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Empirical Study on Price Discovery Role in Non-Precious Metals Market in India

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Abstract

Demand for most industrial metals signifies the pick-up in the level of economic activity in the country. Industrial metals saw asubstantial increase in trading interest onMulti Commodity Exchange, which raises the need to analyse the market efficiency and the relationship between spot and futures market.Statistical tools like ADF, Johansen Co-integration Test and Vector Error Correction Model (VECM) are applied to see the lead lag relationship between spot and future market of various industrial metals like Copper, Aluminium, Nickel, Lead and Zinc. Empirical results prove bidirectional causality and Spot market adjusts at a faster pace to restore long-run equilibrium in most of the industrial metals.

Keywords: Future Price, Johansen Co–integration Test, Metals, Spot Price, Vecm Granger Causality Test

1. Introduction

There has been a significant rise in trading interest in industrial metals on MCX, India. All non-precious metals together has seen a compounded annual growth rate of 38% over 2006-2013 (Figure 1). This has led to non-precious metals being amongst the most widely traded commodities on the exchange (Figure 2). Efficiency of Futures market is believed to play a significant role in price discovery and hedging. Price discovery is the process of unearthing the assets full information[13]. It is generalized that Futures market are efficient risk management tool which insulate the participants from unexpected changes in the commodity price movements as futures prices more quickly respond to new information due to lower transaction costs and flexibility of short selling[3]. On the other hand, futures market are also criticised for rise in prices due to speculative activities. This makes the futures market role in price discovery and efficient market hypothesis the most debated.

The price discovery function aims to explain whether price changes in futures markets lead price changes in spot markets or vice versa[15]. Effective price discovery function requires the participation by different players like investors, producers, arbitrageurs, consumers, brokers, etc. Also lack of volumes implying thin markets are expected to be inefficient as low trading volumes would mean a poor reflection of information. For Efficient market hypothesis to hold true it is understood that the prices in both the markets reflect the new information within instantaneous time. However empirically many times it is proved that futures market play dominant role in price discovery and spot market are satellite or follows the change and reflects new information after a time lag[8, 13, 15]. As opposed to these,[3, 16] observed spot market to lead. Many others have observed bidirectional causality indicating that the market is efficient and no lead lag is observed[6, 17, 28]. The lack of conclusive statement on price discovery creates scope for further examination of the issue.

1.1 Indian Metal Market Scenario

Trade in industrial metals have picked pace and has grown at CAGR of 38% over 2006-2013. Spot and future price movement for all metals under study have been given in Figure 3.

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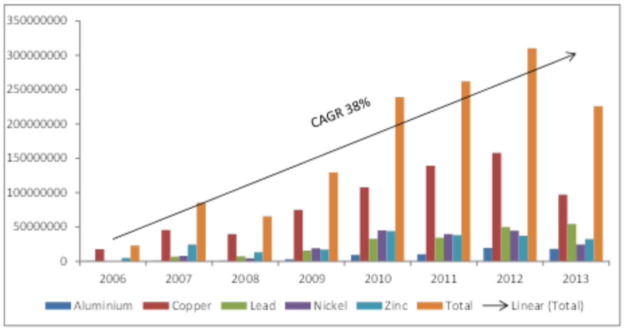


Figure 1. Value of trade (Rs. Lakhs) of Industrial Metals.

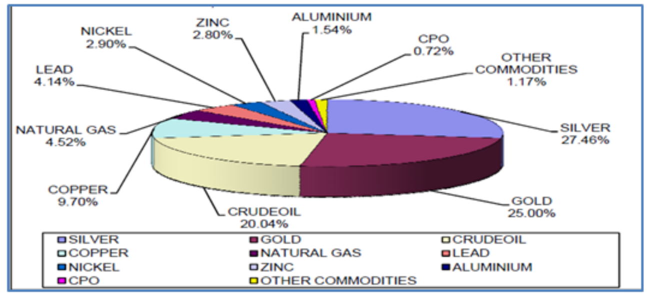
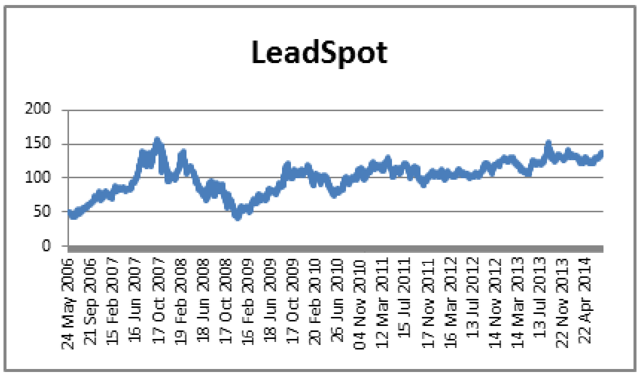
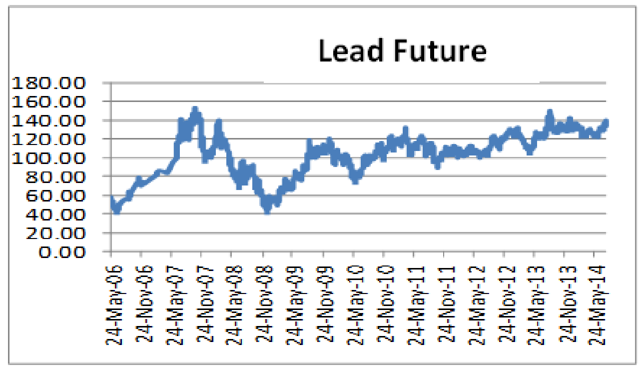
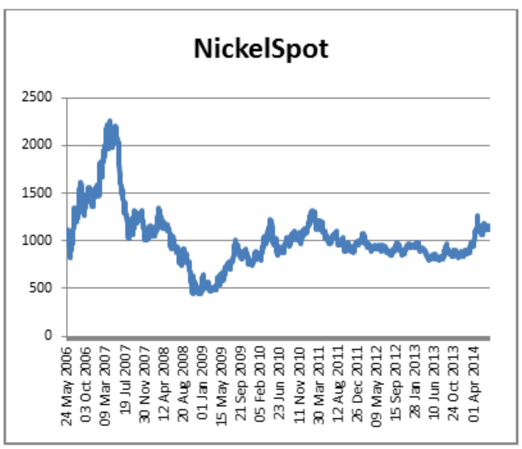
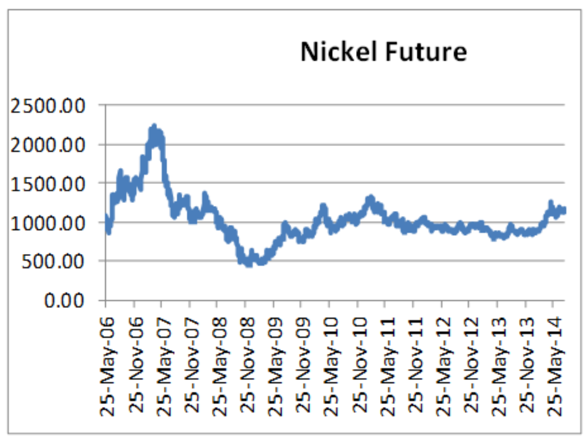


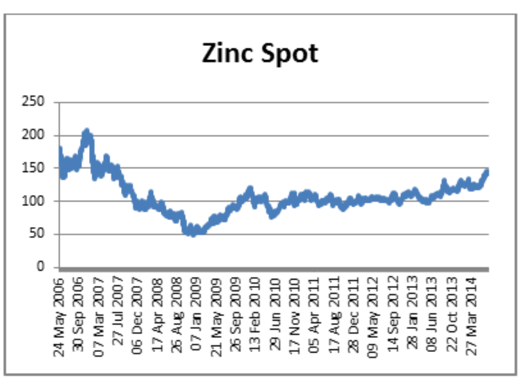
Figure 2. Percentage share of the value of commodities traded at MCX. Source: Forward Market Commission's Annual Report 2013[14].

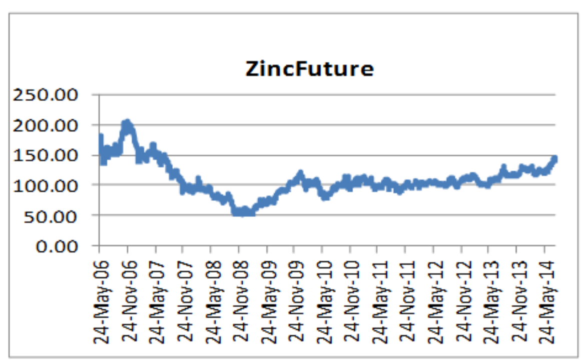












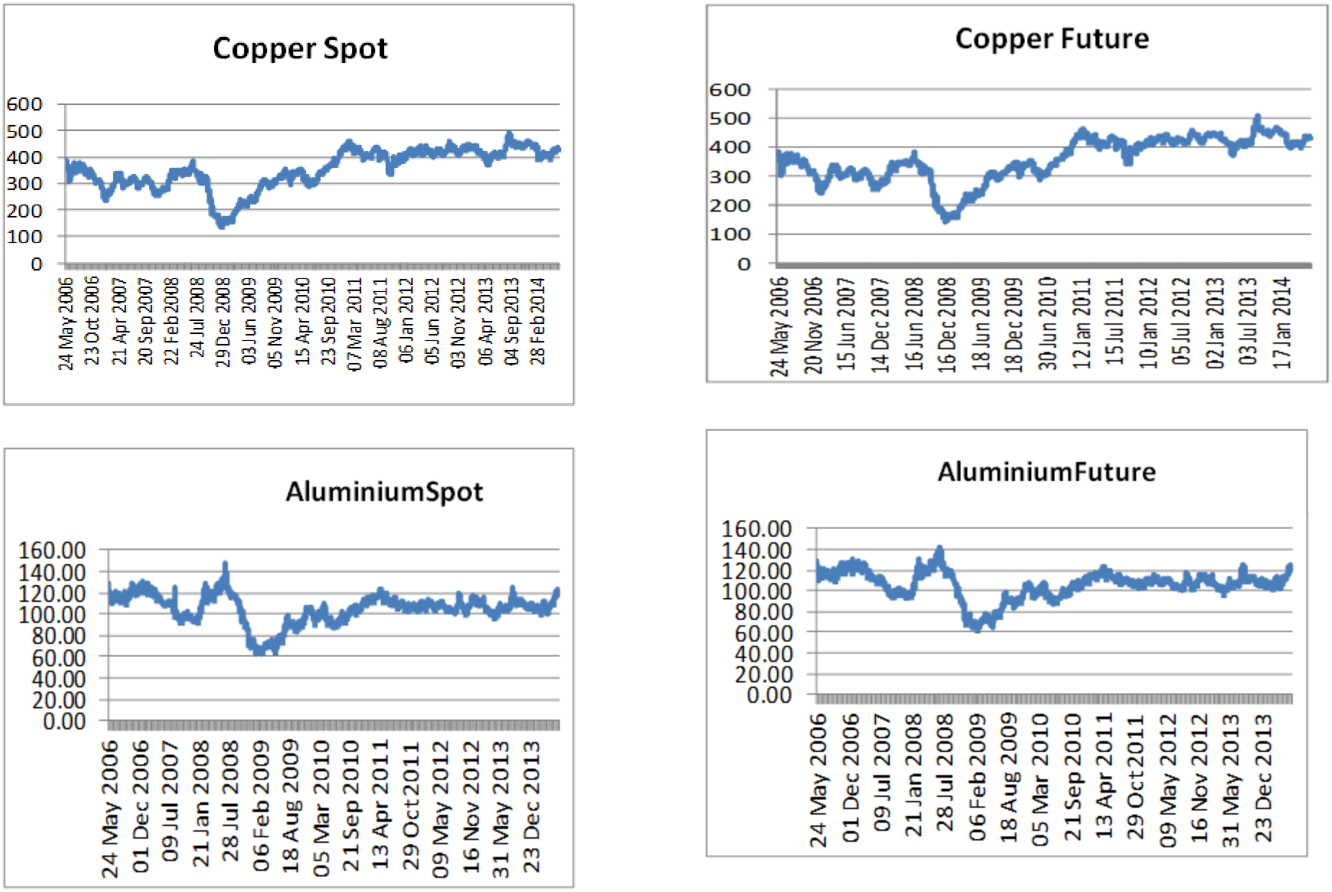


Figure 3. Daily spot and future price at MCX, India.

2. Literature Review

2.1 Literature Review on Lead-lag Study between Spot and Futures Market – General Overview of National and International Work

Researchers world over have studied the pattern of causality between spot and future prices in different commodities. The studies conducted have shown mixed and in conclusive results. Limited study has taken place in India concerning the cointegration and lead-lag dynamics on non-ferrous industrial metals.One of the earlier and the most cited studies is that of (Garbade & Silber, 1983)[15] who took 7 different storable commodity contracts (wheat, corn, oats, orange juice, copper, gold and silver) traded on Chicago Board of Trade (CBOT) and COMEX. For majority of the commodities, the study observed that future drive spot; more than 75% of information is captured in the future market (for wheat, corn and orange) which is then captured by spot market. Further, (Choksi, 1984)[7] studied copper contract on London Metal Exchange for the 1969-1974 and founding general future prices to be far more stable than spot prices and the variation in prices is a function of future expectation of currency movement and excess demand for copper. Researcher highlighted that for the purpose of pricing, future market serves as a primary market. Defending the speculative allegation on the Futures market,(Edwards, 1988[11] postulated that futures volatility showcases quick reaction by future market to the any new information floated which then is reflected in spot market. Further building on the seminal work of Fama et al.(1988), (Ng & S., 1994) explained strong link between fundamental demand-supply condition and volatility in metal prices. The researchers have studied the fundamentals of supply-demand conditions and its impact on variance and correlation between forward prices and spot prices as also the impact on spread between them. The study undertaken with reference to 4 industrial metals (Aluminium, Copper, Lead, and Zinc) and 1 precious metal (Silver) for the period 1986-1992; resulted in confirming the theory that the spot-and-forward returns are strongly related to variations in fundamental demand-supply conditions in case of industrial metals. For the commodity Silver, the results differ as agents hold large inventories of these metals as a value accretion. Reasoning liquidity in most metal contracts traded on London Metal Exchange (LME) to play a vital role in the price discovery[13]. The researchers studied the price discovery role of futures market by developing a model to capture existence of contango or backwardation in the long-run spot-future equilibrium relationship. They developed on the Garbade and Silber[15] methodology an equilibrium model of commodity future and spot prices where the elasticity of arbitrage services and convenience yields is considered finite. The model when applied to prices of non-ferrous metals (aluminium, copper, Nickel, Zinc, and Lead) from LME found that for all the metals having liquid futures market, price discovery takes place in futures price. Lead metal was an exception to this finding. Further in Indian context,[4] studied two agriculture commodities, to understand the efficiency and volatility spillover effects between the futures and spot market. They observed that the futures market played active price discovery role in the spot market.

There is also evidence of spot market leading the futures market. (Choudhary & Bajaj, 2012)[9] studied price data for 31 securities for the period April 2010-March 2011. They studied the role of information transfer and price discovery for future and spot prices of securities. The study proved cointegration between series using Johansen Cointegration and Engel Granger residual approach. They proved that spot market leads the futures market in case of 19 securities and vice versa in case of balance 12 securities. Also (Figuerola-Ferretti & Gonzelo, 2010)[13] in case of Lead metal reported spot price to lead futures prices as futures contract for Lead had least liquidity on LME and hence spot price was reported information dominant. Further (Lokare, 2007)[21] studied the efficacy and performance of commodity derivatives in steering the price risk management. He studied the comovement between the spot and futures prices of various agriculture (Rice, wheat, Sugar, Rubber, cotton, Mustard, etc) and non-agriculture commodities (Gold, copper, lead, zinc, brent crude oil, Furnace oil,etc) using cointegration framework. Results of cointegration for almost all the commodities show an evidence of co-integration in both spot and future prices, indicating that there is operational efficiency. Volatility in futures market (standard deviation of prices) is studied to analyze the price discovery role of future market. The volatility in the future price has been substantially lower than the spot price in case of some commodities indicating an inefficient utilisation of information.

Another set of researchers suggested feedback causal relation between spot and futures prices of commodities indicating that both market react instantaneously to the information. For example, (Chen & Lin, 2004)[5] studied the linear and non linear causality between spot and futures price of Lead metal from London Metal Exchange. Other variables used in the causality study were inventory and UK Treasury bill interest rate. The study observed cointegration adjusted bidirectional causality between spot and futures price of Lead metal. Further in similar vein, (Chopra & Bessler, 2005)[8] studied the question of price discovery in the spot or futures market for commodity-pepper based on data from IPSAT market, Kerala for period October 2001 to February 2003. Researchers have observed one cointegrating relationship between spot price, nearby month future price and first distant month future price. Further the researchers have found that the price discovery function happened in both the future price series (nearby and first distant market) and that the spot market responds to this information reflected in the two futures contract within contemporaneous time. They employed cointegration Trace test to study the number of cointegrating vectors between the 3 price series. After that the researcher employed test on exclusion of series from the cointegrating space. They further employed directed acyclic graphs to study the interrelationship among the 3 series. Further, (Dash & Andrews, 2010)[10] studied the market behavior in terms of contango and backwardation and also the causality with reference to many agriculture commodities, non-agriculture commodities (cotton, menthe oil) and metals (gold, silver and aluminium ingots). They observed that for most commodities under study price discovery mechanism proved effective and that there was bi-directional causality between futures and spot.In similar vein, (Purohit, Chhatwal, & Puri, 2012)[28] examined the cointegration between spot and futures market for crude oil for the period 2006-2010. The study concluded by proving bi-directional causality between spot and futures market. The study employed VECM model to test causal relation.

Yet another argument highlighted by literature is no consistent lead-lag relation between the spot and future prices. This generally can be attributed to exogenous factors or policy level changes that may impact the relation. For example,[3] studied the linear and non-linear causality between spot and futures price for west texas intermediate crude oil for the period 1991-2007. They found no consistent lead-lag relation between the prices. Further, (Jackline & Deo, 2011)[17] examined the relationship between the futures and spot market for the commodities like lean hogs and pork bellies. The researchers observed that there was no lead lag relationship between the two markets for both the commodities under study. The result provided the evidence that there was no profitable arbitrage that exists and that the selected markets were perfectly efficient. Hence they concluded that there was no profitable arbitrage opportunity.

As can be observed from the above analysis, no conclusive empirical relation is established between the two price series. This leaves a scope for further study in this direction.

2.2 Literature on Lead-lag Study in India – Focusing on Industrial Metals

This paper attempts to empirically investigate the relationship existing between the spot and futures market of non-precious metals as no substantial work on causality effects has been carried out using industrial metals in India. With the trade in industrial metals gaining momentum on MCX, the study is likely to benefit the traders and regulators to take informed trading decision.

(Lokare, 2007)[21] studied the volatility and basis risk for many agriculture commodities, metals, oilseeds and some other commodities. He tested efficiency in the markets but did not test causality. Further the period for which non-precious metals are studied is short (2003 only). (Iyer & Pillai, 2010)[16] in their study of price discovery and convergence in the markets had considered copper and nickel for the period 2005-2008 out of the industrial metals category. They further studied the rate of the convergence of information from one market to another to understand whether futures market is an effective hedge tool. The study used Engle granger approach, ECM and Granger causality to test cointegration and information flow between spot and futures market. Mixed result were obtained i.e., in case of copper, unidirectional causality was found to run from futures to spot market. In case of Nickel, spot market leads futures. Further, (Dash & Andrews, 2010)[10] studied market behavior and causality between spot and futures of certain agricuture and non-agri commodities traded on NCDEX. From industrial metals, they had considered only Aluminium ingot for 2005-2007. They found Aluminium ingot prices to be a contango market for about 69% times anda bi-directional causality relation was found between spot and futures prices. Similarly[1] studied causality between spot and near month future price for two metals i.e. copper and aluminium for 2006-2011. By applying Vector Error Correction Model based on cointegration, they found bi-directional causality in spot and futures market.

As to the best of our knowledge, no comprehensive study is carried out with reference to all industrial metals in India. The paper focuses on five metals i.e. aluminium, copper, nickel, lead and zinc and covers fairly large period from 2006-2014 based on data availability. Moreover, with the strong growth of the commodity derivative market in India, it would be interesting to test which of the two markets (spot or future) reacts faster. Industrial metals have become a substantial part of the trading activity on MCX, India. The objective of the paper is to examine whether their exists long-run relationship between the future price and the underlying spot market for non-precious metals and to explore the causal relation between the two markets. An understanding of lead-lag relationship between spot and future market can help the investors maximize their returns by understanding that the impact of any information influencing the performance of the non-precious metals in India will be visible in which market first - spot or future. This would help the market participants to understand what kind of strategy can be framed when dealing in industrial metals.

3. Sample Size and Data Collection

The Multi Commodity Exchange of India Limited (MCX) is anlargest online national level commodity exchange established in November 2003. It offers futures trading in vast array of commodities like agriculture (cereals, pulses, oil and oil seeds etc), energy, metals (ferrous and non-ferrous metals), Fiber, Weather (carbon credits), Bullion, Plantation, etc. The daily closing price for Aluminium, Lead, Zinc, Nickel and Copper in spot market and near month futures contract is used for the study. MCX also offers mini-contracts in many of these metals. We have not considered mini-contracts in the study due to their recent origin. By concentrating on these five important base metals, the study will help to postulate the general nature of industrial metals prices and causal relationship in base metals market. The sample period covers daily prices starting from May 2006 to August 2014. The contracts gained momentum in these commodities in later part of 2005; hence we selected the period from 2006 and onwards. Data pertaining to price series were collected from the MCX, India website.

4. Research Methodology

We have applied the Vector Error Correction Model after studying the cointegrating relationship between spot and futures market.

4.1 Test of Stationarity

At firstvariables were checked for stationarity. As the study deals with time series data, to avoid spurious results the data is tested for stationarity using Augmented Dickey Fuller test. It helps to determine the order of integration of time series variables. An I (0) series is stationary in level, whereas, an I (1) series is random walk and achieves stationarity with differencing. The ADF test uses the existence of a unit root as the null hypothesis using the equation

$$\Delta Y_t = \beta_1 + \beta_2 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \in_t \quad (1)$$

Where, $\in_t$ represents error term, $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc.

The null hypothesis is that $Y_t = Y_{t-1} + \in_t$, where $\in_t \sim NID(0, \sigma^2)$.The null hypothesis of non-stationarity is rejected, if coefficient of Y_{t-1} is significantly different from zero.

4.2 Test of Cointegration

Once the order of integration of variables is established, it is necessary to check for cointegration between them to know whether we are modelling an empirically meaningful relationship. To study whether there islong term equilibrium relationship between the future and spot price, Johansen Cointegration test is used. Cointegration test would help to analyze the existence of any stationary linear combination among the non-stationary variables of same order. Futures market serves as an effective risk management tool if future prices are tightly linked to the prices in spot market[29]. If any linear combinations are found, it will indicate the existence of long run inter-linkages between the series. Two of the most widely used cointegration models by prior researchers are those proposed by (Engle & Granger, 1987)[12] and (Johansen S. , 1995)[18].

The paper tests cointegration between variables using Johansen co-integration test [18, 19]. Johansen cointegration test is widely used tool to test cointegration. It helps understand whether long-run relationship exists between variables. The test is applied to data in levels form.Further as Johansen cointegration method is sensitive to lag order selection. We estimate appropriate lag length based on Schwarz information criterion. Johansen co-integration methodology takes its starting point in the Vector Auto Regression (VAR) of order P given as

$$y_t = A_1 y_{t-1} + \ldots + Ap\, y_{t-p} + Bx_t + \in_t \quad 2.$$

Where, y_t is a vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables, and $\in_t$ is a vector of innovations. We may further rewrite the VAR as

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t \in_t \quad 2.1.$$

Another most important aspect is that of having deterministic component in the model; i.e. whether an intercept and/ or trend should enter in the cointegrating equation and VAR. We have allowed for linear deterministic trend in data with intercept in cointegrating Equation as the time series are showing a stochastic trend. Further, Johansen cointegration method uses trace test and maximum eigenvalue test to determine number of cointegrating associationship between variables. The tests are formulated as given below

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i) \quad 2.2$$

And

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad 2.3$$

Where, r is the number of cointegrating vectors under the null hypothesis, λ_i is the estimated value for the i^{th} ordered eigenvalue from the Π matrix.

(Refer to (Asteriou & Hall, 2007) for further explanation[2])

4.3 VECM Granger Causality Test

The causality between future and spot market is studied by employing VECM Granger Causality test. This test has been employed by (Purohit, Chhatwal, & Puri, 2012)[1, 4, 20, 28] to name a few. The study uses the log returns of the raw data for further process of understanding Causation.

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \quad 3.$$

Where

P_t = present price of commodity, P_{t-1} = previous period prices of commodity

The lead-lag relationship between the future and spotmarket will be treated with the help of VECM granger causality test. It is to be noted that regression analysis deals with the dependence of one variable on the other but it does not essentially mean causation. Granger (1988) pointed out that if spot and futures prices are cointegrated then causality must exist in at least one direction. Finding of cointegration between variables help to represent each series by an error correction model which includes last period's equilibrium error with adding intercept term as well as lagged valuesof first difference of each variable. The casual relationship can be studied by examining thestatistical significance and relative magnitude of the error correction coefficient and coefficient on laggedvariable. Consider the VECM specification as under.

$$\triangle F_t = \propto + \delta_f \hat{e}_{t-1} + \sum\nolimits_{i=1}^{n} \beta_i \Delta S_{t-i} + \sum\nolimits_{i=1}^{n} \propto_j \Delta F_{t-j} + \mu_t \quad 4.$$

$$\Delta S_t = \propto + \delta_s \hat{e}_{t-1} + \sum\nolimits_{i=1}^{n} \beta_i \Delta F_{t-i} + \sum\nolimits_{j=1}^{n} \propto_j \Delta S_{t-j} + \in_t \quad 5.$$

Where, S = log return Spot Price, F= log return of Futures Price, and = Error term, is the equilibrium error which measures how the dependent variable in one equation adjusts to the previous period's deviation that arises from long run equilibrium, is a difference operator.

For testing VECM causality between spot and future price of underlying commodity, optimal lag length of each series were tested by using the Schwarz information criterion. The Error correction term measures long run associationship. A significant coefficient of error correction term indicates the presence of long-term causal relation (Granger,1988). For example, in Eq.4, if is significant, this will suggest that future price will adjust to attain equilibrium when deviation from equilibrium takes place. Short run causal relation can be established if the coefficients of lagged variables (jointly are not equal to zero. We used Wald diagnostic test for this purpose.

5. Empirical Results

SIBM Pune Research Journal, Table 1 provides the descriptive stats for all the industrial metals spot and futures price of near month contract. The Jarque-Berastatistic indicates that time series data is not distributed normally. High standard deviation is observed in case of Nickel prices indicating wide fluctuation in the prices. The mean values of Spot price are found to be lower than future price of near month contract for all the metals.

5.1 Test of Unit Root

At first it was checked whether each series are stationary. We applied the Augmented Dickey Fuller test (ADF) to raw data series which proved non-stationary (results are

Table 1. Descriptive statistics

Parameters	Lead		Nickel		Zinc		Aluminium		Copper	
	S	F	S	F	S	F	S	F	S	F
Mean	104.3	104.7	1020.3	1022.9	107.5	108.2	103.4	104.0	364.1	366.0
Median	107.5	108.1	957.5	959.9	103.6	104.0	105.8	106.8	396.6	399.7
Maximum	156.4	152.5	2259.9	2240.0	207.3	205.9	146.6	142.3	497.6	510.0
Minimum	41.5	42.1	439.9	455.0	49.5	51.0	62.6	63.4	135.7	141.4
Std. Dev.	23.0	22.8	310.9	304.3	27.9	27.8	13.9	13.9	78.9	79.3
Skewness	-0.7	-0.7	1.5	1.5	0.8	0.8	-1.0	-1.0	-1.0	-1.0
Kurtosis	3.1	3.1	6.6	6.4	4.3	4.3	4.1	4.0	3.3	3.2
Jarque-Bera	184.5	191.4	2114.1	1972.4	432.4	417.8	371.9	364.6	344.9	316.7

S stands for Spot and F stands for Future not produced here). Table 2 shows ADF test applied on log returns of copper, zinc, aluminium, lead, nickel spot and future prices. It was observed that there turn series proved stationary by rejecting null hypothesis of unit root as the observed t-statistic is more than the critical values.

As observed from Table 3, the Johansen cointegration test, both Trace statistic and Maximum Eigen value test, indicates at least 1 cointegrating equation. This means that the spot and future price share a common stochastic trend and will move together in the long-run. Hence the null of no cointegration is rejected and spot and future price for all metals share a long-term cointegrating relationship. As for all metals, the cointegration relationship is established between spot and future price; there has to be a valid Error correction term between them. We further proceed to understand the causal relationship between them.

Table 2. Results of ADF test for stationary of data

Commodities	Null hypothesis	ADF test	
		t-statistic	p-value
LEAD	Spot price has unit root	-49.8252	0.0
	Futures price has unit root	-29.8321	0.0
NICKEL	Spot price has unit root	-48.0132	0.0
	Futures price has unit root	-46.9192	0.0
ZINC	Spot price has unit root	-51.4274	0.0
	Futures price has unit root	-47.3107	0.0
COPPER	Spot price has unit root	-52.9288	0.0
	Futures price has unit root	-49.5608	0.0
ALUMINIUM	Spot price has unit root	-56.6364	0.0
	Futures price has unit root	-48.8388	0.0

Test critical values at 1%, 5% and 10% levels are -3.433, -2.862 and -2.567 respectively

5.2 Vector Error Correction Model Estimates

The coefficient of cointegrating equation i.e. the Error correction term is statistically significant and negative in case of all the industrial metals when VECM is estimated using commodity futures as dependent variable. The Error correction coefficient indicates that futures price adjusts in order to establish long-run equilibrium. In the equation with future returns as dependent Variable; the lag values of spot returns are significant up to 6 lags in case of Lead, Zinc and Aluminium indicating that spot returns has an impact on future return for 6 days. In case of Nickel and Copper; spot returns are significant up to 5 lags and 7 lags respectively.

Further, the Wald test of coefficient diagnostic on lagged terms of spot prices reject the null hypothesis that coefficient of spot return have no impact on future return (expressed as spot(-1)=spot(-2)=…=spot(-n)=0). The P-value result of Wald test is given in Table 4. This indicates that in short run there is granger causality from spot to future price.

Further, we estimated VECM with commodity spot as dependent variable. As can be observed from Table 5, the coefficient of cointegrating equation is found statistically significant in case of all the industrial metals. This indicates that spot prices also adjust in response to previous period's deviation from equilibrium. Further, it is observed that lags of future return are found statistically significant indicating the impact of future returns on spot return. In case of Lead and Copper, up to 7 lags of future return are found significant indicating the impact of future return on spot return for 7 days. For Aluminium,

Table 3. Results of cointegration

Cointegration between variables	No. of Cointegrating Eq.	Trace test				Maximum Eigenvalue			
		Eigen value	Statistic	CV at 0.05	P-value**	Eigen value	Statistic	CV at 0.05	P-value**
Lead Spot and Futures	H0: r=0 (None)*	0.07	165.55	25.9	0.00	0.07	155.92	19.4	0.00
	H1: r ≤ 1 (At most 1)	0.0	9.63	12.5	0.14	0.004	9.63	12.5	0.14
Nickel Spot and Futures	H0: r=0 (None)*	0.1	228.6	15.5	0.0	0.1	225.3	14.3	0.0
	H1: r ≤ 1 (At most 1)	0.0	3.3	3.8	0.1	0.0	3.3	3.8	0.1
Zinc Spot and Futures	H0: r=0 (None)*	0.1	297.1	25.9	0.0	0.1	288.3	19.4	0.0
	H1: r ≤ 1 (At most 1)	0.0	8.8	12.5	0.2	0.0	8.8	12.5	0.2
Copper Spot and Futures	H0: r=0 (None)*	0.1	168.1	15.5	0.0	0.1	165.7	14.3	0.0
	H1: r ≤ 1 (At most 1)	0.0	2.3	3.8	0.1	0.0	2.3	3.8	0.1
Aluminium Spot and Futures	H0: r=0 (None)*	0.1	300.1	15.5	0.0	0.1	296.5	14.3	0.0
	H1: r ≤ 1 (At most 1)	0.0	3.6	3.8	0.1	0.0	3.6	3.8	0.1

Trace test indicates 1 cointegratingeqn(s) at the 0.05 level, Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values, * denotes rejection of the hypothesis at the 0.05 level

Table 4. Vector error correction model for commodity futures as dependent variable

Commodity Future Variables	Lead (lag length = 8) Coeff. T-value	Zinc (lag length = 6) Coeff. T-value	Nickel (lag length = 5) Coeff. T-value	Aluminium (lag length = 6) Coeff. T-value	Copper (lag length = 7) Coeff. T-value
Coint Eq	-0.196 - 5.456003*	-2. 576 22. 66922*	-1.372 -11.87608*	-0.623 -4350333*	-0.744 -2.901725*
Futures (-1)	-0.076 - 0.476659	1.086 10.607*	0.394 3.77661*	-0.290 -2.127519*	-0.171 -0.673171
Futures (-2)	-0.081 - 0.559201	0.711 8.187409*	0.304 3.477842*	-0.222 -0.839488*	-0.104 -0.44293
Futures (-3)	-0168 - 1.312069	0.403 5.800338*	0.132 1.921019	-0.203 -2.018244*	-0.112 -0.54847
Futures (-4)	-0.170 - 1.569205	0.177 3.445963*	-0.031 -0.627121	-0.148 -1.910652*	-0.041 -0.241934
Futures (-5)	-0.251 - 2.80465*	0.018 0.554694	-0.031 -1.067628	-0.109 -2.020812*	0.035 0.275766
Futures (-6)	-0.157 - 2.264913*	-0.056 3.326444*		-0.049 -1.631387*	0.095 7.093038
Futures (-7)	-0.209 - 4.240387*				0.018 0.38264
Futures (-8)	-0.105 - 3.615116*				
Spot (-1)	-0.729 - 4.724418*	-1.679 16.94041*	-1.009 -10.902*	-0.555 -4.198673*	-0.007 3.013565*
Spot (-2)	-0.548 - 3.910856*	-1.206 13.75899*	-0.772 -9.883188*	-0.461 -4.051661*	-0.006 -2.873826*
Spot (-3)	-0.401-3.574997*	-0.830 11.39944*	-0.485 -7.935852*	-0.345 -3.765606*	-0.005-2.932171*
Spot (-4)	-0.310-2.977685*	-0.510 -9.09695*	-0.267 -6.21395*	-0.253 -3.708745*	-0.004 -3.428184*
Spot (-5)	-0.199-2.35698*	-0.256 6.666648*	-0.108 -4.508627*	-0.188 -4.200704*	-0.004 -4.660189*
Spot (-6)	-0.159-2.4852048*	-0.084 4.150987*		-0.087 -3.928402*	-0.002 -4.636441*
Spot (-7)	-0.076-1.733867				-0.001 -5.074666*
Spot (-8)	0.036-1.513784				
C	0.000 0.055707	0.000 0.042306	0.000 -0.028551	0.000 0.049788	0.000 0.001607
R squar	0.469	0.690	0.427	0.441	0.463
Adj. R-sq.	0.465	0.689	0.424	0.438	0.460
SE Equation	0.021	0.013	0.021	0.014	0.017
Durbin-Watson	2.026	2.017	2.033	2.033	2.025
F-Statistic	110.151	400.208	157.241	142.314	134.305
Wald test (Co-eff. Spot(-1)... Spot (-n)=0 (P-value	0.0000*	0.0000*	0.0000*	0.0002*	0.0000*

Note: *denotes the rejection of null hypothesis 5 per cent level of significance.

significant impact of future return on spot return is observed up to 5 lags. Impact of future return on spot return is observed in case of Zinc for up to 2 lags and in case of Nickel; only at 5th lag. This might be attributed to lower trading volumes in futures market in both of these metals.

Further, the Wald test of coefficient diagnostic on lagged terms of future return jointly, reject the null hypothesis that coefficient of future return have no impact on spot returns (expressed as Future(-1)=Future(-2)=…=Future(-n)=0). The P-value result of Wald test is given in Table 5. This indicates that in short run there is granger causality from future to spot price.

Over all, the coefficient of ECM in both the equations with futures and spot as dependent variables respectively, suggest that when the cointegrated series are in disequilibrium, both the series, i.e. futures prices as well as spot prices adjust in order to re-establish the equilibrium. The adjustment coefficient of ECM in case of Lead, Nickel, Aluminium and Copper indicate faster adjustment to the long run equilibrium is brought about by change in spot price. Thus, bidirectional causality is found from futures to spot and spot to futures in case of all industrial metals.

6. Conclusion

We investigated the price discovery role of spot and futures

Table 5. Vector error correction model for commodity spot as dependent variable

Commodity Future Variables	Lead (lag length = 8) Coeff. T-value	Zinc (lag length = 6) Coeff. T-value	Nickel (lag length = 5) Coeff. T-value	Aluminium (lag length = 6) Coeff. T-value	Copper (lag length = 7) Coeff. T-value
Coint Eq	-2.889 - 15.262228*	-0.669 3.994662*	-1.378 -12.47439*	-3.118 -22.46798*	-3.459 -27.14117*
Futures (-1)	-1.470 - 8.273127*	-0.315 1.964335*	0.119 1.197159	-1.481 -11.67323*	1.794 15024521*
Futures (-2)	1.196 - 7.424852*	-0.281 1.977622*	0.000 -0.003515	-1.027 -9.409868*	1.257 12.18301*
Futures (-3)	0.943 6.683173*	-0.214 -1.814665	0.038 0.586244	-0.653 -7.414054*	0.878 10.27343*
Futures (-4)	0.696 5.815535*	-0.130 -1.430674	-0.052 -1.127195	-0.345 -5.257683*	0.524 7.899862*
Futures (-5)	0.502 5.169481*	-0.078 -1.263945	-0.055 -2.143718*	-0.127 -2.965689*	0.281 6.101105*
Futures (-6)	0.276 3.782751*	-0.019 0.592516		-0.031 -1.432844*	0.112 2.067928*
Futures (-7)	0.177 3.509815*				0.020 2.067928*
Futures (-8)	0.048 1.763597				
Spot (-1)	-2.222 - 12.14957*	-0.552 3.331308*	-0.891 -7.992869*	-2.238 -17.1079*	-255.924 -19.5092*
Spot (-2)	-1.760 - 10.58062*	-0.444 3.162493*	-0.565 -6.045477*	1.603 -13.82903*	-185.907 -15.39468*
Spot (-3)	-1.395-9.479759*	-0.391 3.476805*	-0.370 -5.021224*	-1.104 -11.43647*	-127.991-12.1523*
Spot (-4)	-1.069-8.553099*	-0.334 4.016152*	-0.267 -5.023682*	-0.677 -9.081208*	-86.968 -10.05837*
Spot (-5)	-0.831-8.07358*	-0.278 5.156538*	-0.117 -3.766357*	-0.388 --7.476142*	-51.561 -7.810668*
Spot (-6)	-0.505-6.339152*	-0.205 7.486716*		-0.139 -4.81001*	-26.865 -6.001641*
Spot (-7)	-0.411-7.245298*				-9.778 -4.092905*
Spot (-8)	0.160-1.774143*				
C	0.000 0.061731	0.000 0.02668	0.000 -0.072506	0.000 0.120867	0.002 0.121796
R squar	0.601	0.478	0.524	0.700	0.899
Adj. R-sq.	0.598	0.475	0.522	0.698	0.899
SE Equation	0.024	0.021	0.023	0.013	0.887
Durbin-Watson	2.016	2.044	2.032	2.027	2.011
F-Statistic	187.356	164.447	232.468	420.426	1387.386
Wald test (Co-eff. Spot(-1)... Spot (-n)=0 (P-value	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*

Note: *denotes the rejection of null hypothesis 5 per cent level of significance.

market for non-precious metals. Aluminium, Copper, Lead, Nickel and Zinc prices from Multi Commodity Exchange of India are analysed. The study concludes that spot and future prices of non-precious metals share a long term cointegrating relationship. Vector Error correction Model based on cointegration method is used for analysis. The results of the test indicate that the spot and future prices for all non-precious metals are found to beI (1) and attains stationarity in first difference form. They are found cointegrated in long-run.VECM results reveal strong evidence of bi-directional causality in case of all of the non-precious metals. Spot market does not appear to be just a satellite of the futures market. They have a role to play in price discovery process.

The lead lag relationship highlights that there exist no exploitable profitable arbitrage opportunity in these markets when daily data is analyzed. Industrial metals unlike precious metals have limited use as investment property. Bidirectional causality from future to spot and from spot to future indicates that two variables may be used to forecast each other effectively. Further, it is observed that when futures prices and spot prices deviate from the equilibrium, the spot prices will tend to correct faster to restore equilibrium relation.

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