Do commodity futures help in price discovery and risk management? Evidence from India

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July 24, 2015

Abstract

In 2003, trading of commodity futures in India shifted from single commodity, regional exchanges to national exchanges that trade multiple commodities. This paper examines price discovery and hedging effectiveness of commodity futures after this change. We conclude that, on average, futures prices do discover information relatively efficiently, but helps to manage risk less effectively. The paper examines the factors that affect the role of commodity futures in price discovery and hedging effectiveness. High volatility in spot prices increases the cost of trading by raising the margins and thus adversely impacts informed trading. The hedging effectiveness of commodity futures is majorly affected by disruptions caused by various policy interventions in both spot and futures markets, and mismatch between the grade specified in the futures contract and what is available for delivery in the market.

JEL classification: G13, G32,
Keywords: Commodities futures, price discovery, hedge ratio, variance reduction, cost of carry, settlement costs.

*A previous version of the paper was circulated as "Do futures markets help in price discovery and risk management for commodities in India?" The authors are with the Finance Research Group, IGIDR, Bombay. `http://www.ifrogs.org` Email address: `sargam@igidr.ac.in`, `nidhi@igidr.ac.in` Corresponding author: `susant@igidr.ac.in` We thank the Forwards Markets Commission for access to the data used in this paper. The views presented in this paper are the authors own and not that of their employer.

Contents

1 Introduction

In the last few years, the commodity derivatives markets have gained significant importance particularly due to increased price volatility. Higher volatility in commodity prices impacts the producers, processors, exporters, importers, as well as the end consumers of these commodities. Consequently, governments and regulators worldwide have realised this importance and have eased the norms and policies that govern the derivatives markets to provide an effective channel for price dissemination and risk management.

A similar shift in the policy was seen in India when the government moved away from decades of restrictive policies and announced the liberalisation of commodity derivatives markets in the "National Agricultural Policy" of 2000. The government announced that it would step away from the rigid price and production controls it exercised[1] "once there were futures markets available to economic agents for hedging market price risk." This led to wide-spread reforms, particularly in the development of national markets processes of trading and clearing. Currently, commodity derivatives trade on national exchanges rather than regional markets where local trading interests may sway price determination.

A clear outcome of these changes has been a significant growth in the commodity futures trading. The total traded volumes in commodity futures in India increased from US $ 29 million in 2003 to US $ 3330 million in 2013. But do these new national futures markets, that trade multiple commodities simultaneously, play the price discovery and risk management role as that of a well functioning derivatives markets? In this paper, we focus on two questions about the commodity derivatives markets:

1. Does the commodity derivatives market in India aid price discovery?
2. How effective are these markets for the purpose of hedging?

The analysis uses daily prices of a set of seven commodities for a period from 2003 onwards when national trading started on the electronic exchanges upto January 2014. The period of analysis includes the recent period that was characterised by significant price volatility which resulted in large government and regulatory intervention (by way of ban on the futures, increase in margins, position limits). The commodities analysed include five agricultural commodities and two non-agricultural commodities. Castorseed,

[1]Specifically, the policy referred to the controls on the sugar industry.

pepper, sugar, soya oil, and wheat are among the agricultural commodities. The non-agricultural commodities are crude oil and gold.

We expect that prices and risk are likely to be determined through domestic factors in agricultural commodities, while the non-agricultural commodities are more likely to be affected by global factors. The futures market with a national trading platform is expected to help in consolidating information for better price discovery for agricultural commodities. Thus, we expect futures to have a greater role in price discovery and hedging effectiveness for agricultural commodities, while they may be more important only for hedging effectiveness, rather than price discovery, for non-agricultural commodities.

With a relatively long time series of daily prices, we use the Information Share (IS) methodology (Hasbrouck, 1995) to estimate the role of futures in price discovery. The measure captures which market moves first in response to information arrival. The market with higher information share is the market that contributes more to price discovery.

We use two approaches to estimate how efficiently the futures can be used for hedging price risk. First, is a static approach in which the optimal hedge ratio i.e. the fraction of underlying position hedged in the futures market is estimated for the entire period. This approach ignores the policy and market microstructure changes that occur overtime. Our second approach accounts for these changes and uses a time-varying model to estimate the optimal hedge ratio. Using these hedge ratios, variance reduction from hedged portfolio is derived to measure the hedging effectiveness. If futures are a useful hedging tool, then we obtain high variance reduction.

Contrary to our expectations, we find a consistently high degree of price discovery across different commodity futures, and on an average a relatively lower degree of hedging effectiveness. Non-agricultural commodity futures have high price discovery and low hedging effectiveness. Hedging effectiveness and price discovery are both relatively high for agricultural futures, but both vary significantly across the five agricultural commodities.

A closer examination of the futures markets reveals that price discovery of the futures market is particularly related to the volatility in the spot market. When the spot volatility increases, the margins in the futures market increase, which reduces the leverage provided by these markets. Reduced leverage increases the costs of trading on the futures market and thus adversely impacts the price discovery function of these markets. We do not find any evidence that trading activity or the degree of proprietary trading impact the price discovery function in the futures market. In addition, we find that regulatory interventions such as outright bans adversely impact the price discovery function of the futures market.

In relation to hedging effectiveness, we find that the usefulness of the futures market as a tool for risk management depends on the substitutability of the underlying commodity with the commodity specified in the futures contract, and the storage and transactions costs. These factors get reflected in terms of contemporaneous price differences between futures and spot prices, that is, the basis. Higher values of the basis and greater variability in the basis itself reduces the hedging effectiveness of the futures market. Factors such as poor warehousing infrastructure, mismatch between grades of the underlying commodity and grades to be delivered and multiplicity of laws governing the commodities markets could be the factors that cause the basis to vary widely.

The paper contributes to the literature by providing evidence for both price discovery as well hedging effectiveness in futures markets. So far, most of the papers in this literature investigate only one of these functions of the futures markets and thus, do not provide a complete understanding of the role of these markets. The paper further contributes by delving into the factors that could be responsible for the varying role of the futures market in price discovery as well as risk management.

The paper is structured as follows. Section 2 briefly reviews the literature. Section 3 offers a background of the commodity derivatives market in India. Section 4 describes the methodology. The data used in the analysis is described in Section 5. Section 6 presents the empirical findings. Section 7 links the results with the underlying issues in these markets. Section 8 concludes.

2 Literature

Price discovery and risk management are two of the most important functions of the derivatives market. Several papers in the past have examined how well the futures markets serve these two functions. Price discovery rests on whether new information is incorporated first in futures prices or in spot prices. Black (1976) provides an early evidence on price discovery function of commodity futures markets and finds that these markets facilitate informed production, storage and processing decisions. Using data on four agricultural and three non-agricultural commodities from Chicago Board of Trade (CBOT) and the Commodity Exchange (Comex), Garbade and Silber (1983) find that while there was evidence of information dissemination from the futures to the cash market, there were considerable silppages between the two markets in short time intervals. These slippages adversely affected the arbitrage between these two markets which eventually had an impact on the risk transfer function by these markets.

Subsequent studies including Yang *et al.* (2002), Zhonga *et al.* (2004) and Mattos and Garcia (2004) also examine the price discovery function in various markets. Though the results were mixed, but with higher trading activity, futures prices appear to play a more dominant role in the pricing process, while in lightly traded markets, neither long-run relationships nor short-run leads and lags can be found between the two markets. More recently, using data from 1991-2006, Chinn and Coibion (2014) show that while energy and agricultural futures prices can generally be characterized as unbiased predictors of future spot prices, these markets fair badly in the case of precious and base metals.

Fewer studies have explored the risk management function of the commodity derivatives market. Hedging in the spot market is particularly useful in case of any long-term requirement for which the prices have to be confirmed to quote a sale price but to avoid buying the physical commodity immediately to prevent blocking of funds and incurring large holding costs (Tomek and Peterson, 2001). Switzer and El-Khoury (2007) investigate the efficiency of the New York Mercantile Exchange (NYMEX) Division light sweet crude oil futures contract market for the recent periods of extreme conditional volatility. Crude oil futures contract prices are found to be unbiased predictors of future spot prices. Both futures and spot prices exhibit asymmetric volatility characteristics. Hedging performance is improved when asymmetries are accounted for.

In the Indian context, Naik and Jain (2002) examine prices from the older regional exchanges, and show that information flows from the futures market to the spot markets. Kumar *et al.* (2008) analysed the hedging properties of the Indian commodity futures using data for both agricultural and non-agricultural commodities for the period from 2004 to 2008. They find that the effectiveness of the futures contracts to hedge risk was low. They also find that hedging effectiveness is lower for non-agricultural commodity futures compared to agricultural commodity futures.

There are relatively fewer studies that create a nexus between the price discovery and the risk transfer function of the futures market. While the broad evidence indicates that the futures market enables price discovery but does not work very efficiently for risk management, the absence of studies examining both these functions together does not allow to draw a complete perspective on the efficacy of the futures market. It is not clear that if futures prices play an efficient role in price discovery in a market, then, hedging effectiveness is also high or vice versa. This study attempts to fill this gap by providing evidence on both these functions.

3 Commodity derivatives markets in India

Commodity futures have been trading in India since 1875 (Thomas and Varma, 2010), which points to an economic need for these contracts that has been present for a long time. Despite the government enacting laws to control the prices and supply of certain commodities and imposing outright bans on derivatives trade in commodities, these contracts have continued to trade both formally on exchanges as well as in informal markets (Sahadevan, 2002). The "National Agricultural Policy" of 2000 brought significant reforms to these markets. It led to the setting up of processes for the development of national markets for trading and clearing systems.

Broadly, the commodities markets at present exist in two distinct forms in India: the over-the-counter (OTC) market, and the exchange based market (Sahadevan, 2002). The spot markets are essentially OTC markets and participation is limited to people who are directly involved with the commodity, i.e. farmers, traders, processors and wholesalers. A majority of the derivatives trading takes place through the exchange-based markets with standardised contracts and settlements, allowing an active participation by people who are not associated with the commodity.

Currently, there are 22 exchanges[2] carrying out futures[3] trading activities in about 69 commodities. Most of the volumes are however concentrated on national exchanges rather than the regional exchanges.

The wide span of time for which these national markets have been in existence, including periods of different levels of restrictions on these markets, provide fertile grounds to revisit the question of the role played by the commodity futures markets.

[2]There are 6 national and 16 regional exchanges that trade in commodities in India.
[3]Options trading is prohibited under the current law.

4 Methodology

The tests of how well the futures markets help in price discovery and hedging effectiveness are based on the relationship between the futures prices and the spot market prices. The detailed approach and the specific measures that we use in the paper are described in the following sections.

4.1 Measuring price discovery

In the case of the price discovery, the research focuses on the *lead-lag* relationship between the spot and futures prices. There are several implementations of this basic idea, ranging from the cross-correlations between the time series of spot and futures returns and Granger-Causality between these two, upto tests of cointegration between the spot and futures prices, and more complex econometric models (Garbade and Silber, 1983; Geweke, 1982). In each case, if there is statistically robust evidence that the futures price leads the spot price, the futures price is said to discover prices.

Among the models used to measure the contribution of a market in price discovery is the information share (IS) metric proposed by Hasbrouck (1995). The measure captures between a set of markets, which market moves first in the process of price adjustment. It is computed by estimating an econometric model (vector error correction model (VECM)) on the returns obtained from the prices of different markets. The value of the measure lies between 0 and 1. For a two market case, the market with an information share value significantly greater than 0.5 dominates the price discovery process. Thus, between the spot and the futures market, if $\text{IS}_{\text{futures}} > 0.5$, then futures market dominates price discovery. Conversely, if $\text{IS}_{\text{futures}} < 0.5$, then spot market dominates price discovery.

Other than the IS, studies in the literature typically use the coefficients associated with the leads and lags of the returns on the different markets to ascertain temporal dependence. Hasbrouck (1995), however, shows that even though such studies have made reasonable conclusions on price leadership, these models are econometrically mis-specified. The IS approach is based on the idea that the efficient price of the security is implicit in the observed market price, and that the efficient price is the same across all market prices (Garbade and Silber, 1983). The IS uses this implicit efficient price and breaks down the sources of variation in the estimated efficient price. The market that contributes larger variation to the implicit efficient price is the one that dominates price discovery.

In the paper, we use daily closing prices from the futures and the spot market to estimate the information share for each commodity. This is done in three ways:

1. Estimate the $IS_{futures}$ for the entire period.
2. In order to examine if the contribution of the futures markets in price discovery has changed over the years, we compute the $IS_{futures}$ on a rolling basis with 2-years (500 trading days) as the window size.
3. In order to assess the contribution of the futures markets in the more recent period characterised by high price volatility and regulatory interventions, we compute the $IS_{futures}$ from 2010 onwards.

4.2 Measuring hedging effectiveness

The measurement of hedging effectiveness relies on a framework based on the perspective of an agriculturist. The agriculturist is exposed to price uncertainty during the time between sowing and harvest. The changes in the commodity price can change the returns of investment in the commodity. With the futures market, the agriculturist can hold a hedged portfolio, where the value realised at harvest time T is what was expected, $E(S_T)$. The hedged portfolio has a long position in the spot and a short position in the futures contract. The net position is then $S - F$ where S is the inherent exposure to the spot and F is the explicit exposure in the futures. Thus the agriculturist can lock in the price and transfer the price risk fully or partially.

Consider two agriculturists, one who hedges and the other who does not hedge. Both use the futures markets to set the expected price of sale at F_0, but only one uses the futures to hedge the value at sale. The difference in returns can be presented through the realised value at harvest time T, when the commodity is sold, as follows:

A: Unhedged portfolio, at t=T	S_T
B: Hedged portfolio, at t=T	$S_T + F_0 - F_T$

Thus, even though both start the sowing period ($t = 0$) with the same expectation of how much will be received at harvest ($t = T$), the value realised at harvest will be different. The unhedged portfolio earns S_T which may be very different from the expected value F_0. But the hedged portfolio will earn F_0 as long as $(S_T - F_T) = 0$.

The above statement holds if the contract matures at the same time T as the commodity is to be sold. What happens if the commodity is sold at a different time $t = T'$? In a well-functioning market, the futures price F_t is equal to the spot price, S_t, and C which is the cost of carry[4], at every time t. The cost of carry, C, includes the cost of capital and the cost of storing the commodity, which is a function of interest rates and warehousing charges that has to be paid when the commodity is delivered to the seller stored in a warehouse. This implies that the comparison between the value realised for a hedged and unhedged portfolio at T' is:

A: Unhedged portfolio, at $t = T'$	$\mathrm{S}_{T'}$
B: Hedged portfolio, at $t = T'$	$\mathrm{S}_{T'} + \mathrm{F}_0 - \mathrm{F}_{T'}$

Here, the hedged portfolio realises a value of F_0, if $(\mathrm{S}_T - \mathrm{F}_T) = C$. This implies that the effectiveness of the hedge using the futures contract depends upon whether (F_t - $\mathrm{S}_t = C$) at all times. When the market is well-established, there ought not to be significant changes in either the cost of capital or the warehousing charges, especially over short intervals of a week or a month.

Thus, the characteristics of returns on the hedged portfolio, $(\mathrm{F}_t - \mathrm{S}_t)$, become the basis of the measurement of hedging effectiveness. The lower the average value of this difference, and less variable it is, the better the hedging effectiveness is likely to be. Both the average difference as well as the volatility of these will have an effect on how well the futures contract can be used to reduce the exposure from an investment in the commodity.

In order to capture the degree of hedging effectiveness, one needs to get a measure of the optimal hedge ratio. The literature on the computation of the optimal hedge ratio can be divided into two broad categories: *static* and *time-varying*.[5] Several approaches have been used to capture these two types of hedge ratios. Techniques used to compute static hedge ratios include the classical regression methods (Ederington, 1979), error correction models. The dynamic or time-varying models include conditional volatility models, rolling window regressions, and Kalman filter (Anderson and Danthine, 1983; Cecchetti *et al.*, 1988).

There is a significant debate in the literature on which of these measures performs better in evaluating hedging effectiveness. Various studies have found that conventional OLS outperforms the volatility based measures. Lien *et al.* (2002) compare the performances of the hedge ratios estimated from

[4]It is also referred as the basis.

[5]Lien and Tse (2002) provide an excellent review of the available techniques to estimate hedge ratios.

the OLS method and the constant-correlation VGARCH (Vector Generalized Autoregressive Conditional Heteroskedasticity) model by examining ten spot and futures markets covering currency futures, commodity futures and stock index futures. They find that the OLS hedge ratio performs better than the VGARCH hedge ratio. Bystrom (2003) also finds that the static OLS hedge ratio performs better than the time varying one, estimated through GARCH or rolling window with 50 periods length method. Using Korean index futures (KOSTAR), Moon *et al.* (2009) find that the simple rolling OLS is superior to all the other popular multivariate GARCH models. Lien (2005) shows that in the absence of structural changes in the out-of-sample data, OLS provides a better hedge ratio that outperforms the hedge ratio derived from the error correction model.

Based on the findings of these studies, we use the OLS framework to examine the hedging effectiveness of the commodities futures markets. In particular, we consider a naive hedge and the conventional OLS regression framework to capture the static hedging ratio, and a rolling window OLS framework to capture the time varying hedge ratio. We describe each of these approaches in the subsections below.

4.2.1 Estimating variance reduction for naive hedge

The naive one-to-one hedge ratio is calculated assuming that each spot contract is offset by exactly one futures contract, that is, the optimal hedge ratio is assumed to be equal to 1. However, often the spot commodity has multiple grades compared to the grade that is used to define the futures contract. If the spot commodity is not of the same grade as the futures grade, the two prices are not perfectly correlated. In this case, the optimal hedge ratio is different from 1, and can vary between 0 and 1. In order to account for the differences in the grade of the underlying and the grade that is used to define the futures contract, we consider four values of hedge ratio, i.e. HR = 0.25, 0.50, 0.75, 1.

For each value of HR, we calculate the variance of the hedged portfolio, Var(Hedged), and unhedged portfolio, Var(Unhedged) as follows:

$$\text{Var(Hedged)}_i = \text{Var}(r_{\text{spot},i,t} - HR \times r_{\text{futures},i,t}) \quad (1)$$

$$\text{Var(Unhedged)}_i = \text{Var}(r_{\text{spot},i,t}) \quad (2)$$

where $r_{\text{spot},i,t}$ indicates returns on the spot market for commodity 'i' at time

‘t’, and $r_{\text{futures},i,t}$ indicates the returns on the futures market for commodity ‘i’ at time ‘t’. The returns are calculated as the first difference of logarithmic closing prices.

Once we obtain the variance of the hedged and unhedged portfolio, we follow Ederington (1979) and compute the variance reduction (VarRedn) derived from hedging as (in%):

$$\text{VarRedn} = 100 \cdot \{1 - \frac{\text{Var(Hedged)}}{\text{Var(Unhedged)}}\} \tag{3}$$

A high variance reduction implies high hedging effectiveness from using the futures contract.

4.2.2 Estimating optimal hedge ratio using regression framework

In this approach, instead of using an ad-hoc value of HR, we estimate the minimum variance optimal hedge ratio by estimating the following regression for each commodity:

$$r_{\text{spot},i,t} = \alpha + \beta \cdot r_{\text{futures},i,t} + \epsilon_{i,t} \tag{4}$$

The estimated value of β ($\hat{\beta}$) represents the optimal HR (Myers and Thompson, 1989). Since we get only one value of the HR for the entire period, we call this as a “fixed parameter” approach. We use the estimated HR to compute the variance reduction as described in Section 4.2.1.

4.2.3 Estimating optimal hedge ratio using rolling window regression

For a long timespan of data, it is possible that the regression parameters are time varying rather than static. We use a rolling window regression to derive time varying estimates of the HR. Thus for each commodity, we compute the optimal hedge ratio (β) using a rolling window regression model specified by Equation 4 to account for time variation in the hedge ratio. We consider a window size of 3-months and roll it over by one day.

Once we obtain time-varying HR estimates, we compute variance reduction as described in Section 4.2.1 for each value of HR. We take the average value of the variance reduction obtained for all the windows and compare them with the results obtained from static estimates of the hedge ratio.

Table 1 Details of commodities analysed

The table presents the details of the commodities used in the analysis. *Exchange* indicates the exchange from which the data is used to analyse the quality of prices. *Period* is the sample period used in the analysis, and *Ban period* indicates the period during which futures trading was banned.

Commodity	Exchange	Period	Ban period
Agri commodities			
Pepper	NCDEX	Apr '04 - Jan '14	-
Soya Oil	NCDEX	Dec '03 - Jan '14	May '08 - Nov '08
Castor seed	NCDEX	Jul '04 - Jan '14	-
Sugar	NCDEX	Jul '04 - Jan '14	May '09 - Sep '10
Wheat	NCDEX	Jul '04 - Jan '14	Feb '07 - May '09
Non-agri commodities			
Crude oil	MCX	Feb '05 - Jan '14	-
Gold	MCX	Nov '03 - Jan '14	-

5 Data details

The analysis uses daily data from two major national commodity exchanges in India: Multi Commodity Exchange (MCX) and National Commodity and Derivatives Exchange (NCDEX) for the period between 2003 to 2014. MCX has a dominant market share in terms of volumes traded in non-agricultural commodities, while NCDEX has a dominant share in agricultural commodities trading. Table 1 presents the set of commodities analysed in the paper.

As described in the table, we focus on five agricultural and two non agricultural commodities. We exclude the period during which trading on a commodity was banned. The data consist of daily closing prices on the futures contract as well as the spot market. Since most of the liquidity is concentrated on the near month futures contract, we restrict the study to the prices of the near month contract. We roll over to the next month contract two days before the expiry.

Table 2 Summary statistics of the sample

The table presents the summary statistics for the price data of the commodities analysed. These include volatility in spot prices (σ_{spot}) and correlation between spot and futures prices ($\rho_{s,f}$) along with contemporaneous values of some market outcomes on liquidity and participation. These include the daily average values of the traded volume and the average maximum open interest (OI) in the futures contract in a month. Also, presented is the fraction of the traded volumes and the open interest that can be attributed in a month to proprietary traders, as compared to their customers and clients.

			Market size		Prop. positions	
	σ_{spot}	$\rho_{s,f}$	Trd. Vol (Rs. lakhs)	Avg OI (Contracts)	Trd. Vol (in %)	Avg OI
Agri commodities						
Castorseed	1.90	0.58	242	4,965	19.94	13.42
Pepper	1.10	0.52	2,906	4,455	29.55	13.21
Soya oil	0.56	0.65	9,088	34,085	43.92	26.12
Sugar	0.49	0.28	14	27,485	26.62	17.44
Wheat	0.77	0.32	413	18,630	29.37	22.88
Non-agri commodities						
Crude Oil	4.52	0.13	535,934	2,917,800	52.65	22.00
Gold	1.02	0.40	745,188	22,024	55.70	33.00

Table 2 presents the summary statistics for the commodities analysed in the study. We see that a large part of the commodity derivatives volumes is concentrated in the non agricultural commodities: crude oil and gold. Within the agricultural commodities, soya oil is the most actively traded commodity. Higher volumes are also related to higher proportion of proprietary trading in these commodities.

6 Results

We now discuss the results obtained for price discovery as well as hedging effectiveness of the futures market.

6.1 Price discovery

Table 3 presents the IS estimates of the futures market for each commodity[6] for the entire period, and for the more recent subsample from 2010 onwards,

[6] We only report the value of $IS_{futures}$, since the value of IS_{spot} is 1-$IS_{futures}$.

Table 3 IS of the futures market

The table presents the results of the estimates of the IS of the futures market. The estimates are presented for the full period spanning from 2004-2014 (Full period), for a subset period (Post 2010), and average, median and standard deviation of the 2-years rolling window estimates (Rolling window).

	Full period	Post 2010	Rolling window		
			Mean	Median	SD
Castor Seed	0.66	0.68	0.64	0.65	0.21
Pepper	0.50	0.52	0.58	0.63	0.21
Soya Oil	0.65	0.69	0.58	0.59	0.16
Sugar	0.56	0.10	0.41	0.35	0.30
Wheat	0.88	0.81	0.83	0.86	0.12
Crude	0.94	0.99	0.93	0.95	0.06
Gold	0.56	0.36	0.69	0.74	0.18

and for the 2-years rolling window period.

For the full period, we observe that the IS of the futures market is greater than 0.5, indicating that the futures market indeed dominates price discovery for almost all these commodities. The near month crude oil futures contracts have got the highest value of IS (0.94), indicating that it is largely the crude oil futures market that discovers prices. The mean and median values of the rolling window estimates mirror the pattern, indicating that there has not been a significant difference in the time-varying IS and the full sample IS. However, the standard deviation of the IS_{futures} for sugar in the rolling window estimates is significantly high, indicating that the share of the futures market in case of sugar varies significantly.

In the more recent period, futures continue to play a significant role in price discovery, except for sugar and gold, where IS_{futures} dropped significantly after 2010. There was a ban on sugar between May 2009 and September 2010, which could likely explain the decline in the IS of the futures market in the period post 2010. In the case of the gold contract, a reason could be the recent ban on imports on the spot commodity that was placed by the central bank of India. This could have influenced the use of futures by traders and its effectiveness in price discovery.

6.2 Determinants of futures market share in price discovery

In the previous section, we find that futures market plays a dominant role in price discovery for most of the commodities. In this section, we examine if the share of the futures market in price discovery is related to observable market characteristics. We begin by examining which factors influence the share of futures in price discovery. To the extent that higher trading facilitates greater incorporation of information into prices, a positive relation between price discovery and trading volumes on the futures market is expected (Chakravarty *et al.*, 2004). We also expect a negative relation between spot volatility and the share of the futures market in price discovery. Higher spot volatility results in imposition of higher margins which reduces the leverage and increases the costs of trading on the futures market (Aggarwal and Thomas, 2015). Finally, to the extent that proprietary traders are informed traders, a positive relation between the share of proprietary traders in total volumes and information share of the futures market can be expected. To test this relation, we estimate a fixed effects panel regression specified as:

$$IS_{\text{futures},i,t} = \alpha_i + \beta_1 \cdot Volumes_{i,t} + \beta_2 \cdot Volatility_{i,t} + \beta_3 \cdot PropShare_{i,t} + \epsilon_{i,t} \quad (5)$$

where $IS_{\text{futures},i,t}$ indicates the 2-year rolling window IS estimate of the futures market for commodity i in time period t, $Volumes_{i,t}$ indicates the median value of the logarithmic volumes of commodity i during the estimation period t, $Volatility_{i,t}$ indicates the median value of the spot volatility for commodity i in time period t, and $PropShare_{i,t}$ indicates the share of proprietary traders in trading volumes.

Table 4 Determinants of futures market price discovery

The table presents the fixed effects regression results for the equation:

$$IS_{\text{futures},i,t} = \alpha_i + \beta_1 \cdot Volumes_{i,t} + \beta_2 \cdot Volatility_{i,t} + \beta_3 \cdot PropShare_{i,t} + \epsilon_{i,t}$$

where $IS_{\text{futures},i,t}$ indicates the 2-year rolling window IS estimate of the futures market for commodity i in time period t, $Volumes_{i,t}$ indicates the median value of the logarithmic volumes of commodity i during the estimation period t, $Volatility_{i,t}$ indicates the median value of the spot volatility for commodity i in time period t, and $PropShare_{i,t}$ indicates the share of proprietary traders in trading volumes. Individual firm intercepts are suppressed. Heteroskedasticity consistent White standard errors are reported.

	Estimate	Std. Error	t-stat	p-value
Volumes	0.033	0.02	1.21	0.22
Volatility	-8.768	2.45	-3.56	0.00
PropShare	0.002	0.00	0.86	0.38
# of obs.	15,106			

Table 4 reports the estimation results. The dependent variable is the IS of the futures market. We find that the coefficient with traded volumes turns out to be positive but insignificant, implying that higher trading activity is not related to higher share of futures market in price discovery. We find an inverse relation between volatility and IS$_{futures}$, validating the hypothesis that higher volatility increases the margins which raises the cost of trading in the futures market and thus adversely impacts informed trading. The coefficient for the variable, share of proprietary traders in total traded volumes, turns out to be insignificant, indicating that proprietary trading does not have any relation with price discovery on the futures market.[7]

6.3 Hedging effectiveness

We now discuss the results related to the role of the futures market in hedging effectiveness. We describe the results based on naive hedge ratio and OLS based hedge ratio separately in the following sections.

[7] Another factor that might be influencing trading and price discovery on the futures market could be the liquidity costs. However, our data limitations do not allow us to investigate the role of this factor.

6.3.1 Variance reduction using naive hedge

Table 5 Variance reduction obtained for naive hedge

The table presents the percentage variance reduction obtained for hedged portfolios, where the spot is combined with the futures for some value of the hedge ratio. For each commodity, the variance reduction of the hedged portfolio is calculated for four values of hedge ratio: 1.00, 0.75, 0.50, 0.25. The hedged portfolio for any commodity where the variance reduction is the highest, has been highlighted in the values below.

in (%)

	Var. Redn of the hedged portfolio			
	HR =			
Commodity	1.00	0.75	0.50	0.25
Castorseed	4.48	16.71	**20.28**	14.12
Pepper	-40.11	-10.62	9.64	**13.86**
Soya oil	-1.12	16.8	**23.94**	17.48
Sugar	-58.2	-29.94	-8.01	**3.19**
Wheat	-41.55	-18.36	-1.63	**5.18**
Crude oil	-22.29	-11.26	-3.41	**0.5**
Gold	-10.12	1.62	**7.76**	7.18

Table 5 presents the results of hedging effectiveness based on variance reduction obtained from hedged portfolios (for HR = 1, 0.75, 0.50, 0.25) for all the seven commodities. Commodities where futures have high hedging effectiveness will have higher variance reduction from hedged portfolio. The table shows that hedging effectiveness varies significantly across different commodities with different values of HR. Within these set of hedge ratios, we find that soya oil and castorseed have got the highest variance reduction values in the range of 20-25%. The value of the hedge ratio that maximises the variance reduction is however different across commodities.

6.3.2 Variance reduction using regression based HR

We now discuss the results for hedging effectiveness based on hedge ratios estimated from OLS regression. Table 6 presents the results with HRs for the entire period (fixed parameter) as well as for HRs derived over 3-months rolling window (time-varying parameter).

Table 6 Variance reduction of hedge portfolio using fixed-parameter and time-varying parameter models

The table presents the values of estimated hedge ratios ($\hat{\beta}$) as well as the percentage variance reduction obtained on the hedged portfolio vis-a-vis the unhedged portfolio. These results are presented for both conventional OLS model and rolling window OLS. The estimated hedge ratio and percentage variance reduction for the time-varying model (rolling window OLS) are the average of estimates obtained for each window.

	Fixed parameter		Time-varying parameter		Post 2010	
	$\hat{\beta}$ (HR)	VarRedn (%)	$\hat{\beta}$ (HR)	VarRedn (%)	$\hat{\beta}$ (HR)	VarRedn (%)
Castorseed	0.53	36.60	0.50	36.57	0.60	44.05
Pepper	0.32	27.06	0.31	28.43	0.30	25.26
Soya oil	0.49	42.16	0.48	40.54	0.42	37.90
Sugar	0.18	7.47	0.18	10.34	0.18	9.49
Wheat	0.23	10.14	0.22	12.13	0.21	11.11
Crude Oil	0.15	1.67	0.13	3.29	0.14	1.58
Gold	0.40	16.02	0.37	15.05	0.37	15.68

We do not find significant difference in the results obtained from time-varying parameter approach versus the fixed parameter approach. The average hedge ratios and percentage variance reduction from the two approaches are comparable. The results from estimation for the period post 2010 are also similar.

Within agricultural commodities, the estimated variance reduction for the soya oil futures contract is the highest (42.2%), while that from the sugar futures contract is the lowest (7.4%). This implies that soya oil producer can reduce the risk of volatile soya oil prices at the time of sale of his output in the market by 42%. At Rs. 1,00,000/ton of soya oil, this translates into a saving of Rs.227/ton[8] for a soya oil producer who holds a hedged position and soya oil prices see a price drop in a day of 95% probability. The farmer with a sugar futures position, on the other hand, has to face 92% risk in the price at sale since the futures give a reduction of only 8%. At Rs.32,000/ton of sugar, this translates into a saving of Rs.36/ton for the same probability of a drop in prices in a day for a farmer with the futures contract. Thus, the soya oil producer stands to benefit more from using futures than the sugar farmer.

[8]This is approximated as the change in the Value at Risk at 95% probability for a hedged position on a ton of soya oil, compared to an unhedged position of the same size.

6.4 Determinants of futures market hedging effectiveness

The degree of hedging effectiveness for most of the commodities used in the analysis appears to be low. In Section 4.2, we described that the effectiveness of a hedged portfolio depends on the substitutability of the underlying commodity with the commodity specified in the futures contract and the cost of storage and other transactions costs. These two factors get reflected in terms of the difference between the futures and the spot price, ($F_t - S_t$), that is the basis. The lower is the average value of this difference, and less variable it is, the higher the hedging effectiveness is likely to be. Thus, both the average basis as well as the variability in the basis can be expected to affect the degree of hedging effectiveness. In addition, when spot volatility is high, one would expect higher returns from a hedged portfolio. Thus, we expect that spot volatility will have a positive impact on the degree of variance reduction. We test these hypothesis using the following fixed effects regression framework:

$$VarRedn_{i,t} = \alpha_i + \beta_1 \cdot Volatility_{i,t} + \beta_2 \cdot Basis_{i,t} + \beta_3 \cdot \sigma_{basis,i,t} + \epsilon_{i,t} \quad (6)$$

where $VarRedn_{i,t}$ indicates the 3-months rolling window based variance reduction for commodity i in time period t, $Volatility_{i,t}$ indicates the median value of the spot price volatility for commodity i during time period t, $Basis_{i,t}$ indicates the logarithmic difference between the futures and the spot price for commodity i during time t, and $\sigma_{basis,i,t}$ indicates the variation in the basis of commodity i at time t.

Table 7 Determinants of futures market hedging effectiveness

The table presents the fixed effects regression results for the equation:

$$VarRedn_{i,t} = \alpha_i + \beta_1 \cdot Volatility_{i,t} + \beta_2 \cdot |Basis_{i,t}| + \beta_3 \cdot \sigma_{basis,i,t} + \epsilon_{i,t}$$

where $VarRedn_{i,t}$ indicates the 3-months rolling window based variance reduction for commodity i in time period t, $Volatility_{i,t}$ indicates the median value of the spot price volatility for commodity i during time period t, $Basis_{i,t}$ indicates the logarithmic difference between the futures and the spot price for commodity i during time t, and $\sigma_{basis,i,t}$ indicates the variation in the basis of commodity i at time t. Individual firm intercepts are suppressed. Heteroskedasticity consistent White standard errors are reported.

	Estimate	Std. Error	t-stat	p-value
Volatility	10.88	3.10	3.50	0.00
|Basis|	-0.39	0.29	-1.35	0.17
σ_{basis}	-5.91	1.15	-5.09	0.00
# of obs.	17,658			

Table 7 reports the estimation results. The dependent variable is the variance reduction obtained from the hedging portfolio over a 3-months rolling window for a commodity. We find that the coefficient with volatility turns out to be positive and significant, validating the hypothesis that when the prices of the spot commodity are more volatile, the hedging effectiveness improves. The coefficient with the basis turns out to be negative but insignificant.[9] The coefficient with the basis risk (σ_{basis}) that captures the variability in the basis is negative and significant, again validating the hypothesis that more the difference between the actual spot and futures commodity varies, lower will be the hedging effectiveness.

7 Discussion

The analysis from the previous section indicates that for the commodities analysed in the study, though the futures market plays an important role in the price discovery function, they serve poorly in the risk management function. While the price discovery function depends on which market incorporates new information first, the degree of hedging effectiveness depends on the level of association between the spot prices and the futures prices. This level of association, in turn, depends on the cost involved in undertaking a futures position, that is storage and transactions costs, and the grade difference between the underlying commodity and the commodity specified under the futures contract. The greater is the difference, the lower will be the degree of price association between the spot and the futures commodity, and thus, the lower will be the hedging effectiveness.[10] If there are exogenous factors that disrupt the relationship between the spot and the futures prices, the hedging effectiveness can further reduce.

In the Indian context, there are several exogenous factors that could be directly affecting the relation between the spot and the futures prices. Firstly, the grade of the commodity. The Indian commodities exchanges typically trade limited high quality grades for any commodity. However, there is very

[9]A reason for this could be the high correlation between the basis and the basis risk. An independent regression specification without the basis risk yielded a negative and coefficient.

[10]This is similar to analysis by Garbade and Silber (1983) who show that the risk transfer function depends on the elasticity of arbitrage between the futures and the cash market. Greater elasticity fosters more highly correlated price changes, and thereby facilitates the risk transfer function. The elasticity of supply of arbitrage services is constrained by, among other things, storage and transaction cost.

little grade standardisation in the spot market. This implies that there can frequently be a significant gap in the quality of what is traded and what is delivered, causing ($S_T - F_T$) to be wider than expected.

Secondly, the warehousing infrastructure in India. The futures exchanges gather orders from across the nation on a single platform, and the delivery are made in warehouses, which issue a warehouse depository receipt (WDR) that the seller transfers to the buyer. The scarcity of warehouses in the country along with absence of standardisation[11] has a two-way impact on ($S_T - F_T$). First, is due to added cost of transportation of commodity to and from limited number of warehouses. Second, the discrepancy in the grade leads to wide variation in the quality of delivery received at the exchange.

Finally, the multiple laws governing the spot market for commodities, such as state laws, Essential Commodities Act (ECA), 1955, and Food Standards and Safety Act (FSSA), 2006 may have an adverse impact on ($S_T - F_T$) through S_T. This is due to different rules on permitted inventory of agricultural commodities. The requirement for FSSA compliant grades for futures contracts can cause a gap between available supply of the commodity and what can be delivered, and thus affecting the ($S_T - F_T$). For example, the quality of pepper permitted under FSSA 2006 is very different from what is available for sale in the spot market leading to divergence in the price in the spot market and the price of the grade traded in the futures.

8 Conclusion

All derivatives trading in India, particularly those trading on agricultural commodities, undergo intense scrutiny and criticism from the policy community. The popularly voiced concern is that very different participants trade these financial instruments compared to agriculturists, giving rise to derivative prices that are driven by different factors than those that drive the underlying commodity price. In response, the government has frequently intervened in the working of these markets, starting from controls on storage of the commodity at the level of the state government to a national ban on trading these derivatives, particularly when the underlying prices rise.

[11] The Warehousing (Development and Regulation) Act was passed in 2007, with the Warehousing Development and Regulation Authority as the independent regulator becoming operational by the end of 2010. However, there has been very little implementation of the regulatory mandate till now.

In our analysis of the price discovery and hedging effectiveness of the commodity derivatives markets in India, we find that these markets play a consistent role in price discovery across most of the seven commodities analysed. But we find that the hedging effectiveness is low, and has wider variation across the commodities, particularly agricultural.

We find that these two outcomes are not related to other microstructure outcomes such as market liquidity or market size. We conclude that the high volatility in spot market negatively impacts the share of the futures market in price discovery. On the other hand, high volatility in spot market improves hedging effectiveness of the futures market, while a variation in spot and futures prices lower the hedging effectiveness for these markets.

Thus, we conjecture that issues that prevent the following relationship from holding – ($S_T - F_T = C$) – also hinder hedging effectiveness of the futures markets. Some of these issues include a lack of standardisation of underlying commodities and mismatch between grades available and grades to be delivered. Along with this, the state exerts significant control on the inventory of the commodity held by traders, as well as the supply of deliverable commodity in the market and suspension of trading in the futures contracts.

Thus these factors cause disruptions in either the spot price or the futures price or both, in such a way that the hedging benefits from futures trade in commodities is significantly reduced. Therefore, while the commodity futures markets were reformed so that futures markets could substitute price controls by the government for commodity price risk management, government interventions themselves are likely to be the most significant barrier to futures providing good hedging effectiveness against commodity price risk.

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