Journal of Business and Management Sciences, 2013, Vol. 1, No. 6, 128-132
Available online at http://pubs.sciepub.com/jbms/1/6/2

DOI:10.12691/jbms-1-6-2

Reconnoitering the Causal Relationship in Crude Oil Market during Crisis

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Received August 01, 2013; Revised November 21, 2013; Accepted November 22, 2013

Abstract The purpose of this paper is to study in Indian context (during the recent US financial crisis period), whether there is significant impact of Crude Oil future trading on crude spot prices or there is no such impact. We examine the effect of futures trading volume of crude oil to crude oil spot prices in the Multi Commodity Exchange of India (MCX) from January 2007 until Dec 2009. The vector autoregressive model (VAR), Granger Causality Wald test, Variance Decomposition and Impulse Response Function are applied to the data collected. The results exhibited that bidirectional causality runs from crude spot prices to futures trading volume.

Keywords: *crude oil, MCX, VAR, Variance Decomposition, impulse response*

Cite This Article: P.Lakshmi, and S.Visalakshmi, "Reconnoitering the Causal Relationship in Crude Oil Market during Crisis." *Journal of Business and Management Sciences* 1, no. 6 (2013): 128-132. doi: 10.12691/jbms-1-6-2.

1. Introduction

Commodity market denotes markets that trade in primary rather than industrial merchandises. Soft commodities are agricultural crops such as wheat, coffee and sugar. Hard commodities are mined goods such as gold, silver and crude oil. Stakeholders access about 50 main commodity markets internationally with chastely financial dealings progressively out stripping corporal trades in which goods are supplied. Derivatives contracts are the first way of participating in commodities. Commodity markets can include physical trading and derivatives trading using spot prices, forwards, futures, and options on futures. A financial derivative is a financial instrument whose value is derived from a commodity termed an underlying asset. Derivatives are either exchange-traded or in OTC markets. An increasing number of derivatives are traded via clearing houses some with Central Counterparty Clearing, which provide clearing and settlement services on a futures exchange, as well as off-exchange in the OTC market.

Derivatives such as futures contracts, Swaps and forward contracts have become the primary trading instruments in commodity markets. Futures are traded on regulated commodities exchanges.

Crude oil as a commodity, accounts for nearly 40% of the global energy demand and its consumption is estimated to be over 85 million barrels per day. Crude oil has wide application and global appeal. When refined, it gives an array of automobile fuels, lubricants, asphalt and petrochemical send-products like plastic, detergent, chemical fertilizer and rubber. Accordingly, changes in crude oil price have a sizeable impact on world economy. As price goes up, cost of transportation also amplifies. In turn, this raises costs of manufacturing and distribution, adversely affecting end-product prices. This has an industry-wide impact and adds to inflationary pressure. Thus, crude oil is the backbone of today's global economy and it is the largest traded commodity in the world. India is the world's 4th largest crude oil consumer with consumption at 3.1 million barrels per day. India imports almost 70% of its total consumption. Crude oil is the biggest component of India's import basket as well and its price affects overall economy. Rapid economic development is expected to further increase its consumption. Indian commodity market is growing phenomenally and crude oil is one of the most traded commodities on domestic bourses.

Crude abandoned thousands of investors when the prices tumbled from over $147 a barrel in July 2008 to less than $34 in Jan 2009. Many investors in India went bankrupt, but the fact that speculators concurrently made the price extraordinary and unrealistically high, is one major reason. Prices just exploded in a natural progression of demand and supply. Some earned while a majority lost their trust in Crude. But being a commodity without which the world can't move, Crude is still in the top five. As is present in any market, traders of any commodity will also react to a change in global happenings by changing the price of said commodity. Especially in the wake of the recent financial crisis in US all the segments of worldwide financial markets reacted badly and have led to huge losses. The motive of the present study is to analyze this aspect of impact with regard to the Indian crude oil spot and futures markets by a causal study of the commodity futuresmarket.

2. Review of Literature

The review is done under two perspectives. viz., studies related to Commodity markets and on research applying econometric analysis.

[12] tested the price discovery process of the nascent gold futures contracts in the Multi Commodity Exchange of India (MCX) over the period 2003 to 2007 by employing vector error correction models to show that futures prices of both standard and mini contracts lead spot price.

[17] established a causal relationship between the nominal exchange rate and foreign direct investment in India using a time series data between 1992 and2010. They employed unit root test, Johansen cointegration test and Vector Auto regression (VAR) model to show whether the variables under consideration exhibit stationarity and a long run association respectively. The findings exhibited the absence of long term association between the two variables under consideration.

[9] examined to discern the long-run relations between FDI and economic development in China in the comprehensive framework, which incorporates determinants as output, FDI, capital formation, employment, human capital and international openness using VAR Impulse Response, Variance Decomposition, Johansen Co-integration and VECM. The findings indicated that in the long run, FDI tends to decrease economic growth; economic development in China seems to be fueled by domestic capital accumulation and employment growth; FDI inflows do crowd out domestic capitals, and reduce employment growth, whilst the latter increases the former.

[18] carried an empirical research on the influence of real exchange rate of RMB's volatility on US FDI in China, adopting GARCH model, the VAR model and cointegration theory, based on quarterly data from 1994 to 2009.The result revealed that there was a stable relationship among the volatility of real exchange rate, real exchange of RMB and US foreign direct investment in China.

[19] focused on price dynamics of depositary receipts (DRs) issued by Taiwanese and Hong Kong firms. The empirical results using VECM and VAR indicated that long-term equilibrium relationships between depositary receipts and underlying security prices exist for firms listed in Hong Kong, a free-entry market, but do not necessarily exist for firms listed in Taiwan with foreign ownership restrictions.

[6] examined the role of futures market in the price discovery process using a two-regime threshold vector autoregression (TVAR) and a two-regime threshold autoregression for six commodities. The findings revealed that the rate of convergence of information is slow, particularly in the non-expiration weeks and also finds evidence for price discovery process happening in the futures market in five out of six commodities.

[1] analyzed two competing models in price volume relationships in Indian commodity futures market using correlation coefficient and Granger causality test with vector auto regressive methodology. The Findings exhibited contemporaneous correlation between volume and price change in some of the cases, but in general on the basis of the presence of Granger causality it followed that SIH is supported.

Financial investors are generally most active in futures markets, rather than spot markets, as they do not want to take delivery of the physical commodity, which is expensive to store and to finance. Instead, the role of financial investors is to act on informed views on the prospects for supply and demand as well as to be paid to take on the commodity price risk that producers, and to a lesser degree consumers, wish to hedge. There are two broad channels through which commodity futures markets can affect the production and consumption decisions of participants in spot markets: (i) they allow firms to hedge their exposures to movements in spot prices, thereby smoothing their consumption expenditure and/or production cash flows over time and lowering the cost of capital; and (ii) they provide a potential source of influence over spot prices. If the sole function of futures markets was to provide hedging services to producers and consumers, the welfare implications would be unambiguously positive [20].

Our contribution to the extant literature in the crude market analyses this issue by discussing the causal relationship between spot and futures prices during the financial crisis period.

The remainder of the paper is structured as follows. Our econometric model and elucidations of our technique are presented in section 3.Section 4 discusses our main empirical results while Section 5 concludes.

3. Methodology

The data set consists of daily closing futures price and trading volume of crude oil futures contracts between January 2007 and Dec 2009 and it is obtained from the MCX website www.mcxindia.com. Eviews 6.0 package is used for arranging the data and implementation of econometric analyses.

The vector autoregressive model (VAR) is estimated using time series that have been transformed to their stationary values. Stationarity of each data series is examined with ADF test with intercept and KPSS test. Both the tests confirm that price series and volume series are nonstationary but become stationary after taking the first difference. Hence, it can be concluded that both the series have unit root. Thus, as per VAR framework of Granger causality, it becomes necessary to carry out the causality test on their first difference so that both the series are stationary. For a set of n time series variables $y_t = (y_{1t}, y_{2t,}..., y_{nt})'$, a VAR model of order p (VAR(p)) can be written as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + u_t \qquad (1)$$

where the A_i are (nxn) coefficient matrices and $u_t = (u_{1t}, u_{2t}, ..., u_{nt})'$ is an unobservable i.i.d. zero mean error term.

[21] has pointed out that the Granger causality test is very sensitive to the number of lags used in the analysis. [22] suggested using more rather than fewer lags.

In view of this, we have used lag length based on Akaike information criteria and Schwarz information

criteria to have a robust conclusion. For a two-variable VAR(1) with k=2.,

$$y_t = b_{10} - b_{12} z_t + c_{11} y_{t-1} + c_{12} z_{t-1} + \varepsilon_{yt} \quad (2)$$

$$z_t = b_{20} - b_{21} y_t + c_{21} y_{t-1} + c_{22} z_{t-1} + \varepsilon_{zt} \quad (3)$$

with $\varepsilon_{it} \sim i.i.d(0, \sigma^2_{\varepsilon i})$ and $\text{cov}(\varepsilon_y, \varepsilon_z) = 0$.

In matrix form:

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix} \quad (4)$$

Impulse response analysis inspects and evaluates the impact of shocks cross-section. Variance decomposition disintegrates unit incremental shock of each variable for certain proportion to its own reason and other variables contribution.

4. Discussion of Results

To model Contracts and Spot Price we have to choose the order, p, VAR (p) based on Akaike and Schwarz Criterion. The value of AIC, LR, HQ & FPE is lower in eighth lag (Table 1). So Lag length for VAR is eight.

Table 1. VAR Lag Order Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-8100.02	NA	347623.4	18.43463	18.4455	18.43879
1	-7986.91	225.4447	271202	18.18637	18.21899	18.19885
2	-7936.15	100.9533	243826.8	18.07997	18.13433	18.10076
3	-7900.8	70.12816	227042.6	18.00865	18.08476	18.03775
4	-7841.81	116.7642	200342.4	17.88354	17.9814	17.92096
5	-7505.18	664.8515	93988.51	17.12668	17.24628*	17.17242
6	-7492.76	24.4618	92206.31	17.10753	17.24889	17.16159
7	-7488.56	8.260045	92164.21	17.10707	17.27017	17.16945
8	-7476.11	**24.42071***	**90409.19***	**17.08785***	17.27269	**17.15854***

*indicates lagorder selected by the criterionLR:sequential modified LR test statistic (each test at 5% level)FPE: Final prediction errorAIC: Akaike information criterionSC: Schwarz information criterionHQ: Hannan-Quinn information criterion.

Table 2. VAR Estimates

LAG	CONTRACTS	SPOTPRICE
CONTRACTS(-1)	-1.146938[-33.7225]	-0.00107[-1.27753]
CONTRACTS(-2)	-1.200176[-23.3254]	0.000792[0.62754]
CONTRACTS(-3)	-1.220274[-18.7977]	0.000348[0.21874]
CONTRACTS(-4)	-1.179178[-17.0714]	3.59E-05[0.02120]
CONTRACTS(-5)	-0.995899[-14.4471]	-0.0003[-0.17731]
CONTRACTS(-6)	-0.263267[-4.07879]	-0.0014[-0.88584]
CONTRACTS(-7)	-0.12701[-2.49237]	0.000202[0.16117]
CONTRACTS(-8)	-0.061525[-1.82329]	-0.00132[-1.58745]
SPOTPRICE(-1)	-2.294241[-1.67139]	-0.10749[-3.19074]
SPOTPRICE(-2)	0.941035[0.68119]	0.052662[1.55326]
SPOTPRICE(-3)	3.111214[2.25483]	-0.03579[-1.05681]
SPOTPRICE(-4)	1.095239[0.79384]	0.072428[2.13902]
SPOTPRICE(-5)	1.927784[1.39993]	0.039195[1.15973]
SPOTPRICE(-6)	2.091341[1.51618]	-0.02887[-0.85273]
SPOTPRICE(-7)	-2.231332[-1.61920]	-0.02956[-0.87399]
SPOTPRICE(-8)	0.30533[0.22271]	-0.14384[-4.27499]
C	0.226635[0.06120]	0.051008[0.56120]
R-squared	**0.740341**	**0.070029**
Adj. R-squared	0.735521	0.052768
Sum sq. resids	10373667	6248.363
S.E. equation	109.7015	2.692337
F-statistic	153.6087	4.056941
Log likelihood	-5367.997	-2109.23

The crude price series are well fitted by the VAR model. The VAR model manages to capture the behavior of the crude trading volume and the crude spot prices. The explanatory power of VAR CONTRACT equation is good as the value of R^2 is high (0.740341)(Table 1). It shows that CONTRACT influence on its own variable is strong and remains throughout 8 lags. But none of the lag of contract had any significant effect on Spot prices which shows that contracts do not influence spot prices.

For SPOT prices equation the R^2 value is low (0.070029) which shows that the variability of spot price depends on other variables. One day lag is significant for spot prices. Spot price does not influence Contract price. From the tabulated values we can conclude that Contracts influence contract alone and spot prices don't influence Contract and only one day influence is present with its own variable. Other variables influence on Spot price is more evident.

Table 3. VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: SPOTPRICE			
Excluded	Chi-sq	df	Prob.
CONTRACTS	19.39096	8	0.0129
All	19.39096	8	0.0129
Dependent variable: CONTRACTS			
Excluded	Chi-sq	df	Prob.
SPOTPRICE	14.44154	8	0.071
All	14.44154	8	0.071

The two hypotheses relating to contracts and spot prices; that SPOTPRICE do not granger cause CONTRACT,

CONTRACT do not granger cause SPOTPRICE are rejected due to significant Chi square value (Table 3). Therefore the causality appears to be bidirectional between spot and contract.

Table 4a. Variance Decomposition of Contracts

Period	S.E.	CONTRACTS	SPOTPRICE
1	109.7015	100	0
2	166.808	99.86323	0.136771
3	167.5829	99.48901	0.510989
4	167.6224	99.45029	0.549709
5	167.8838	99.32253	0.677466
6	168.473	99.30605	0.693949
7	177.1474	99.37090	0.629097
8	195.8982	99.05943	0.940569
9	196.7493	98.36679	1.633205
10	196.8088	98.36469	1.635311

The error variance in forecasting (Table 4a) starts due to innovations in contract to contract and is close to 100% at all time horizons but contract to spot starts with zero and it rises slowly. The error variance in Spot price (Table 4b) due to innovation in Spot price is close to 100% throughout the time horizon but the spot price to contract starts with very less and started increasing steadily reflecting time to build effect.

The cross variable impulse response function (Figure 1) shows that an innovation in contract produces no movement in spot price at first and has very slight variation till ten days. In the same manner Spot Price changes contracts in third day slightly and remains slight variation. The spot price impulse response own variable is large for one day and decays after that. It confirms table -2 VAR statistics. Contract price response to its own variable is very strong up movement on first day and came down and reverses on the next day. It implies the relationship is very volatile.

Table 4b. Variance Decomposition of Spot price

Period	S.E.	CONTRACTS	SPOTPRICE
1	2.692337	0.255193	99.74481
2	2.709741	0.394627	99.60537
3	2.724936	1.069687	98.93031
4	2.730674	1.196947	98.80305
5	2.740618	1.191390	98.80861
6	2.74197	1.244504	98.7555
7	2.744604	1.371278	98.62872
8	2.750423	1.729962	98.27004
9	2.776357	1.745123	98.25488
10	2.780502	1.969893	98.03011

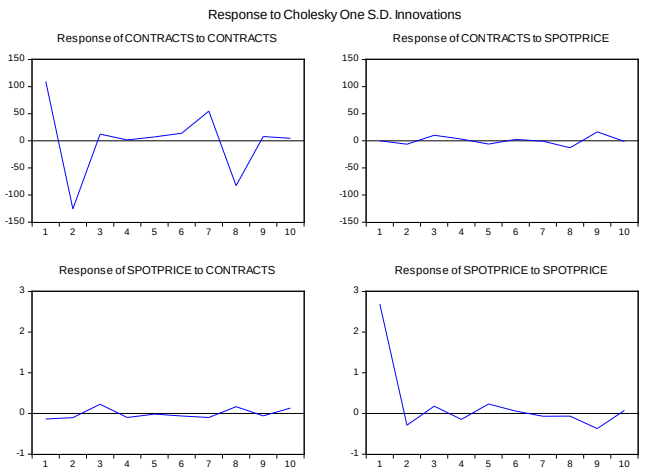

Figure 1. Cross Variable Impulse Response Function

5. Conclusion

The present study explored the relationship between spot and future prices in the Indian crude oil market especially during the recent US financial crisis, applying econometric techniques. This analysis is relevant to understand whether during turbulent times trading volume overplays fundamentals in the crude market as it is a highly sought after commodity with consistently increasing demand. From the Granger causality results it is evident that for Crude oil bidirectional causality is found from spot prices to futures trading volume for all the data series. The VAR results show that future Contracts' influence on its own variable is strong. But none of the lag of contract had any significant effect on Spot prices which shows that future contracts do not influence spot prices. The cross variable impulse response function shows that an innovation in futures contract produces no movement in spot price at first and has very slight variation till ten days. Overall, we conclude that during crisis, there is no clear evidence that the futures trading in the Indian crude oil market has had an enveloping effect on crude prices; instead, the evidence is consistent with the fact that other global and macroeconomic factors could be the key determinants of crude oil prices.

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