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Can futures price be a powerful predictor? Frequency domain analysis on Chinese commodity market ☆

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ABSTRACT

This paper presents the causal relationships between futures and spot prices of six metal and agriculture commodities in Chinese commodity market, using GC test, frequency domain approach proposed by Brietung and Candelon (2006) and Garbade–Silber (G–S) Model. Frequency domain approach indicates that futures price of each commodity is really a powerful predictor for spot price in both long and short terms, but not vice versa. From the results of G–S model, futures price of each commodity decides more than 70% of the price movements, which plays a dominant role in price discovering process. There are bi-directional casual relationships between futures and spot prices of all the six commodities excluding aluminum (Al) from the conclusions of time domain GC test.

1. Introduction

Futures markets serve several functions, among which price discovery function is usually regarded as the leading indicator of judging the efficiency of a futures market. The existence of causal relationship between futures and spot prices is usually used as a best description of price discovery function in empirical studies. If close causality exists, either price can provide signals for the other in price movements to avoid risks. Obviously, it is very important for market participants to know whether there is a bidirectional or unidirectional causal relationship between the two prices, for financial risk management is really vital in arbitraging and hedging. Moreover, the causal relationship can be useful to judge if the market has a good information transformation and if price movements adjust to the information volatility well.

Numerous insights have yielded about our topic, but they generally ignore the possibility that the strengths and/or directions of the causal relationships could vary over different frequencies. If causality exists, when can futures price be a powerful predictor? When in reverse? When can't? These questions are rarely fully studied but rather practical in investing. The frequency domain approach gives a complete inter-frequency characterization of causality, instead of a one-shot measure which is supposed to apply across all periods only with one result. This paper will first apply frequency domain approach (or called “a spectral-density approach”) to study the causality between futures and spot prices, which is never used before in previous papers; furthermore, we have paid great attention to the booming but neglected emerging market, Chinese commodity market.

After Chinese transition into a market economy, various commodity futures markets have been launched to discover price and hedge risks. Among them, metal and agricultural branches are the most active and fluctuant transacting ones from past to now. To summarize, metal and agricultural commodity futures contracts are in larger quantities, relatively faultless and briskly traded, so they are good representatives of Chinese commodity futures market. So, the study can be a useful reference to evaluate if Chinese commodity futures market operates efficiently in price discovering.

2. Literature review

As mentioned above, numerous empirical studies have discussed the causal relationships between futures and spot prices. The majority of empirical researches have already focused on both commodity and stock index futures markets. In previous empirical studies, co-integration test, time domain Granger Causality test (GC test) and error correction model (ECM) have been widely employed, including Engle–Granger two-step procedure and Johansen's methodology.

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Maslyuk and Smyth (2008) explore whether WTI and Brent crude oil spot and futures prices contain unit roots with one and two structural breaks, by using Lagrange multiplier unit root test (LM test) with two structural breaks. They find that each of the oil price series can be regarded as a random walk so that it is not possible to forecast based on past behaviors.

There are also complex methods which have concerned more factors to investigate further about this issue. The seminal work of Garbade and Silber (1983) provides the theoretical foundation. They developed an equilibrium model to explain which price is decisive in price movements. Brenner and Kroner (1995), Watkins and McAleer (2002) both apply the cost-of-carry asset pricing model to show the existence of co-integration between futures and spot prices. The results show that spot and futures prices are co-integrated. Bekiros and Diks (2008) investigate the linear and nonlinear causal relationships between futures and spot prices of WTI crude oil covering two different periods. The results imply that there is a strong bi-directional Granger causality between futures and spot prices in either period.

In addition, an increasing number of studies begin to focus on "spillovers and volatility" problems. All of the papers of Bessembinder et al. (1995), Lean et al. (2010) and Jin et al. (2012) apply mean-variance (MV) approach; they all investigate finance, oil and commodity markets, respectively. The results show that MV exists only in commodity market; neither oil nor finance market has MV. It means that futures and spot prices do not dominate each other in finance and oil markets; while in commodity market, they reinforce and affect each other. Models of risk-reverse and mean-variance framework are developed in the paper of Netz (1995). The results support the hypotheses of increased storage sensitivity and reduced spot price volatility. Figuerola-Ferretti and Gonzalo (2010) present an equilibrium model for commodities, the results indicate that commodity markets are in backwardation and futures prices are "information dominant" in highly liquid futures markets (Al, Cu, Ni, and Zn). Liu and Tang (2011) discuss the volatility of commodity futures convenience yield. They find that the volatility of the convenience yield is heteroskedastic for industrial commodities. Jacks (2007) draws his analysis from the historical records on the establishment and prohibition of some futures markets, the paper proves that futures markets are systematically associated with lower levels of commodity price volatility.

With fast developing paces of global financial integration, the characteristics of emerging futures markets are becoming hot studying issues. Both of the papers written by Batchelor et al. (2007), Kavussanos and Visvikis (2004) are based on the investigations of shipping freight markets. They both apply VECM model and GC test to discover the lead–lag relationships between spot and forward freight agreement (FFA) prices, returns and volatilities are studied as well. The conclusions indicate that spot and FFA prices are co-integrated and there is a bi-directional causality between the two prices. Botterud et al. (2010) analyze futures and spot prices in Nord Pool electricity market, they find that futures price tends to be higher than spot price and the average convenience yield is negative. Moreover, spot price exhibits some seasonality in electricity market. Last but not the least, the number of Chinese market studies is really limited. The study of He and Xie (2012) is based on the previous researches and it gives a summary of Chinese sugar market. The authors analyze futures and spot prices with a co-integration framework, and they find that Chinese sugar spot market has a pricing power, but sugar futures price still leads spot one in price discovery.

As explained above, the attention paid to Chinese commodity market is really insufficient, and previous studies ignore the possibility that strengths and/or directions of Granger causality may vary in different frequencies. So, the paper will first fully study the details of causality with frequency domain method, which has never been used on this topic before.

Table 1
Summary descriptive statistics for the prices series.

Commodity	Mean	Max.	Min.	Std. Dev.	Skew.	Kurt.	J.-B.
Al future	4.1912	4.2876	4.0056	0.0491	−0.9489	4.2345	235.5660
Al spot	4.1920	4.2865	4.0065	0.0488	−0.9514	4.3290	247.5673
Cu future	4.7301	4.8733	4.3827	0.1085	−1.4192	4.3760	456.8564
Cu spot	4.7321	4.8756	4.3788	0.1052	−1.3694	4.2299	413.8710
Zn future	4.1840	4.3263	3.9403	0.0776	−1.0562	3.9947	250.5759
Zn spot	4.1808	4.3227	3.9345	0.0769	−1.0969	4.0289	269.8333
b future	3.6109	3.7604	3.5130	0.0459	1.2877	4.9031	470.4069
b spot	3.5993	3.7231	3.5267	0.0493	0.8884	3.0300	144.8752
s future	3.7004	3.8975	3.4100	0.1388	−0.5063	1.9157	99.7860
s spot	3.6955	3.8865	3.4191	0.1428	−0.4670	1.8048	104.3115
c future	4.2450	4.5224	4.0111	0.1230	0.3154	2.2837	41.8334
c spot	4.2342	4.4956	4.0168	0.1217	0.2991	2.3233	37.4562

Notes: All the price data series are tested with their natural logarithm forms.

3. Data

The data sets are price series of futures and spot closing prices of six commodities (i.e. bean, sugar, cotton, aluminum (Al), copper (Cu), and zinc (Zn)), at a daily frequency, spanning the period from 9th May, 2008 to 20th November, 2012. All the data series are obtained from Wind database. We exclude the unmatched pairs and get 1103 pairs for each commodity. Futures prices are conducted from the daily closing prices on futures contracts one month prior to the expiration month; we roll-over nearby futures contracts to form a continuous time series. The prices of metal commodity futures are from SHFE (Shanghai Futures Exchange) while agricultural ones are from Zhengzhou Commodity Exchange (CZCE). We give the descriptive statistics of all price data series in Table 1. The results of unit root test and JJ test for co-integration are given in Tables 2 and 3.

According to Table 1, except Al and Cu, average prices of futures are higher than spot ones; volatility ranges of futures prices are larger than those of spot prices excluding Bean and Sugar. Especially, the kurtoses of metal commodity series are all significantly higher than 3, which indicates that each distribution of metal commodity series have a high peak and fat tails. The J–B results also provide significant evidence that all the series are non-normal distributions even at 1% significance level.

In Table 2, both Dickey–Fuller and Phillips–Perron tests indicate that each data series has a unit root; each series is not stationary at 1% significance level before taking the first-difference. In conclusion, they are integrated of order 1, or I (1). This unique order of integration allows us to proceed with co-integration analysis in the framework of Johansen and Juselius.

Table 3 provides the results of JJ co-integration test (Johansen, 1988). According to the AIC criterion, a VAR (6) model was selected for our system, to ensure the time series properties of the data are reflected in the modeling procedure. Both the trace and maximal eigenvalues suggest the presence of one co-integrating vector for the two variables.

4. Methodology

4.1. Granger Causality test (GC test)

If two variables are co-integrated, Granger Causality Test can give evidence to prove if there exists directional causality between them. Granger Causality Test model (Granger, 1969) is specified as:

$$S_t = \sum_{i=1}^{P} \alpha_{1i} S_{t-i} + \sum_{j-1}^{P} \beta_{1j} F_{t-j} + e_{1t} \tag{1}$$