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A DYNAMIC FACTOR ANALYSIS

by Isabel Vansteenkiste

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In 2009 all ECB publications feature a motif taken from the €200 banknote.

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Abstract

This paper analyses the importance of common factors in shaping non-fuel commodity price movements for the period 1957-2008. For this purpose, a dynamic factor model is estimated using Kalman Filtering techniques. Based on this set-up we are able to separate common and idiosyncratic developments of commodity prices. Our estimation results show that there exists one common significant factor for most non-fuel commodity prices and that this common factor has recently become increasingly important in driving non-fuel commodity prices. However during the seventies and early eighties, the co-movement was much higher. In a next step, we then rely on an instrumental variable approach to uncover which variables could be linked to the common factor. We find that the main statistically significant variables are the oil price, the US dollar effective exchange rate, the real interest rate but more recently also global demand (as measured by a proxy for global industrial production).

Keywords: Commodity prices, dynamic factor and Kalman filter.

JEL Classification: E30, F00

Non-technical summary

Although the share of primary commodities in global output and trade has declined over the past century, fluctuations in commodity prices continue to affect global economic activity. For many countries, especially developing countries, commodity price movements have a major impact on overall macroeconomic performance, owing to their large impacts on real output, the balance of payments, and government budgetary positions, and because of the consequent difficult problems they pose for the conduct of macroeconomic policy. However, also for industrial nations, commodity prices play a nontrivial role in transmitting business cycle disturbances and in affecting inflation rates (Borenzstein and Reinhart, 1994).

Interest in understanding commodity price developments, and even more so in non-fuel commodity price developments, has however fallen over the past ten to fifteen years, as prices were relatively low and stable in nominal terms (and even declining in real terms). However, more recently, interest in commodity price developments resurfaced as prices of several non-fuel commodity prices reached record highs during 2007 and 2008. In addition, current boom was also broader based and longer lasting than usual (see Helbling et al., 2008).

Such a strong and long lasting upward movement was unprecedented in history and raised the question: why did commodity prices rise so sharply during the past couple of years? In the literature, besides commodity specific factors – such as geopolitical risks, weather conditions and crop infestations – Helbling et al. (2008) for instance – note that the boom was likely being driven by both supply and demand factors. In addition, for non-fuel commodity prices, the decline in the real effective exchange rate of the dollar and high oil prices may have added momentum to the upward price movement. However, at the same time, some other studies have noted that speculation may also have been behind the upward movement in commodity prices.

In this paper, we try to analyse which factors have been driving developments in 32 selected non-fuel commodity prices. To do so, we rely on a dynamic factor model to uncover the extent to which developments in individual commodity prices are driven by a common factor and which macroeconomic fundamentals can be linked to movements in the common factor.

This paper also fits into the excess co-movement literature on commodity prices. The existence of excess co-movement of commodity prices was first suggested by Pindyck and Rotemberg (1990), who provided a formal test of excess co-movement. They have argued that a broad range of prices of largely unrelated commodities display excess co-movement in the sense that they show a persistent tendency to move together, even after accounting for the linear effects of macroeconomic shocks. Pindyck and Rotemberg (1990) argue that such excess co-movement comes about because 'traders are alternatively bullish or bearish on all commodities for no plausible reason'. Several subsequent studies have however either confirmed or rejected the excess co-movement hypothesis (see Deb et al., 1996).

The dynamic factor analysis of this paper shows that there exists one common factor which has - with a few exceptions - a significant impact on individual non-fuel commodity price developments. This is true even after accounting for the fact that some non-fuel commodities may be related on the demand and/or supply side. Movements in the common factor can to a large extent be linked to a number of macroeconomic fundamentals which are said to be relevant according to the existing literature, namely developments in the US dollar effective exchange rate, the US real interest rates, input costs (as proxied by fertilizer and oil prices) and more recently also global demand.

The role of the common factor in influencing individual non-fuel commodity prices appears to have been particularly large during the seventies, when the average correlation between the common factor and individual non-fuel commodity price series was nearly one. Thereafter, the impact appears to have declined substantially as idiosyncratic elements became more important and the impact reached a trough around 2000, when prices were also at a historical low. More recently, the common factor has been playing an increasingly large role in determining developments in individual non-fuel commodity prices, however, it remains far below that during the seventies, indicating that idiosyncratic shocks remain important in explaining recent developments. In addition, looking at the common factor, the recent upward movement are strongly correlated with our macroeconomic fundamentals. This would us lead to reject the excess co-movement hypothesis which would argue that speculation results in correlation between commodities for no plausible reason.

1 Introduction

Although the share of primary commodities in global output and trade has declined over the past century, fluctuations in commodity prices continue to affect global economic activity. For many countries, especially developing countries, commodity price movements have a major impact on overall macroeconomic performance, owing to their large impacts on real output, the balance of payments, and government budgetary positions, and because of the consequent difficult problems they pose for the conduct of macroeconomic policy. However, also for industrial nations, commodity prices play a nontrivial role in transmitting business cycle disturbances and in affecting inflation rates (Borenzstein and Reinhart, 1994).

Interest in understanding commodity price developments, and even more so in non-fuel commodity price developments, has however fallen over the past ten to fifteen years, as prices were relatively low and stable in nominal terms (and even declining in real terms) (see Figure 1). However, more recently, interest in commodity price developments resurfaced as prices of several non-fuel commodity prices started to increase sharply and reached record highs in nominal terms in the course of 2007 and 2008.

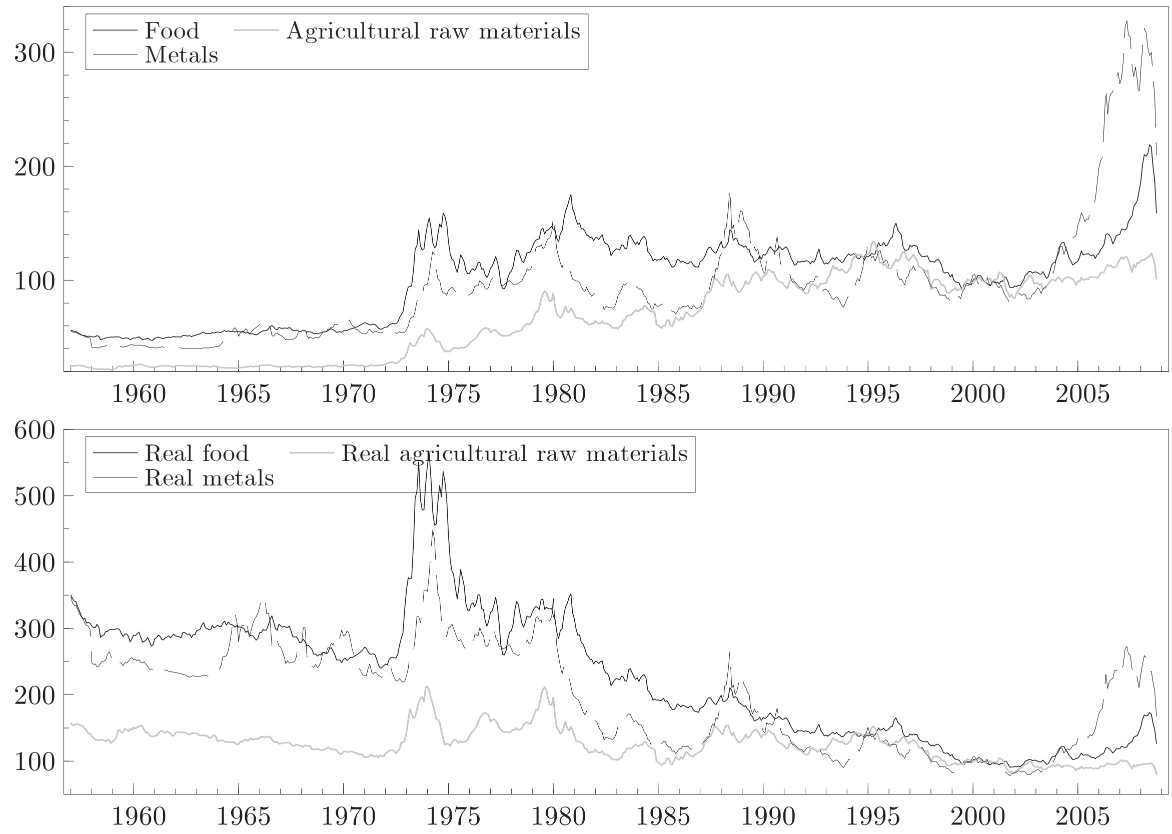


Figure 1: Non-Fuel Commodity Price Developments, Index (2000=100)

Besides reaching record highs in nominal terms, the commodity price boom has in addition

- according to Helbling, 2008 - been unusual in at least three important aspects. First, it has lasted much longer than earlier booms. For instance, the boom in metal prices lasted for 58 months, as compared with 22 months for earlier booms. Second, the price increases (in real terms) are also much larger than earlier booms. For instance, in food, more than 30% as compared with 20% in earlier booms. Third, the boom was much broader based, involving at least four and during much of 2005 all five of the major commodity groups (i.e. oil, metal, food, beverages, and agricultural raw materials).

Such unprecedented movements in commodity prices raise the question as to what has been driving these developments. The existing literature seems to point towards a wide range of factors that may have caused the recent upward movement in commodity prices.

Next to commodity specific factors – such as geopolitical risks, weather conditions and crop infestations – Helbling and others (2008) note that increased demand from fast growing developing countries, which are accounting for larger and larger shares of annual consumption growth of commodities, is playing an important role. While some large developing countries have been growing rapidly for years, in some cases decades (e.g. China), a combination of rapid industrialization and higher commodity intensity of growth, coupled with rapid income per capita growth, has increased significantly the demand for commodities from these countries.

Soaring petroleum prices have also had a knock-on effect on the prices of many other commodities. For example, the increase in the demand for biofuels, which in turn has increased demand for some food and non-food crops, is in part driven by concerns about high oil prices. For agricultural commodities it has also raised the input costs (see FAO, 2007). On average, the pass through of oil prices to food prices has been estimated at 0.18 (Baffes 2007, p.6). The pass through to metals, which involve several energy-intensive processes, is probably even higher.

The depreciation of the US dollar against a wide range of currencies may also have played a role, because most commodities are quoted in US dollars. Commodities therefore become cheaper for consumers that hold other currencies and the profits for producers become smaller – the two effects combining to an increase in prices in US dollars (see FAO, 2007).

Finally, Calvo (2008) argues that excess liquidity and low interest rates have been contributing to the price increases. Low interest rates would result in the expansion of money supply. They would also decrease the demand for liquid assets by sovereigns like China, Chile or Dubai. Both effects would eventually lead to an increase in prices. But not all prices would move at the same time as some prices are more flexible than others. Among the most flexible, according to Calvo (2008), are the commodity prices. A similar argument has been made by Frankel (2005, 2006).

However, in addition to these "fundamental " factors, some studies have noted that speculation may also be behind the upward movement in commodity prices. Indeed, in particular in the case of base metals - and especially copper and nickel - it has been argued that the cost structure of the industry cannot explain current price levels (Veneroso, 2008). However, also Bastourre et al. (2008) show that speculation can act as an amplification factor to commodity cycles and in history around 56% of the time non-fuel commodity price developments were driven by chartist behavior. One of the counter arguments that recently prices reflect fundamentals rather than speculation is the question "Where are the stocks " (see Krugman, 2008). Along this line of argumentation, if speculators were the main force pushing commodity prices far above the level justified by fundamentals, excess supply should be observed. And while for base metals, Veneroso (2008), shows that stocks were accumulating at very large levels, for other commodities the evidence is less compelling.

Taken together, the existing literature points towards a wide range of common underlying determinants which may be driving non-fuel commodity prices. However, at the same time, the literature remains inconclusive as to the relative importance of these factors. In particular, there is no consensus on the relative weight that should be attributed to speculation versus (i.e. supply and demand) fundamentals in driving non-fuel commodity prices. The main reason for this inconclusiveness is the lack of adequate time series that measure or proxy several of the potential drivers. Indeed, only indirect proxies are available to measure the degree of speculation and a true measure of global demand and supply for non-fuel commodities also does not exist (nor do such measures for global demand and supply often exist at the individual commodity level). Nevertheless, the current developments in non-fuel commodity prices have raised the question whether global fundamental factors, versus speculation or rather a coinciding of individual commodity specific shocks have been driving prices. In order to check this conjecture, we take in this paper in a first step an agnostic approach and estimate a dynamic factor model whereby we try to establish whether there are common factors behind the price developments in the group of non-fuel commodity prices without trying to measure them directly or specify directly which factors those could be. In this context, we can then also assess the importance of this common factor for each individual series and check how the importance of this common factor has changed over time. In a next step, we then try to determine the extent to which this common factor is driven by macroeconomic shocks, or whether, in fact, it confirms the presence of excess co-movement in non-fuel commodity prices. The existence of excess co-movement of commodity prices was first suggested by Pindyck and Rotemberg (1990). They have argued that a broad range of prices of largely unrelated commodities display excess co-movement in the sense that they show a persistent tendency to move together, even after accounting for the linear effects of macroeconomic shocks. Pindyck and Rotemberg (1990) argue that such excess co-movement comes about because 'traders are alternatively bullish or bearish on all commodities for no plausible reason'. Several subsequent studies have however either confirmed or rejected the excess co-movement hypothesis (see Deb et al., 1996)

The dynamic factor analysis of this paper shows that there exists one common factor which has - with a few exceptions - a significant impact on individual non-fuel commodity price developments. This is true even after accounting for the fact that some non-fuel commodities may be related on the demand and/or supply side. Movements in the common factor can to a large extent be explained by a number of macroeconomic fundamentals, namely developments in the US dollar effective exchange rate, the US real interest rates, input costs (as proxied by fertilizer and oil prices) and more recently also global demand. Hence although basic correlation analysis would suggest that there exists excess co-movement among non-fuel commodity prices, this co-movement appears to be mostly explained by underlying macro fundamentals, hence refuting the idea that this co-movement comes about because of sympathetic speculative buying.

The role of the common factor in influencing individual non-fuel commodity prices appears to have been particularly large during the seventies, when the average correlation between the common factor and individual non-fuel commodity price series was nearly one. Thereafter, the impact appears to have declined substantially as idiosyncratic elements became more important and the impact reached a trough around 2000, when prices were also at a historical low. More recently, the common factor has been playing an increasingly large role in determining developments in individual non-fuel commodity prices, however, it remains far below that during the seventies, indicating that idiosyncratic shocks remain important in explaining recent developments. In addition, looking at the common factor, the recent upward movement can be largely linked to our macroeconomic fundamentals. This would suggest that the co-movements uncovered across non-fuel commodity prices may to a large extent be driven by macroeconomic fundamentals, hence, once again, rejecting the excess co-movement hypothesis which would argue that speculation results in correlation between commodities for no plausible reason.

The structure of the paper is as follows. In Section 2 we discuss the dynamic factor model. Next in Section 3 we discuss the data series used in the analysis and Sections 4 to 6 then present the estimation results.

2 The Linear State-Space Model

The methodology employed consists in the estimation of a dynamic common factor model for a set of non-fuel commodity inflation series using Kalman filtering techniques. Modelling common fluctuation in economic variables by using the dynamic factor approach is a common approach in the business cycle literature. For instance, studies which have applied such techniques are Montfort et al. (2003), Kose et al. (2003) and Stock and Watson (1989). In general, using a dynamic factor model to analyse linkages presents clear advantage as compared to simpler and more direct approaches like the one that analyses the evolution of pure bi-variate correlation (see among the others Baxter and Stockman (1989), Gerlach (1988), Stockman (1988) and more recently Doyle and Faust (2002)). First, the analysis of simple correlation cannot allow for the separation of the idiosyncratic component from the purely common source of joint co-movements. Second, static correlation analysis, by definition, misses the possible persistence of common fluctuations.

The general model specification assumes the process for real GDP growth (in the case of the business cycle literature) or commodity price inflation (in our case), labelled as $y_{i,t}$, $i = 1, ..., n$ and $t = 1, .., T$, is driven by an idiosyncratic autoregressive component and a latent component f_t, which is common to all series. This latent component - or common factor - is also assumed to follow a univariate autoregressive process. For instance, specific to each i we get:

$$y_{i,t} = a_i y_{i,t-1} + b_i f_t + \varepsilon_{i,t} \quad \forall i \tag{1}$$

where b_i is the exposure, or loading, of series i to the common factors. Although the setup accommodates multiple factors, for clarity of exposition in this section we write equations as if we had only one factor. Both the factor and the idiosyncratic components follow autoregressive processes of order q and p_i respectively:

$$f_t = \phi_{0,1} f_{t-1} + ... + \phi_{0,q} f_{t-q} + \eta_{0,t} \tag{2}$$

$$\varepsilon_{i,t} = \phi_{i,1} \varepsilon_{t-1} + ... + \phi_{i,p_i} \varepsilon_{i,t-p_i} + \sigma_i \eta_{i,t} \tag{3}$$

where σ_i is the standard deviation of the idiosyncratic component, and $\eta_{i,t}\tilde{}N(0,1)$ for $i = 0$ and $i = 1, ..., n$ are the innovations to the law of motions (2) and (3), respectively. The factors' innovations are i.i.d. over time and across i. The latter is the key identifying assumption in the model, as it postulates that all co-movements in the data arises from the factors. The factors' innovations are also assumed to be uncorrelated with one another. Note that expressions (1)-(3) can be viewed as the measurement and transition equations, respectively, in a state-space representation.

Given the relatively large dimension of the vector of estimated parameters, we use a two-step procedure when computing ML functions, involving first the application of the Expectations Maximisation (EM) algorithm and subsequently the application of the Broyden-Fletcher-Goldfarb-Shanno (BFGS) maximisation algorithm.[1]

Besides estimating the standard model, we also estimate in this paper an extension to this model by introducing dynamic factors which are common only to a sub-set of series, in addition to a single factor common to all the commodity price series. More precisely, let us consider n commodity groups, and for each group (group j) k_j series. We will refer to these series by using the notation: $y^j_{i,t}$ where $j = 1, ..., k_j$ indexes the series of the j^{th} considered group.

Let f_t be, again, an unobserved factor affecting all of the series, and $n_{j,t}$ be a factor common to all the series in group j. We will refer to them as the global common and group-specific common factors. Each series $y^j_{i,t}$ can thus be decomposed into four separate components:

$$y_{i,t} = a_i y_{i,t-1} + b_i f_t + c^j_i n_{j,t} + \varepsilon^j_{i,t} \quad \forall i \quad \forall j$$

Here, b_i measures the impact of f_t on the i^{th} series of group j and c^j_i measures the impact of the group-specific common component on the i^{th} series of group j. As before, we assumed that $(\varepsilon_{i,t}...\varepsilon_{n,t,t}, w_t, n_{i,t})$ are uncorrelated at all lead and lags, which is achieved by assuming that ε is white noise and that ε, f and the n_js are independent.

Denoting with $\left(\sigma^j_i\right)^2$ the variance of $\varepsilon^j_{i,t}$, we have

$$V[\varepsilon] = \begin{bmatrix} \begin{bmatrix} (\sigma^1_1)^2 & & 0 \\ & \ddots & \\ 0 & & \left(\sigma^{k_1}_1\right)^2 \end{bmatrix} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \begin{bmatrix} (\sigma^1_n)^2 & & 0 \\ & \ddots & \\ 0 & & (\sigma^{k_n}_n)^2 \end{bmatrix} \end{bmatrix}$$

Both, the global and the group-specific common factors are assumed to follow univariate autoregressive processes of order one:

$$f_t = \phi_{0,1} f_{t-1} + ... + \phi_{0,q} f_{t-q} + \eta_{f,t} \quad (4)$$
$$n_{j,t} = \vartheta_{0,1} n_{j,t-1} + ... + \vartheta_{0,qq} n_{j,t-qq} + \eta_{n,t} \quad (5)$$
$$\varepsilon_{i,t} = \phi_{i,1} \varepsilon_{t-1} + ... + \phi_{i,p_i} \varepsilon_{i,t-p_i} + \sigma_i \eta_{i,t} \quad (6)$$

where we add the following identification condition:

$$V \begin{bmatrix} \eta_{f,t} \\ \eta_{1,t} \\ \vdots \\ \eta_{n,t} \end{bmatrix} = Id_{n+1}$$

[1] For a discussion of state-space models and the Kalman filter, see Harvey (1989, 1990) or Hamilton (1994).

3 Data

We use 32 monthly nominal non-fuel commodity price series starting in January 1957 and going until May 2008. In general, the series are taken from the International Monetary Fund database (IMF IFS). We use data for a wide range of different commodity types. The data is selected on the basis of availability for the entire sample period. The commodities included can be split into 3 main categories, namely food, agricultural raw material, and metals. Within the food category, the commodities included are: cocoa, coffee, tea, coconut oil, groundnuts, groundnut oil, palm oil, linseed oil, soybeans, soybean meal, soybean oil, copra, maize, rice, wheat and sugar. The agricultural raw materials in the model are: cotton, jute, rubber, wool and timber and the metals in our sample are: aluminum, copper, lead, nickel, tin and zinc (see Appendix A for further details regarding the series we include in the estimations). We aggregate the series to quarterly frequency to avoid strong monthly fluctuations to affect the outcome for the global factor.[2]

Table 1 below contains the cross-correlation coefficient for some selected non-fuel commodity price inflation series. The Table shows the correlation between quarterly year-on-year inflation rates from 1957Q1-2008Q1. In general, the correlation coefficients are positive, with few exceptions and the highest correlation coefficients can be found between soybean oil and palm oil and between wheat and maize. Sugar by contrast seems to be little correlated with other commodity prices. In general, however, commodity prices tend to be mostly correlated with other prices within the same category (such as oils, grains, metals...). However, in some cases, the correlation is also high between commodities from very different categories (such as tin and palm oil or tin and rubber - a similar finding was made for rice with tin - not shown in Table 1). Such findings have motivated the existence of the excess co-movement literature (see Pindyck and Rotemberg (1990)).

With regards to the first order autocorrelation (see Table 1, last row), all commodity price inflation series exhibit positive autocorrelation, with tin and cocoa having the highest autocorrelation.

4 The case of one common factor

In this section, we present the general model as shown in Section 2, equations 1 to 3. Before estimating the model, we first need to determine the number of common factors f in the model. To do so, a number of criteria have been suggested in the literature. Forni et al. (2004) suggest an informal criterion based on the portion of explained variances, whereas Bai and Ng (2005) and Stock and Watson (2005) suggest consistent selection procedures based on principal components. Below, in Table 2, we present outcome of the Bai and Ng tests. On the basis of either three criterion, we will select the model with 1 common factor.

[2]We did not include fertilizers or energy prices in our sample as these commodities tend to proxy input costs for many of these commodities and hence may in fact drive their price developments. Including them may influence our estimation of the global factor and hence we decide a priori to exclude them.

Table 1: First order autocorrelation and cross-correlations

	Cocoa	Coffee	Palm	Soy	Wheat	Maize	Sugar	Cotton	Rubber	Al	Ni	Sn
Cocoa	1.00	0.50	0.38	0.34	0.19	0.19	0.03	0.29	0.36	0.11	-0.08	0.19
Coffee	0.50	1.00	0.30	0.19	-0.03	-0.03	-0.05	0.27	0.35	0.28	0.11	0.19
Palm	0.38	0.30	1.00	0.83	0.44	0.49	0.08	0.45	0.50	0.31	0.19	0.51
Soy	0.34	0.19	0.83	1.00	0.48	0.62	0.18	0.44	0.41	0.32	0.22	0.50
Wheat	0.19	-0.03	0.44	0.48	1.00	0.72	0.19	0.42	0.55	0.08	0.16	0.38
Maize	0.19	-0.03	0.49	0.62	0.72	1.00	0.24	0.31	0.43	0.20	0.36	0.36
Sugar	0.03	-0.05	0.08	0.18	0.19	0.24	1.00	0.10	0.13	0.29	0.07	0.12
Cotton	0.29	0.27	0.45	0.44	0.42	0.31	0.10	1.00	0.61	0.24	0.05	0.30
Rubber	0.36	0.35	0.50	0.41	0.55	0.43	0.13	0.61	1.00	0.44	0.25	0.34
Al	0.11	0.28	0.31	0.32	0.08	0.20	0.29	0.24	0.44	1.00	0.62	0.31
Ni	-0.08	0.11	0.19	0.22	0.16	0.36	0.07	0.05	0.25	0.62	1.00	0.31
Sn	0.19	0.19	0.51	0.50	0.38	0.36	0.12	0.30	0.34	0.31	0.31	1.00
AutoCor	0.84	0.82	0.81	0.81	0.82	0.80	0.77	0.79	0.84	0.83	0.82	0.84

Table 2: Criteria for selecting the number of factors

	Bai and Ng criteria		
r	IC_{p1}	IC_{p2}	IC_{p3}
1	-1.05*	-0.097*	-0.145*
2	-0.096	-0.086	-0.134
3	-0.090	-0.075	-0.130
4	-0.075	-0.044	-0.120
5	-0.060	-0.038	-0.116
6	-0.035	-0.014	-0.114
7	-0.029	0.014	-0.099
8	0.010	0.050	-0.080
9	0.015	0.060	-0.068
10	0.045	0.098	-0.062

The maximal number of factors for the Bai and Ng criteria is r_{max}=10.
An asterix indicates the minimum.

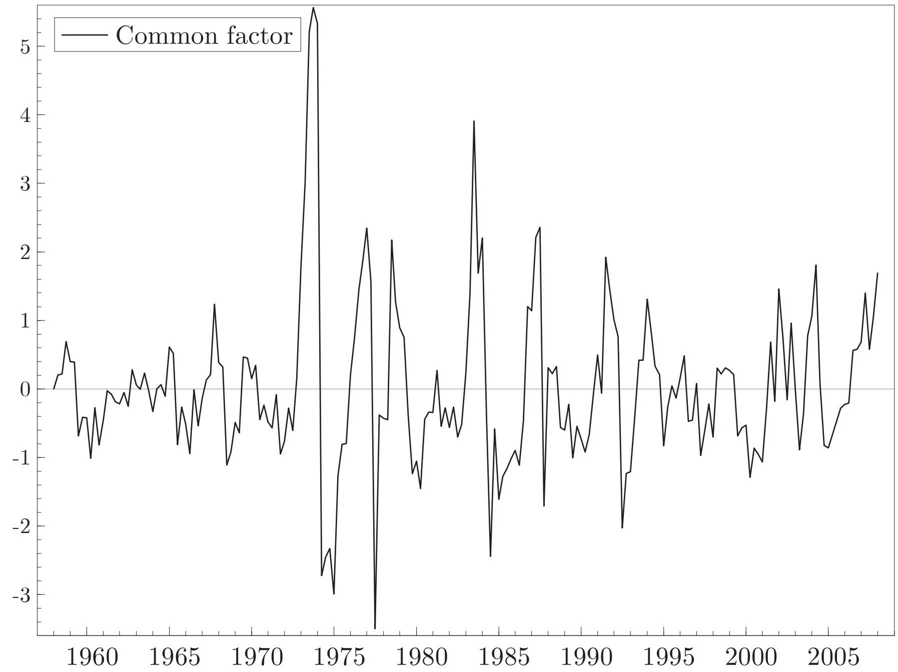


Figure 2: Common Factor for Non-Fuel Commodity Prices

Figure 2 plots the estimated common factor. According to this factor, non-fuel commodity prices booms and busts tend to be relatively short lived and movements were particularly volatility during the seventies and early eighties, as opposed to the sixties and the most recent period. This pattern and the timing conforms reasonably well with common wisdom on commodity price cycle (see for instance Arango et al., 2008 for a discussion on the historical patterns of commodity price movements).

The parameter estimates of the model are given in Table 3. The lagged dependent variable turns out to be high and very significant in all cases, while the impact coefficient of the global component on individual commodity prices ranges widely as does the significance. In general, however, the impact of the global component on the individual commodities is statistically significant at the 5% level. Insignificance is found in the case of tea, sugar, jute, wool and nickel. The global factor also exhibits a relatively high degree of autocorrelation, as indicated by the value of 0.6 for the coefficient d, which suggests high persistence of the common price developments on individual commodity price inflation.

The presence of a statistically significant common factor for most non fuel commodity prices would - at prima facie - confirm the presence of excess co-movement among non-fuel commodity price series. Nevertheless, to fully understand whether there is excess co-movement among non-fuel commodities, we need to consider whether we can explain developments in this common factor by means of underlying macroeconomic fundamentals. This is discussed in section 5.1.

Based on the model estimates, it is possible to derive some measure of synchronisation in commodity price developments, by looking both at the amount of volatility of each of the

Table 3: Parameter Estimates of Model with Common Factor

	a_i		b_i		σ_i
Cocoa	0.79**	(0.04)	0.11**	(0.04)	0.55
Coffee Brazil	0.82**	(0.04)	0.03	(0.03)	0.57
Coffee Central America	0.81**	(0.04)	0.05*	(0.03)	0.57
Coffee Africa	0.82**	(0.04)	0.07**	(0.03)	0.56
Tea	0.73**	(0.05)	0.13**	(0.04)	0.70
Coconut oil	0.74**	(0.03)	0.45**	(0.05)	0.13
Groundnuts	0.61**	(0.06)	0.09*	(0.05)	0.78
Groundnut oil	0.82**	(0.04)	0.20**	(0.04)	0.54
Linseed oil	0.83**	(0.03)	0.23**	(0.04)	0.43
Palm oil	0.76**	(0.04)	0.35**	(0.05)	0.41
Copra	0.71**	(0.03)	0.45**	(0.05)	0.10
Soybeans	0.66**	(0.05)	0.21**	(0.05)	0.61
Soybean Meal	0.69**	(0.05)	0.14**	(0.05)	0.62
Soybean oil	0.78**	(0.04)	0.31**	(0.05)	0.45
Rice	0.82**	(0.03)	0.19**	(0.04)	0.47
Wheat	0.79**	(0.04)	0.16**	(0.04)	0.54
Maize	0.74**	(0.04)	0.17**	(0.04)	0.57
Sugar EU	0.81**	(0.04)	-0.05	(0.04)	0.57
Sugar ISA	0.77**	(0.05)	0.00	(0.04)	0.64
Sugar US	0.75**	(0.05)	-0.02	(0.04)	0.65
Cotton	0.68**	(0.04)	0.27**	(0.05)	0.53
Jute	0.78**	(0.04)	0.00	(0.04)	0.63
Rubber	0.75**	(0.04)	0.17**	(0.04)	0.51
Timber	0.72**	(0.05)	0.12**	(0.04)	0.65
Wool Coarse	0.89**	(0.04)	-0.03	(0.03)	0.48
Wool Fine	0.86**	(0.04)	0.01	(0.03)	0.51
Aluminum	0.83**	(0.04)	0.07**	(0.03)	0.55
Copper	0.78**	(0.04)	0.14**	(0.04)	0.56
Lead	0.81**	(0.04)	0.17**	(0.04)	0.52
Nickel	0.83**	(0.04)	0.03	(0.03)	0.57
Tin	0.84**	(0.04)	0.17**	(0.03)	0.49
Zinc	0.79**	(0.04)	0.20**	(0.04)	0.52
$\phi_{0,1}$	0.57**	(0.06)			

Coefficients in this table show the estimates from equations 1 to 3. * denotes significance at the 10% and ** at the 5% level.

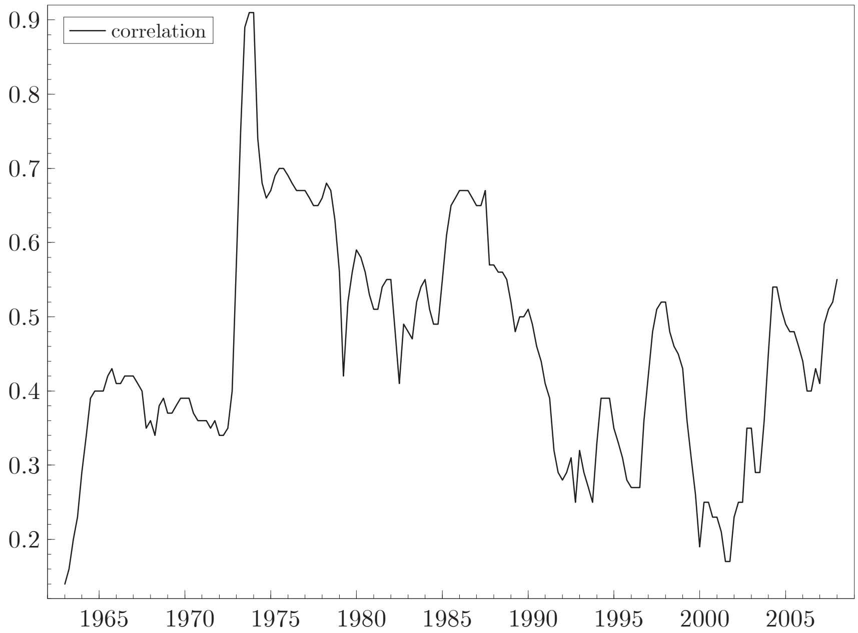


Figure 3: Average 4-year rolling window correlation between common factor and individual commodity price developments.

commodity price inflation series that is explained by the volatility of the common factor and to the effect of the evolution of the common factor on each of these series. In Table 4 we present the shares, S_i, of the total commodity price inflation variance accounted for by the common factor. In the case of coffee, copra, coconut oil, wheat, wool and copper the role of the common factor is particularly large, as its variance explains one third or more of these commodities' price inflation variance. For the other commodities, the variance tends to be lower, and, for some is very low (like cocoa, jute, groundnuts, timber, and in particular sugar) where the common factor variance explains less than 10% of the commodity price inflation variance.

In addition to computing the amount of volatility in each series which is accounted for by the common factor volatility, we also compute the correlation between the global factor and the individual series. Unlike in the case of the share of variance explained by the common factor, here the emphasis is more on the contemporaneous impact of the common factor on an individual commodity's price inflation, rather than on the entire effect (including lagged responses to the common factor), which is captured by the b_i's in Table 3. Figure 3 plots the average 4 year rolling correlation between the common factor and each individual series. As can be seen the correlation has been on average relatively high - i.e. 0.43 - and during the seventies was at some point nearly 1, suggesting that the common factor was particularly important in driving commodity prices at the time. Around the turn of the century the correlation has dropped significantly, and was nearly zero in 2000, its lowest level in the sample. The correlation appears to have risen again more recently to around 0.65, so slightly above the sample average but still much lower than during the seventies and early eighties.

Table 4: Average Correlation and Shares of Variance accounted by Common Factor (Full Sample Estimation Results) Factor

	Share of variance from global factor	Correlation w/ global factor
Cocoa	0.03	0.45
Coffee Brazil	**0.38**	0.26
Coffee Central America	**0.40**	0.25
Coffee Africa	**0.32**	0.31
Tea	0.10	0.18
Coconut oil	**0.41**	0.92
Groundnuts	0.02	0.42
Groundnut oil	0.11	0.39
Linseed oil	0.14	0.39
Palm oil	0.29	0.73
Copra	**0.42**	0.90
Soybeans	0.16	0.60
Soybean Meal	0.07	0.53
Soybean oil	0.24	0.66
Rice	0.12	0.53
Wheat	**0.39**	0.40
Maize	0.28	0.60
Sugar EU	0.02	0.25
Sugar ISA	0.00	0.10
Sugar US	0.00	0.18
Cotton	0.12	0.44
Jute	0.05	0.28
Rubber	0.18	0.50
Timber	0.07	0.39
Wool Coarse	**0.32**	0.28
Wool Fine	**0.33**	0.28
Aluminum	0.15	0.19
Copper	**0.32**	0.40
Lead	0.14	0.48
Nickel	0.13	0.41
Tin	0.19	0.46
Zinc	0.27	0.40
Average	0.19	0.43

Average correlation shows $Corr(f_t, y_{i,t})$.

This evidence would suggest that recently, commodity prices have indeed become more synchronised, however this level of synchronisation is - from a historical perspective - not unusual and follows in fact a period of "exceptionally " low correlation. This result would suggest that recently at least it is not likely that sympathetic speculative buying has been driving the recent price boom.

Looking at the individual commodity series, Table 4 shows that the correlation between the common factor and the individual commodity was extremely high in the case of coconut oil (0.92), copra (0.90) and palm oil (0.73).

5 Explaining Common Factor Developments

Based on the correlation evidence presented above, one cannot however, possibly say anything about the reason for the overall level of synchronisation in commodity price inflation. In principle, synchronisation can be attributed to three different causes: (1) all commodities are affected by a common shock, to which they react in similar ways; (2) a subgroup of the commodities - or possibly even only a single commodity - experiences a shock, which is transmitted to the other commodities through the various transmission channels and (3) the commodities happen to experience similar commodity-specific shocks. All these cases would be captured as a shock to the common factor in the current estimation framework, without us being able to distinguish between these different cases. Although a quantification of the different explanations to the observed level of overall synchronisation is not possible in our current setup, we can nevertheless try to gain some insights into the causes behind the changes in the degree of synchronisation documented above. In this context, it is possible to make inferences about the changing relative importance of common shocks and spillover effects. If merely the variance of η_t changes, this would indicate a change in the relevance of common shocks for international growth fluctuations. If, however, the change in the variance of η_t is accompanied by a change of the variance of ε_t in opposite direction this would indicate a change in the importance of spillover effects.

The Charts in Appendix B show the evolution of the variance of η_t and ε_t using a four year rolling window. Chart 4 above shows the summary of these charts, depicting the variance of η_t and the average 4 year rolling variance of ε_t (unweighted). The results indicate that the variance of η_t, after being low and stable during the sixties, rose sharply during seventies. This increase in the variance of η_t during this period may be the result of both the end of the Breton Woods era (and hence a significant drop in the dollar exchange rate) and the oil shocks that occurred, therefore reflecting the impact of a truly common shock (rather than demonstrating increased integration and spillovers across non-fuel commodity prices). This is further confirmed by the sharp rise in variance in ε_t during the same period, which may reflect the increase in idiosyncratic volatility related to the consequences of the oil price shocks to which commodity prices react in very different ways.

After some fluctuations during the eighties, we then see during the nineties in general a decline in the variance of η_t whereas developments in ε_t differ across commodities and do not reveal a clear common pattern. Such results would suggest that over time, spill-over effects and integration of commodity price developments has actually declined, a finding already partly shown also in Figure 3 above. This would also be an indication that speculative activity, which has increased in volume over time, has not led to an increase in co-movement of commodity prices.

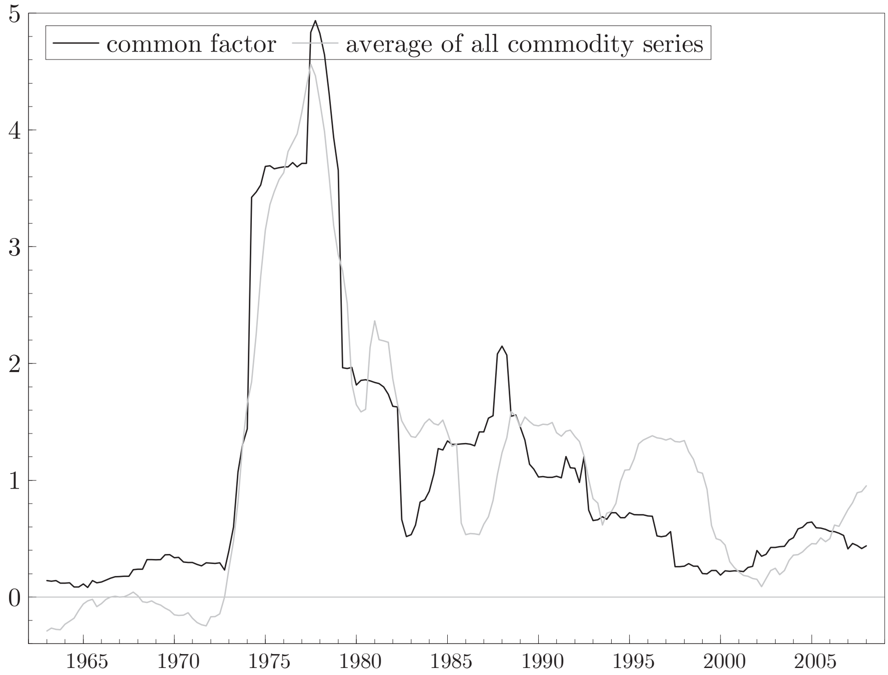


Figure 4: Average variance of common and idiosyncratic shocks

5.1 The role of fundamentals in explaining the common factor

Having uncovered the presence of a statistically significant common factor among most non-fuel commodity prices, it could be informative to analyse whether and if so, which variables can explain developments in this common factor. According to the existing literature (see for instance Dornbush, 1985, Chu and Morisson, 1986, Borenzstein and Reinhart, 1994, Alogoskoufis et al. 1990 and also section 1 for an overview) several aggregate macro economic time series could affect developments in non-fuel commodity prices and hence be driving developments in the common factor. In this section, we consider which of these proposed series can explain movements in our common factor. In more detail, we consider the following explanatory variables in our regression, based on data availability and the existing literature:[3]

- The dollar effective exchange rate (see FAO, 2007). Proxied in our analysis by the dollar effective exchange rate by using the broad effective exchange rate of the US dollar from the Federal Reserve Board of Governors.
- Oil prices (see Baffes, 2008). Proxied in our analysis by the UK Brent spot price.
- The real interest rate (see Calvo, 2008). Proxied in our analysis by the US short term interest rate deflated by US CPI inflation.
- Other input costs, namely fertilizer prices (see FAO, 2007). Proxied in our analysis by phosphate rock and potash prices from the IMF IFS.

[3] Ideally, we would also need to use a proxy for the supply of commodities. However, data limitations prevented us from included a proxy for this determinant in the regression analysis.

- Financial variables (see Carrera et al, 2008). Proxied in our analysis by the Dow Jones stock market index.
- Demand (see Borenzstein and Reinhart, 1994). Proxied in our analysis by industrial production in the OECD countries + six major non OECD countries (being Russia, China, India, Brazil, Indonesia and South Africa).

We allow, for each of the series, for up to 4 possible lags. Given the large number of explanatory variables, we decide upon the model estimation by means of a general-to-specific approach, using PcGets. Within PcGets an undominated, congruent model is selected, even though the precise formulation of the econometric relationship is not known a priori. Starting from a general model which is congruent with the data evidence, statistically insignificant variables are eliminated, with diagnostic tests checking the validity of the reduction, to ensure a congruent final selection (see for instance Hendry and Krolzig, 1999 and 2000).

The majority of the literature on commodity price determination has used a single equation framework. The analyses differ by the indices used, estimation period, frequency, and exact set of right-hand-side variables. However, OLS is the universal technique of choice (see for instance Dornbush, 1985). In these estimations, commodity prices appeared to be overly sensitive to fluctuations in the explanatory variables though (such as industrial production or the exchange rate). As noted in Borenzstein and Reinhart (1994) industrial production and the real exchange rate, commonly used explanatory variables in these regressions, are endogenous. As a result, not surprisingly, the parameter estimates of the OLS regression are unreliable. For this reason, we apply in this paper an instrumental variable approach whereby we use lags of the explanatory variables as instruments.

To analyse whether the estimated coefficients and selected variables using the PcGets algorithm change over time, we estimate our model using two different subsamples: one from 1973-2008 and another from 1990-2008. The regression results are presented in Table 5 below. The table shows the variables selected through the general-to-specific methodology. The table shows that several of the "fundamentals" we considered turn out to be statistically significant. In more detail, both oil and fertilizer prices have a positive significant coefficient, while the dollar effective exchange rate and the interest rate have a negative sign. Industrial production, finally, was not significant for the full sample estimate but is so for the shorter sample period, suggesting that world growth can be linked to the common factor more recently.

In general, the fit of both regressions is quite good, with an R^2 of approximately 0.7 in both cases. This is confirmed when we look at the actual and fitted values, as presented in Appendix C. The Figures in the Appendix in addition show that, especially for the estimate of short sample, the fitted value of the regression tracks fairly well the recent increase in the common factor, suggesting that at a quarterly frequency overall speculation has not been an important driving force in the increase in non-fuel commodity prices.[4] In more general terms, this finding would go against the presence of excess co-movement among commodity prices.

6 A Common Factor Model with Group Specific Effects

In this section, we present the estimation results of the extension of the general model by introducing dynamic factors which are common only to a sub-set of series, in addition to a

[4] As we do not consider the factors that have been driving up oil prices, it remains however possible that oil prices have been driven up by speculation, in turn influencing developments in non-fuel commodity prices.

Table 5: Regression of Common Factor on Various MacroEconomic Time Series

	1973Q1-2008Q1		1990Q1-2008Q1	
Variable	coefficient	standard dev.	coefficient	standard dev.
Constant			-0.46	(0.13)
common factor (-1)	0.40**	(0.06)		
common factor (-4)	-0.28**	(0.05)	-0.59**	(0.08)
Oil Brent			0.43**	(0.12)
Oil Brent (-2)	0.33**	(0.08)	0.59**	(0.11)
Dollar Effective Exchange Rate	-0.29**	(0.13)	-0.31**	(0.12)
Dollar Effective Exchange Rate (-1)	-0.37**	(0.13)		
Dollar Effective Exchange Rate (-2)			-0.31**	(0.14)
Dollar Effective Exchange Rate (-4)			-0.27**	(0.12)
Real interest rate	-0.27**	(0.07)	-0.59**	(0.16)
Industrial Production (-4)			0.44**	(0.14)
Potash			0.43**	(0.10)
Phosphate Rock (-4)	0.31**	(0.08)	2.25**	(0.59)
R^2	0.66		R^2	0.70
$R(adj)^2$	0.64		$R(adj)^2$	0.65

* denotes significance at the 10% and ** at the 5% level. For all variables we use first differences of the log levels.

single "global " factor. The model set-up is discussed in Section 2. We chose the sub-groups in such a way as to pool together non-fuel commodities which we know are in one way or the other related. In this context, the empirical literature provides pointers to commodities that are jointly produced or consumed, which is the criterion used here for judging whether commodities are related. Some cereals, natural fibres and food grains, certain beverages and some metals are known to be jointly produced, at least in certain important supply regions (Akiyama and Duncan, 1982; Coleman and Thigpen, 1991). Examples of joint production include coffee and cocoa in Côte d'Ivoire, copper and lead in the former Soviet Union and substitution between wheat, (beet) sugar, cotton and maize in agricultural production in many parts of the world. An example of joint consumption includes copper, zinc, gold and lead to produce metallic alloys.

Based on results from the empirical literature, we include in this analysis 11 non-fuel commodities and divide them into 4 groups: (1) coffee-cocoa (2) cotton-maize-sugar-wheat; (3) palm oil and soybean oil and (4) copper-zinc-lead. Prices within each group are related a priori, whereas prices between any two commodities in different groups are unrelated a priori. The resulting factors and parameter estimates of this model are presented in Figure 5 and Table 6. Figure 5 also plots the common factor from this model together with the common factor from the one factor model, presented in Section 4. As can be seen from the estimation results, the impact of both the common factor and the group-specific factors is in all cases (except in the case of coffee for the common factor) statistically significant, indicating that even after allowing for group specific factors, there exists a common factor across all these non-fuel commodity groups which is statistically significant. To see the relative importance of the various common factors, Table 7 shows the shares of the variance that can be accounted for by the common factors. As the Table shows, the global factor accounts for an important share of the variance and in several cases it turns out to be more important than the group-specific factor. Such results may suggest that "sympathetic speculative buying" is in fact affecting non-fuel commodity prices. However, when repeating the exercise from section 5.1, as presented in Appendix D, we find again that the macroeconomic fundamentals explain a large part of the movements in the common factor hence suggesting that the co-movement uncovered across the various commodity types is not excessive.

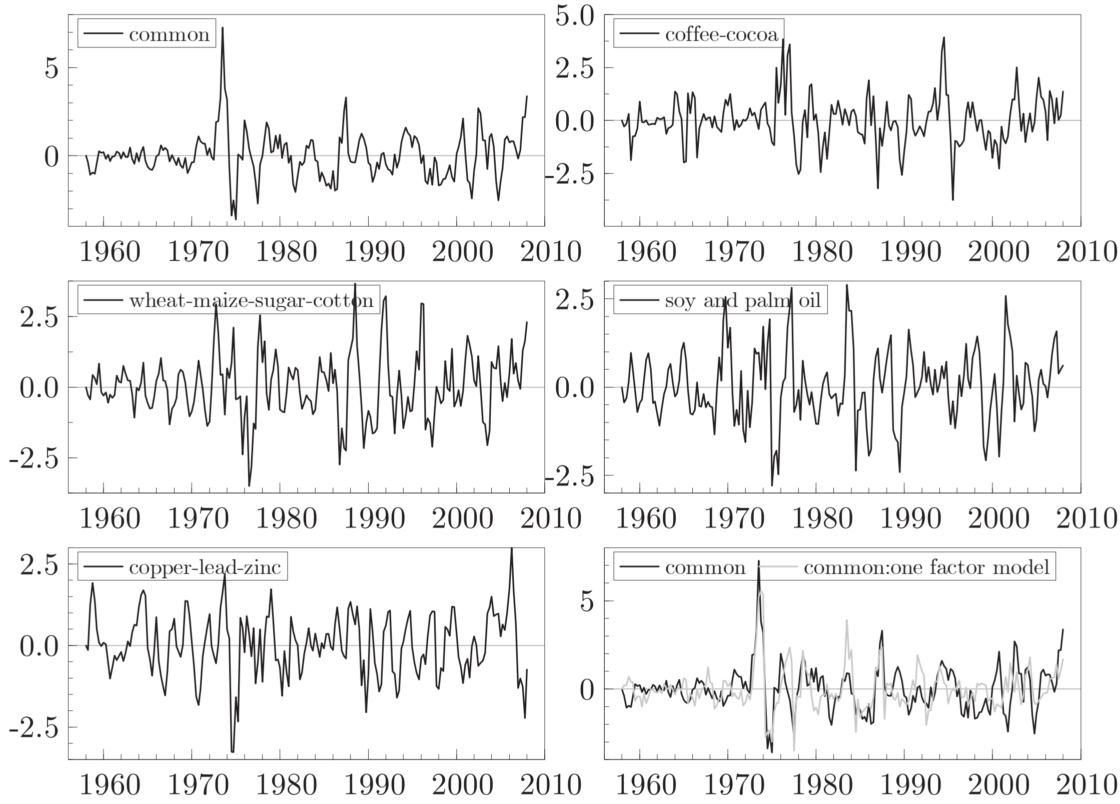


Figure 5: Common and Group-Specific Factors

Table 6: Parameter Estimates of Model with Group Specific and Common Factor

	a_i^j		b_i^j		c_i^j	
Cocoa	0.78**	(0.04)	0.07**	(0.03)	0.14**	(0.04)
Coffee Africa	0.66**	(0.08)	0.00	(0.04)	0.49**	(0.07)
Wheat	0.54**	(0.06)	0.36**	(0.06)	0.38**	(0.05)
Maize	0.68**	(0.04)	0.21**	(0.04)	0.21**	(0.04)
Sugar ISA	0.82**	(0.04)	0.08**	(0.03)	0.07**	(0.03)
Cotton	0.48**	(0.06)	0.43**	(0.05)	-0.29**	(0.05)
Palm oil	0.70**	(0.05)	0.17**	(0.03)	0.48**	(0.03)
Soy oil	0.73**	(0.04)	0.18**	(0.03)	0.34**	(0.03)
Copper	0.73**	(0.04)	0.14**	(0.03)	0.27**	(0.03)
Lead	0.84**	(0.04)	0.10**	(0.03)	0.16**	(0.03)
Zinc	0.69**	(0.05)	0.13**	(0.03)	0.49**	(0.03)
$\phi_{0,1}$	0.66**	(0.06)	$\vartheta_{0,1}$	0.49**	(0.12)	
$\vartheta_{1,1}$	0.54**	(0.07)	$\vartheta_{2,1}$	0.41**	(0.07)	
$\vartheta_{3,1}$	0.43**	(0.07)				

* denotes significance at the 10% and ** at the 5% level.

Table 7: Average Correlation and Shares of Variance accounted by Common and Group Factors (Full Sample Estimation Results)

	Share of variance from		Correlation w/	
	global factor	group factor	global factor	group factor
Cocoa	0.12	0.20	0.18	0.35
Coffee Africa	0.10	0.89	0.14	0.79
Wheat	0.36	0.22	0.68	0.55
Maize	0.29	0.15	0.45	0.39
Sugar ISA	0.03	0.03	0.14	0.11
Cotton	0.61	0.11	0.78	0.46
Palm oil	0.12	0.38	0.36	0.63
Soy oil	0.15	0.32	0.31	0.62
Copper	0.30	0.47	0.37	0.59
Lead	0.04	0.03	0.25	0.28
Zinc	0.22	0.39	0.36	0.58

Average correlation shows $Corr(f_t, y_{i,t})$ and $Corr(n_t, y_{i,t})$

7 Conclusion

Although the share of primary commodities in global output and trade has declined over the past century, fluctuations in commodity prices continue to be important for global economic activity. For many countries, especially developing countries, commodity price movements have a major impact on overall macroeconomic performance. Interest in understanding commodity price developments, and even more so in non-fuel commodity price developments, has however fallen over the past ten to fifteen years, as prices were relatively low and stable in nominal terms (and even declining in real terms). However, more recently, interest in commodity price developments resurfaced as prices of several non-fuel commodity prices reached record highs during 2007 and 2008. In addition, the current boom was also broader based and longer lasting than usual (see Helbling et al., 2008).

Such a strong and long lasting upward movement was unprecedented in history and raised the question: why did commodity prices rise so sharply during the past couple of years? In this paper, we try to analyse which factors have been driving developments in 32 selected non-fuel commodity prices. To do so, we relied in a first step on a dynamic factor model to determine the extent to which developments in 32 individual non-fuel commodity prices are driven by a common factor. In a second step, we then considered which macroeconomic fundamentals can be linked to movements in the common factor. As such this paper also fits into the excess co-movement literature on commodity prices.

The analysis of this paper shows that developments in non-fuel commodity price have recently become increasingly driven by common dynamics. However this level of synchronisation is - from a historical perspective - not unusual and follows in fact a period of exceptionally lower correlation. Movements in the common factor can to a large extent be linked to a number of macroeconomic fundamentals which are said to be relevant according to the existing literature, namely developments in the US dollar effective exchange rate, the US real interest rate, input costs (as proxied by fertilizer and oil prices) and more recently also global activity (as measured by a proxy for global industrial production). Taken together the evidence from this paper would thus suggest that it is unlikely that sympathetic speculative buying has been driving the most recent commodity price boom.

8 Appendices

A Specification for Commodity Prices

COCOA: International Cocoa organization daily price. Average of the three nearest active futures trading months in the New York Cocoa Exchange at noon and the London Terminal market at closing time, c.i.f. US and European ports, (USD/Mt), The Financial Times, London.

COFFEE (ARABICA): International Coffee Organization (New York) price. Average of El Salvador central standard, Guatemala prime washed and Mexico prime washed, prompt shipment, ex-dock New York, (Cents/pound), Bloomberg Business News.

COFFEE (ROBUSTA): International Coffee Organization (New York) price. Average of Côte d'Ivoire Grade II and Uganda, standard, prompt shipment, ex-dock New York. Prior to July 1982, arithmetic average of Angolan Ambriz 2 AA and Ugandan Native Standard, ex-dock New York, (Cents/pound), Bloomberg Business News.

TEA: From July 1998, Mombasa auction price, for best PF1, Kenyan tea (International Tea Committee, London). Prior to July 1998 is London auctions, average price received for good medium, c.i.f. UK warehouses, (Cents/Kg), London, Tea Brokers Association, the Financial Times.

COPRA: Philippines/Indonesian, bulk, c.i.f. N.W. Europe, (USD/Mt), The World Bank.

LINSEED OIL:any origin, (USD/Mt), The World Bank

COCONUT OIL: Philippine/Indonesian, bulk, c.i.f. Rotterdam, (USD/Mt.), Oil world, Hamburg.

GROUNDNUT OIL: Any origin, c.i.f. Rotterdam. Prior to 1974, Nigerian bulk, c.i.f. UK ports, (USD/Mt), Oil world, Hamburg.

GROUNDNUTS: 40/50 (40 to 50 count per ounce), c.i.f. Argentina, (USD/Mt), Datastream.

PALM OIL: Malaysian/Indonesian, c.i.f. Northwest European ports, (USD/Mt), Oil world, Hamburg. Prior to 1974, UNCTAD.

SOYBEANS: US, c.i.f. Rotterdam, (USD/Mt), Oil world, Hamburg.

SOYBEAN MEAL: Argentina, 45/46 percent protein, c.i.f Rotterdam, (USD/Mt), Oil world, Hamburg.

SOYBEAN OIL: Dutch, f.o.b. ex-mill. Prior to 1973, Dutch crude oil, ex-mill, (USD/Mt), Oil world, Hamburg.

MAIZE: US No. 2 yellow, prompt shipment, f.o.b. Gulf of Mexico ports, (USD/Mt), USDA, Grain and Feed Market News.

RICE: Thai, white milled, 5 percent broken, nominal price quotes, f.o.b. Bangkok, (USD/Mt), Arkansas, Little Rock: USDA, Rice Market News.

WHEAT: US No. 1 hard red winter, ordinary protein, prompt shipment, f.o.b Gulf of Mexico ports, (USD/Mt), Washington: USDA, Grain and Feed Market News.

SUGAR EU: EU import price, unpacked sugar, c.i.f. European ports. Negotiated price for sugar from ACP countries to EU under the Sugar Protocol, (Cents/pound), EU Office in Washington.

SUGAR ISA: International Sugar Organization price. Average of the New York contract No. 11 spot price, and the London daily price, f.o.b. Caribbean ports Prior to 1976, New York contract No. 11, spot price, f.o.b. Caribbean and Brazilian ports, (Cents/pound), International Sugar Organization, London and The Journal of Commerce.

SUGAR USA: CSCE contract No. 14, nearest futures position, c.i.f. New York. Prior to June 1985, US spot import price, contract No. 12, c.i.f. New York, (Cents per pound), Wall Street Journal and Dow Jones. Prior to June 1985 New York Journal of Commerce and Weekly Review of the market, Coffee Sugar and Cocoa Exchange Inc.

COTTON: Middling 1-3/32 inch staple, Liverpool Index "A", average of the cheapest five of fourteen styles, c.i.f. Liverpool. From January 1968 to May 1981 strict middling 1-1/16 inch staple. Prior to 1968, Mexican 1-1/16, Units: Cents/pound, Cotton Outlook Liverpool.

HARDWOOD LOGS: Malaysian, meranti, Sarawak best quality, sale price charged by importers, Japan. From January 1988 to February 1993, average of Sabah and Sarawak in Tokyo weighted by their respective import volumes in Japan. From February 1993 to present, Sarawak only, USD/Cm, The World Bank

RUBBER: Malaysian, No. 1 RSS, prompt shipment, f.o.b. Malaysian/Singapore ports, Cents/pound, The Financial Times.

JUTE: Bangladesh, raw, white D, f.o.b. Chittagong/Chalna, USD/mt, The World Bank.

WOOL COARSE: 48's clean, dry combed basis. Prior to January 1987, 50's, Cents/kg, Commonwealth Secretariat.

WOOL FINE: 64's clean, dry combed basis, Cents/kg, Commonwealth Secretariat.

PHOSPHATE ROCK: Moroccan, 70 percent BPL, contract, f.a.s. Casablanca. Prior to 1981, 72 percent BPL, f.a.s. Casablanca, USD/Mt, The World Bank.

ALUMINUM: London Metal Exchange, standard grade, spot price, minimum purity 99.5 percent, c.i.f UK ports. Prior to 1979, UK producer price, minimum purity 99 percent, USD/Mt, Wall Street Journal, New York and Metals Week, New York.

COPPER: London Metal Exchange, grade A cathodes, spot price, c.i.f. European ports. Prior to July 1986, higher grade, wirebars, or cathodes, Cents/pound, Wall Street Journal, New York and Metals Week, New York.

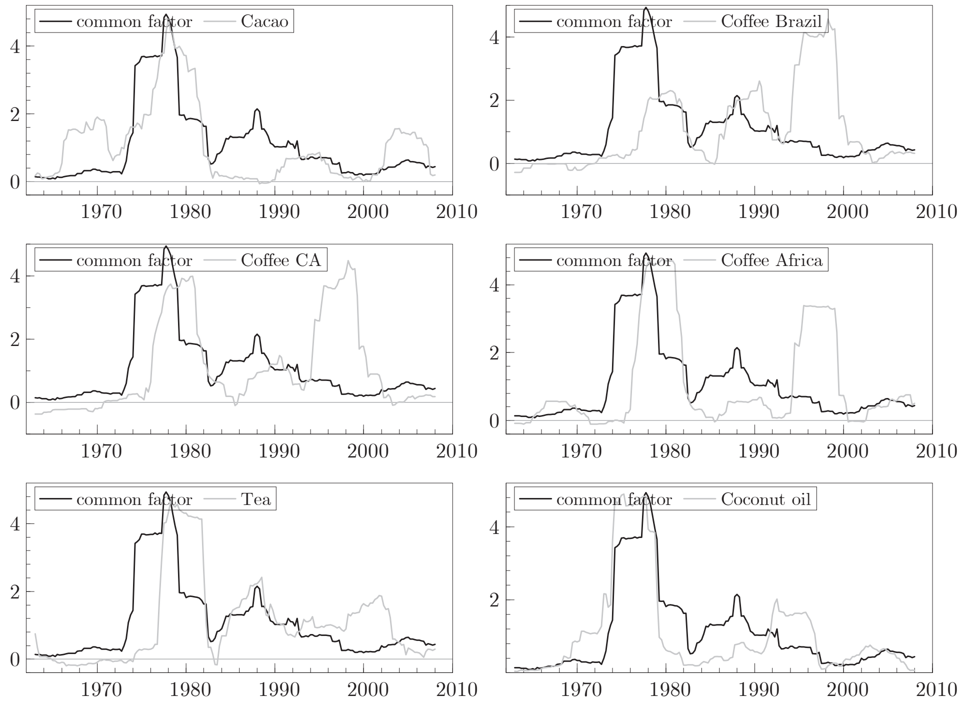
LEAD: London Metal Exchange, 99.97 percent pure, spot price, c.i.f. European ports, USD/Mt, Wall Street Journal, New York and Metals Week, New York.

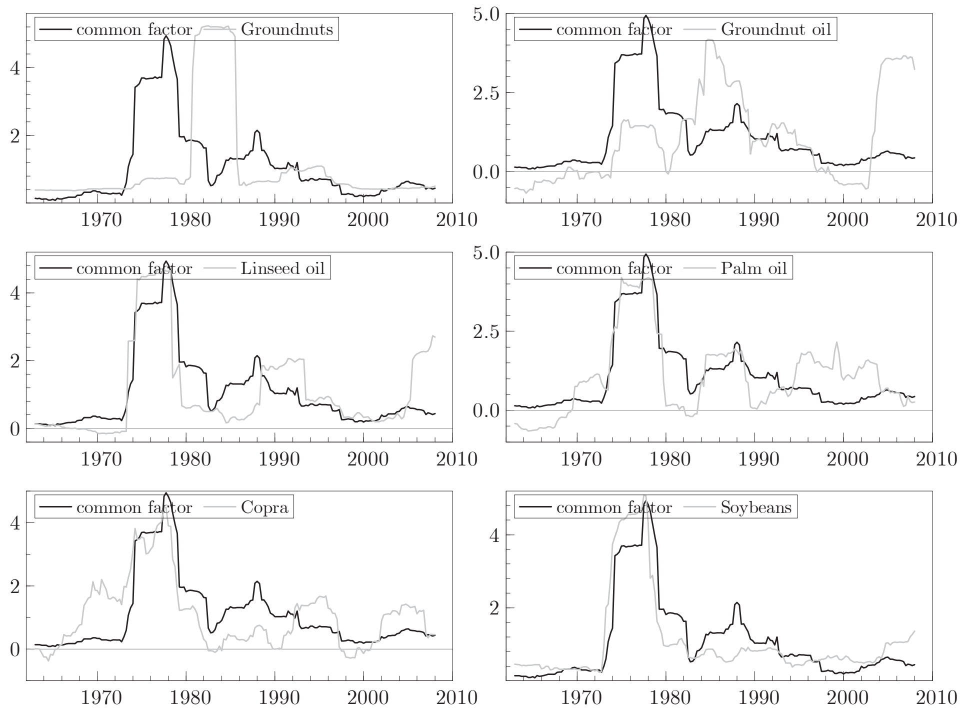
NICKEL: London Metal Exchange, melting grade, spot price, c.i.f. Northern European Ports. Prior to 1980 INCO, melting grade, c.i.f Far East and American ports, USD/Mt, London Metal Bulletin.

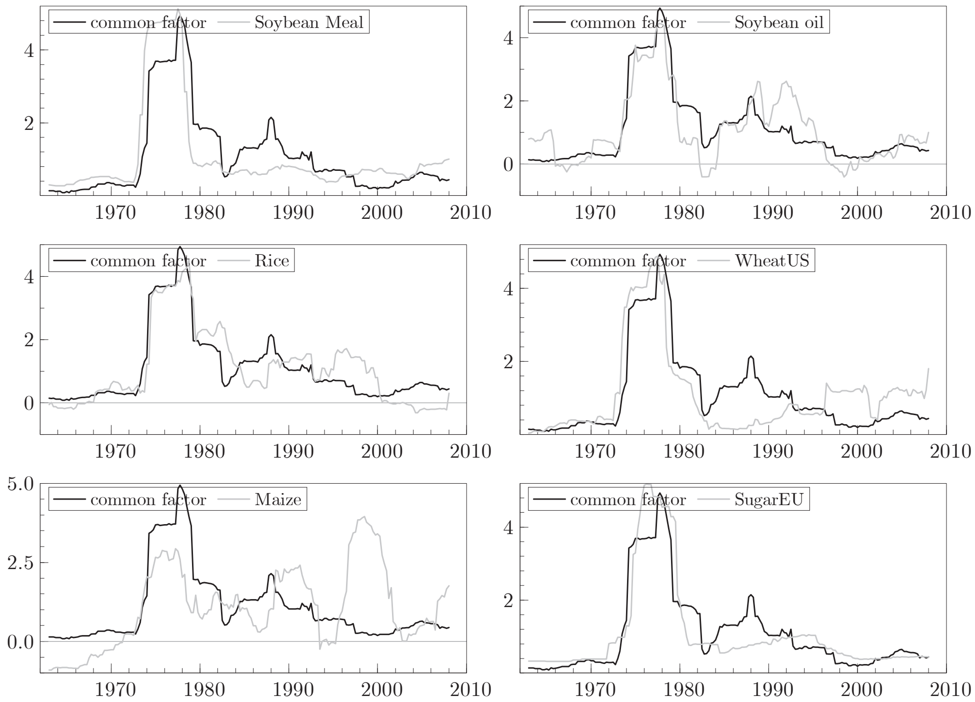
TIN: London Metal Exchange, standard grade, spot price, c.i.f. European ports. From December 1985 to June 1989 Malaysian, straits, minimum 99.85 percent purity, Kuala Lumpur Tin Market settlement price. Prior to November 1985, London Metal Exchange, Cents/pound, Wall Street Journal.

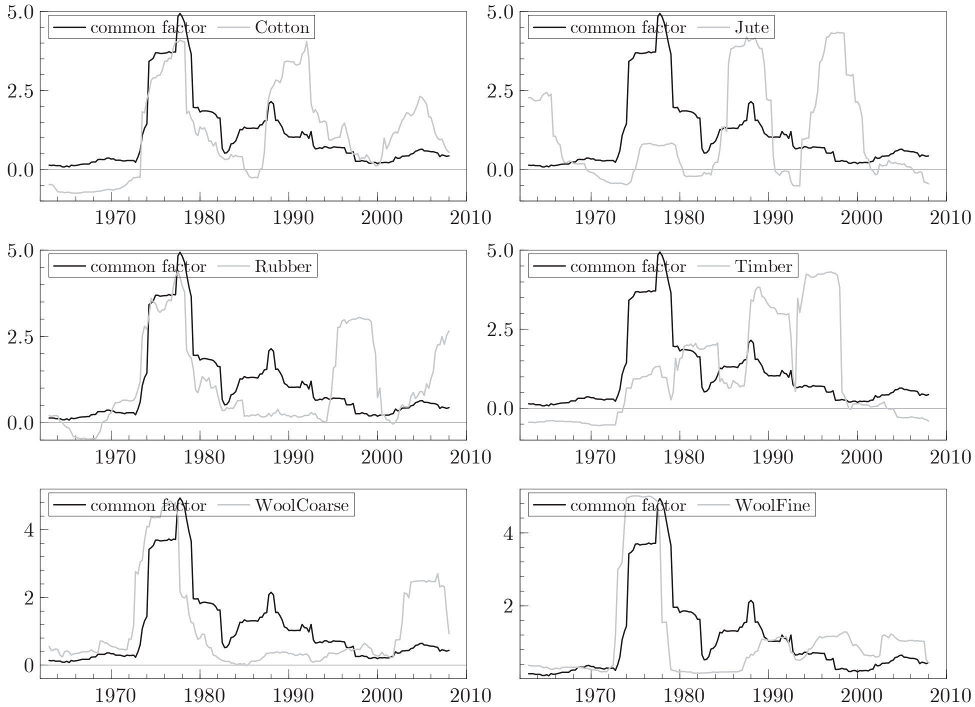
ZINC: London Metal Exchange, high grade 98 percent pure, spot price, c.i.f UK ports. Prior to January 1987, standard grade, USD/Mt, Wall Street Journal and Metals week.

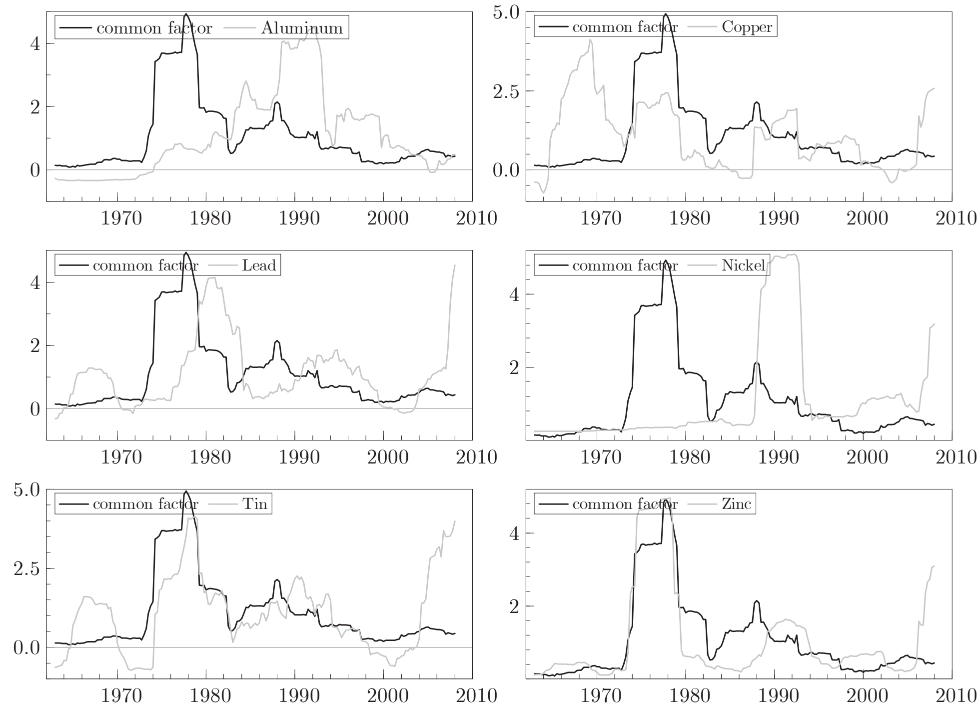
B Average variance of common and idiosyncratic shocks



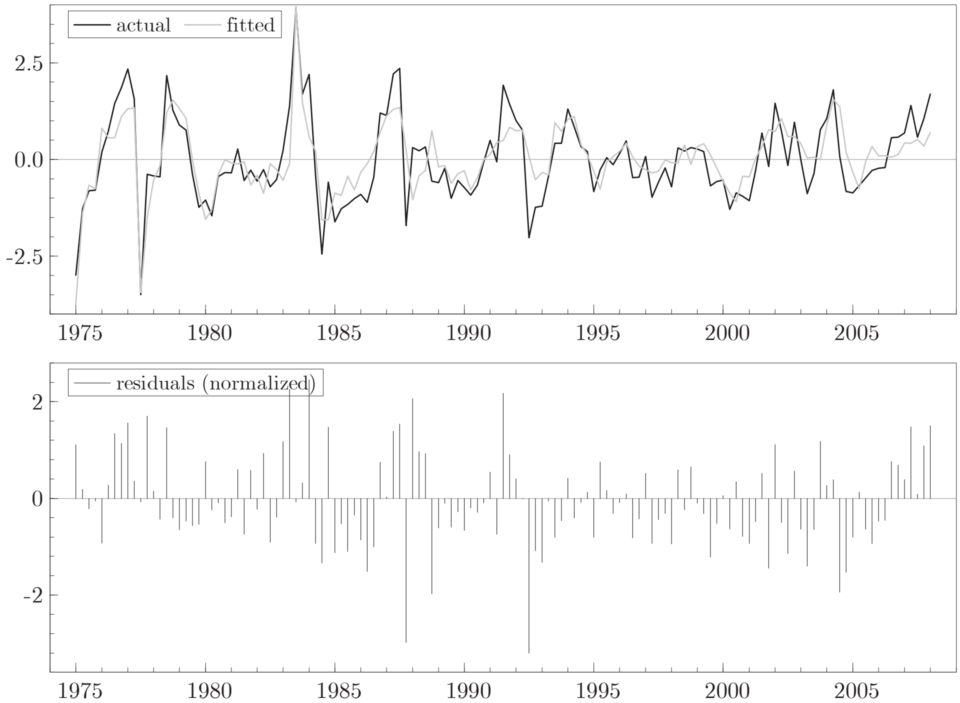


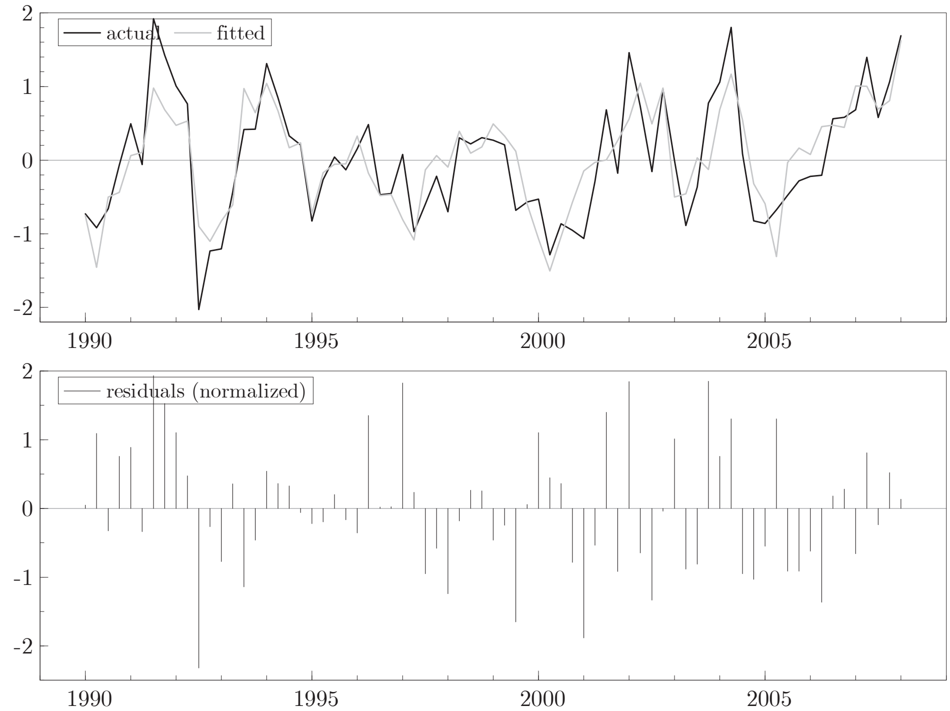

common factor
Soybean Meal
Soybean oil
Rice
WheatUS
Maize
SugarEU
1970
1980
1990
2000
2010


common factor
Cotton
Jute
Rubber
Timber
WoolCoarse
WoolFine
1970
1980
1990
2000
2010


common factor
Aluminum
Copper
Lead
Nickel
Tin
Zinc
1970
1980
1990
2000
2010
0
2
4
0.0
2.5
5.0

C Actual and fitted values for common factor IV regression



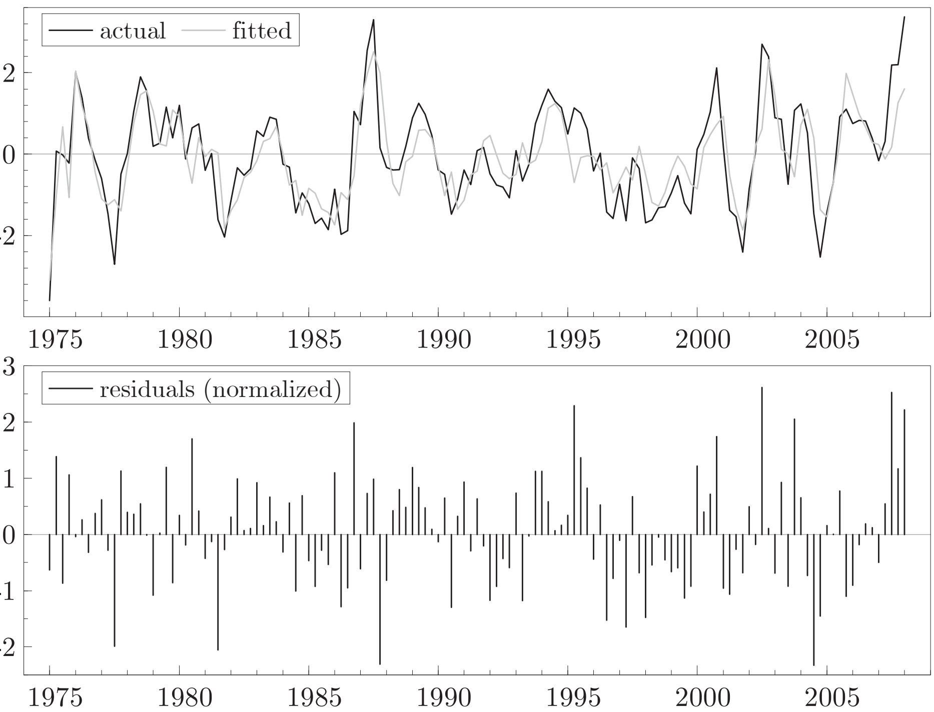


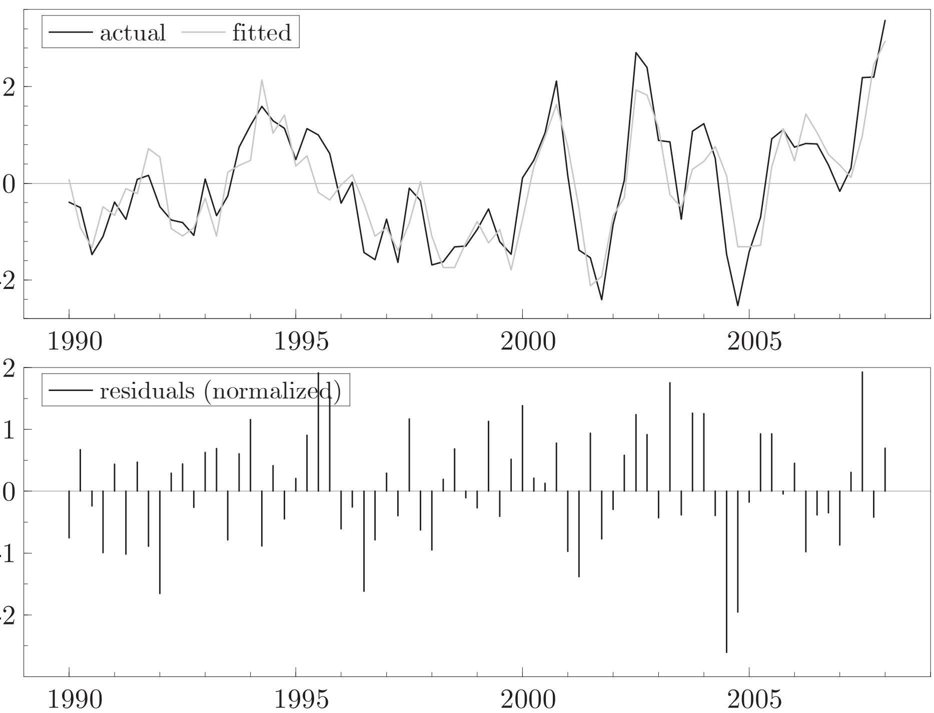
D Actual and fitted values for common factor IV regression based on Model from Section

Table 8: Regression of Common Factor on Various MacroEconomic Time Series

	1973Q1-2008Q1		1990Q1-2008Q1	
Variable	coefficient	standard dev.	coefficient	standard dev.
common factor (-1)	0.58	(0.07)	0.52	(0.08)
common factor (-4)	-0.24	(0.06)		
Oil Brent	-1.24	(0.57)	2.31	(0.89)
Oil Dubai	1.54	(0.67)		
Oil Dubai (-2)			1.01	(0.20)
Oil WTI			2.00	(0.83)
Dollar Effective Exchange Rate (-4)	-0.24	(0.08)		
Real interest rate (-2)			-2.70	(0.42)
Real interest rate (-3)			-2.73	(0.40)
Industrial Production	0.59	(0.18)		
Industrial Production (-1)	0.58	(0.19)		
Industrial Production (-3)			1.56	(0.31)
Industrial Production (-4)			0.85	(0.29)
Phosphate Rock (-1)			4.53	(0.68)
Phosphate Rock (-2)			5.18	(0.83)
Phosphate Rock (-3)	0.45	(0.17)		
Phosphate Rock (-4)	0.55	(0.16)		
R^2	0.62		R^2	0.78
$Radj^2$	0.59		$Radj^2$	0.75

* denotes significance at the 10% and ** at the 5% level. For all variables we use first differences of the log levels.


actual
fitted
residuals (normalized)
1975
1980
1985
1990
1995
2000
2005


actual
fitted
residuals (normalized)
1990
1995
2000
2005

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