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Indian and Chinese Metal Futures Markets: A Linkage Analysis

Ravi KUMAR,[1] Babli DHIMAN[2]
[1] Mittal School of Business, Lovely Professional University, Phagwara
e-mail: ravi.kr24193@gmail.com
[2] Mittal School of Business, Lovely Professional University, Phagwara
e-mail: babli.dhiman@lpu.co.in

Abstract. This paper aims to test the long-run and short-run relationships between the Indian and Chinese metal futures markets using the weekly closing prices of three nonferrous metals, that is, copper, aluminium, and zinc, for the period of 2009–2020. The empirical results show no cointegration for any of the three metals. The Granger causality test suggests a unidirectional relationship from India to China for copper futures and bidirectional causality for aluminium and zinc futures markets. This paper contributes to the literature by studying the relationship between the mentioned two emerging markets, which are top producers and consumers in commodities and have growing futures markets. The results have important implications for investors, portfolio makers, and policymakers of emerging economies.

Keywords: short-run relationship, long-run relationship, Granger causality, cointegration, futures market

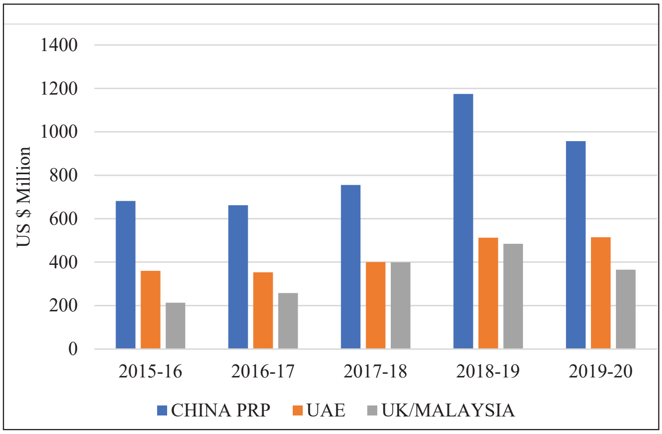
JEL Classification: C22, G13, G15

1. Introduction

Trading in commodities has a much longer history than today's frequently traded asset classes such as shares, mutual funds, and even real estate. It dates back to the era when people had no common currency, and the barter system prevailed. Trading in commodities is still taking place in modern times, rather with more complex contracts such as futures and options, with more dedicated nationalized institutions, regulators, and other vital stakeholders. The commodity futures market in countries such as India and China have been multiplying. In the initial decades of established commodity markets, authors emphasized studying the relationship between the spot and the growing futures market commodities. The objectives of such relationships are to know the efficiency of the futures market. The long-run and short-run relationships are found using the cointegration and Granger causality tests. Modelling the market's volatility is important and exciting in studying the risk involved in trading. The integration of world markets and liberalizing trade barriers across nations allowed futures market study a broader scope. This was also fuelled by the development of futures markets in different countries. The salient features of this market attracted not only producers but also hedgers and investors. With the development of the market and the growing number of stakeholders, the authors' interest shifted to studying linkages of different commodity futures markets of the world in the liberalized trade environment. The first study of cross-border linkages of the Chinese commodity futures market is claimed (Hua and Chen, 2007).

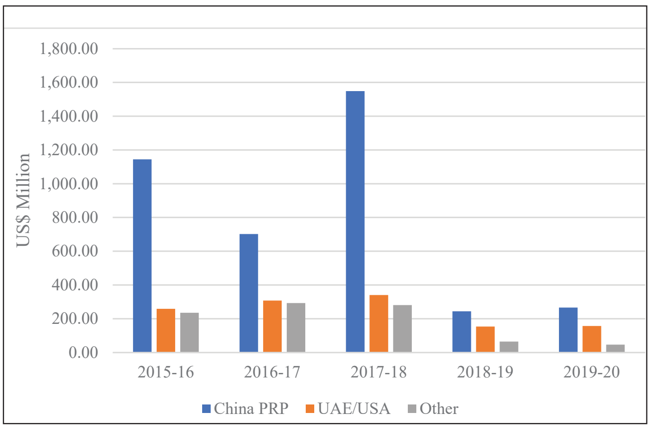
The commodity futures markets in countries such as India and China have been growing rapidly, but the scholarly literature available on the linkages of the futures market is unmatched. However, since 2007, various researchers have contributed to the study of cross-country linkages of commodity futures markets (Hua and Chen, 2007; Fung, Tse, Yau, and Zhao, 2013; X. Li and Zhang, 2008, 2009, 2013). Literature provides that the stock and commodity derivatives of a developing nation have often been studied, considering financially dominant economies such as the USA, the UK, and Brazil. As far as financial derivatives are concerned, the angle of comparison with developed nations may suffice. But when trading the commodities, and their derivatives are considered, the largest producer and consumer economies deserve to be studied, as they affect a major portion of the world market. Aroul and Swanson (2018) mention that India and China lead in the supply of manufactured goods and services among the emerging economies. They share a similar development history and have adjusted their political rigidity to keep themselves abreast with global capitalism (Aroul and Swanson, 2018). China is one of the largest importers of copper, which is mostly used in electrical conductivity. China has also been one of the largest producers and exporters of aluminium, having wide application in construction, transportation, and packaging. Demand and supply of commodities in the emerging markets have a major role in the price fluctuation of nonferrous metals (Hu et al., 2017). Wang and Wang (2019) showed how China dominates the global base metal consumption and how the industrial growth in China has a significant impact on the overall price of base metals.

Figure 1 shows that the aluminium import in India is largely from China itself. Similarly, *figures 2–3* show that China has been one of India's largest importers of copper and zinc. With the selected commodities (copper, aluminium, and zinc), this paper intends to study the relationship between Indian and Chinese metal futures markets.



Source: Ministry of Commerce, GoI (Government of India)

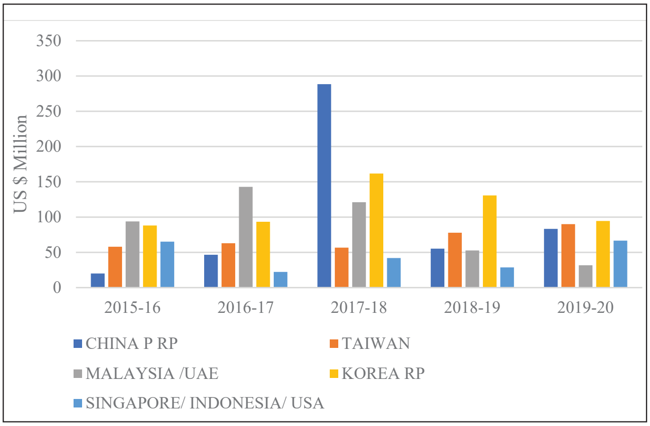
Figure 1. *Top aluminium importing sources for India*



Source: Ministry of Commerce, GoI

Note: for the years 2015–16, the grey bar is for the UK and for all other years is for Malaysia.

Figure 2. *Top copper export destinations for India*



Source: Ministry of Commerce, GoI

Note: Grey bar denotes Malaysia for 2015–16 and 2017–18, Singapore for 2016–17, Qatar for 2018–19, and UAE for 2019–20.

Figure 3. *Top zinc export destinations for India*

So, although the linkages between the commodity markets have been studied, the literature is mostly limited to the developing economies. The commodity futures markets of emerging economies with a large scale of production, consumption, and international trade need to be explored further. The article bridges the gap by finding the linkages of the Indian metal futures market with the Chinese one. The paper's findings are helpful for the metal industries of emerging countries, investors, portfolio managers, and regulators. Section 2 of the paper includes a brief literature review of price discovery and cross-country linkages of commodity derivatives. Section 3 discusses the data and methodology of the study. Results are discussed in section 4. Last, section 5 concludes the paper with the conclusion and limitations of this research.

2. Literature Review

Chinese and Indian Metal Futures Markets

The empirical results from the literature suggest that China's metal futures market has changed its adjective from inefficient to efficient in price discovery. This is evident from the results of Chowdhury (1991) and Xin, Chen, and Firth (2006), as the market was found to be inefficient for copper, lead, tin, and zinc in 1991, but again in 2006 copper and aluminium futures traded on Shanghai futures exchanges had a major role in the price discovery process using data from the years 1999 to

2004. The test used in the study was the Johansen cointegration test. An important metal, copper, has a big market in China. Indriawan, Liu, and Tse (2019) describe copper futures and steel rebar futures in China as the most active metal contracts and as informationally more efficient than other metal futures such as iron ore and aluminium. In the long run, copper stock prices have a significant asymmetric impact from demand shocks and supply shocks; however, in the short run, demand shocks have such an impact on stock prices (Hu et al., 2017). Copper futures prices in China, the US, and the UK are found to be cointegrated with the least contribution from the Chinese market in the process of price discovery (Hua, Lu, and Chen, 2010). Klein and Todorova (2021) examined the effect of the introduction of the night session on the volatility of the metal futures market at Chinese exchanges. It has been found that, unlike the day session, the copper futures traded at night session has an impact from the volatility at the London Metal Exchange (LME). On the contrary, the aluminium futures at Shanghai Futures Exchange (SHFE) show no impact from the LME. The authors suggest one more important finding – namely that there is no increase in the volume of trade in the metal futures after the introduction of the night trading session at the Chinese exchange.

Linkages between Commodity Futures Markets

It is noteworthy that Hua and Chen (2007) claim to be the first to study the cross-country linkages of China's metal and agricultural commodity futures markets with the rest of the world markets. The authors studied the linkages by finding the cointegration among the commodity futures markets. Fung et al. (2013) studied the linkages of Chinese futures markets with the US, the UK, Japanese, and Malaysian markets using the lead–lag relationship between the Chinese market and world markets. Hua and Chen (2007) used cointegration tools to find the long-term relationship, while Fung et al. (2013) found a short-run relationship by employing a causality test. X. Li and Zhang (2008) and X. Li and Zhang (2009, 2013) also traced linkages in the price for copper futures of the Chinese market and world markets. X. Li and Zhang (2008) studied the time-varying correlation between the futures markets of China and the UK by employing the rolling sample method. Not only dynamic correlation but cointegration and Granger causality tests also confirmed the result of strong connections among copper futures markets. X. Li and Zhang (2013) included India and Chicago with the UK and Chinese markets. The short-run, or causal, relationship and the long-run relationship could be studied using the structural vector autoregression model to trace inter-market linkages.

The Chinese commodity futures market has been increasing its interaction with the US commodity futures market, and the relationship between the markets have strengthened over the years from 2000 to 2010 (Tu, Song, and Zhang, 2013). Like the effect of the US market on Chinese futures, the UK market also has a dominating role. X. Li and Zhang (2009) and Sinha and Mathur (2013) studied the effect of UK markets on the metal futures of China and India using the Johansen cointegration test. The copper futures market in Shanghai has a strong connection with London, and the Shanghai market has a more prominent role in the price discovery process. Bidirectional information flow and long-run relationship has been found between the US and Chinese copper futures markets (Guo, 2017). Similarly, a significant correlation and long-run relationship are found among the copper futures markets of Shanghai, London, and New York. Further, the copper futures markets of Shanghai and London are most significantly integrated among the three markets (Rutledge, Karim, and Wang, 2013). The Indian metal market (copper, aluminium, and zinc futures) has been found to have a unidirectional impact from world markets; moreover, commodities of all categories are found to be cointegrated with the world markets (Kumar and Pandey, 2011). Pradhan, Hall, and Toit (2021) reveal for the period of 2009–2020 with regard to Indian exchanges that there has been a long-run unidirectional causality (from spot to futures) and a short-run bidirectional causality for metal futures, including copper and aluminium.

Various other researchers have contributed to the study of relationships, or linkages, among futures markets worldwide using cointegration test and causality test to study the long-run and short-run relationship (Booth, Brockman, and Tse, 1998; X. Li and Zhang, 2009; Aroul and Swanson, 2018; Aruga and Managi, 2011). For the copper futures in London and the UK, both markets influence each other for being informationally linked. However, if quantified, the London metal exchange has a greater influence on the Shanghai futures exchange (X. Li and Zhang, 2009). Tsiaras (2020) investigated the volatility transmission among the precious and industrial metal futures and found evidence of strong volatility spillover from gold to metals, including copper, aluminium, and zinc. The author also finds the zinc futures market to have less impact than the copper and aluminium futures markets.

3. Data and Methodology

For this analytical study, data on the Indian and Chinese metal futures markets have been collected from secondary sources. The official websites of Multi-Commodity Exchange (MCX) in India and of Shanghai Futures Exchange (SHFE) in China have been used to collect data. Weekly closing prices have been collected for each commodity for 12 years from 1 January 2009 to 31 December 2020, with 626 observations. Three commodities, including copper, aluminium, and zinc, have been identified for the study. A few other metal commodities are also common in both of the exchanges but could not be considered in the study due to nonavailability of synchronized data for a common time frame, as some products traded in both countries have either been launched late or are currently inactive in either of the countries. 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 by demand and supply mechanisms in the Chinese markets. This has been done giving due importance to the turnover of contracts of each commodity. The basis of this methodology for tabulation is inspired by Hua and Chen (2007). For all the three metals, on any date, SHFE has 12 contracts, each expiring in the period of January–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. For convenience, continuous price series of copper, aluminium, and zinc from MCX (India) have been denoted as ICOPPER, IALUMINIUM, and IZINC respectively. Similarly, the price series from SHFE (China) have been named CCOPPER, CALUMINIUM, and CZINC. For the non-trading Friday 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 their 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 measure of data, quotations from SHFE have been converted into per kg, and prices from both the exchanges have been converted into dollars using daily exchange rates. In this way, all the variables happen to be in US dollars per kg.

For the analysis, the level of integration has been checked for all the series. The Augmented Dickey–Fuller (ADF) test has been used to test the presence of unit root in the series. 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. Since the ADF test is said to have low power in rejecting the null hypothesis of the presence of unit root, we also employ a stationary test named KPSS (Kwiatkowski–Phillips–Schmidt–Shin) test. The null hypothesis of this test is different from that of the ADF test. In the KPSS test, the null hypothesis is taken as stationarity in the series. The optimal lag length for this study has been taken following the Schwarz information criterion (SIC).

For the long-run relationship, the Johansen cointegration test has been used. Authors identify this test as superior to other tests for its robustness (Sendhil and Ramasundaram, 2014). For applying this test, the precondition is that all the variables under consideration should be integrated at the same level (all the variables should be either I(1) or I(2)). The Johansen method for the cointegration test uses two different statistics. These are Trace statistics and Eigen-value statistics.

Most of the time, both methods yield similar results. To confirm the findings, we also used Autoregressive Distributed Lag (ARDL) bound test to know the cointegration between the markets. This test can be applied irrespective of the level of integration of the two series; however, none of the series should be integrated or order 2. This test uses the F test to decide whether to reject the null hypothesis or not. The null hypothesis of this test happens to be no cointegration between the variables.

The short-run relationship is estimated using the Toda–Yamamoto Granger causality test (Toda and Yamamoto, 1995). The Toda–Yamamoto method is an alternative and improvement over the Granger causality test. This test uses an augmented structured vector autoregressive (SVAR) at level $k+d_{max}$, where k is the optimal lag length, and d_{max} is the maximum order of integration. It generates asymptotic VAR (vector autoregressive) static in the form of a Chi-square distribution. If we have two series Y_t (Indian commodity market price series) and X_t (Chinese commodity market price series), then Y_t is said to Granger cause X_t if the values of the future of X_t can be better predicted using the past values of both Y_t and X_t than it can be by using the past values of X_t only. The equation for Granger causality can be estimated by following the VAR model.

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} + \theta_1 X_{t-1} + \ldots + \theta_p X_{t-p} + e_t \quad (1)$$

$$X_t = \beta_0 + \beta_1 X_{t-1} + \ldots + \beta_p X_{t-p} + \gamma_1 Y_{t-1} + \ldots\ldots + \gamma_p Y_{t-p} + V_t \quad (2)$$

Null hypothesis of equation (1), (H0): $\Theta_1 = \Theta_2 = \ldots \Theta p = 0$, which implies that X_t does not Granger cause Y_t. Similarly, for equation (2), the null hypothesis is: $\gamma_1 = \gamma 2 = \ldots = \gamma_p = 0$, which implies that Y_t does not Granger cause X_t.

4. Results and Discussion

This section presents the results. First, descriptive statistics are presented in *Table 1*. Next, in *Figure 4*, the graphical representation of data illustrates the nature of the data collected. The preliminary statistics suggest that India's prices have always been on the higher side for all the three metals under consideration. The Jarque–Bera test indicates that only the copper series from both of the exchanges are normally distributed.

Table 1. *Descriptive statistics*

	ICOPPER	CCOPPER	IALUMINIUM	CALUMINIUM	IZINC	CZINC
Mean	6.66	7.66	1.95	2.19	2.26	2.68
Median	6.69	7.59	1.93	2.17	2.19	2.59
Maximum	10.16	11.43	2.78	2.85	3.59	4.29
Minimum	3.16	3.49	1.28	1.54	1.07	1.48
Std. Dev.	1.31	1.46	0.27	0.26	0.47	0.5
Skewness	0.15	0.13	0.26	-0.09	0.4	0.78
Kurtosis	3.1	2.96	3.17	2.26	2.99	3.92
Jarque–Bera	2.72	1.72	7.98	14.98	16.31	85.01
Probability	0.26	0.42	0.02	0	0	0
Sum	4170.23	4792.59	1217.59	1367.66	1416.88	1677.31
Sum Sq. Dev.	1068.93	1329.6	44.91	43.67	137.9	158.13
Observations	626	626	626	626	626	626

Source: own edition based on authors' calculations

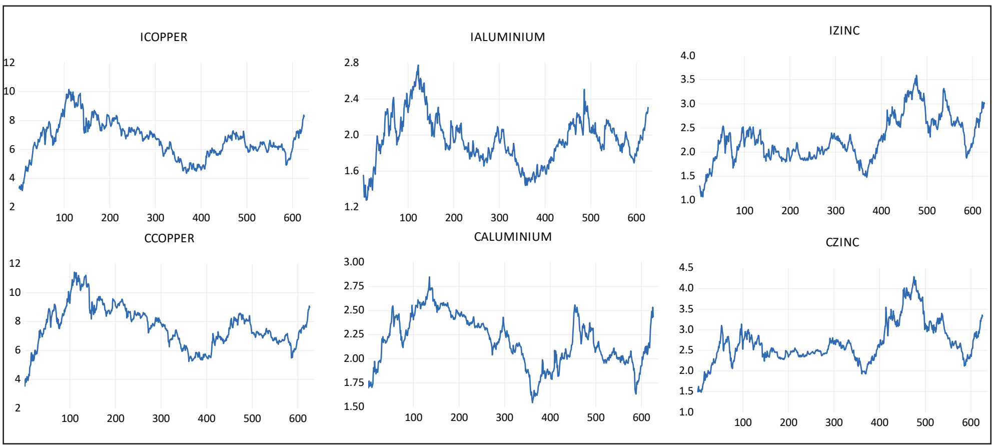


Figure 4. *Graphical representation of data*

The ADF test result for the presence of unit root is also different for copper futures presented in *Table 2*. The CCOPPER series at 5% level of significance is found to be stationary at level. All the other series at 5% significance level are non-stationary at level. At first difference, all the series are found to be stationary. However, the KPSS test suggests all the series to be integrated of order 1. Since the CCOPPER series seems to be fractionally cointegrated of orders 0 and 1, we conducted only the ARDL bound test for the copper series. For the other two metal series, we conducted both tests, i.e. the ARDL bound test and the Johansen cointegration test.

Table 2. *Results for the unit root test*

	ADF				KPSS	
Variables	At level		At first difference		At level	At first difference
	t-statistic	P-value	t-statistic	P-value	t- statistic	t-statistic
ICOPPER	-2.675	0.079	-25.750	0	0.658	0.228
CCOPPER	-2.891	0.047	-26.468	0	0.722	0.287
IALUMINIUM	-2.645	0.085	-24.793	0	0.279	0.079
CALUMINIUM	-2.268	0.183	-24.910	0	0.915	0.150
IZINC	-2.334	0.162	-25.271	0	1.380	0.051
CZINC	-2.592	0.095	-27.383	0	0.971	0.086

Source: own edition based on authors' calculations

Note*: At 5% significance level, the critical value of the t-statistic is 0.463 for the KPSS test.*

We have found the optimal lag length following the Akaike information criteria (AIC) for the three pairs of time series. These results are presented in *Table 3*.

Table 3. *Optimal lag length*

Pairs of variables	optimal lag length
ICOPPER – CCOPPER	7
IALUMINIUM – CALUMINIUM	3
IZINC – CZINC	4

Source: own edition based on authors' calculations

Note*: The optimal lag length has been taken following the Akaike information criteria (AIC).*

Results for the long-run relationship have been reported in *Table 4* (Johansen cointegration test results) and *Table 5* (ARDL bound test results). The Johansen cointegration test reports no cointegration between Chinese and Indian metal futures (aluminium and zinc). The result is supported by the ARDL bound test findings, which indicate no long-run relationship for the copper, aluminium, and zinc futures of MCX and SHFE. This result indicates that metal futures prices in the Indian and Chinese markets do not move together in the long run. These findings are contrary to the findings of Kumar and Pandey (2011) and Sinha and Mathur (2013), where authors found linkages between metal futures markets traded on MCX (India) and London Metal Exchange (UK). The results of copper markets should also be studied bearing in mind the conclusions of X. Li and Zhang (2008) and Hua et al. (2010), where authors found a long-run relationship between copper futures markets of SHFE (China) and LME (UK).

Table 4. *Johansen cointegration test results*

		Trace statistic		Eigenvalue statistics	
Variables	Hypothesis	Trace statistic	P-value	Eigen-stat	P-value
ICOPPER – CCOPPER	r = 0	---	---	---	---
	r< = 1	---	---	---	---
IALUMINIUM – CALUMINIUM	r = 0	14.402	0.073	8.507	0.330
	r< = 1	5.895	0.015	5.895	0.015
IZINC – CZINC	r = 0	14.334	0.074	8.121	0.367
	r< = 1	6.213	0.013	6.213	0.013

Source: own edition based on authors' calculations

Table 5. *ARDL bound test results*

Variables	F-statistic	Lower bound	Upper bound
ICOPPER – CCOPPER	2.84	3.62	4.16
IALUMINIUM – CALUMINIUM	2.97	3.62	4.16
IZINC – CZINC	2.85	3.62	4.16

Source: own edition based on authors' calculations

Note: *The lower and upper bound are at 5 % level of significance.*

Table 6. *Toda–Yamamoto Granger causality test results*

Dependent variable	Independent variable	Chi-square	Degree of freedom	P-value
ICOPPER	CCOPPER	4.192	7	0.757
CCOPPER	ICOPPER	133.75	7	0
IALUMINIUM	CALUMINIUM	8.761	3	0.033
CALUMINIUM	IALUMINIUM	60.724	3	0
IZINC	CZINC	8.670	4	0.07
CZINC	IZINC	179.728	4	0

Source: own edition based on authors' calculations

Finally, *Table 6* reports the Toda–Yamamoto Granger causality test results. The findings suggest bidirectional causality for aluminium (at 5 per cent significance level) and zinc (at 10 per cent significance level) markets. For copper futures markets, the causality is unidirectional: from the Indian to the Chinese market. This suggests that both metal markets affect each other significantly in the short run. Our findings from the short-run causality test are partially similar to the findings of Kumar and Pandey (2011).

5. Conclusions

India and China are the two emerging economies that provide the largest markets in the world. The economies often easily achieve to be considered among the top producer and consumer economies and as the leading exporting and importing economies. This study examines the short- and long-term relationship between Indian and Chinese metal futures markets. Copper, aluminium, and zinc futures are taken as the proxy for the metal futures market in both countries. The Johansen cointegration test and the ARDL bound test collectively suggest no cointegration between the markets. The Toda–Yamamoto approach of Granger causality suggests bidirectional Granger causality for aluminium and zinc and unidirectional causality for the copper futures market. The empirical results conclude that India's and China's metal futures markets have no long-run relationship but a remarkable short-run causal relationship. Futures prices seem to have an effect on each other in the short run only. These findings have important implications for investors and portfolio managers. Government policies on import-export and trade barriers may also draw significant conclusions from the results. This study has obvious limitations concerning restrictions on the analysis of time series data. The study leaves enormous scope for further research on cross-border linkages between emerging economies with different tools to explore the hidden possibilities in commodity futures.

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