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Common dynamic factors in driving commodity prices: Implications of a generalized dynamic factor model

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ABSTRACT

Identification of the price drivers of commodity prices is difficult because economic indicators reflect commodity prices with lead or lag, and some commodities have spillover effects to other commodities. A generalized dynamic factor model is capable of accounting for these characteristics and can be applied to panel data of monthly returns of a vast variety of commodities. The empirical results indicate that four common dynamic factors exist that account for much of the variation in the commodity returns. The identification of the common dynamic factors is conducted by interchangeably creeping an economic indicator into the commodity return panel data and examining the ratio of variance explained by the common factors. The four common factors correspond to the U.S. inflation rate, the world industrial production, the world stock index, and the price of crude oil.

1. Introduction

Commodity prices were relatively stable in the latter half of the 1990s but rose sharply from 1999 into 2008. The surge in commodity prices during the first half of 2008 marked the high point of the cyclical upswing in these prices. The prices collapsed in the tumultuous environment created by the financial crisis that occurred in the fall of 2008. Subsequently, commodity prices have fluctuated within some bands and have not exceeded the historical high prices recorded in 2008. The boom that occurred in the commodity markets prior to 2008 was pervasive. The commodities boom that ended in 2008 raised many issues, including whether commodity prices were supported by real demand or were simply a bubble, which economic factors drive commodity prices, the number of factors that must be considered to achieve an understanding of commodity prices, and many other considerations. Previous studies have proposed various factors that affected commodity prices; however, few studies have quantitatively analyzed the contributions of these factors to price variations of a huge variety of commodities (Byrne et al., 2013; West and Wong, 2014). Therefore, there is controversy over the metric to evaluate the effects of economic indicators on commodity prices.

Traditional theories failed to explain the upward trend of commodity prices between January 1999 and June 2008. Instead, economists and researchers proclaimed that commodity prices were in a phase of a 'super cycle' (Humphreys, 2010; Jerrett and Cuddington, 2008; Klotz et al., 2014; Radetzki, 2006; World Bank Group, 2015). This 'super cycle' was primarily generated by the strong demand for raw materials that was produced by the explosive growth of China and India. During the examined time period, these nations underwent relatively material-intensive growth.

Radetzki et al. (2008) also observed supply-side causes for commodity price increases. In particular, mining capacities did not increase over the course of the past two decades because of poor prices and low investor confidence during the period immediately before and after 1999. Traditionally, 3–5 years have typically been required before investments in minerals or energy result in new installations that are ready to contribute to the production of these resources. In general, the establishment of new capacity in minerals and energy to match the accelerated demand trends is a more time-consuming process than many individuals commonly assume. In fact, this process may require a decade or longer. Therefore, a strong gap between demand and supply existed with respect to commodities between 1999 and 2008.

Several macroeconomic indicators are potential persuasive candidates for explaining variations in commodity prices. The dollar exchange rate may be a co-driver of commodity prices in part because these prices are denominated in dollar currency (Sjaastad, 2008); thus, a weaker dollar may lead to higher commodity prices. Inflation is also an important consideration with respect to commodity prices. Inflation may influence commodity prices because inflation pushes production costs of commodities up. Akram (2009) investigated not only whether a decline in real interest rates and the US dollar contributed to higher commodity prices but also whether commodity prices displayed overshooting behaviors in response to changes in real interest rates. In particular, he analyzed the behaviors of the real prices of crude oil, food, metals and industrial raw materials by applying structural vector autoregressive (VAR) models. He concluded that commodity prices increased significantly in response to reductions in real interest rates and that a weaker dollar led to higher commodity prices. Sari et al. (2010) examined the co-movements among the US dollar/euro exchange rate, oil prices, and the spot prices of precious metals. These

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researchers found that the commodity prices they examined responded significantly to a shock in the exchange rate.

During the past decade, funds for investment and speculation have moved easily among different markets. For instance, hedge funds invest not only in equity- and debt-based assets but also in real assets such as real estate and commodities. Actually, investment in commodities is profitable; various trading strategies, such as moving average technical trading, momentum-based trading strategies, and dynamic trading strategies based on a mean-variance investor framework, produce statistically significant profit in oil, gold, silver and platinum markets (Narayan et al., 2013, 2015; Westerlund and Narayan, 2013; Westerlund et al., 2015). It is plausible that speculative money flows into the commodity markets cause commodity booms and volatile variations in commodity prices. Therefore, stock indices and money supply are candidates to explain variations in commodity prices. Inflation may influence commodity prices because investors move away from stocks and bonds and toward physical assets during the periods of expected inflation.

Previous studies revealed that commodity prices are affected by certain economic indicators. However, no study has examined to what extent each economic indicator affects commodity prices when we comprehensively adopt all economic indicators as explanatory variables. Furthermore, previous studies do not take into consideration the fact that economic indicators reflect commodity prices with lead or lag.

Two features of commodity price variations are important to identify drivers of commodity prices: co-movement of commodity prices and spillover effects of commodity on other commodities. Many commodity prices co-move with other commodity prices, and consequently, high cross-correlations among returns of different commodities are observed. Factor model is appropriate to model the co-movement of commodities prices (Byrne et al., 2013; West and Wong, 2014; Yin and Han, 2015).

In fact, spillover effects are one of the key characteristics for understanding commodity prices. High crude oil prices may increase the prices of other commodities through cost-push effects because the production of other commodities may depend either directly or indirectly on the use of crude oil (Baffes, 2007). Zhang and Wei (2010) found that there was consistently a positive and significant correlation coefficient for the relationship between the crude oil price and the gold price during the period between 2000 and 2008. Hammoudeh et al. (2010) examined the conditional volatility for the prices of the four major precious metals. These researchers found significant short- and long-run interdependencies among these prices, and the prices also demonstrated short- and long-run dependencies on news and on past volatility.

Co-movement of commodity prices is appropriately modeled by factor models. Byrne et al. (2013) employed a factor augmented vector auto regression (FAVAR) approach to investigate the relationship between commodity prices and macroeconomic determinants. West and Wong (2014) used a static factor model to capture co-movements of commodity prices. Yin and Han (2015) applied a dynamic latent factor model to returns of commodities. However, these factor models represent simultaneous variations in commodity prices and do not incorporate lead/lag properties of commodity prices into economic indicators.

The aim of this paper is to identify the common factors that affect a vast variety of commodity prices. Our study is distinguished from previous studies by the coverage of commodities and characteristics of a factor model that we employ. In previous studies, few categories of commodities have been analyzed, with the number of commodities being less than 25. Our empirical analysis examines data from 1995 to 2015 and extends to a broad range of commodities, including commodity indices (8), agricultural products (12), chemicals (15), energy (21), metals (14), precious metals (12), and other commodities (2), where the number of commodities in each category is given in parentheses. The total number of commodities amounts to 84. A generalized dynamic factor model is employed in our analysis for two reasons: first, commodity prices have shown strong (inter)dependencies on other commodity prices, and some commodities have spillover effects on other commodities; and second, variations in commodity prices lead or lag changes in other commodity prices. A generalized dynamic factor model is capable of accounting for these characteristics and can be applied to panel data of monthly returns of a wide range of commodities. Our study is the first attempt to apply the generalized dynamic factor model to a vast variety of commodity prices. In contrast to the previous studies that employed the factor models, the generalized dynamic factor model is more appropriate to capture lead/lag structures in commodity prices. The empirical results indicate that four common dynamic factors exist that account for much of the variation in the commodity returns. The common factors are a linear combination of lag operators, and it is not straightforward to disentangle the relations between economic indicators and commodity prices. This problem is circumvented by interchangeably creeping an economic indicator into the commodity return panel data and examining the ratio of variance explained by the common factors. The four common factors correspond to the world industrial production, the inflation rate, the world stock index, and the price of crude oil.

This paper is organized as follows. In Section 2, we introduce our model and methodology. We focus on the generalized dynamic factor model and explain how the number of common factors affecting commodity prices is determined. Section 3 describes our dataset and documents our empirical results; in particular, we identify the common dynamic factors that affect commodity prices and examine the proportion of the variance in these prices that is explained by the identified factors. Section 4 concludes our study.

2. The identification of the common factors that affect commodity prices

2.1. The generalized dynamic factor model

We review Forni et al. (2000) and Hallin and Liska (2007) to introduce our notations and explain our extension. The observed return of the examined commodities, x_{it}, is expressed as the finite realization of a double array $\{X_{i,t},\ i = 1, 2, \ldots, n,\ t \in \mathbb{Z}\}$ of random variables, where n is the total number of commodities. Co-movements of commodity returns are well addressed by factor models. Principal component analysis and factor analysis are among the best known types of factor models. These two types of analyses are categorized as static factor models because they examine contemporaneous co-movements among the observations. The static factor model is not appropriate for our purposes because changes in certain factors might lead or lag changes in the examined commodity returns. Therefore, dynamic factor models are better suited for our purposes. A dynamic factor model is represented as follows:

$$x_{it} = \chi_{it} + \xi_{it}, \tag{1}$$

$$\chi_{it} := \sum_{j=1}^{q} b_{ij}(L) u_{jt}, \tag{2}$$

$$b_{ij}(L) := \sum_{k=1}^{\infty} b_{ijk} L^k, \tag{3}$$

where L stands for the lag operator. In the above equation, the variable u_{jt} $(j = 1, \ldots, q)$ represents common shocks or factors that affect commodity returns, whereas the variables $\chi_{it} = x_{it} - \xi_{it}$ and ξ_{it} are known as the common component and the idiosyncratic component of x_{it}, respectively. The q-dimensional process $\{\mathbf{u}_t := (u_{1t}, u_{2t}, \ldots, u_{qt})',\ t \in \mathbb{Z}\}$ represents orthogonal white noise. An exact dynamic factor model was first proposed by Geweke (1977); in this model, idiosyncratic components are assumed to be mutually orthogonal.

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