Can Futures Price be a Powerful Predictor? Frequency Domain Analysis on Chinese Commodity Market[F]

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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.

JEL classification: C13 C32 G14

Keywords: Futures Price; Spot Price; Chinese Commodity Market; Frequency Domain Approach; Garbade-Silber Model

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

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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. Svetlana Maslyuk and Russell 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. Robin J. Brenner and Kenneth F. Kroner (1995),Clinton Watkins and Michael 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. Stelios D. Bekiros and Cees G.H. 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 Hendrik Bessmbinder et al. (1995), Hooi Hooi Lean et al. (2010) and Na 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 Janet S. Netz (1995). The results support the hypotheses of increased storage sensitivity and reduced spot price volatility. Isabel Figuerola-Ferretti and Jesús 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). Peng Liu and Ke Tang (2010) discuss the volatility of commodity futures convenience yield. They find that the volatility of the convenience yield is heteroskedastic for industrial commodities. David S. Jacks (2006) 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 Roy Batchelor et al. (2007), Manolis G. Kavussanos and Ilias D. Visvikis (2003) 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. Audun Botterud et al. (2009) 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 Ling-Yun He and Wen-Si 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.

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 Table 2 and Table 3.

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.

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. 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.

Table 2 The unit root tests results

Commodity	LNFi/LNSi		DLNFi/DLNSi	
	ADF	PP	ADF	PP
Al future	-1.9928	-2.0793	-35.5215	-35.5171
Al spot	-1.9474	-2.1778	-28.6972	-29.5783
Cu future	-1.2414	-1.4080	-21.2482	-33.0955
Cu spot	-1.4831	-1.4506	-13.5892	-30.0871
Zn future	-1.8046	-1.8434	-35.0777	-35.0257
Zn spot	-1.7211	-1.8166	-29.9965	-30.1570
b future	-2.7293	-2.7052	-22.2101	-35.8888
b spot	-1.7878	-1.4317	-9.2799	-40.2436
s future	-1.3114	-1.3121	-21.8386	-34.1875
s spot	-1.2350	-1.2220	-29.7095	-30.0397
c future	-0.9769	-1.0731	-20.3534	-31.4472
c spot	-1.2841	-1.0491	-7.02618	-13.4425
1% critical value: -3.436			5% critical value: -2.864	

Notes: We use LNF_i/LNS_i , $DLNF_i/DLNS_i$ to represent the natural logarithm form and first difference transformation of each series pair. The critical values are for the null hypothesis: there is a unit root in each series. Each LNF_i , LNS_i has a unit root even at 1% significance; each $DLNF_i$, $DLNS_i$ is stationary at 1% significance.

Table 3 JJ test for co-integration

commodity		*trace*	max
Al	r=0	58.34340	53.7740
	r=1	4.56998	4.56998
Cu	r=0	139.3667	137.7132
	r=1	1.65354	1.65353
Zn	r=0	178.6032	175.0807
	r=1	3.52250	3.52250
Bean	r=0	37.2111	33.2945
	r=1	3.91661	3.91661
Sugar	r=0	43.5372	39.7056
	r=1	3.83158	3.83158
Cotton	r=0	43.1298	41.4893
	r=1	1.64052	1.64052
5% critical values	r=0	20.2618	15.8921
	r=1	9.16455	9.16455

Notes: the critical values are for the null hypothesis: r =0; we should accept the null hypothesis at 5% significance when r=1.

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 (1986)) is specified as:

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

$$F_t = \sum_{i=1}^{P} \alpha_{2i} S_{t-i} + \sum_{j=1}^{P} \beta_{2j} F_{t-j} + e_{2t} \tag{2}$$

S_t, F_t are the logarithms of spot and futures prices, respectively[1].

e_{1t}, e_{2t} are white noise series, and not related. To test for Granger causality in this system, alternative causal relations are likely to be found for each commodity: (i) there is a unidirectional Granger causality from S_t to F_t if not all α_{2i} is zero, but all β_{1j} are zero; (ii) There is a unidirectional Granger causality from F_t to S_t if not all β_{1j} is zero, but all α_{2i} are zero; (iii) There is a bidirectional Granger causality between S_t and F_t if neither α_{2i} nor β_{1j} are zero; (iv) There is no Granger causality between S_t and F_t if all α_{2i} and β_{1j} are zero.

4.2 Frequency Domain GC Test

This approach is based on the study of Geweke (1982), Hosoya (1991), who proposed measures of causality in a frequency-domain approach. And Brietung and Candelon (2006) suggest a more developed procedure which allows the test at some pre-specified frequencies. The measure suggested by Gweke (1983), Hosoya (1991) is defined as:

$$M_{y \to x}(\omega) = \log \left[\frac{2\pi f_x(\omega)}{|\psi_{11}(e^{-i\omega})|^2} \right] \tag{3}$$

$$= \log \left[1 + \frac{|\psi_{12}(e^{-i\omega})|^2}{|\psi_{11}(e^{-i\omega})|^2} \right] \tag{4}$$

[1] They represent the same meaning in the rest of the paper.

The measure is zero if $\left| \quad_{12}(e^{i\bullet}) \right| \quad 0$, in which case we say that y does not cause x at frequency .

As in the stationary case, the resulting causality measure is defined as the follows:

$$M_{y\bullet x}(\quad) \quad \log ! \frac{\left| \quad_{12}(e^{\bullet}) \right|^2}{\left| \quad_{11}(e^{\bullet}) \right|^2} \tag{5}$$

In order to test the hypothesis that y does not cause x at frequency we consider the null hypothesis as the follows

$$M_{y\bullet x}(\quad) \quad 0 \tag{6}$$

Following Brietung and Candelon (2006), null hypothesis $M_{y\bullet x}(\quad) \quad 0$ is equivalent to the linear restriction:

$$H_0 : R(\quad) \quad 0 \tag{7}$$

Where $[\quad_1, \ldots \quad_p]$ and

$$R(\quad) \quad \begin{matrix} \cos(\quad)\cos(2\quad)\ldots\cos(p\quad) \\ \sin(\quad)\sin(2\quad)\ldots\sin(p\quad) \end{matrix} \tag{8}$$

According to Brietung and Candelon (2006), F Statistic is approximately distributed as $F(2, \tilde{T} \quad 2p)$ for $\quad [0, \quad]$, we use the F statistic to judge if null hypothesis should be rejected, that is if there is a causal relationship between futures and spot prices at some certain frequencies.

4.3 Garbade-Silber Model

The seminal model of Garbade and Silber (1983) provides the theoretical foundation. They developed an equilibrium model to explain which price is decisive in price movements; it is an important indicator to judge if the futures market operates efficiently. The model can be defined as:

$$\begin{matrix} S_t \\ F_t \end{matrix} \quad \begin{matrix} _s \\ _f \end{matrix} \cdot \quad \begin{matrix} \tilde{1} & _s & _s \\ _f & \tilde{1} & _f \end{matrix} \quad \begin{matrix} S_{t-1} \\ F_{t-1} \end{matrix} \cdot \quad \begin{matrix} e_{ts} \\ e_{tf} \end{matrix} \tag{19}$$

$_s$, $_f$, $_s$, $_f$ are coefficients; e_{ts}, e_{tf} are random errors. $_s$ reflects the previous futures price's impact on today's spot one; $_f$ reflects the previous spot price's impact on today's futures one. The constant terms $_s$ and $_f$ reflect any trends in both the price series. The ratio $_s/(\ _s+\ _f)$ provides an indication of price discovery occurring in each market. The ratio is usually between 0 and 1, if it is more than 0.5, then futures price plays the dominant role in price discovery; if it is less than 0.5, the situation is in reverse.

5. Empirical Results

5.1 GC test

Table 4 GC test for spot and future prices of each commodity

Commodity	Null hypothesis	F statistic	P value
Al	St does not Granger Cause Ft	1.7318	0.0691
	Ft does not Granger Cause St	23.8168***	8.00E-41
Cu	St does not Granger Cause Ft	3.0514**	8.00E-04
	Ft does not Granger Cause St	10.5085***	4.00E-17
Zn	St does not Granger Cause Ft	3.0419**	8.00E-04
	Ft does not Granger Cause St	18.0155***	1.00E-30
bean	St does not Granger Cause Ft	4.7292**	1.00E-06
	Ft does not Granger Cause St	5.1192**	2.00E-07
sugar	St does not Granger Cause Ft	2.5005*	5.70E-03
	Ft does not Granger Cause St	12.1278***	5.00E-20
cotton	St does not Granger Cause Ft	4.4498**	4.00E-06
	Ft does not Granger Cause St	32.1465***	9.00E-55

Notes: F-statistic for the null hypothesis: there is no Granger Causality; * Indicates significance at the 10% level; ** Indicates significance at the 5% level; *** Indicates significance at 1% level.

To begin with, we need to specify if there exists a bidirectional or unidirectional Granger causality between futures and spot prices of each commodity. The results of GC test for each commodity are presented in Table 4.

From Table 4, it shows that except commodity Al, other five commodities all have significant bidirectional Granger causal relationships between spot and futures prices. For commodity Cu, Zn, bean, sugar and cotton, spot and futures prices affect each other obviously. However, for commodity Al, only unidirectional Granger causality exists from futures price to spot price, which indicates that futures price leads spot price but the situation is not vice versa, spot price of Al has little effect on predicting futures price.

5.2 Frequency domain GC test

From Figure 1 to 5, the figures of causality running between S_t and F_t in frequency domain approach are presented, along with their 10% and 5% critical values (broken lines parallel to the frequency axis) for the frequencies in the interval $[0, \pi]$. The length of the period (P) is measured in day, which is calculated by $P = 2\pi/\omega$. The results in frequency domain approach support the conclusions of time domain GC test in part 5.1. However, frequency domain analysis provides much clearer and more accurate details of the directions and strengths of causalities between S_t and F_t in different frequencies, which have never been given before.

In the figures of metal commodities (Al, Cu and Zn) ,all the curves representing Granger causality from F_t to S_t are far from the broken line in any frequency, only the curve of Cu has an exception of 2.43 <ω[2]< 2.66, corresponding to a wave length of 3 days. It demonstrates that futures price is a significant predictor for spot price in any frequency; only for commodity Cu, the predictive power will be obviously weakened in short run. So, metal commodity futures market has a good price discovery function covering all frequencies. Conversely, for commodity Al, no significant Granger causality from S_t to F_t is found except 0<ω<0.67, corresponding to more than 9 days, it means that spot price can be used to estimate futures price only in long term, but still not robust enough. However, obvious feedbacks exist between S_t and F_t of Cu and Zn, although spot prices don't have powerful predictive effects in all frequencies, but covering the most. For commodity Cu, no significant Granger causality from S_t to F_t is found only when 0.55<ω<1.32, corresponding to a period of 5 to 12 days. Hence, there exists a feedback between spot and futures prices of Cu in both short and long horizons, but the feedback will be weakened in medium-run cycles. Figure 3 presents the curves of Zn, the curve describing the causality from S_t to F_t shows ups and downs along the broken line .When $\omega \in [0, 0.86] \cup [1.72, 2.65]$, Granger causality exists, corresponding to a period longer than 8 days, or shorter than 3 days. In other words, spot price can't lead futures price powerfully in medium-run cycles.

The analyses above support the evidence that Chinese metal futures market plays a dominant

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[2] All the frequency intervals mentioned in empirical results are determined by the broken line of 5% significance level.

role in price discovery, it leads the price movements in any frequency. Conversely, Granger causality from S_t to F_t is significant only in long term, in short and medium terms, futures price influences spot price slightly. Cu commodity market is the most efficient one because there exists a feedback with great significance, but the causality from S_t to F_t is still weakened in medium run. The conclusion is robust that F_t is Granger causality to S_t in any frequency, for each commodity. So we can conclude that Chinese metal commodity futures market has a powerful price discovery function.

Similarly, for agricultural commodities, generally speaking, we find significant Granger causality from F_t to S_t for each commodity, but the figures have obvious differences when compared with those of metal commodities. Figure 4 reveals the curves of commodity bean; both the two curves show strong ups and downs along the broken line in different frequencies, and the peaks are much sharper, it indicates that the result is more significant. In the figures of sugar and cotton, Granger causality from F_t to S_t cannot be found only when 2.38<ω<2.64 for sugar, and the one-way causality is strong in medium and long terms. In Figure 4, futures price can be applied to estimate spot price accurately when ω ∈ [0, 0.78] ∪ [1.44, 2.3] ∪ [2.83,], corresponding to 1 to 5 days or more than 8 days. To sum up, Granger causalities from F_t to S_t of the three agricultural commodities are significant in any frequency. So, agricultural commodity futures market has a powerful price discovery function. In reverse, spot price of bean cannot provides predictive power for futures price when ω ∈ [1.23, 1.79] , corresponding to 3-5days, while the situation is ω ∈ [0.5, 0.97] for cotton, corresponding to 7 - 13 days. For bean and cotton, the causality from S_t to F_t is robust in both short and long runs, but it is not significant enough in medium term. However, for sugar, Granger causality from S_t to F_t is robust only when ω is smaller than 1.26, a period of more than 5 days, it gives the proof that the spot price of sugar can be used to predict futures price in medium and long runs.

In both agricultural and metal commodity futures markets, futures price Granger causes spot price in any frequency, which is in accordance with the conclusion of time domain GC test in part 5.1. However, the reverse causal relationship from S_t to F_t is found significant only in long term, and it will be much weaker in short and medium terms. So, we can conclude that bidirectional Granger causalities exist between futures and spot prices of agricultural commodities, but the feedbacks are really not obvious enough in medium frequencies. Among agricultural commodity branches, bean market is the most efficient and informative, because the feedback is robust for most frequencies. In a word, we can conclude that Chinese agricultural commodity futures market has a powerful price discovery function.

When we compare metal and agricultural commodity markets, it is found that spot market of agricultural commodities is more efficient and informative than that of metal ones, because Granger causality from S_t to F_t of agricultural commodities market is more robust than that of metal commodities market. However, both two futures markets perform well in price discovering because significant Granger causality from F_t to S_t is found in each market. Cu and bean markets are more mature and efficient than others, they both have bi-directional causalities between the two prices in any horizon length, comprehensively speaking. As the two branches are earlier built and have more transaction volume, this conclusion is really reasonable and reliable. For commodity Al, Granger causality from S_t to F_t exists only in long term and is really very weak, so we judge that spot price of Al has little influence on futures price, which is in accordance with the conclusion of time domain approach. To sum up, Chinese commodity futures market has powerful price discovery function. The details are displayed in Table 5.

Table 5 Summary of the results of GC causality in frequency domain

Horizon length	Al	Cu	Zn	Bean	Sugar	Cotton
Long term causality	Ft↔St	Ft↔St	Ft↔St	Ft↔St	Ft↔St	Ft↔St
Medium term causality	Ft→St	Ft↔St	Ft→St	Ft↔St	Ft→St	Ft↔St
Short term causality	Ft→St	Ft↔St	Ft↔St	Ft↔St	Ft→St	Ft→St

Notes: → represents a unidirectional causality; ↔ represents bidirectional causalities.

5.3 G-S model

From part 5.2, we have solved the puzzle: when can futures and spot prices be credible and accurate predictors for each other? And when cannot? In this part, we will get to know further about which price is decisive in price discovering process with G-S model .The empirical results are explained in Table 6.

From the table, generally speaking, the estimated values of T-statistics for all $_s$ and $_f$ are significant, all of the values of $_s/(_s+_f)$ are more than 0.5, around o.7, it means that futures price leads the price movements in Chinese commodity market, futures price is in dominant role in price discovery. All the values of $_f$ are positive except cotton, it indicates that futures and spot prices of Al, Cu, Zn, bean and sugar fluctuate in the same direction. For cotton, $_s$ is positive while $_f$ is negative, so futures price leads spot price to the same direction while spot price leads futures price to the opposite direction, however, cotton futures market is still in dominant role in price discovery.

The outcomes of G-S model are in accordance with the conclusions in part 5.2, they both indicate that futures and spot prices affect each other, but futures price is really much more decisive.

Figure 1 Al ---- (Ft→St)

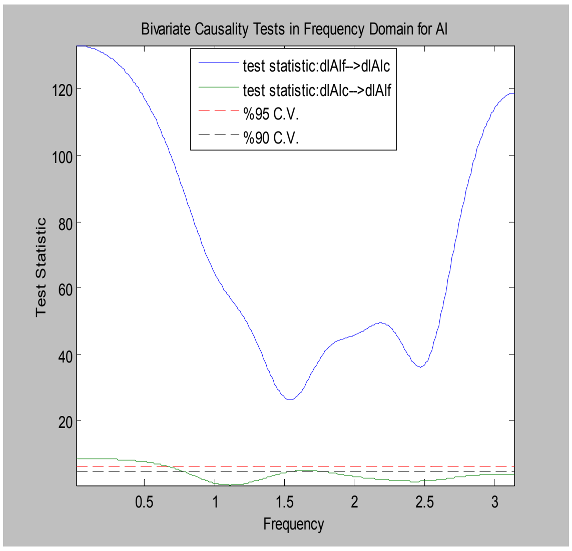

Figure 2 Cu---- (Ft↔St)

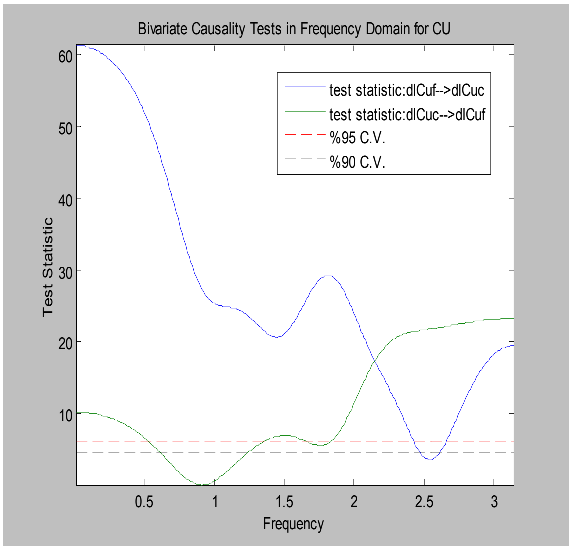

Figure 3 Zn---- (Ft↔St)

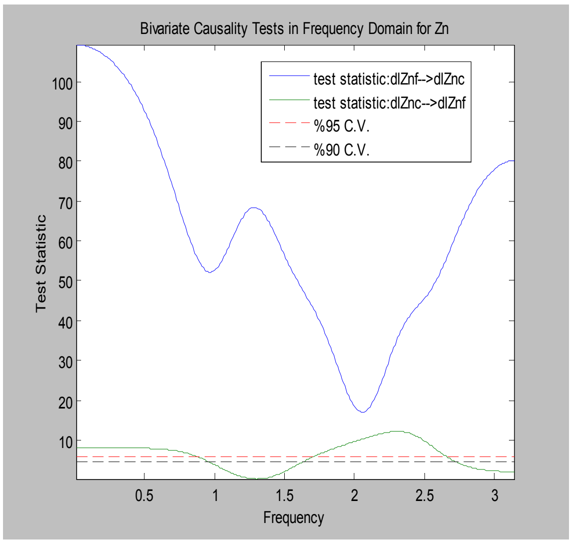

Figure 4 bean---- (Ft↔St)

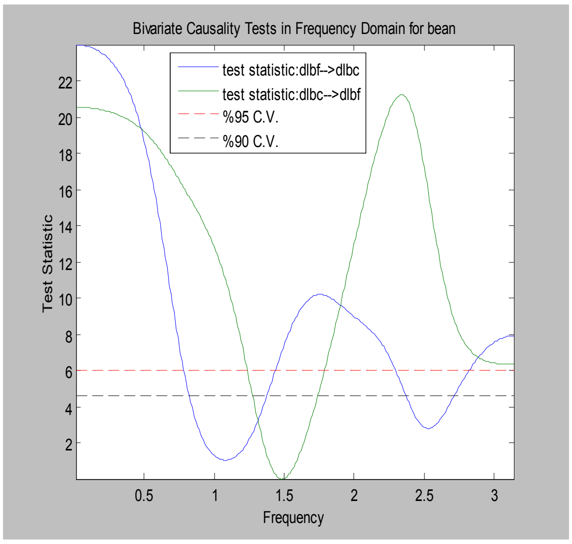

Figure 5 cotton----(Ft↔St)

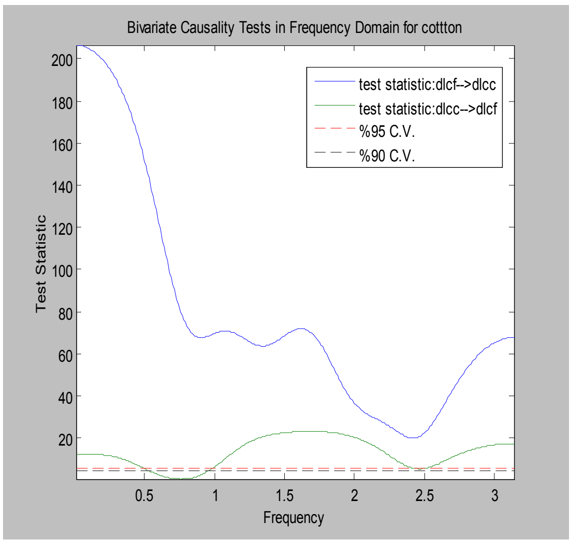

Figure 6 sugar----(Ft↔St)

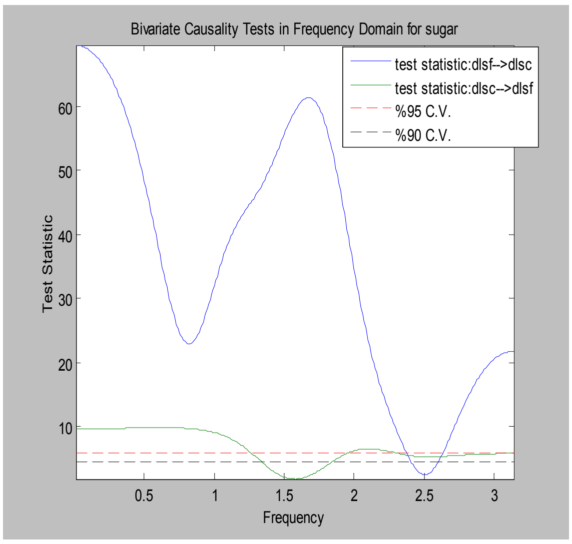

Table 6 G-S model results for six commodities

Commodity	coefficient	value	T-statistics	P-value	incidence
	$_s$	0.0005	2.0196	0.0437	
Al	$_s$	0.3832	12.0279***	0.0000	$_s/(\ _s+\ _f)$
	$_f$	-0.0004	-1.2395	0.2154	=0.7405
	$_f$	0.1343	3.3111**	0.0010	
	$_s$	0.0010	1.8473	0.0650	
Cu	$_s$	0.2279	6.7378***	0.0000	$_s/(\ _s+\ _f)$
	$_f$	-0.0005	-0.9764	0.3291	=0.7203
	$_f$	0.0885	2.5243*	0.0117	
	$_s$	-0.0038	-7.1066	0.0000	
Zn	$_s$	0.4945	11.9936***	0.0000	$_s/(\ _s+\ _f)$
	$_f$	0.0014	2.0867	0.0371	=0.7004
	$_f$	0.2115	4.1382**	0.0000	
	$_s$	-0.0009	-3.3191	0.0009	
Bean	$_s$	0.0317	6.4221***	0.0000	$_s/(\ _s+\ _f)$
	$_f$	0.0002	0.5351	0.5927	=0.6982
	$_f$	0.0137	1.6943	0.0905	
	$_s$	-0.0001	-0.4197	0.6748	
Sugar	$_s$	0.0615	6.1504***	0.0000	$_s/(\ _s+\ _f)$
	$_f$	0.0008	1.8696	0.0632	=0.6856
	$_f$	0.0282	1.9714	0.0489	

	$_{s}$	-0.0018	-11.5911	0.0000	
	$_{s}$	0.0859	22.1909***	0.0000	$_{s}$/($_{s}$+ $_{f}$)
Cotton	$_{f}$	-0.0003	-0.5716	0.5677	=0.7881
	$_{f}$	-0.0231	-2.1557*	0.0313	

Notes: * Indicates significance at the 10% level; ** Indicates significance at the 5% level; *** Indicates significance at 1% level. We only pay attention to the significance of $_{s}$, $_{f}$ estimations.

6. Conclusions

This paper first applies frequency domain approach to examine the causality between futures and spot prices, and first pays great attention to an emerging market neglected before, Chinese commodity market. Our study gives a complete inter-frequency characterization of causality, instead of a one-shot measure used in previous researches. Previous studies just show the lead-lag relationship result without details, while this paper is supposed to show clearer details about the directions and strengths of causalities. We give the horizon length(s) when futures price can predict spot price most accurately, which is never given in previous studies but really practical and needed for both markets and investors. All above are the meanings and purposes of this paper.

From GC test, we know that there exists a bi-directional causality between futures and spot prices of each commodity (Cu, Zn, bean, sugar and cotton) except Al; for commodity Al, causal relationship is unidirectional from futures to spot price. For further study, when can futures and spot prices be powerful vehicles for each other in price discovery, in long or short term? To solve this puzzle, we apply frequency domain approach, its empirical results support the evidence that feedbacks exist between futures and spot prices in long term of all the commodities; in short term, for Al, sugar and cotton, causality is unidirectional from futures to spot price, but bi-directional for other three. Granger causality from spot to futures price will be obviously weakened in short and medium terms for all the commodities, especially in medium term. Only the prices of Cu, bean and cotton have feedbacks during medium-run cycles. To sum up, we can judge that futures price is an accurate predictor for spot price in any frequency. Chinese commodity futures market has great efficiency in price discovering process. Then we use G-S model to find out which price is decisive in price discovery, it is found that futures price is the leading and striking price, which decides more than 70% of forward price movements of each commodity.

The study in this paper is useful in some aspects: For investors, it helps them to know more about the efficiency of markets, which will help them in hedging and risk aversion, estimating forward price movements more accurately, so that they can confirm when investing and arbitraging chances appear and how long they will last; For our market, this paper can be a good reference to evaluate the operating situations of Chinese commodity market because metal and agricultural commodity branches are good representatives, both of them have efficient price discovery functions, leading to less unreasonable volatility in price movements. So, we can judge that Chinese commodity market is well established and has enough maturity; it operates efficiently and has good abilities to endure unreasonable shocks. The conclusions in this paper may be very helpful in economic order management and financial policy settings of Chinese market.

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