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Co-movements in commodity prices: Global, sectoral and commodity-specific factors

Libo Yin [a,*], Liyan Han [b]

[a] School of Finance, Central University of Finance and Economics, China

[b] School of Economics and Management, Beihang University, China

HIGHLIGHTS

- We study the co-movement in commodity prices with a dynamic latent factor model.
- We decompose commodity prices into global, sectoral, and idiosyncratic components.
- A common global factor is an important source of volatility for commodity prices.
- The common dynamic properties increase in importance since 2004.

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ABSTRACT

This paper characterizes the co-movements in commodity prices with a dynamic latent factor model that decomposes commodity returns into global, sectoral, and idiosyncratic components. The results indicate that global and sectoral factors are important sources of co-movements in commodity returns. A subsample analysis further reveals that the global factor increases significantly in importance since 2004, which indicates an increasing integration among commodity markets.

1. Introduction

The feature of co-movements in commodity prices prompts a new search for the fundamentals. From a theoretical point of view, Alquist and Coibion (2014) show a factor structure for commodity prices in which the common factor captures the combined contribution of all aggregate shocks that affect commodity markets.

However, research from an empirical standpoint generates mixed views. Byrne et al. (2013) document a significant degree of co-movements. West and Wong (2014) find that commodity prices consistently display a tendency to revert towards one factor. However, evidence for co-movements has recently been challenged by Daskalaki et al. (2014) who find that none of the factors could explain the co-movements of commodity returns.

This paper contributes to the empirical evidence on the significance and the structure of the common dynamic properties of commodity price fluctuations. By employing a Bayesian dynamic latent factor model, we relate international commodity returns to one global, six sectoral, and 24 commodity-specific factors. This decomposition measures the extent to which global, sectoral, and commodity-specific components explain the variation in commodity prices.

Perhaps the most related approach to our own are Gospodinov and Ng (2013) and Moench et al. (2013). The first one decomposes commodity convenience yields into factors and uses these estimated factors for forecasting inflation. However, it does not put any limitations on the structure of factors. The second one puts a block structure on the panel and estimates global and sectoral macroeconomic factors.

* Corresponding author.
E-mail address: yinlibowsxbb@126.com (L. Yin).

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2. Methodology

We tackle the issue by applying a dynamic latent factor model proposed by Kose et al. (2003). We suppose that there are three types of factors: the single global factor (f_t^w), J sectoral factors ($f_{j,t}^s$, one each for each sector) and N commodity-specific factors ($f_{n,t}^c$, one per commodity). Therefore, the model is given by:

$$y_{i,t} = \beta_i^w f_t^w + \beta_i^s f_{j,t}^s + \beta_i^c f_{n,t}^c + \varepsilon_{i,t}, \tag{1}$$

where $y_{i,t}$ is the demeaned log returns for commodity i ($i = 1, \ldots, N$) from month $t-1$ to t ($t = 1, \ldots, T$). We assume that the evolution of each factor follows an AR(q) process, respectively:

$$f_t^w = \rho_1^w f_{t-1}^w + \cdots + \rho_q^w f_{t-q}^w + u_t^w, \tag{2}$$

$$f_{j,t}^s = \rho_{j,1}^s f_{j,t-1}^s + \cdots + \rho_{j,q}^s f_{j,t-q}^s + u_{j,t}^s, \quad (j = 1, 2, \ldots, J), \tag{3}$$

$$f_{n,t}^c = \rho_{n,1}^c f_{n,t-1}^c + \cdots + \rho_{n,q}^c f_{n,t-q}^c + u_{n,t}^c, \quad (n = 1, 2, \ldots, N), \tag{4}$$

where $u_t^w \sim \left(0, \sigma_w^2\right), u_{j,t}^s \sim \left(0, \sigma_{j,s}^2\right), u_{n,t}^c \sim \left(0, \sigma_{n,c}^2\right)$ and $E\left(u_t^w u_{t-s}^w\right) = E\left(u_{j,t}^s u_{j,t-s}^s\right) = E\left(u_{n,t}^c u_{n,t-s}^c\right) = 0$ for $s \neq 0$.

The dynamic factor model attributes all of the co-movements in commodity returns to the global, sectoral and commodity-specific factors via the factor loadings β_i^w, β_i^s and β_i^c. In the extreme, a commodity with $\beta_i^w = \beta_i^s = 0$ will have a return that is completely idiosyncratic, displaying no co-variation with other commodities.

The idiosyncratic errors $\varepsilon_{i,t}$ are assumed to be normally distributed, but may be serially correlated. It is likewise governed by an auto-regression of order p with normal errors:

$$\varepsilon_{i,t} = \rho_{i,1}\varepsilon_{i,t-1} + \cdots + \rho_{i,p}\varepsilon_{i,t-p} + u_{i,t}, \tag{5}$$

where $u_{i,t} \sim \left(0, \sigma_i^2\right)$, and $E\left(u_{i,t}u_{i,t-s}\right) = 0$ for $s \neq 0$. We set the orders of the AR processes, p and q, equal to two. Other non-zero values for p and q produce similar results.

To implement Bayesian analysis, we use the following conjugate priors:

$$\left(\beta_i^w, \beta_i^s, \beta_i^c\right)' \sim N\left(0, I_3\right), \quad (i = 1, 2, \ldots, N), \tag{6}$$

$$\left(\rho_{i,1}, \ldots, \rho_{i,p}\right)' \sim N\left[0, \operatorname{diag}\left(1, 0.5, \ldots, 0.5^{p-1}\right)\right], \quad (i = 1, 2, \ldots, N), \tag{7}$$

$$\left(\rho_1^w, \ldots, \rho_q^w\right)' \sim N\left[0, \operatorname{diag}\left(1, 0.5, \ldots, 0.5^{q-1}\right)\right], \tag{8}$$

$$\left(\rho_{j,1}^s, \ldots, \rho_{j,q}^s\right)' \sim N\left[0, \operatorname{diag}\left(1, 0.5, \ldots, 0.5^{q-1}\right)\right], \quad (j = 1, 2, \ldots, J), \tag{9}$$

$$\left(\rho_{n,1}^c, \ldots, \rho_{n,q}^c\right)' \sim N\left[0, \operatorname{diag}\left(1, 0.5, \ldots, 0.5^{q-1}\right)\right], \quad (n = 1, 2, \ldots, N), \tag{10}$$

$$\sigma_i^2 \sim IG\left(6, 0.001\right), \quad (i = 1, 2, \ldots, N) \tag{11}$$

where IG () denotes the inverse-gamma distribution, and the prior on the innovation variances is quite diffuse. Experimentation with tighter and looser priors for both the factor loadings and the autoregressive parameters do not produce qualitatively important changes in the results.

We measure the extent of influences of three kinds of factors on each commodity by computing the factors' contributions to the total variability in a commodity's return:

$$\theta_i^w = \left(\beta_i^w\right)^2 \operatorname{var}\left(f_t^w\right) / \operatorname{var}\left(y_{i,t}\right), \tag{12}$$

$$\theta_i^s = \left(\beta_i^s\right)^2 \operatorname{var}\left(f_{j,t}^s\right) / \operatorname{var}\left(y_{i,t}\right), \tag{13}$$

$$\theta_i^c = \left[\left(\beta_i^c\right)^2 \operatorname{var}\left(f_{n,t}^c\right) + \operatorname{var}\left(\varepsilon_{i,t}\right)\right] / \operatorname{var}\left(y_{i,t}\right), \tag{14}$$

where

$$\operatorname{var}\left(y_{i,t}\right) = \left(\beta_i^w\right)^2 \operatorname{var}\left(f_t^w\right) + \left(\beta_i^s\right)^2 \operatorname{var}\left(f_{j,t}^s\right) + \left(\beta_i^c\right)^2 \operatorname{var}\left(f_{n,t}^c\right) + \operatorname{var}\left(\varepsilon_{i,t}\right), \quad i = 1, 2, \ldots, N, \tag{15}$$

and $\theta_i^w, \theta_i^s, \theta_i^c$ are the proportions of the total variability in commodity i's return attributable to the global, sectoral and commodity-specific factors, respectively. To ensure that θ_i^w, θ_i^s and θ_i^c sum to one, we orthogonalize the factors (using the global, sectoral, commodity-specific factor ordering) at each replication.

3. Data

We use a monthly data set of 24 commodities starting in January, 1991, and ending in May, 2014. We measure monthly return as first differences in the log-levels of the price of first-month futures contracts. The data are obtained from Bloomberg. The summary statistics are reported in Table 1. Most of the commodity returns exhibit negative skewness, and excess kurtosis with a fat tail and non-normal distribution, as verified by the Jarque–Bera test.

4. Empirical results

4.1. Global and sectoral factors and loadings

Fig. 1 depicts means and 0.05 and 0.95 quantiles of the posterior distributions of the global and sectoral factors.

The estimated global factor series is naturally interpreted as a normalized index of global commodity returns. It is relatively low before 2004s, and increases substantially, with a notable uptick in the beginning of 2005. This could be explained by the emergence of commodity index investment. It also shows a sharp downturn during the 2008 financial crisis, thus clearly supporting a synchronized fall in prices of a broad set of commodities.

The estimated sectoral factors perform similarly to the global factor. The significant fluctuations generally help to detect significant co-movements across sectors, after accounting for worldwide co-movements. For example, several of the peaks and troughs of the energy factor coincide with of big oil price fluctuations reference dates: Gulf Wars I and II, the announcement of OPEC cut production to shore price, the Lehman bankruptcy and TARP legislation, the Euro zone crisis, the US debt-ceiling dispute, and other major shocks. Further, there are some notable differences between the global factor and the sectoral factor, indicating that these two factors play different roles at different points over time and around the globe, which should be distinguished.

4.2. Variance decompositions

We turn next to the estimates of the variance decompositions, the key metric for assessing the degree of co-movements in commodity returns. Table 2 reports averages across various commodity sectors of the means and 0.05 and 0.95 quantiles for the posterior distributions.

As full-sample results show the global factor explains a significant fraction of the commodity prices fluctuations. The average θ_i^w estimate is 16.86%, while the average θ_i^s and θ_i^c estimates are 32.57% (50.57%). The global and sectoral shocks together account for roughly half (49.43%) of commodity prices fluctuations, while commodity-specific shocks account for just over half. Notably, the global factor edges out the sectoral factor as dominant which explains more than 68% of grains prices variability, though both play important roles.

We further estimate the model separately over the 1991–2003 and 2004–2014 subsamples, since the emergence of commodity