the general price level shares these shocks as well. If this is the case, commodity price indices, being weighted averages of commodity prices, can also be expected to be cointegrated with one another and possibly with the general price level, since they may have the same combination of permanent shocks in common. Which situation applies in practice becomes the relevant empirical question.

### 3 The Selected Commodity Indices

As mentioned before, we have chosen four broadly based indices:

1. Commodity Research Bureau index (CRBI);
2. Goldman Sachs index (GSCI);
3. Economist index (ECI);
4. World Bank commodity index based on 33 internationally traded primary commodities (WBI).

Although all four indices use commodity prices expressed in US dollars, they vary considerably in their coverage and weights given to component commodities. The CRBI is a quarterly average of daily indices of 21 commodities putting an *equal weight* on them. The GSCI has 22 commodities but puts a weight of over 50% (51.26) on energy while the ECI and the WBI exclude energy and precious metals entirely (see Table 1). Crimmins (1993, p. 2) notes: “The Goldman Sachs Commodity Index (GSCI) measures the total return of a world-production weighted basket of commodity futures contracts. The GSCI has been back calculated to 1970 using futures data for all commodities with liquid, tradeable futures contracts which satisfy our inclusion criteria. Of necessity the composition of the GSCI has changed dramatically over time as new commodities met the GSCI liquidity threshold.” The ECI is based on 24 commodities weighted according to the imports of OECD countries. The CRBI, WBI and ECI are broadly based indices which give a substantial weight to ‘soft’ (agricultural) commodities. For additional details see Table 1.

We have used two general price indices in our analysis: the US consumer price index (CPI) and the US wholesale price index (WPI).<sup>3</sup>

The graph of the (logs of the) four indices in Figure 1 highlights a sharp increase in their level during the early 70s, due to the oil crisis and more generally to the increase in raw materials prices, followed by a further increase at the end of the decade, which is a reflection of the second oil crisis. The amplitude of the fluctuations dampens during the 80s, but a somewhat cyclical behavior is still present.

The indices tend to move together, this property being more evident for the first part of the sample. The contemporaneous correlation coefficients are fairly high (the highest is 0.96 between CRBI and ECI, and the lowest 0.73 between GSCI and ECI). The empirical autocorrelation functions of the variables start at very high values, higher than 0.9, and slowly decay, suggesting that the variables may be well approximated as I(1) processes.

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<sup>3</sup>The CPI and WPI were extracted from the *International Financial Statistics* CD-ROM data base.

## 4 Commodity shocks: permanent or cyclical?

As mentioned previously, the main questions that seem relevant in this context are the following:

1. How much is there in common among the four commodity price indices?
2. How much of this commonality is related to the US price indices such as CPI and WPI?

Given the nonstationarity of the variables involved, and in light of the suggestions of the theoretical model, both questions may be addressed within a cointegration framework<sup>4</sup>. A direct route would be to study cointegration among the indices and the price index in a five-variable system. This would be a desirable property of the data, and it would provide some answers to both questions. It seems more appealing, though, to follow a different route, which would give us stronger answers and a more general framework. We will thus exclude for the moment the price variable (the CPI or WPI price index), in order to extract a “pure” signal from the indices which should not be contaminated, so-to-speak, by the target it refers to.

As is well known from the literature, the larger the cointegration rank, i.e., the number of stationary linear combinations of nonstationary variables, the smaller the number of common stochastic trends driving the long run evolution of the variables. If the indices measured exactly the same quantity, they should be driven by the same trend; if this quantity measured in common is related to a price index, this trend would drive the behavior of prices as well. The greatest commonality in the nonstationary behavior of the variables would correspond in our case to a cointegration rank being equal to three for the four indices. As we saw from the theoretical model this need not be the case, since shocks may be more diversified.

In order to evaluate whether this is the case, we construct VAR models, check for their accuracy in representing the variables, and then apply tests for the determination of the cointegration rank.

Formally, a VAR( $k$ ) for a vector of  $n$  variables  $\mathbf{x}_t$  can be written as:

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<sup>4</sup>For brevity we will only sketch the considerable volume of empirical results that were obtained, which are available from the authors upon request.

$$\mathbf{x}_t = \sum_{j=1}^k \mathbf{A}_j \mathbf{x}_{t-j} + \boldsymbol{\delta} + \boldsymbol{\epsilon}_t \text{ with } \boldsymbol{\epsilon}_t \sim \text{IN}_n(\mathbf{0}, \boldsymbol{\Sigma}). \quad (1)$$

where  $\boldsymbol{\delta}$  is a vector of  $n$  constants,  $\mathbf{A}_j$  is an  $n \times n$  matrix of autoregressive coefficients, and  $\boldsymbol{\epsilon}_t$  is a vector of  $n$  unobserved errors which have a zero mean and constant covariance matrix  $\boldsymbol{\Sigma}$ . When the variables being modelled are  $I(1)$  but satisfy  $r < n$  long run equilibrium relationships  $\boldsymbol{\beta}'\mathbf{x}_t$  which are  $I(0)$ , the VAR model (1) can be written as a vector equilibrium-correction mechanism (VECM: see Johansen (1991, 1995) and Hendry (1995)):

$$\Delta \mathbf{x}_t = \sum_{j=1}^{k-1} \boldsymbol{\Gamma}_j \Delta \mathbf{x}_{t-j} + \boldsymbol{\alpha} (\boldsymbol{\beta}' \mathbf{x}_{t-1}) + \boldsymbol{\delta} + \boldsymbol{\epsilon}_t, \quad (2)$$

where  $\Delta$  is the first difference operator,  $\boldsymbol{\Gamma}_j = -\sum_{i=j+1}^k \mathbf{A}_i$ , and  $\boldsymbol{\alpha}$  and  $\boldsymbol{\beta}$  are  $n \times r$  matrices of rank  $r$  such that  $\boldsymbol{\alpha}\boldsymbol{\beta}' = -\left(\mathbf{I}_N - \sum_{i=1}^k \mathbf{A}_i\right)$ .

Since  $r$  is not known a priori its value was determined empirically, on the basis of the customary Johansen's (1991) maximum eigenvalue and trace test statistics. A VAR with five lags (with unrestricted intercepts and no trend) is a proper statistical representation for the four indices, and the hypothesis of the cointegration rank being equal to two is accepted (Table 4).<sup>5</sup> Thus, we will maintain that *two* common trends, not just one, underlie the behavior of the indices when examined by themselves.

Any attempt at understanding the message in the commodity prices revolves around the nature of the shocks accruing to the indices. From our multivariate analysis, but subject to caution that our analysis is conducted on *nominal* indices, the graphs of the two estimated common stochastic trends (Figure 2) suggest the presence of two counterweighing forces at work for long-run movements, namely, a common trend which exhibits a decline following the second oil shock, while a second one shows a small upward tendency.

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<sup>5</sup>In fact, this choice is confirmed by the significance of the error correction terms in the VECM, and it is robust to an increase in the lag length. The recursive Chow tests support the stability of the VAR parameters. Repeating the analysis for the subsample 76Q1-93Q4 (with possibly a different behavior following the first oil shock) there are no changes in the cointegration results.

This result sets the stage for analyzing how these two common trends combine with each other into the permanent (i.e., nonstationary) components of the commodity price indices. From a methodological point of view there exist various ways of separating permanent from transitory components under the constraints imposed by cointegration, achieving identification by characterizing the nature of each component. In what follows we adopt the Gonzalo and Granger (1995 – GG) decomposition, where the common trends are taken to be linear combinations of the  $I(1)$  observable variables, imposing on the transitory components the constraint that they are a linear combination of the error correction terms.<sup>6</sup>

## 4.1 The permanent components

The combination of the common trends into the permanent component of each variable helps in characterizing the similarities among indices. Figure 3 exhibits the behavior of the variables with their estimated permanent components. The commodity price indices can therefore be differentiated according to the behavior of their permanent component. The striking result is that GSCI has a markedly different behavior relative to the other indices. The increase in the indices during the first part of the sample is reflected in the increase of the permanent components.

As of the question related to the decline in the prices in the 1980s, Figure 3 shows that the decline in commodity prices is reflected only in the energy dominated GSCI and the WBI, and to a lesser extent by the CRBI. But only the permanent component of the WBI index follows somewhat such a decline, which is absent from the other permanent components. On the basis of our results, therefore, the evidence in favor of the secular nature of the decline in nominal commodity prices is mixed. We note that throughout the ‘80s current US dollar prices of energy and several important agricultural products, especially coffee, cocoa, grains, and cotton were in decline. Increases during the 1980s were exhibited in some of the metals such as aluminum, copper, and nickel. Nevertheless, these results are consistent with a declining long term trend of *real* commodity prices suggested by the previously cited IMF studies.

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<sup>6</sup>We also used the Beveridge-Nelson-Stock-Watson (Stock and Watson, 1988a 1998b – BNSW) decomposition, where the permanent component of each variable is characterized as a linear combination of purely random walks, but this did not affect the results.

The beginning of the 1990s are characterized by a certain divergence between permanent components and indices with the former greater than the latter. This would indicate a certain pressure on nominal commodity prices to *increase* due to secular factors. Indeed, the nominal prices surged from late 1993 to early 1995, the ECI rising more than 20%.

## 4.2 The cyclical components

In our framework the cyclical (or transitory) components of each variable are obtained by subtracting the permanent component from the original variables (Figure 4). The result shows that in the 1970s the oil shocks brought about a big surge in these components which were subsequently absorbed. In the 1980s, therefore, all indices are characterized by a strong decline in their transitory components, lending a strong support in favor of the cyclical explanation for this decline. The early 1990s are marked by smaller fluctuations.

It is clear from the graph that these components are highly correlated with one another (the smaller coefficient is 0.95), implying that the information in the components can be synthesized.. In fact, performing a principal component analysis suggested that a single factor explains most of the correlation and can be interpreted (on the basis of the factor score coefficients) as a simple average of the four cyclical components. Traditional Box-Jenkins analysis and the use of information criteria indicates that this single factor is best represented as an ARMA(3,3) process.<sup>7</sup>

## 5 Relationship with the General Price

We can now relate these results to the price index movements, considering CPI and WPI in turn. The issue is whether there is cointegration among the indices and the price measures. For this hypothesis to be accepted, given that there exist two cointegration relationships among the indices, the cointegration rank in a five variable VAR which also includes a price measure

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<sup>7</sup>We also performed a common cycle analysis à la Vahid and Engle (1993), which does not provide any evidence of common cycles at the order zero or one (results available upon request) which would correspond to the case where a combination of the variables in first differences is either a white noise or an MA(1) process.

has to be larger than or equal to three. An alternative procedure, following another suggestion by Gonzalo and Granger (1995), is to test whether the two common trends which drive the indices are cointegrated with the price measure. The number of common trends which drive these three variables coincides with that for the five variables of interest, the four indices and either CPI or WPI. In our context, we prefer this second procedure, because it let us keep the information contained in either CPI or WPI separate from that in the commodity price indices. Note that an inference theory for this case has not been developed yet, hence the critical values used are only approximate. Yet, both procedures lead to the same result, so that we also use the latter to check the conclusions of the former.

The results in Table 3 differ for CPI and WPI. For CPI the hypothesis of rank two is accepted, which implies that one common trend drives the four indices and CPI, so that there are two cointegration relationships among the indices, and two relationships among them and CPI. For WPI only rank one is accepted, which implies that there exists only one cointegration relationship among the indices and WPI. These results are confirmed by the outcome of the cointegration tests in the five variable VARs, which indicate rank equal to four in the case of CPI, and to three for WPI.

As was noticed in the theoretical analysis for a particular scheme of shocks, when the cointegration relationships involve several indices this outcome is compatible with the lack of bivariate cointegration between the indices and the price measures. Actually, this is what we find in bivariate analyses with our data, which also seem to be affected by misspecification, in particular parameter nonconstancy (thus providing a further reason for adopting a multivariate framework).

For the cyclical movements, Figures 5 and 6 show the common cyclical factor with inflation measured as rates of change in either the CPI or the WPI. In both cases the factor tracks inflation fairly accurately, which suggests that the former can be a valid forward indicator of the latter. More evidence in this direction comes from Granger causality tests which show that the common cyclical factor has the interesting feature of Granger-causing inflation measured both as CPI and WPI first differences (at 4, 8, 12 lags – see Table 4), but it is not caused by inflation. This result is particularly encouraging, since the cyclical factor is obtained without referring to the target variable.

## 6 Concluding remarks

This paper has used the cointegration framework to decompose *a vector* of commodity indices into components that can subsequently be related to the target variables, CPI and WPI.

It has been shown that the permanent components of the indices are driven by two stochastic trends which are cointegrated with either CPI or WPI (the indices and the prices are cointegrated). Previous findings of lack of cointegration seem to be due to the consideration of a bivariate framework. The fact that two stochastic trends and not just one drive the indices casts also some doubts on previous empirical results on the Prebisch-Singer hypothesis, even if our conclusions are in overall agreement with the pessimistic view that in the long-term real commodity prices tend to decline.

Most of the variability in the cyclical components of the indices can be explained by just one common factor which is strongly related with inflation, thus providing an interesting indicator of future price movements.

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## 7 Appendix - The Permanent-Transitory Decomposition

Formally, equation (2) can be also reparameterized to yield:

$$\mathbf{x}_t = \mathbf{x}_0 + \mathbf{C}(1)\delta t + \mathbf{C}(1) \sum_{j=1}^{t-1} \boldsymbol{\epsilon}_{t-j} + \mathbf{C}^*(L)\boldsymbol{\epsilon}_t, \quad (3)$$

where  $\mathbf{C}^*(L) = (\mathbf{C}(L) - \mathbf{C}(1))/(1 - L)$ , and  $\mathbf{C}(L)$  is the matrix polynomial in the lag operator  $L$  in the Wold representation for  $\Delta\mathbf{x}_t$ , namely,

$$\Delta\mathbf{x}_t = \mathbf{C}(L)\boldsymbol{\epsilon}_t. \quad (4)$$

>From  $\mathbf{C}(1) = \boldsymbol{\beta}_\perp (\boldsymbol{\alpha}'_\perp \boldsymbol{\Phi} \boldsymbol{\beta}_\perp)^{-1} \boldsymbol{\alpha}'_\perp$ , where  $\boldsymbol{\alpha}_\perp$  and  $\boldsymbol{\beta}_\perp$  are  $n \times (n - r)$  and satisfy  $\boldsymbol{\alpha}'_\perp \boldsymbol{\alpha} = \boldsymbol{\beta}'_\perp \boldsymbol{\beta} = \mathbf{0}$ , such that  $(\boldsymbol{\alpha} : \boldsymbol{\alpha}_\perp)$  and  $(\boldsymbol{\beta} : \boldsymbol{\beta}_\perp)$  are full rank  $n$ , while  $\boldsymbol{\Phi}$  is the mean-lag matrix, it follows that

$$\mathbf{x}_t = \underbrace{\mathbf{x}_0 + \delta t + \boldsymbol{\beta}_\perp (\boldsymbol{\alpha}'_\perp \boldsymbol{\Phi} \boldsymbol{\beta}_\perp)^{-1} \boldsymbol{\alpha}'_\perp \sum_{j=1}^{t-1} \boldsymbol{\epsilon}_{t-j}}_{\text{permanent component}} + \underbrace{\mathbf{C}^*(L)\boldsymbol{\epsilon}_t}_{\text{transitory component}}. \quad (5)$$

$n-r$  common trends

(5) is the multivariate version of the Beveridge-Nelson decomposition of a time series into its permanent and transitory components.<sup>8</sup>

The alternative representation suggested by Gonzalo and Granger (1995) (see also Johansen (1995, p. 40)) is:

$$\mathbf{x}_t = \underbrace{\mathbf{x}_0 + \delta t + \boldsymbol{\beta}_\perp (\boldsymbol{\alpha}'_\perp \boldsymbol{\beta}_\perp)^{-1} \boldsymbol{\alpha}'_\perp \mathbf{x}_t}_{\text{permanent component}} + \underbrace{\boldsymbol{\alpha} (\boldsymbol{\beta}' \boldsymbol{\alpha})^{-1} \boldsymbol{\beta}' \mathbf{x}_t}_{\text{transitory component}}. \quad (6)$$

$n-r$  common trends       $r$  equilibria

The common trends in (6) are not pure random walks as in (5), even if their I(1) component is also driven by  $\boldsymbol{\alpha}'_\perp \sum_{j=1}^{t-1} \boldsymbol{\epsilon}_{t-j}$ .

Although the characterizations are theoretically different, for the problem at hand there is little difference across decompositions, so that the results obtained appear to be quite robust.

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<sup>8</sup>Notice that the possibility that  $\mathbf{x}_t$  is I(2) is ruled out by the fact that  $(\boldsymbol{\alpha}'_\perp \boldsymbol{\Phi} \boldsymbol{\beta}_\perp)$  is of full rank.

**Table 1: Composition of 4 Commodity Price Indices**

Component	Index			
	CRBI	GSCI	WBI	ECI
Energy	14.28	51.26	-	-
Livestock	14.28	13.59	-	47.4
Crops	42.84	25.38	53.2	-
Misc <sup>a</sup>	9.52	-	19.7	19.3
Base metals <sup>b</sup>	4.76	6.59	27.1	33.3
Precious metals	14.28	3.19	-	-

*a* : For the CRBI this component includes orange and lumber juice; for the WBI it includes agricultural nonfood items - cotton, jute, tobacco, and rubber.

*b* : The CRBI includes only copper; the GSCI includes aluminium, copper, zinc, nickel, lead and tin; he WBI further includes phosphate rock and iron ore.

**Table 2: Four Commodity Indices  
Tests on the Cointegration Rank  $r$  – VAR(5) – 70Q1-93Q4**

Rank	Max( $\mu_i$ )	95%	Trace	95%
$r = 0$	35.32**	27.1	71.91**	47.2
$r \leq 1$	22.4*	21.0	36.6**	29.7
$r \leq 2$	10.62	14.1	14.2	15.4
$r \leq 3$	3.58	3.8	3.58	3.8

The estimation sample period is 72Q1-93Q4.

\* significant at 5% significance level

\*\* significant at 1% significance level

**Table 3: Tests on the Cointegration Rank  $r$  70Q1-93Q4**

<b>Two common trends and CPI - VAR(4)</b>				
<b>Rank</b>	<b>Max(<math>\mu_i</math>)</b>	<b>95%</b>	<b>Trace</b>	<b>95%</b>
$r = 0$	20.6	22.0	42.7**	34.9
$r \leq 1$	12.9	15.7	22.12*	20.0
$r \leq 2$	9.2	9.3	9.2	9.3
<b>Two common trends and WPI - VAR(2)</b>				
<b>Rank</b>	<b>Max(<math>\mu_i</math>)</b>	<b>95%</b>	<b>Trace</b>	<b>95%</b>
$r = 0$	30.7**	22.0	45.2**	34.9
$r \leq 1$	8.7	15.7	14.5	20.0
$r \leq 2$	5.8	9.3	5.8	9.3

The estimation sample period is 72Q1-93Q4.

\* rejected at 5% significance level

\*\* rejected at 1% significance level

**Table 4: Common Cyclical Factor and Inflation Granger Causality Tests**

<b>CPI</b>			
<b>Lags</b>	<b>Infl <math>\nRightarrow</math> CCF</b>	<b>CCF <math>\nRightarrow</math> Infl</b>	
4	3.97**	2.96**	
8	1.12	2.90**	
12	0.64	2.46**	
<b>WPI</b>			
<b>Lags</b>	<b>Infl <math>\nRightarrow</math> CCF</b>	<b>CCF <math>\nRightarrow</math> Infl</b>	
4	1.76	4.01**	
8	1.79	4.19**	
12	1.13	2.86**	

\* rejected at 5% significance level

\*\* rejected at 1% significance level

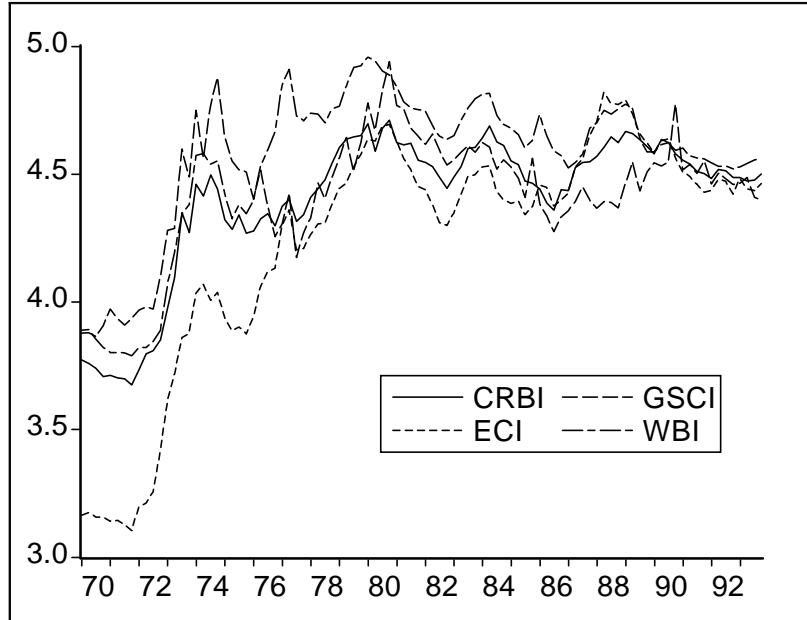


Figure 1: The Commodity Price Indices (logs)

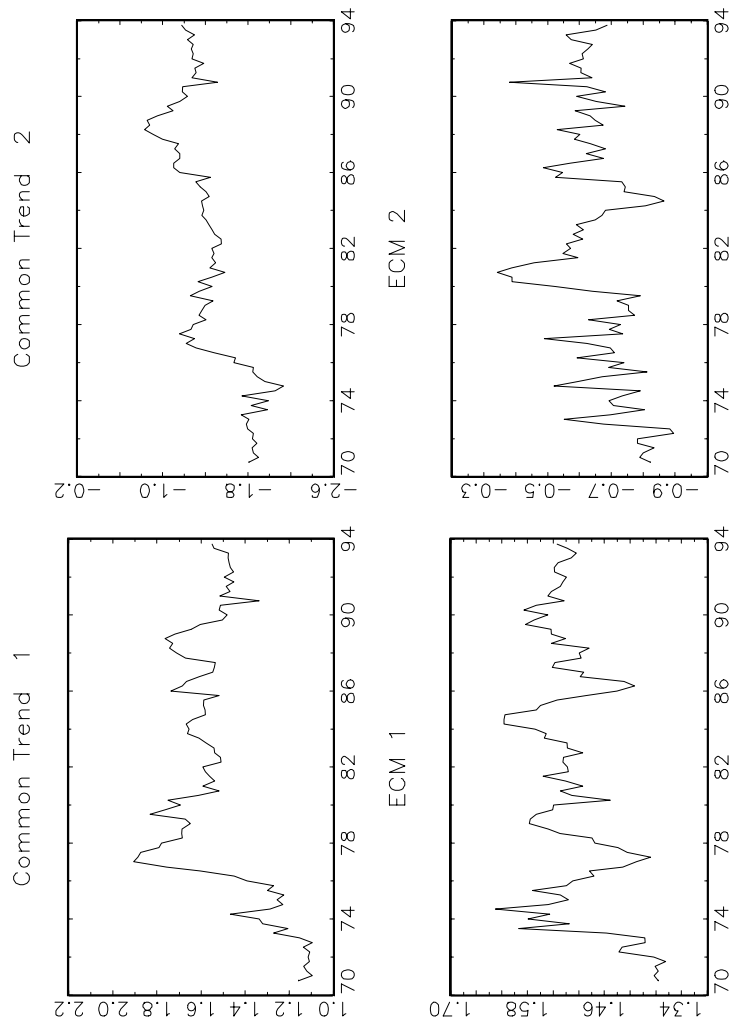


Figure 2: Common Trends and EC Terms

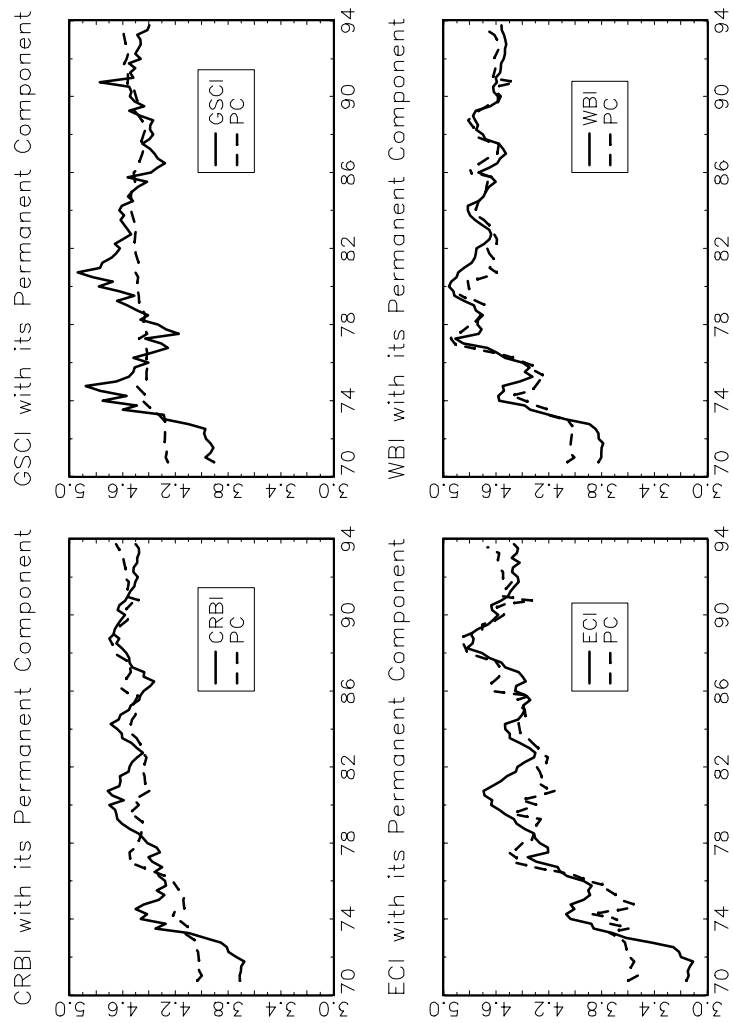


Figure 3: Permanent Components – GG Decomposition

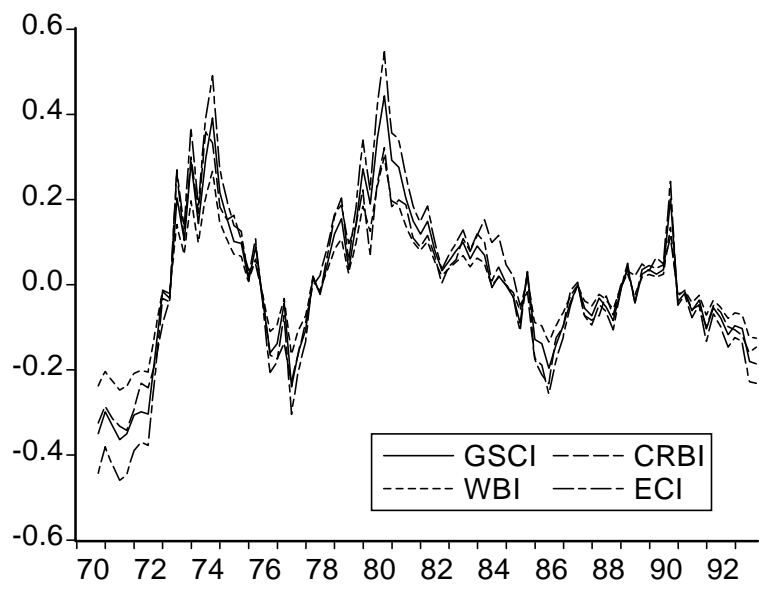


Figure 4: Cyclical Components

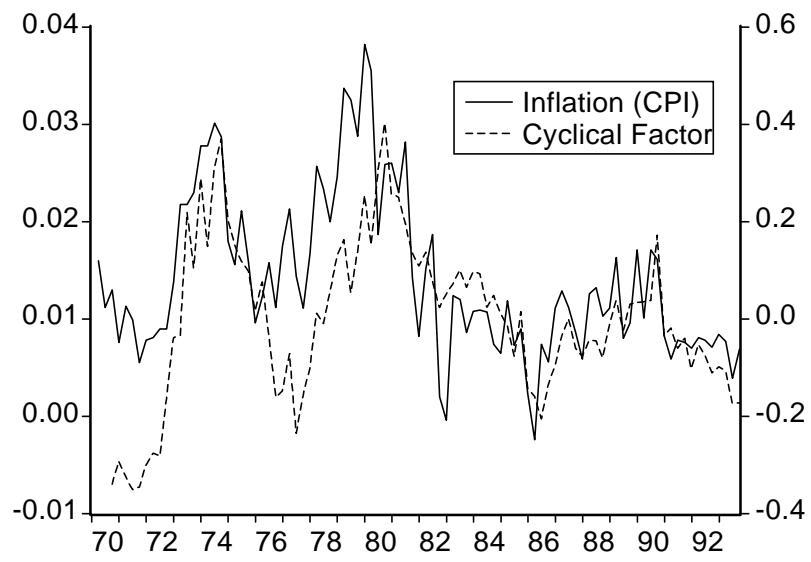


Figure 5: Common Cyclical Factor and Inflation ( $\Delta$ CPI)

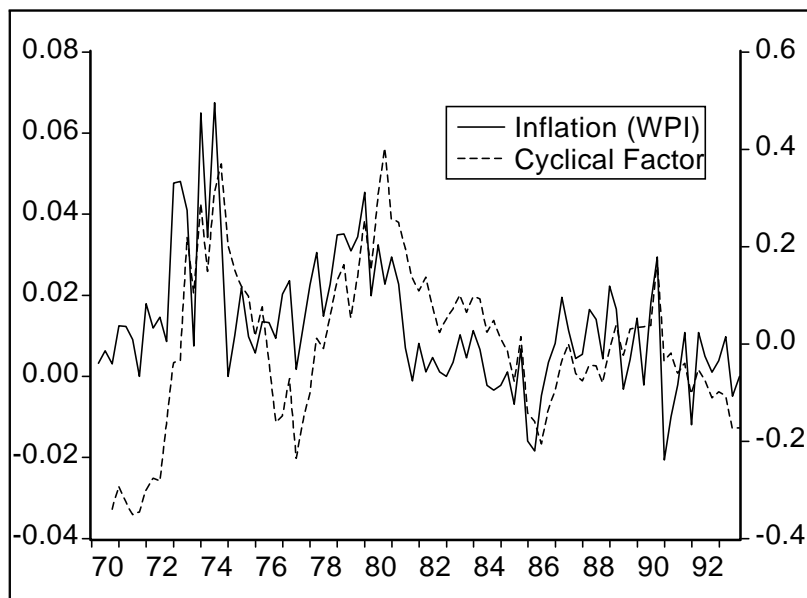


Figure 6: Common Cyclical Factor and Inflation ( $\Delta$ WPI)