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Price Nexus between Spot and Futures Market of Lead: An Econometric Investigation

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Abstract

Lead is the blue-grey metal found in the earth's crust which can be recycled infinitely without deteriorating its chemical properties. It is not only ductile but also malleable and corrosion-resistant.This piece of research identifiesthemechanism ofprice discovery between the physical and futures marketsof lead and examines the hedging efficacy of the lead futures.The study is focused on the Indian lead markets and the study period covers from 2013 to2020.In the short run price discovery is observed to be bi-directional whereas, in the long run, information flows from the futures to its corresponding cash market. Spot market fails to discover the futures price of lead in the long run. The study finds a lack of hedging efficacy in the lead futures market. It is found that the average scalping index over the study period is almost 429 percent which indicates speculative activities in the lead futures market. This piece of research will be helpful for the hedgers in selecting the number of futures contracts they should hold to mitigate the spot market risk. The regulators will be able to frame policies to develop and deepen the lead markets.

Keywords: Causality, Cointegration, Futures, Hedge, Lead, Metal

1. Introduction

Base metal commodities are vital for the Indian economy because these are considered the base for producing consumer goods. Lead is the blue-grey metal found in the earth's crust which can be recycled infinitely without deteriorating its chemical properties. It is not only ductile but also malleable and corrosion-resistant. It is widely used in batteries. The futures contract of lead is actively traded in commodity exchange because of itsinherent characteristics of price discovery and spot exposure management. The growth of the Average Daily Turnover (ADT) henceforth ADT, of metal futures, has been steady and robust over the past 10 years. During this period fund houses are allowed to trade in commodity futures in India. Further, the government also permitted index futures trading and developed a domestic benchmarking system. In the year 2019-20, the ADT of commodity futures accounts for 23 percent over the year 2018-19. Similarly, the ADTof lead futures also gained strong momentum in MCX, India (Samal, 2024). Since 2014-15, there has been a rise in the ADT of the metal futures traded at MCX, India.

Due to the futures contract capacity of price discovery and spot risk management, it attracts producers, consumers, importers, exporters, and traders to participate actively (Samal & Das, 2023). Hedgers intending to mitigate spot market risk also use the futures contract (Erasmus & Geyser, 2024).By anticipating the movement of futures pricesto reap profit speculators participate in the market and increase liquidity (Eswaran & Ramasundaram, 2008). According to Park and Lim (2018) Movement in futures prices indicates the expectations of producers, consumers, importers, exporters, traders, and other stakeholders (Samal, 2024). The futures market is expected to absorb the information faster as compared to its cash market for efficiently discharging the functions of price discovery (Biswal, 2008).

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The study aims to explore the hedging and price discovery characteristics of the lead futures market of India. This piece of research answers the research questions as follows: Does the futures market of lead successfully perform the function of price discovery? Does the flow of information between the markets are bidirectional? Does there exist hedging efficacy in lead futures? How many futures positions are needed to acquire to mitigate the spot market risk? This piece of research verifies the long-run integration between the physical and futures market of lead by employing a cointegration test. The price discovery of lead markets is explored by using the VEC model and Causality test. To check the endogeneity and endogeneity between the markets the study employs a variance decomposition test.The study employs the hedge ratio technique to find the hedging efficacy of lead futures.

2. Literature Review

There has been a large number of research studies are being conducted concerning price discovery, hedging efficacy, and volatility of returns of commodity futures at both national and international levels. Studies conducted have divergent views on price discovery, hedging efficacy, and volatility of returns of commodity futures. The advantages provided by the futures marketattract its stakeholders to participate in reaping the benefits and also remain the central attraction for researchers.

The futures market should impound the information coming into the market faster as compared to its cash market for efficiently discharging the functions of price discovery. Antoniou *et al.* (2008) studied the composite Index from 1988 to 1993 and found that there was informational inefficiency from 1988 to 1990. Kellard *et al.* (1999) supported the long-run equilibrium theory of selected futures but didn't find any evidence in favor of short-run efficiency. In contrast, Sahadevan (2002) doesn't find pieces of evidence in favor of cash and futures market integration. The paper uses data from 1996 to 2001 and suggests to use of advanced trading rings and modern warehousing facilities. By supporting Sahadevan (2002), Naik and Jain (2002) found that all the selected commodities except caster seed are not efficient. Zhong *et al.* (2004) studied the Mexican Index futures and found shreds of evidence in support of the price discovery function. By supporting Zhong *et al*. (2004), So and Tse (2004) concluded that the futures segment leads the price discovery role. Biswal (2008) concludes that indices futures discover the prices of its cash market. Their study period ranges from 2005 to 2007. In contrast, Bose (2008) doesn't find a long-run association in selected commodities markets.

Kumar and Pandey (2011) studied the various commodities futures available in MCX, India, and opined that the cash market of energy commodities has less effect on price discovery. In contrast to Kumar and Pandey (2011), Samal (2024) supports a bi-directional information flow between the markets of crude oil. Ali and Jabir (2011) concluded that wheat and rice have low informational efficacy. Srinivasan (2011) considered indices futures from 2005 to 2010 and observed that the information flows cash to the futures market. By supporting Srinivasan (2011), David and Shaun (2011) found that the influence of the cash market is larger in comparison with its futures.Dey and Maitra (2012) found unidirectional causality between the selected commodities markets. Their study period ranges from 2006 to 2010. Sehgal *et al*. (2012) explored sheds of evidence in favor of the price discovery role of futures. In contrast toSrinivasan (2011) and David and Shaun (2011), Edward and Rao (2013) found that the futures leads the price dissemination function. Arora and Chandar (2017) observed a bidirectional flow of information. Swain and Samal (2017) found a lack of hedging efficacy in raw jute futures.

Xu (2018) supported the role of futures in price discovery. Samaland Das (2022) evaluated thenickel market of India and found pieces of evidence in support of the price discovery role of futures. Further, they found that nickel futures don't have hedging efficacy. Their study sample period covers seven years. Bohl*et al.* (2019) chose the coffee markets of the USA and Brazil and found pieces of evidence in favor of the price discovery characteristics of futures. By considering bitcoin futures Fassas*et al.* (2020) supported the study of Bohl *et al.* (2019) and argued in favor of the futures'rolein spot price determination. Samal (2024) concluded that there

is less efficiency in commodity futures in line with Ali and Jabir (2011). Mishra and Kumar (2022) employed the "Component Share" (CS) and "Information Share" (IS) measures and supported the futures'role in spot price determination. In another research, Samal and Das (2023) considered aluminum futures and found that the aluminumfutures market successfully discovered its cash price. Their study doesn't support the hedging efficacy of the selected futures contract. Kim (2024) found that commodity risk factor affects the term and spot premiums differently. Samal (2024) extended the research of Kumar and Pandey (2011) and supported bi-directional information flow between the markets of crude oil. Erasmus and Geyser (2024) investigated the cross-hedging potential of the South African agricultural market and found sheds of evidence in support of it.Bermpei *et al*. (2025) opined a downward trend of convenience yield for holding agro-commodities. Frino *et al.* (2025) supported the leading role of futures over spot concerning price dissemination.

The research papers found a countable number of the Indian commodity futures market in comparison with other developed nations. In connection with the base metal market of India, the research papers are limited and the results of the studies are divergent as the time frame used is different. Base metals play a crucial role in shaping thecountry's economy. Among all other metals, inherent characteristics of lead like corrosion-resistant, ductile, malleable,and recyclable properties make it superior. Various stakeholders of the market use leadfutures for mitigating the spot market risk and anticipating the future spot price. Considering the above, this piece of research answers the research questions as follows: Does the futures market of lead successfully perform the function of price discovery? Does the flow of information between the markets are bidirectional? Does there exist hedging efficacy in lead futures? How many futures positions are needed to acquire to mitigate the spot market risk?

3. Research Methodology

3.1 Data

The closing pricesseries of lead cash and futures market are considered from the Commodity Insight Year Book (CIYB) of MCX, India from 2013 to 2020 which is presented in Table 1. The study uses daily high-frequency data. The period is chosen considering the continuity in trading, the volume of trade, and open interest. Further during the chosen time frame, commodity futures registered significant momentum (Samal, 2024). The study selects the VEC model over other models due to its degree of accuracy and acceptability to use in cases when non-stationary series become stationary at first differenced (Rout *et al*., 2021).

3.2 Unit Root Test

The basic features of leadmarkets are exploredby using descriptive statistics. The ADF ("Augmented Dicky-Fuller") andthe PP ("Phillip & Perron") test for checking the stationarity of the selected commodity. For this purpose,"the regression equation with a drift" can be mentioned as:

$$\Delta y_t = \varphi + \partial y_{t-1} + \sum \theta \Delta y_{t-j} + u_t \qquad (1.1)$$

3.3 Co-Integration Test

Thispiece of research explores the long-run association between the series of leads by using"Johansen's cointegration" test (Johansen, 1995). The cointegration ("intercept in the cointegrating equation, no deterministic trend") can be mentioned as follows:

$$H_1(r): \Pi_{y_t-1} + Bx_t = \alpha\left(\beta' y_{t-1} + P_0\right) + \alpha_\perp \gamma_0 \quad (1.2)$$

For examining the null "trace and the maximum eigenvalue" tests are considered.If the study will reject the null of no cointegration between the series, then it will motivate to employthe "Vector Error Correction

Table 1. Data sample

Lead						
	Market	Contract Size	Contract Type	Price	Frequency	Period
Cash segment	Mumbai of India	5 MT	-	Closing Price, ₹/ Kg	Daily Data	2013 to 2020
Futures segment	MCX of India	5 MT	Near-Month	Closing Price, ₹/ Kg	Daily Data	2013 to 2020

Model" (VECM) to study the direction of information flow between the cash and the futures market.

3.4 VEC Model

The "Vector Error Correction Model" is usedwhen non-stationary series become stationary at first difference. The two variables (spot and futures) VEC model can be mentioned as:

$$\Delta \ln S_t = a + \sum_{i=1}^{k-1} \beta_i \Delta \ln S_{t-i} + \sum_{j=1}^{k-1} \phi_J \Delta \ln f_{t-J} + \lambda_1 ECT_{t-1} + u_{1t} \quad (1.3)$$

$$\Delta \ln f_t = a + \sum_{i=1}^{k-1} \beta_i \Delta \ln S_{t-i} + \sum_{j=1}^{k-1} \phi_J \Delta \ln f_{t-J} + \lambda_2 ECT_{t-1} + u_{2t} \quad (1.4)$$

This piece of study uses"Akaike Information Criteria" (AIC) to determine the lag length of the price series of lead (Gujurati, 1995).

3.5 Hedge Ratio

The study uses the "minimum variance hedge" (h) ratio to identify the number of futures positions needed to manage the cash market risk of lead.

$$h = \rho\ (\sigma\Delta S)/(\sigma\ \Delta F\ ) \quad (1.5)$$

Where the scaling factor (ρ) is multiplied by the ratio of σΔS to σ ΔF.

4. Analysis and Discussion

4.1 Analysis Based on Descriptive Statistics

The trend line of spot-futures prices is presented in Figures 1 and 2 respectively. It is observed that the movements of the cash and futures series of lead are in the same direction from the year 2013 to 2020. Initially, an upward movement was registered by both the series of lead, however, after 2013 the prices consolidated to ₹108 per Kg. by the end of the year 2015. From 2016 to 2015 spot prices of lead moved between the bands of ₹100 to ₹130 per Kg. From the beginning of the financial year, 2017 both pricesstarted moving upward and touched all-timehighs by the end of 2018 and thereafter consolidated.

Table 2 presented above depicts the basic statistics of the cash and futures market of lead traded. The study observed the same level of fluctuation between the markets of the selected commodity. Similarly, the central tendency and the all-time high values of both prices are almost the same. Both prices indicate the leptokurtic series. Moreover, both markets are non-normal.

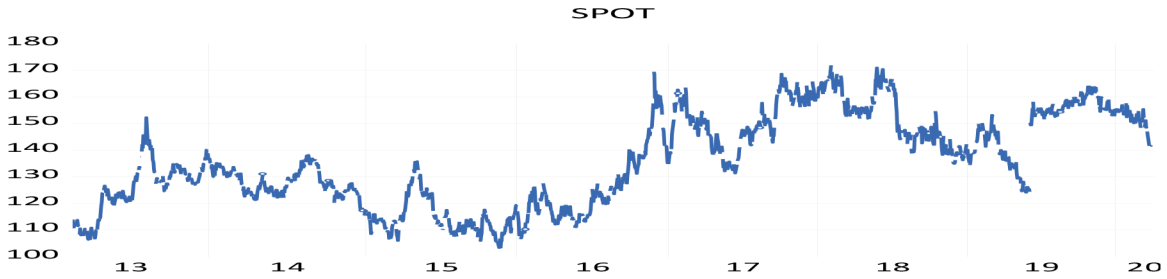


Figure 1. Lead spot trend line.

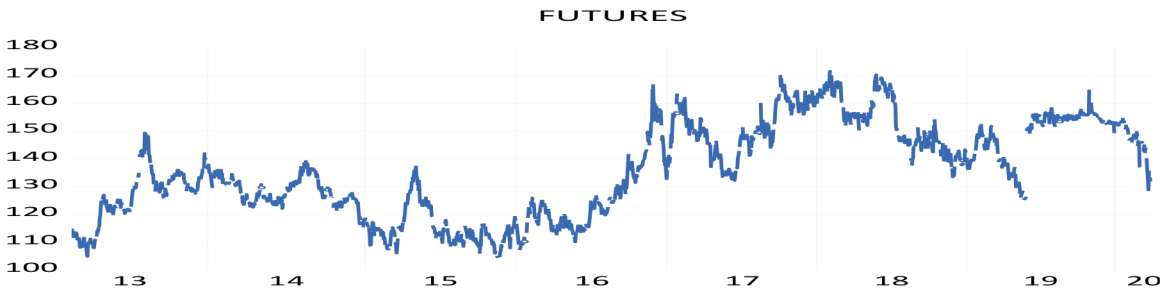


Figure 2. Lead futures trend line.

Table 2. Basic characteristics

Descriptive Stat.	Lead	
	Cash	Futures
Mean	135.76	135.88
Median	134.35	134.72
Maximum	171.90	171.90
Minimum	103.15	104.65
Std. Dev.	17.05	16.57
Skewness	0.09	0.07
Kurtosis	1.87	1.91
Jarque-Bera	101.13	93.28
Probability	0.00	0.00
Sum	250753.6	251116.9
Sum Sq. Dev.	536473.8	507337.2
Observations	1848	1848

Source- Author's calculation.

4.2 Analysis Based on Stationarity Study

After converting the daily data into logarithm form the stationarity of the specified series of prices is examined. The study employs ADF and PP unit root tests. In Table 3 test results of the ADFand PP of unit root are listed. As per the results listed in Table 3, the study finds the unit root at I (0) of the price series of lead. However, the study doesn't support the presence of unit roots at I(1). Even though the series is non-stationary at I(0), it becomes stationary at I(1). Both the tests viz. ADF and PP reveal the same results in all the mentioned specifications. The results of the tests reject the null at a 1 percent statistical level.

4.3 Analysis Based on Co-integration

The existence of a long-run association between the series is necessary to examine the information asymmetry (Samal & Das, 2022). For the variables that are non-stationary at I (0) but stationary at I (1), Johansen's (1998) cointegration is essential to employ to explore the long-run integration between the series of leads (Samal & Das, 2023). This piece of research considers "trace and maximum eigenvalue" tests for testing the H_0 of no cointegration.

The result listed in Table 4 is evident that according to the "trace and maximum eigenvalue" criteria, the null (no cointegration) is rejected at a statistically significant level. As per AIC, the lag length is considered as

Table 3. Stationarity testresults

Test	Series	Spec.	t-value	P-value.
(ADF)	spot	C	-2.450	0.106
		C and T	-3.106	0.105
		None	0.298	0.772
	futures	C	-2.672	0.079
		C and T	-3.109	0.104
		None	0.174	0.736
	Δ spot	C	-43.576	0.000
		C and T	-43.567	0.000
		None	-43.584	0.000
	Δ futures	C	-45.169	0.000
		C and T	-45.165	0.000
		None	-45.179	0.000
(PP)	spot	C	-2.497	0.116
		C and T	-3.082	0.111
		None	0.309	0.775
	futures	C	-2.544	0.105
		C and T	-2.933	0.152
		None	0.175	0.736
	Δ spot	C	-43.600	0.000
		C and T	-43.592	0.000
		None	-43.609	0.000
	Δ futures	C	-45.226	0.000
		C and T	-45.222	0.000
		None	-45.237	0.000

Source- Author's calculation.

Table 4. Results of co-integration

Metal	Criteria	H0	Stat.	C-Value	p-Value
Lead	Trace test	R=0	243.667	15.494	0.000
	Maximum eigenvalue test	R=0	237.015	14.265	0.000

Source- Author's calculation.

two. As the markets of lead are co-integrated in the long run now it is required to check the direction of flow of information between the series by using the VEC model. To explore the endogeneity between the markets of lead, this piece of research employs a variance decomposition test.

4.4 Analysis Based on the VEC Model

According to Samal and Das (2023), "In the price discovery mechanism between spot and futures influential direction has always remained a crucial phenomenon". Results presented in Table 5 show the long-run causal relationship of lead markets in MCX,

Table 5. VECM results

$\Delta \ln S_t$					$\Delta \ln F_t$				
$\Delta \ln S_{t-1}$	$\Delta \ln S_{t-2}$	$\Delta \ln F_{t-1}$	$\Delta \ln F_{t-2}$	€	$\Delta \ln S_{t-1}$	$\Delta \ln S_{t-2}$	$\Delta \ln F_{t-1}$	$\Delta \ln F_{t-2}$	€
-0.171** [-6.292]	-0.059 [-2.683]	0.354** [13.098]	0.095** [3.657]	0.218** [10.362]	0.103** [3.146]	0.020 [0.761]	-0.069** [-2.137]	-0.085** [-2.739]	-0.037 [-1.493]

Source- Author estimation

Table 6. Block exogeneityWaldtest

Metal	H_0(Flow of Information)	x^2- Value	P- value	Observation
Lead	Spot futures	9.933	0.007	Bidirectional
	Future spot	176.089	0.000	

Source - Author estimation

Table 7. Granger causality results

Metal	H0(Flow of Information)	F- Stat.	P- value	Observation
Lead	Spotfutures	340.395	0.000	Bidirectional
	Futurespot	7.121	0.000	

Source - Author estimation

India. The t-statistics of the "Error Correction Term" (ECT) indicate the causal relationship. The coefficient of the ECT is not significant for the spot equation therefore; it reveals that the cash market of lead has no role in the price discovery of its futures.

4.5 Analysis Based on Causality and Variance Decomposition

To identify the information flow between the markets of lead the study uses the "Granger Causality" and "Block Exogeneity Wald" tests. The results tabulated in Table 6 and Table 7 evident a bi-directional flow of information between the cash and futures market of lead. Unlike the long run, in the shortrun bidirectional causality is found between the markets. In the short run, it is observed that both markets cause each other in their price discovery.

From Table 8 it is evident that in the short run, a hundred percent of the "Forecasted Error Variance" (FEV) in futures is explained by itself in period one. In other words,the spot doesn't have any influence on the futures market. For the second period near about 0.5percent of theFEV in futures is explained spot. Therefore spot implies weak exogenoity on futures. The futures market of leadreflects strong endogeneity.

Table 8. Variance decomposition results

Cash			Futures		
Period	Spot	Futures	Period	Spot	Futures
1	76.969	23.030	1	0.000	100.000
2	47.022	52.978	2	0.546	99.453
3	37.422	62.578	3	0.698	99.302
4	32.600	67.399	4	0.747	99.253

Source - Author estimation

Table 9. Results of hedge ratio

Year	p	σ Δ cash of Lead	σ of Δ Futures of Lead	σ Δ cash /σ of Δ Futures	(h)
2013-14	0.31	1.5	1.61	0.93	0.29
2014-15	0.4	1.35	1.46	0.92	0.37
2015-16	0.52	1.80	1.72	1.04	0.54
2016-17	0.4	2.2	2.28	0.96	0.39
2017-18	0.42	1.98	2.2	0.91	0.38
2018-19	0.47	2.13	2.04	1.04	0.49
2019-20	-0.01	2.32	2.37	0.98	-0.01
2013 to 2020	**0.34**	**1.91**	**1.97**	**0.97**	**0.33**

Source - Author estimation

4.6 Analysis Based on MVH Ratio

Table 9 presents the "Minimum Variance Hedge Ratio" (MVHR) results of the lead futures market. It states that for the sub-period 2014-15 0.37 units of futures positions are needed to hold for hedging 1 unit of spot exposure. The MVHR increased to 0.54 for the sub-sample year 2015-16 because of the high scaling factor. The hedge ratio of the sub-sample period increased from the financial year 2013-14 to the year 2015-16 but after that, it started decreasing and reached 0.49 by the end of 2018-19. The hedge ratio was lowest in the sample period 2019-20 because of the lower correlation. For the full-sample year, the MVHR accounts for 0.33 units. The lead futures market reveals hedging inefficiency for all the selected sample periods.

Figure 3 depicts the volume and open interest of lead futures traded at MCX, India. Scalping index results

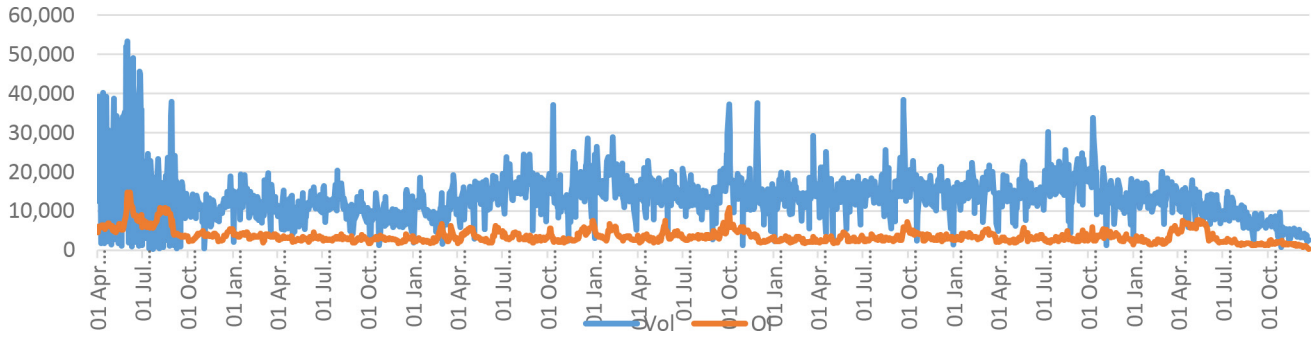


Figure 3. Volume and open interest

Source - Author estimation

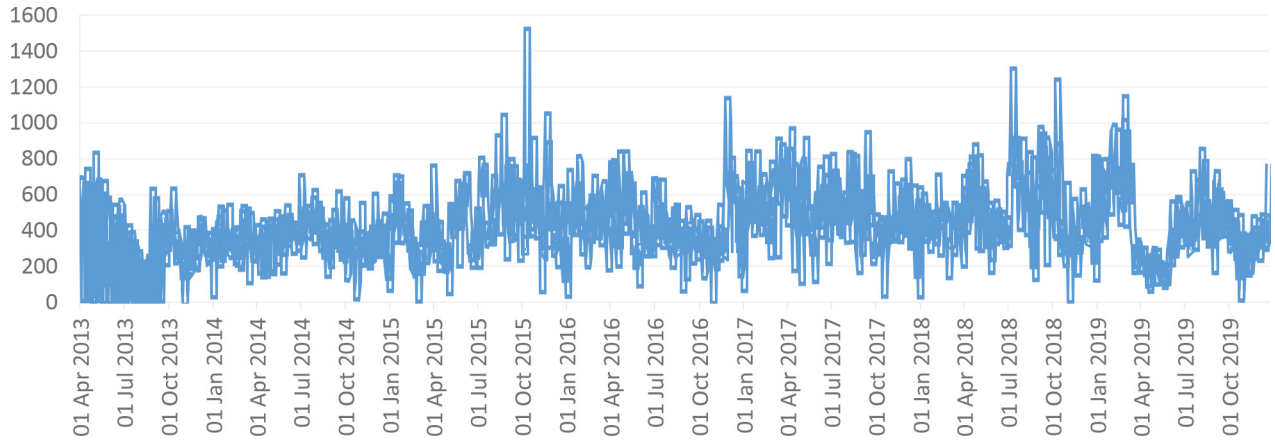


Figure 4. Scalping index.

Source - Author estimation

Table 10. Scalping index (yearly average)

Year	Lead
2013-14	323.61%
2014-15	361.86%
2015-16	470.85%
2016-17	458.33%
2017-18	486.17%
2018-19	546.69%
2019-20	362.39%
2013-14 to 2019-20	429.47%

Source - Author estimation

are presented in Figure 4. Table 10 presents the yearly average of the scalping index of the selected commodity futures. The 'scalping index' refers to the ratio of volume traded to open interest. It presents the extent of speculation in the copper futures segment. It is found that the average scalping index over the study period is almost 429 percent which indicates a large number of speculative activities in the lead futures market.

5. Discussion

The study observed the same level of fluctuation between the markets of the selected commodity. It is found that the markets of lead are co-integrated in the long run (Rout *et al*., 2021; Samal & Das, 2022). Unlike spot, the coefficient of the ECT is statistically valid for the futures market equation. Therefore it reveals the futures market of lead discovers prices of its corresponding cash market (Samal, 2024). The present study observes the unidirectional flow of information in lead markets in the long run. In contrast to the long run, in the shortrun, bidirectional causality is reported (Dey & Maitra, 2012). Unlike the spot market of lead futures market influences the spot in the initial period. During period one, more than 23 percent of the FEV in the spot is narrated by the futures. The influence of futures on the spot increases gradually and for the third period, the spot market of lead indicates strong exogenously (Arora & Chander, 2017). For period 4 more than 67per cent of the FEV in spot is explained by the

futures prices whereas more than 99 per cent of the FEV in futures is explained by futures itself. The hedge ratio was lowest in the sample period 2019-20 because of the lower correlation. For the full-sample year, the MVHR accounts for 0.33 units. The lead futures market reveals hedging inefficiency for all the selected sample periods (Erasmus & Geyser, 2024; Swain & Samal, 2017). This is due to the oligopolistic nature of the metal market (Samal, 2024).The average scalping index was found highest in the year 2018-19 which crossed more than 540 per cent. The average scalping index was found lowest in the year 2013-14. In the selected period of the study, the scalping index remains higher than 300 percent which indicates a large number of speculative activities in the lead futures market.

6. Concluding Remark

Lead is the blue-grey metal found in the earth's crust which can be recycled infinitely without deteriorating its chemical properties. It is not only ductile but also malleable and corrosion-resistant. This piece of research explores both long and short-run price discovery processes in the marketof lead. The results of causality checks identified that there exists bidirectional causality in the shortrun and unidirectional causality in the longrun between the spot and futures market of lead. In the short run price discovery is observed to be bi-directionalwhereas, in the long run, information flows fromthe futures market leadto its corresponding cash market. Spot market fails to discover the futures price of lead in the long run. It is observed that the lead futures market implies strong exogenously on the cash market.The lead futures market reveals hedging inefficiency for all the selected sample yearsdue to the oligopolistic nature of the market. It is found that the average scalping index over the study period is almost 429 percent which indicates a large number of speculative activities in the lead futures market. The average scalping index was found highest in the year 2018-19 which crossed more than 540 percent. The average scalping index was found lowest in the year 2013-14. In the selected period of the study, the scalping index remains higher than 300 percentwhich indicates speculative activities in the lead futures market.

The investors of commodity futures may consider the scalping index before deciding to invest in the market. Theimporters, exporters, and other participants can use lead futures to mitigate the spot price risk.Thispiece of paper will be helpful for the hedgers in selecting the number of contracts they should hold to mitigate the spot market risk. The regulators will be able to frame policies to develop and deepen the lead markets. As the paper selects only one metal commodity, this may not provide the market scenario of all the commodity futures contracts traded. Hence future studies will consider agro commodities and precious metals. Further, the period of the study can be extended. A cross-country comparison among the emerging economies commodity futures market is left for future research.

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