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Background: Commodity markets are rapidly changing across the globe due to technological and financial innovations. The introduction of commodity exchanges and futures trading has significantly affected their price discovery with ramifications for the commodity users and traders. The price discovery mechanism in commodity markets is dynamic and needs regular reassessment.

Objective: This paper aims to determine the price discovery mechanism (the relation between spot and future prices) of gold in the Indian commodity markets for the ten years between 2011-2020 and the direction of the price influence.

Materials & Methods: The current study uses daily gold price data between January 1st, 2011, and December 31st, 2020, from India's Multi Commodity Exchange (MCX). It uses a battery of econometric tools and techniques to understand the relation between the spot and future prices of gold in MCX and its causal direction

Results: The results reconfirm the influence of spot prices of gold on its futures price in the Indian commodities market, which is unidirectional from spot to the futures price.

Conclusion: The study results reconfirm the contrarian nature of gold as a commodity and an investment and reaffirm its status as a safe haven for investors.

Keywords

Gold Market, Price Discovery, VECM, Cointegration, Contrarian, Safe-haven

Examining Prices Discovery in the Gold Market: Evidence from India

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1. Introduction

Commodity markets are rapidly changing. The last two decades have experienced dramatic changes in the world commodity markets. The market setting has changed due to the appearance of new financial setups, deregulation of older markets, economic and technological innovations, and a considerable rise in the consumption of commodities. Due to robust world demand, tight supply, and sensitivity to geopolitical circumstances and climatic conditions, commodity spot prices continue to set new records. The same has been amply aided by recovery from the pandemic and increasing vaccination levels in developed and developing countries. Exploring more on commodity markets, one can observe that the economic environment extended by financial globalization has improved opportunities for trading commodity derivatives. India is one of the largest consumers of gold globally, with the demand for gold increasing from 828.5 tonnes in 2014 to 848.9 tonnes in 2017. The demand for gold remained firm even during a range of challenges, underlining the role of gold as an essential component in household savings and reinforcing the need to bring gold into the financial structure. India's gold consumption accounts for around 25% of the entire world's production, and about 60% of the demand is met through imports, which implies that India's gold production is meager. The highest demand for gold in India is in the form of jewelry, which accounts for about 80%, while bars and coins account for not more than 10% of the demand. Some of the biggest bullion centers in the country are Ahmadabad, Mumbai, Delhi, Chennai, and Hyderabad.

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2. Literature review

The concept of price discovery has evolved and modified over time. Thomson and Foote (1952) defined price discovery as a process in which buyers and sellers arrive at a transaction price for a given quality and quantity of a product at a given time and place. In the futures market, price discovery was defined as using future prices for pricing the cash market transactions (Goodwin & Schroeder, 1991; Lake, 1978; Wiese, 1978). The futures market plays a dominant role in price discovery, which means the futures market leads to the spot market (Silber, 1983). Garbade & Silber developed a model of concurrent price dynamics, known as the G-S model, which suggests that over small intervals of time, the association of price changes is a function of the elasticity of arbitrage between the physical commodity and its counterpart futures market (Garbade, 1983). Their empirical analysis found that about 75% of information is formally integrated into the futures market and then flows into the cash market. There are various approaches to examining the process of price discovery. However, most recent studies use the GS model to study price discovery in the futures market.

Researchers have used econometric tools like cointegration to study price discovery to realize the time series property of commodity prices (Granger, 1987). The advancement in the cointegration theory has provided a new frame to analyze the relationship between spot and futures prices in the commodity market. Jumah examined the long-run relationship between the spot and futures prices of cocoa and coffee and found that the prices of these commodities move together in the long run (Jumah, 1995). Studies have also examined the process of price discovery for storable and nonstorable commodities (Jian Yang, 2001). These studies indicate that asset storability does not affect the cointegration between spot and futures prices. These findings have several implications for commodity production choice, hedging, and commodity price forecasting. Studies of price discovery in the agricultural markets reveal that market efficiency varies from commodity to commodity when comparing the spot and futures markets. The study of price discovery using spot and futures markets also encompasses various other asset classes (Pandey, 2014).

A Brazilian study exploring the relationship between spot and futures prices in the agricultural market, focusing on the effects of trading activity on the price discovery process, found that future prices influenced spot prices. The price discovery analysis in the Indian pepper futures market found a unidirectional causality from futures to spot prices. The adjustment of innovations or shocks in the futures market is relatively faster than in the spot market (Kushankur & Debasish, 2012). Empirical evidence also reveals bidirectional causality between spot and futures prices for certain selected commodities. Silvapulle and Moosa examined the relationship between spot and futures prices of crude oil and found that linear causality testing revealed future prices lead to spot prices; non-linear causality testing revealed a bidirectional effect (Moosa, 1999). It indicates that both spot and futures markets react simultaneously to new information. Bidirectional causality was found between the spot and futures prices of Channa, suggesting that both the spot and futures markets play the leading role in the price discovery process (Purankar, 2014).

The literature review about commodity price discovery indicates that empirical research has been mainly concentrated globally on agricultural produce. And this trend is no different for the Indian markets (Bharat et al., 2018; Singh, 2015). These studies predominantly show that the futures market has effectively served the role of price discovery. More recent studies provide evidence for the importance of the spot market in price discovery in the precious metals markets (Khan & Ramani, 2014). Isabel and Gonzalo studied price discovery in precious metals over periods of abnormal exchange rate volatility, assessed the statistical hedging properties of precious metals markets, and found that the spot market was crucial for price discovery (Gonzalo, 2009). Lokare attempted to examine the effectiveness and performance of commodity derivatives in mitigating price risk for agricultural commodities and metals. Almost all the commodities showed cointegration between the spot and futures prices, indicating a stride towards improved efficacy at a slower pace at the operational level (Lokare, 2007). The price and demand for gold are interdependent and influence each other. Patel estimated the responsiveness of India's demand for gold to changes in its relative price (dependent variable) by attempting to correlate the net flow of gold from (or into) private hoards during the period 1925–42 and 1949–50 (April–May) with two independent variables: the relative price of gold and the consumption of refined sugar as a proxy for real national income (Patel, 1950). The results suggested that: the demand for gold was highly responsive to changes in its relative price. Gold differs from other storable commodities primarily because of the factors that affect the demand for gold. These factors can be classified into four categories: extreme political and economic uncertainty; supply flow and demand for gold; inflation; and government auction policy (Abken, 1979). Often, particular macroeconomic announcements affect commodity prices. It was observed that gold is unique among commodities, with prices reacting to specific scheduled reports. It is inconsistent with gold's traditional role as a haven and store of value. Whereas other commodity prices exhibit a magnifying sensitivity to such announcements becoming highly financialized (Shaun & Marco, 2009), gold does not reveal such tendencies. Studies by the World Gold Council have shown that adding gold to a portfolio increases risk-adjusted returns and enhances performance. A 2011 study examined the role of gold in a portfolio for diversified investors who may already have an allocation to commodities. The analysis found that portfolio performance can be improved if a part of the portfolio is allocated to gold because investment in gold produces better risk-adjusted returns. It was also found that the investor is less prone to a loss in the portfolio because allocation to gold reduces value at risk.

The importance of gold as a value storer emanates from its ability to withstand pricing pressures during a crisis. Several studies have been carried out on the gold bubble. Studies based on gold's role as an inflation hedge, dollar hedge, portfolio diversifier, and a safe haven concluded that there is no need to resort to the irrational bubble explanation to account for the considerable fluctuations observed in the gold market (Białkowski et al., 2015). A safe haven is an asset that provides financial stability during a turmoil situation. Empirical evidence has proved that gold is a safe haven and can be used to hedge extreme stock market situations (Baur & Lucey, 2010; Santhosh & Lagesh, 2011); the most liable explanation for gold price hike during the period 1979 to 1982.

3. Data and methodology

The study is conducted with secondary data collected from the Multi Commodity Exchange (MCX). The study uses daily gold spot and futures prices from January 1st' 2011, to December 31st' 2017. The study uses a bouquet of statistical tools for analysis. Before applying econometric analysis, it is essential to plot the time series data and determine the descriptive statistics. The stationarity of the time series is ascertained through the unit-root test. The Augmented Dickey-Fuller test and Philips Perron test are employed to check the stationarity of the series after converting the spot and futures prices into natural logarithm values. The lag structure to be used is determined using the AIC or SBC criteria. After ascertaining the stationarity of the time series, the Johansen cointegration test is applied to check the long-run relationship between the variables. The Granger Causality test determines the causal relationship between gold spot and futures price. Lastly, the Vector Error Correction Modeling (VECM) is applied to discover the price discovery mechanism in the gold spot and futures market.

4. Analysis & discussion

The analysis starts with testing the price data for cointegration using The Augmented Dickey-Fuller (ADF) test and Philip Perron (PP) test, followed by the application of the VECM to ascertain their relationship. Finally, Granger causality is used to determine the direction of the relationship between the spot and the future price of gold in the commodities market. A detailed discussion of each is made in the subsections below.

4.1. Testing for cointegration

As both the variables are integrated to order of one, we proceeded to the Johansen Cointegration test for the spot and futures price series. The result shows that both the variables, spot price and future price, are non-stationary at their levels and stationary at their first differences (Table 1), as indicated by the t statistic and adjusted t − statistic of the ADF and PP test, respectively. The results show both the test statistics to be more than the critical value at the 5% level when the first difference of the data is taken. Therefore, the null hypothesis that future price and spot price have unit root is rejected. The spot and futures prices are integrated to order one, i.e., I(1) series.

Cointegration refers to a linear combination of non-stationary variables. Engle and Granger showed that it is possible for a linear combination of integrated variables to be stationary and thus integrated at a given lower order (Granger, 1987). It may be possible that non-linear relationships exist amongst integrated variables. In other words, two variables are said to be cointegrated if there exists a long-run equilibrium relationship between them. For a cointegrating relationship, variables must

Table 1. Results of ADF and PP test for Unit Root.

Variables	Levels		1st difference	
	ADF	PP	ADF	PP
Futures Price	−2.953124	−3.144235	−19.37212	−22.94778
Spot Price	−2.357108	−2.451197	−37.96240	−38.13358

Source: Multi Commodity Exchange of India.

usually be integrated of the same order, I (d). On the other hand, if variables are integrated into different orders, they cannot be cointegrated.

The Johansen cointegration test examines the long-run relationship between the test variables and determines the number of cointegrating vectors between them. This test can be done when the time series are integrated into order one or I (1). The confirmation that both the series are integrated of order 1 allows us to proceed with the Johansen Cointegration test. This test is sensitive to the lag length employed. The inappropriate lag length will give rise to problems of overparameterization or under-parameterization. Hence, the Akaike information criteria or Schwarz information criteria decide the optimal lag. The Johansen cointegration test to investigate the long-run relationship between spot and futures prices are given below:

$$\Delta Xt = \sum_{i-1}^{P-1} \tau_i \, Xt - i + \ \pi \, Xt - i + \varepsilon t \, ; \varepsilon t = \approx N \, {}^{\varepsilon_{s,t}}_{\varepsilon_{f,t}} (O, \textstyle\sum)$$

Xt = (St Ft) is the vector of spot and futures prices, each integrated to order one, and the differenced series is I (0). Δ Denotes the first difference operator. The short term and long-run adjustments to change in Xti are measured using the τ_i andπ are 2×2 coefficient matrices. εt is a 2×1 vector of error terms. The Johansen test is based on two criteria: the maximum Eigenvalue test and the trace test. For both test statistics, the null hypothesis indicates a lack of cointegration between the variables, and the alternate is cointegration. The Johansen Cointegration test results for gold spot and futures prices are presented in Table 2.

Table 2 presents the trace and maximum Eigenvalue statistics from January 1st, 2011, to December 31st, 2015. The test statistics are significant at the five percent confidence level. Both the tests reject the null hypothesis of no cointegration at the 5% level, whereas they reject the alternative hypothesis. The analysis reveals at least one cointegrating relationship between gold spot and futures price.

4.2. Vector error correction modeling (VECM)

Once a cointegrating relationship is confirmed, the VECM can be done to understand the relationship between spot and futures prices. The vector correction model helps understand whether the spot market or futures market is efficient and which market effectively serves the process of price discovery. An error correction model shows how the short-term deviations or disequilibrium in the long-run equilibrium relationship due to the random walk component in the prices is restored through the pull and push forces. The VECM for spot and futures prices is given by:

Δ(FP) = β1(FP(-1) −0.96*SP(-1) - 844.522097423) + β2*Δ(FP(-1)) + β1*Δ(FP(-2)) + β4*Δ(SP(-1)) + β5*Δ(SP(-2)) + β6
Δ(SP) = β7 *(FP(-1) −0.96*SP(-1) - 844.522097423) + β8 *Δ(FP(-1)) + β9*Δ(FP(-2)) + β10*Δ(SP(-1)) + β11*Δ(SP(-2)) + β12

The error term denotes the magnitude of disequilibrium between the spot and futures prices. At the same time, the error correction coefficient shows the speed of the adjustment between the spot and futures prices. The error correction coefficient reveals which market is more efficient in information integration. The VECM is performed to examine the price discovery process, and the results are in Table 3.

All the non-stationary variables, constant, and error correction terms are treated as endogenous variables in the error correction equation. The cointegrating equation shows that the error correction in future prices is negative and significant. It means an increase in the previous period's equilibrium error followed by a decrease in the current period of future prices. The error correction of spot prices is positive and significant, implying that an increase in the previous period's equilibrium error leads to a rise in the current period's spot prices. Error correction coefficients suggest that a sustainable long-term equilibrium can be attained by closing the futures and spot price gap. In other words, spot prices rise to meet increases in futures prices while futures prices revert to spot prices. As shown, the error correction coefficient of the spot price is 0.13, and the error correction coefficient of the future price is − 0.39. Since the coefficient of the spot market is less, the spot prices take less time to adjust to the changes in the disequilibrium. It means

Table 2. Johansen cointegration results.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value 0.05	Prob.**
None *	0.008519	22.66555	15.49471	0.0035
At most 1	0.000291	0.746383	3.841466	0.3876

Source: Multi Commodity Exchange of India.

Table 3. Results of VECM.

Co-integrating Eq:	Coint Eq 1	
FUTURE_PRICE(-1)	1.000000	
SPOT(-1)	−0.969514	
	(0.01889)	
	[-51.3364]	
C	−844.5221	
Error Correction:	D(FUTURE_PRICE)	D(SPOT)
CointEq1	−0.399021	0.135811
	(0.02748)	(0.00783)
	[-14.5204]	[1.73428]
D(FUTURE_PRICE(-1))	0.185125	0.021667
	(0.02602)	(0.00741)
	[7.11518]	[2.92228]
D(FUTURE_PRICE(-2))	−0.281086	−0.009724
	(0.02580)	(0.00735)
	[-10.8946]	[-1.32258]
D(SPOT(-1))	0.019455	−0.003294
	(0.09483)	(0.02702)
	[0.20516]	[-0.12189]
D(SPOT(-2))	0.208250	0.026886
	(0.09302)	(0.02651)
	[2.23876]	[1.01427]
C	2.293840	2.948344
	(22.2507)	(6.34076)
	[0.10309]	[0.46498]

Source: Multi Commodity Exchange of India.

the spot prices can absorb information faster and adapt fast to the market changes. However, the above table does not show the significance of the error correction coefficient. For that, we generate a system equation, and the following is obtained (Table 4).

Considering the first equation where future price is the dependent variable and spot price is the independent variable, C(1) is the error correction term. Since the coefficient of C(1) is negative and the probability is less than 0.05, it can be inferred that there is a long-run causality from spot price to future price. Considering the second equation where the spot price is the dependent variable and future price is the independent variable, C(7) is the error correction term. From the table, it can be seen that the coefficient of C(7) is not negative, and the probability is greater than 0.05, i.e., not significant at the 5% level. This result indicates that future price does not lead to the spot price. Thus the results show that the spot prices exhibit a more decisive influence over future prices in the Indian gold market.

Table 4. Results of the VECM system equation.

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	−0.399	0.027	−14.520	0.000
C(2)	0.185	0.026	7.115	0.000
C(3)	−0.281	0.026	−10.895	0.000
C(4)	0.019	0.095	0.205	0.838
C(5)	0.208	0.093	2.239	0.025
C(6)	2.294	22.251	0.103	0.918
C(7)	0.136	0.008	1.734	0.083
C(8)	0.022	0.007	2.922	0.004
C(9)	−0.010	0.007	−1.323	0.186
C(10)	−0.003	0.027	−0.122	0.903
C(11)	0.027	0.027	1.014	0.311
C(12)	2.948	6.341	0.465	0.642

Source: Multi Commodity Exchange of India.

4.3. Granger Causality test

The Granger Causality test examines if the changes in one variable, say y help explain current changes in another variable, say x. If not, it means y does not Granger cause x. The test can be reversed to find the causality between the variables in the opposing direction. By running the Granger causality test, four findings are possible: 1) x granger causes y and not vice versa, 2) y granger causes x and not vice versa, 3) neither variable Granger causes the other, and 4) x and y granger causes each other. Thus, from the Granger causality test, one can infer the causality and direction of the causality.

The equation for the Granger causality test is as follows:

$$\Delta Xt = \alpha + \sum_{i-1}^{P} \beta_{xi}\, \Delta Xt - i + \sum_{i-1}^{P} \beta_{yi}\, \Delta Yt - i + \varepsilon t \quad (1)$$

$$\Delta Yt = \alpha + \sum_{i-1}^{P} \beta_{xi}\, \Delta Yt - i + \sum_{i-1}^{P} \beta_{yi}\, \Delta Xt - i + \varepsilon t \quad (2)$$

where ΔX and ΔY are the first difference operators. The null hypothesis, *y* does not granger cause *x*, is rejected if the coefficient β_{Yi} is significant along with the F test as in equation (1). Similarly, the null hypothesis *x* does not granger cause *y* is rejected if the coefficient β_{Xi} is significant along with the F test as in equation (2). The Granger causality test will help unravel the current study's causal relationship between future and spot gold prices. The results of the Granger Causality test to detect the direction of causality between gold spot and futures prices are in Table 5.

The Granger result shows that we can reject the hypothesis spot price does not Granger cause future

Table 5. Results of the granger causality test.

Null Hypothesis	F − statistic	Prob.
Spot Price does not Granger Cause Future Price	229.973	0.00871
Future price does not Granger cause Spot Price	11.3163	0.19102

Source: Multi Commodity Exchange of India.

price because the probability is less than 0.05, which indicates that spot price ganger causes Future Price. Whereas, the null hypothesis future price does not Granger cause spot price cannot be rejected because the probability is higher than 0.05. It can be inferred from the test results that unidirectional causality runs from the spot market prices to the futures market prices.

5. Conclusion and policy implications

This paper attempts to study the process of price discovery in India's gold spot and futures market. The study found that the spot market plays a dominant role in the Indian gold market price discovery. One reason for the dominance of spot markets in the price discovery process is the information symmetry in the spot market. In a perfectly functioning market, every piece of information is reflected simultaneously in the spot market and its futures market. However, in reality, data can be disseminated in one market first and then transmitted to another market due to market imperfections. Thus the process of price discovery involves uncovering the asset's complete information or permanent value. Prices are determined by commodity demand and supply forces, and the factors influencing price vary between commodities. Several considerations like international gold price, import restrictions, exchange rate, etc., affect gold prices in India. Traditionally, it was believed that risk transfer and price discovery are two essential functions of the futures market. The significance of these contributions depends upon the close relationship between spot and futures prices, which vary from commodity to commodity. Researchers develop different approaches to study the price discovery process in various markets. This research followed the method developed by Garbade and Silver (1983) and the cost of carrying the pricing model to examine price discovery in the Indian gold market.

The cointegration test reveals a long-run relationship between spot and futures prices in the gold market, and there is one cointegrating equation. From the Granger causality test, it is inferred that there is unidirectional causality from spot price to the future price in the gold market. The unit root test confirmed that both the spot price and the futures price series were integrated of order one, which justified the Johansen Cointegration and further VECM. The VECM was used to study the price discovery process in the Indian gold market. The VECM results showed that the spot prices marginally lead the future price. This study refutes the idea of using future prices for pricing cash market transactions in the case of gold. Such a result indicates that the information tends to be discovered in the spot market first and then transferred to the future market. The inference is that the spot market serves as a tool for price discovery in the Indian gold market. This further implies that the spot market is informationally more efficient than the future market in gold. This study negates the idea that the futures market serves as a primary tool in price discovery and risk management, at least in the case of gold. It may be since gold is considered a contrarian investment and safe haven as far as investments are considered. Also, most of India's gold demand is for jewelry, which is a real-time demand (unlike gold bullion), which may explain the prominence of the spot market in gold price discovery.

This study provides scope for further research by extending the model to include other factors like inflation, exchange rate, imports, government policies, and international gold prices that affect the price of gold. This research can be further validated by considering other commodities to represent the commodity market as a whole.

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