SPILLOVER EFFECTS BETWEEN INDOCHINA METAL FUTURES MARKETS

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Abstract: India and China have been at the top of the exporter, importer, producer and consumer economies. The two neighbouring countries provide the largest market in the world. They also share a similar history of development of their commodity derivatives markets. This paper aims to examine the direction of causality and spillover effect between the metal futures markets of the two economies. The analysis is done for metals such as copper, aluminium, zinc and gold in the period 2009 - 2020 by using Granger causality and Dynamic Conditional Correlation -GARCH (DCC-GARCH) models. The gold futures at the Multi Commodity Exchange (MCX) have a unidirectional causality on the gold futures traded at Shanghai Futures Exchanges (SHFE), unlike other metals having bidirectional causality. Similarly, GARCH results report only long-term volatility spillover for gold futures returns, while for the base metals, both short-term and long spillover exist. The findings indicate that the Indian metals futures market has started to influence the Chinese metal futures. The results have important implications for policymakers, regulators, industrialists and offshore traders of physical commodities in hedging their positions.

Keywords: spillover, Granger causality, DCC - GARCH, metal futures market, correlation.

JEL: G0, G1, F0.

I. Introduction

The commodity futures market acts as a transmitter of information to the underlying market and its participants. The metal segment is of great importance in commodities trading for its active role in price discovery and

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risk transfer. Non-ferrous metals have various industrial applications, causing a continuous increase in global demand. Electrical and electronic products, construction, transportation and consumer durables continuously increase the worldwide demand for copper, zinc, aluminium and other base metals. Apart from usage in jewellery, dentistry and electronics, gold has some unique roles and functions. Gold serves as a medium of value storage in times of crisis. Due to its unique features, it is also one of the most actively traded commodities in the world market (Evrim Mandaci, Cagli, & Taskın, 2020).

Volatility spillover in the metal futures market is a relatively less explored area concerning its industrial importance and growing market size (Kang & Yoon, 2016; Lucey, 2013). Most of the available literature considers economies like Brazil, Russia, India and China as the proxies for emerging nations (see Patra & Panda, 2019; Yonghong Jiang, Fu, & Ruan, 2019; Chkili, 2016). The four countries' share in the world population is 42%, while China and India have 36% of the world population. With this background, this paper concentrates on these two nations for studying volatility spillover in metal futures markets. Among the emerging economies, China and India offer a unique comparison site to each other for various other reasons, including their geographical diversity, resources owned, production, and consumption capacity. As per statistics, India is the largest import partner and the fourth largest export partner of China. Both countries entered many trade agreements and formulated policies to strengthen trade relations in the period of 1990-2000, and the next two decades witnessed remarkable figures for various segments of commodities. The two largest markets can potentially influence the world dynamics of trade and change the shape of world demand and supply. The similar history of development and future potential in the commodity markets of the two nations have inspired this study. This paper explores the volatility spillover between the metal futures market of the two seemingly related economies. Results help enrich the literature of volatility spillover among the commodity futures of emerging economies, Portfolio managers, investors, and regulators.

II. Brief Review of Literature

Volatility spillover and transmission have played an important role in making international economic decisions (Seth & Panda, 2018). Forecasting volatilities in any financial asset class is of prime importance for risk management, asset pricing and asset allocation (Chen & Xu, 2019). Volatility spillover in commodities has been weaker than other asset classes, but it has also increased over time. Moreover, agricultural commodities contribute less than metal and energy commodities in spillovers (Chevallier & Ielpo, 2013). Metal markets of the London Metal Exchange (LME) are found to be highly integrated across the market (Ciner, Lucey, & Yarovaya, 2020). In comparison to the agricultural futures market, the metal futures market in China also are more efficient and less risky. However, overall Chinese commodity futures markets lag behind the US market in terms of liquidity and volatility of the market (Liu, Luo, Tse, & Xie, 2020). Risk spillover is found to be extreme between Shanghai and London Gold futures markets in the pre- and post-crisis periods (Wang, Xie, Jiang, & Stanley, 2016). The metal and other agricultural commodities (except wheat) in the Chinese market are found to follow the US market. Studying industrial metals brings it to notice that China still has a passive role in the global price formation of industrial metals despite being an active participant in trading the underlying and its financial derivatives (Siklos, Stefan, & Wellenreuther, 2020). Similarly, in the very recent study of the copper futures market between LME and SHFE, it is reported that despite a considerable increase in the volume of trade after the crisis, the Shanghai copper futures market fails to contribute significantly to global copper futures price formation (Lee & Park, 2020). The volatility spillover between the metal futures markets of LME and SHFE for the period 2007-2016 reveals the increment in the magnitude of spillover from LME, although the direction of information transmission has been varying over time (Kang & Yoon, 2016). Similar results have been obtained by Yin & Han (Yin & Han, 2013) for the copper futures market of London, New York and Shanghai exchanges.

Stock and commodity markets of BRICS countries (representing emerging economies) are studied for their rapid growth and diversification. BRICS countries have higher spillover effects among themselves for gold and oil markets than the spillover to the US and other external developed markets, thus providing diversifying benefits (Patra & Panda, 2019). Yonghong Jiang, Fu, & Ruan (2019) found that precious metals in India and China are more effective in hedging the risk of the stock market than in Brazil and Russia. Chkili (2016) also reports that in times of financial crises (global financial crisis and European debt crisis), gold in the BRICS (Brazil, Russia, India, China and South Africa) countries acts as a safe haven asset. There exists a bidirectional return and volatility spillover between S & P 500, crude oil and gold in the international market (Balcilar, Ozdemir, & Ozdemir, 2019). There has been found a negligible impact of speculation on the volatility of the returns; instead, volatility in the futures markets attracts speculators (Wellenreuther & Voelzke, 2019). The mean and variance of returns of commodity futures are also affected by the news, and the impact could be symmetric or asymmetric. In the case of the Chinese commodity futures market, the effect is found to be asymmetric for copper, aluminium, natural rubber and soybean markets (Liu, Wong, An, & Zhang, 2014). Besides liquidity, economic conditions, and speculation, the market's volatility is also influenced by the market's future expectations (Ye, Guo, Deschamps, Jiang, & Liu, 2020). Volatility spillover in the spot and futures market of petroleum-based commodities is also fuelled significantly by the trading volumes and open interest; higher trading volume exerts speculative pressure, and open interest exerts hedging pressure on the volatility (Magkonis & Tsouknidis, 2017).

III. Data and Methodology

Data

Official websites of MCX (Multi Commodity Exchange) in India and SHFE (Shanghai Futures Exchange) in China have been used to collect the weekly closing prices of copper, aluminium, zinc and gold futures prices. In the Indian commodity futures market, MCX has a market share of more than 98 per cent in the industrial and precious metal segment (Annual report, MCX, 2019-20). Similarly, out of three commodity futures exchanges in China, SHFE has the best-known trading in metals. The period of study for each commodity is 12 years from 2009 to 2020, with 626 observations.

For preparing the continuous data of futures contracts, the front (spot), month method has been used for MCX. For tabulating the data for SHFE, a different approach has been taken for a true representation of prices derived from demand and supply mechanisms in the Chinese markets. This has been done by giving due importance to the turnover of contracts of each commodity. The basis of this methodology for tabulation is inspired by Hua & Chen (2007). For copper, aluminium and zinc on any date, SHFE has 12 contracts, each expiring in January to December for a particular year. For any date in a particular month (X), the closing price of a contract, expiring or deliverable in a month X+2, is considered. For example, for any date in January, the closing price for a contract expiring in March is considered; for dates in February, contracts deliverable in April are considered and so on. For gold futures at SHFE, June and December months contracts are taken following the methodology of Jin, Li, Wang, & Yang (2018) and Jiang, Kellard,

& Liu (2020) as only these two contracts are the most liquid contracts. The closing price of the June month contract is taken for the first four months of the year, and for May to October, the December month contract is considered. For the last two months of the year, the June month contract of the following year is approached.

For the non-trading Fridays in India, Thursday prices have been considered. For the non-trading weeks in China, the average closing price of the previous and next value have been imputed. The Chinese exchanges quote the price of copper, aluminium and zinc futures in Yuan per ton. On the contrary, MCX has quoted prices in Rs per kg. For convenient comparison of descriptive data, quotations from SHFE have been converted into per kg (for copper, aluminium and zinc) and per 10 grams (for gold). Prices from both exchanges have been converted into dollars using daily exchange rates. In this way, all the variables happen to be in US dollars per kg. Return series have been prepared using the logarithmic difference for further analysis.

Tool and Techniques

Granger causality and GARCH models have frequent uses in the literature to study causality and volatility spillover between the markets (Talbi, de Peretti, & Belkacem, 2020). The Granger causality test is conducted to know the direction of information flow for the two markets. Granger's (1969) method of finding the direction of causality focuses on the contribution of lagged values of returns of one market to enhance the prediction of current returns of another market. For example, in the following Granger causality equations, the null hypothesis tested in equation (1) is "Indian market returns does not granger cause Chinese market returns". Similarly, the null hypothesis tested in equation (2) is "Chinese market returns does not granger cause Indian market returns."

$$C_t = a_0 + \sum_{i=1}^{p} \alpha_i I_{t-1} + \sum_{i=1}^{p} \beta_i C_{t-j} + \mu_{1t} \quad (1)$$

$$I_t = b_0 + \sum_{i=1}^{p} \alpha_i C_{t-1} + \sum_{i=1}^{p} \beta_i I_{t-j} + \mu_{2t} \quad (2)$$

where I_t and C_t represent the return from the Indian and Chinese market, respectively, p is the number of lags considered, a_0 and b_0 are the constant terms, α_i and β_i are the coefficients and u_{it} is the error term.

The time series under consideration should be confirmed to be stationary before applying the Granger causality test. To test the presence of unit root, this paper uses the Augmented Dickey-Fuller (ADF) Test. This test is an improvement over the Dickey-Fuller test. The null hypothesis tested by the ADF test is the presence of a unit root in the series. The optimal lag length has been found using VAR selection criteria.

As a precondition of GARCH models, the presence of the ARCH effect is tested using Lagrange Multiplier (LM-ARCH) test. GARCH models are widely accepted models among researchers and academicians for modelling volatility and studying the volatility spillover. In the case of financial time series, there is often a violation of the 'constant volatility' assumption of the ordinary least square (OLS) regression method. To model the time-varying variance of such data, Engle (1982) proposed the Autoregressive Conditional Heteroscedasticity (ARCH) model, which was later superseded by a parsimonious model called Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model proposed by Bollerslev in 1986. Literature related to volatility modelling and spillover is enriched with the usage of various univariate and multivariate GARCH models.

This paper uses the DCC- GARCH model. Using the resulting variance series from the univariate GARCH model, DCC GARCH parameters are estimated. The covariance matrix of the model is as below:

$h_t = D_t R_t D_t,$ (3)

$Dt = \text{diag}\{h^{1/2}_{i,t}\}$ (4)

$Rt = \text{diag}\ (q_{i,j,t}^{1/2})\ Q_t\ \text{diag}(q_{i,j,t}^{1/2})$ (5)

where D_t is the diagonal matrix of the dynamic correlation matrix, h_t is the estimator of conditional correlation and R_t is the dynamic correlation matrix.

The definite matrix is explained as:

$Q_t = c + \alpha\varepsilon_{t-1}\ \varepsilon'_{t-1} + \beta Q_{t-1}$ (6)

where Q_t and Q_{t-1} are the positive definite matrix at times t and t-1, α and β are the ARCH and GARCH terms, respectively.

Dynamic condition correlation coefficient (ρ_{ijt}) is represented as:

$\rho_{ijt} = qijt/\ (q_{iit}\ q_{jjt})^{1/2}$ (7)

where ρijt is the coefficient of dynamic conditional correlation, q_{iit} and q_{jjt} are the different elements of the matrix.

IV. Results and Discussion

Descriptive statistics, including results of the ADF test and ARCH test, presented in Table 1, have an exciting finding that out of the four metals under consideration, only copper's average return at SHFE has been higher than the MCX. The low risk of the aluminium market at SHFE is indicated by the lowest Standard deviation in the return series followed by the gold return series at both exchanges. Also, aluminium is the only metal with positive skewness in both markets. It is noteworthy that China has been the largest producer and exporter of aluminium and aluminium products.

Further, the Jarque-Bera test reports rejection of the normality assumption of data. The return series is confirmed to be stationary using the ADF test. For all the metals return series, the presence of the ARCH effect has also been ensured using the ARCH - LM test.

Table 1.
Descriptive Statistics of Returns

Statistics	MCXCU	SHFECU	MCXAL	SHFEAL	MCXZN	SHFEZN	MCXAU	SHFEAU
Mean	0.00147	0.00150	0.00062	0.00058	0.00135	0.001289	0.00141	0.001256
Median	-0.0009	0.000266	-0.00128	0.000286	0.00166	0.001328	0.00192	0.002086
Maximum	0.13020	0.133594	0.11688	0.089949	0.13305	0.138063	0.08132	0.078614
Miniumum	-0.1740	-0.14377	-0.11496	-0.08668	-0.13157	-0.13188	-0.10193	-0.10574
Std.Dev.	0.03186	0.029878	0.02848	0.019173	0.03536	0.03067	0.02172	0.021183
Skewness	-0.0466	0.164161	0.39064	0.005536	-0.01486	-0.18445	-0.18419	-0.37266
Kurtosis	5.51447	6.548915	4.59713	5.838038	4.05435	5.198754	4.90759	4.712522
Jarque-Bera	164.876	330.796	82.3249	209.7547	28.9725	129.4432	98.2980	90.83923
Probability	0	0	0	0	0	0	0	0
Observation	625	625	625	625	625	625	625	625
ADF Test	-25.265	-26.2846	-24.2728	-24.7226	-25.2782	-27.1245	-240850	-25.109
P-value	0	0	0	0	0	0	0	0
Arch LM Test	0	0	0	0	0.00148	0	0.00069	0

Source: Author's calculation

The Granger causality test is performed to know the direction of causality. The empirical results have been summarised in Table 2. Gold returns at MCX have an impact on the gold returns at SHFE, but the reverse is not true. For the metals, there exists a bidirectional causality. The hypothesis of no Granger causality for copper and aluminium is rejected at a 5% significance level. However, for zinc, this is true at a 10% significance level for the test from SHFE to MCX. To summarise the Granger causality result, there is significant bidirectional information flow between the base metals markets of the two economies, and for gold, the Indian market has a unidirectional impact on the Chinese market.

Table 2.
Granger Causality Test Result

Metal	Null Hypothesis	F-Statistics	P-value
COPPER	MCXCU does not Granger cause SHFECU	22.215	0
	SHFECU does not Granger cause MCXCU	2.3771	0.01588
ALUMINIUM	MCXAL does not Granger cause SHFEAL	35.768	0
	SHFEAL does not Granger cause MCXAL	3.2529	0.03932
ZINC	MCXZN does not Granger cause SHFEZN	43.457	0
	SHFEZN does not Granger causes MCXZN	2.3227	0.07401
gold	MCXAU does not Granger cause SHFEAU	16.619	0
	SHFEAU does not Granger cause MCXAU	1.0016	0.4289

Source: Author's calculation

Results of univariate GARCH and DCC- GARCH have been presented in Table 3 and Table 4, respectively. The univariate GARCH results for the four metals include overall mean (μ), intercept term (ω), ARCH term (α) and the GARCH term (β). Our results report that the GARCH term is positive and significant for all the variables. ARCH term is also positive and significant for all the metals except aluminium markets of both exchanges. ARCH term for copper futures at SHFE is significant at a 10% level of significance. This indicates the persistence of volatility for copper, zinc and gold, as both the ARCH term and GARCH term are significant. For the aluminium futures market of both exchanges, there is an effect of only past variance, not of previous error terms. In other words, for aluminium futures markets, there is only a long-run impact of the shock. The decay in volatility persistence over time is measured by the sum of α and β values (Yadav, Vasakarla, & Arora, 2020). The decay in volatility persistence is slowest for zinc ($\alpha+\beta=0.999$) and fastest for copper ($\alpha+\beta=0.865758$) futures at SHFE.

Finally, the DCC – GARCH results are presented in Table 4, along with the DCC graphs in Figure 1. DCC- GARCH results indicate the volatility spillover effect from one market to another market. DCC α indicates the short-term spillover effect, and DCC β indicates the long-term spillover effect from one market to another. Our findings report the existence of both short-term and long-term spillover effects for copper, aluminium and zinc markets. For the gold futures market, no volatility spillover is reported in the short run; however, in the long run, volatility transmission does occur. The results can be summarised as the Indian and Chinese base metal futures markets are integrated, and gold futures markets have only a long-term spillover effect. The DCC graph shows for all the metals that the conditional correlation has a declining trend in the first half of the decade and a rising trend in the latter half. Overall, for all the metals, the correlation between the two markets has been time-varying in nature.

Table 3.
Univariate GARCH Result

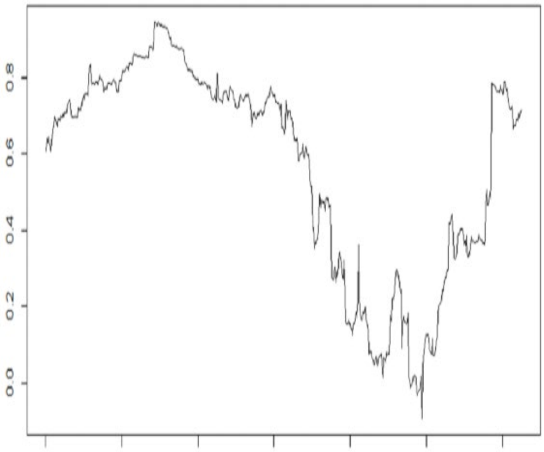
Variables		μ	ω	α	β
MCXCU	Estimate	0.000713	0.000024	0.03142	0.942734
	P-value	0.565168	0.269931	0.021523	0
MCXAL	Estimate	0.000929	0	0.04179	0.930054
	P-value	0.403889	0.396679	0.125666	0
MCXZN	Estimate	0.000889	0.000014	0.040582	0.947095
	P-value	0.48161	0.106439	0.000692	0
MCXAU	Estimate	0.001182	0.000031	0.106401	0.82715
	P-value	0.126958	0.085999	0.010002	0
SHFECU	Estimate	0.001033	0.000116	0.159443	0.706315
	P-value	0.328488	0.081882	0.081295	0
SHFEAL	Estimate	-0.00045	0.000003	0.094756	0.904243
	P-value	0.438727	0.787449	0.35516	0
SHFEZN	Estimate	0.00028	0.000007	0.099374	0.899626
	P-value	0.743235	0.512969	0.017336	0
SHFEAU	Estimate	0.001003	0.000049	0.133083	0.757552
	P-value	0.178244	0.238162	0.02488	0

Source: Author's calculation

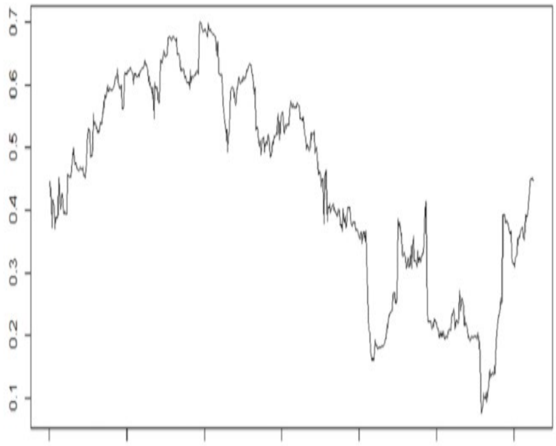
Table 4.
DCC-GARCH Results

Variables		DCC α	DCC β
MCXCU - SHFECU	Estimate	0.035869	0.959267
	P-value	0.00003	0
MCXAL - SHFEAL	Estimate	0.0225	0.975383
	P-value	0.000208	0
MCXZN - SHFEZN	Estimate	0.044794	0.95331
	P-value	0	0
MCXAU-SHFEAU	Estimate	0.033557	0.941284
	P-value	0.84188	0

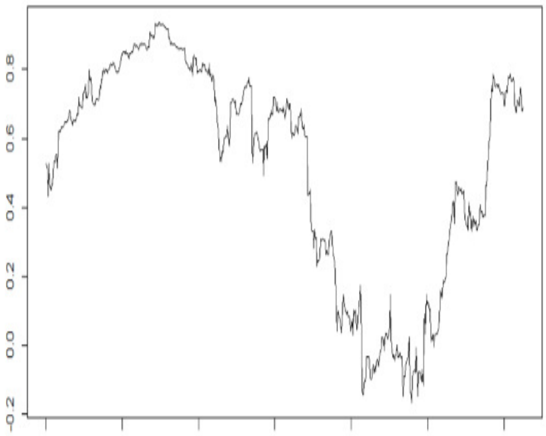
Source: Author's calculation



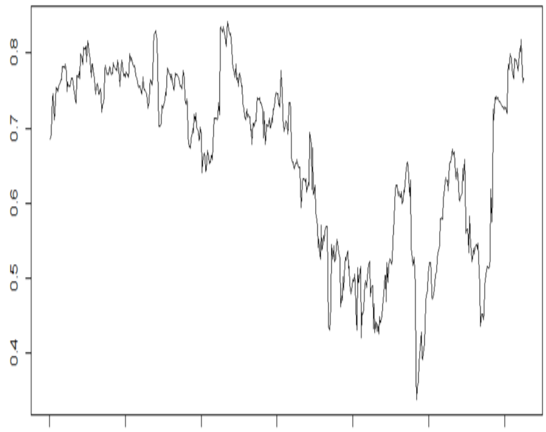
DCC GRAPH OF MCXCU AND SHFECU



DCC GRAPH OF MCXAL AND SHFEAL



DCC GRAPH OF MCXZN AND SHFEZN



DCC GRAPH OF MCXAU AND SHFEAU

Source: Dynamic correlations for different pairs of commodities calculated using the DCC-GARCH model.

Figure 1. Dynamic correlation coefficient graph of metals at MCX and SHFE.

V. Conclusion

This study concentrates on the two market giants, China and India, to study volatility spillover between the metal futures markets. The causal relationship between the MCX and SHFE metal futures is studied using the Granger causality test. In addition, the DCC - GARCH model from the multivariate models of GARCH models has been used for spillover analysis between the markets. Our results have been summarised in the following points.

1. The copper, aluminium and zinc markets of the two exchanges have bidirectional causality, and the gold futures market has unidirectional causality, that is, from MCX (India) to SHFE (China).
2. There is a persistence of volatility for copper, zinc and gold, as both the ARCH term and the GARCH term are significant. Therefore, the metal markets of the two economies have an influence on each other. For the aluminium futures market of both exchanges, there is only a long-run impact of the shock. The decay in volatility persistence is slowest for zinc and fastest in copper futures at SHFE. The fastest (copper) and the slowest (zinc) decay in volatility persistence is observed at SHFE.
3. The Indian and Chinese base metal futures markets are found to be integrated (short and long-run spillover found), whereas gold futures markets have only a long-term spillover effect.
4. Although the conditional correlation between the two markets has been time-varying in nature, it can be inferred from the graph that the conditional correlation has a declining trend in the first half of the decade and a rising trend in the latter half.

The empirical results indicate that the Indian metal futures market influences the Chinese metal futures. The findings have important implications for industrialists and offshore traders of physical commodities in hedging their positions and for regulators and government in framing the trade and investment policies. Moreover, this study can be extended to other important commodity futures including energy (crude oil, natural gas) and agricultural (soybean, soya oil, corn, cotton) commodities in different emerging and developed economies.

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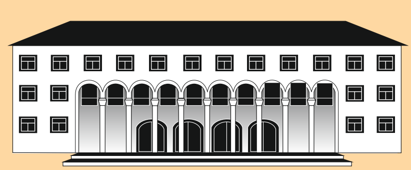

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