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Indira Gandhi Institute of Development Research (IGIDR)
General Arun Kumar Vaidya Marg
Goregaon (E), Mumbai- 400065, INDIA
Email(corresponding author):
GFd@hgfh

Abstract

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Indira Gandhi Institute of Development Research (IGIDR)
General Arun Kumar Vaidya Marg
Goregaon (E), Mumbai- 400065, INDIA
Email (corresponding author): susant@igidr.ac.in

Abstract

In 2003, trading of commodity futures 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 and concludes that,on average, futures prices do discover information relatively efficiently,but helps to manage risk less efficiently. The paper uses the viewpoint of the hedger to conjecture what factors may improve hedging effectiveness. These include high settlement costs caused by few and widely dispersed delivery centers and an unreliability of warehouse receipts,a mismatch between the grade specified in the futures contract and what is available for delivery in the market, and disruptions caused by various policy interventions in both commodities spot and futures markets.

Keywords: Commodities futures, price discovery, hedge ratio, variance reduction, cost of carry, settlement costs

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The authors are with the Finance Research Group, IGIDR, Bombay. http://www.ifrogs.org/papers.html 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.

Do futures markets help in price discovery and risk management for commodities in India?

Nidhi Aggarwal Sargam Jain Susan Thomas*

June 16, 2014

Abstract

In 2003, trading of commodity futures 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 and concludes that, on average, futures prices do discover information relatively efficiently, but helps to manage risk less efficiently. The paper uses the viewpoint of the hedger to conjecture what factors may improve hedging effectiveness. These include high settlement costs caused by few and widely dispersed delivery centers and an unreliability of warehouse receipts, a mismatch between the grade specified in the futures contract and what is available for delivery in the market, and disruptions caused by various policy interventions in both commodities spot and futures markets.

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Contents

Table 1 Comparing traded volumes on equity and commodity derivatives in India

	Total Traded Volumes (USD million)					
Market	2003		2008		2013	
Commodity derivatives	29		1019		3330	
of which						
Agricultural	28	(96%)	244	(24%)	400	(12%)
Non-agricultural	1	(4%)	775	(76%)	2930	(88%)
Equity derivatives	92		3281		5793	
Equity spot	128		890		498	

Source: The *Indian Securities Markets Review, 2002-2003*, *Fact Book, 2013*, NSE, and FMC.

1 Introduction

After decades of restrictive policies, the Government of India suggested 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. Now commodity derivatives trade on national exchanges rather than regional markets where local trading interest may sway price determination. And there is a regulator with a mandate to monitor the workings of these markets.

A clear outcome of these changes has been a significant growth in the commodity futures trading (Table 1). But does trading on 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?

We analyse these questions for a set of eight commodities for a period from 2003 onwards when national trading started on the electronic exchanges upto

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

January 2014. The eight commodities include six agricultural commodities and two non-agricultural commodities. Castorseed, pepper, rubber, 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 consolidate 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 the 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.

Two approaches are used to estimate how effectively the futures can be used for hedging price risk. The first is to compare the price risk in any commodity with and without a futures contract. If futures are a useful hedging tool, then risk ought to be lower for the hedged portfolio (the one with a futures contract). The reduction in the variance of the hedged portfolio measures the hedging effectiveness of the futures contract. A more standard measure uses the variance reduction in spot returns when estimated as a function of futures returns using a regression framework.

Contrary to our expectations, we find a consistently high degree of price discovery across different commodity futures on average, and a relatively lower degree of hedging effectiveness on average. 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 six agricultural commodities.

A closer examination of the performance of the futures finds no correlation with other market outcomes such as the traded volume (which measures liquidity) and open interest (which measures size) in the futures markets. We conjecture that the level and variation of hedging effectiveness may instead be more closely linked to transactions costs of trading in both the futures and spot commodity markets. These costs may be in the form of too few delivery centers at exchanges, low credibility of warehouse receipts, lack of standardisation of underlying commodities and mismatch between grades available and grades to be delivered. Further, there is a multiplicity of laws governing inventory held, and and supply available, of the commodity for trading. These may also adversely influence hedging effectiveness in the agricultural commodities futures.

The paper is structured as follows. Section 2 offers a background about the commodity derivatives market in India and the research examining their role in price discovery and hedging effectiveness. Section 3 presents the approach used in this paper to measure these roles in the post-liberalisation period. The data used in the analysis is described in Section 4. Results and their interpretation are presented in Section 5. Section 6 concludes.

2 Role of commodities derivatives in India

Commodity futures have been trading in India since 1800 (Thomas and Varma, 2010), which points to an economic need for these contracts that has been present for a long time. These contracts have continued trading both formally on exchanges as well as in informal markets despite the government enacting laws to control the prices and supply of certain commodities or outright bans (Sahadevan, 2002). The reforms of 2000 brought significant changes to the markets trading these commodities, with nation-wide markets that allowed the participants to access the markets, and use derivatives to manage price risk on the underlying.

The wide span of time for which these 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.

Several research papers have examined the relationship between commodity futures and spot prices, some of which analyse the price dynamics between the two markets. Naik and Jain (2002) examine prices from the older regional exchanges, and show that information flows from the futures market to the spot markets. Studies examining the price discovery function of the newer national multicommodity exchanges tend to analyse the period shortly after the start of the national exchanges in 2003 (Easwaran and Ramasundaram (2008), Lokare (2007)).

It is well acknowledged that changes to market microstructure take time for full adoption, particularly in markets where participants have lower access to capital. Capital is required for the development of systems that can interface with electronic trading platforms, or to be compliant with the more stringent real-time margin based risk management processes of the modern exchanges. We find the slow adoption of changes to market microstructure in other financial markets in India as well.[2] An analysis of the most recent data from the commodity derivatives markets ought to reflect the equilibrium trading response of the participants in the commodity derivatives markets.

Fewer studies have analysed the use of these contracts to reduce price risk of commodities. 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. This study shows 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.

In this paper, we re-examine of the price discovery and risk management role of the Indian commodities futures markets. A reason to do so is to understand the relevance of these markets in the more recent period which was characterized by significant price volatility resulting in large government and regulatory intervention (by way of ban on the futures, increase in margins, position limits). One reason is to update the analysis using the most recent data. However, the key motivation is to examine these two roles of the commodities markets after allowing for a sufficiently long period within which the microstructure changes can be fully assimilated by all participants.

3 Analytical approach

All tests of how well a futures market helps in price discovery or 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.

[2]For example, Aggarwal and Thomas (2014) find that it took a full year before the algorithmic trading intensity in the equities markets stabilized after the introduction of co-location facilities at the equity markets of the National Stock Exchange

3.1 Measuring price discovery using the Information Share

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, 1982; 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) 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 dominate 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 (1982)). 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 each commodity. This is presented in Table 2, separately for two different periods:

1. The $\text{IS}_{\text{futures}}$ for the full period (2004-2014).
2. In order to assess the contribution of the futures markets in the period

after the global financial crisis of 2008, we calculate the IS_{futures} from 2010 onwards.

3.2 Measuring hedging effectiveness by comparing the risk of hedged and unhedged portfolios

The measurement of hedging effectiveness relies on a framework based on the perspective of an agriculturist. The agriculturist uses the futures market for both price discovery and hedging as follows:

$$\mathrm{E}(\mathrm{S}_T) = \mathrm{F}_t \quad \text{at } t = 0$$

where $\mathrm{E}(\mathrm{S}_T)$ denotes the expected spot price at time 'T', and F_0 denotes the futures price at time 't' = 0. Once the decision has been made for what to sow, the agriculturist has exposure to the commodity spot price. This means that changes in the the commodity price can change the returns of the 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, $\mathrm{E}(\mathrm{S}_T)$. 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.

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	$\mathrm{S}_T + \mathrm{F}_0 - \mathrm{F}_T$

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 $(\mathrm{S}_T - \mathrm{F}_T) = 0$.

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[3], at every time

[3] It is also referred as the basis.

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 $t = T'$	$S_{T'}$
B: Hedged portfolio, at $t = T'$	$S_{T'} + F_0 - F_{T'}$

Here, the hedged portfolio realises a value of F_0, if $(S_T - F_T) = C$. This implies that the effectiveness of the hedge using the futures contract depends upon whether (F_t - $S_t = C$) 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, $(F_t - S_t)$, 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 the paper, we calculate the hedging effectiveness of the commodity futures contracts using two approaches:

1. Estimate returns from a hedged and unhedged portfolios on each commodity, and then compare the average returns and volatility of each.

   If the futures contract is a good hedge, then the volatility of the hedged portfolio will be lower than that of the unhedged portfolio.

2. Calculate the hedging effectiveness by estimating the reduction in variance in the returns of an unhedged portfolio compared to an optimal hedged portfolio.

   This is done using a regression framework on the returns of the two portfolios.

Estimating variance of a hedged and unhedged portfolio

When we construct the hedged portfolio to calculate the hedging effectiveness of the futures contract, the variance comparison has to be done of the unhedged portfolio with that of the optimal hedged portfolio. This issue arises because often the spot commodity has multiple grades compared to the grade that is used to define the futures contract. If there is perfect correlation between the two grades, then there is a correlation close to 1 of the changes in the spot and futures prices. In this case, the amount of the offsetting (opposite) futures position that needs to be purchased is of the same value as the commodity to be sold. The amount of the offsetting position is called the *hedge ratio* and is denoted as HR. In this case, the optimal hedged portfolio is denoted as ($S_t -$ HR$\times$ F_t).

If the spot commodity is not 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 this section, we calculate the hedged portfolio for all the commodities assuming four values of HR: 1, 0.75, 0.50, and 0.25. These give us four different hedged portfolios. For each hedged portfolio, we then carry out the following steps:

1. Calculate the standard deviation (σ) of the unhedged portfolio for each commodity i.

   This is denoted as $r_{\text{unhedged},i,t}$ where 'i' represents the commodity, and 't' represents the time.

2. Calculate the mean and standard deviation of the hedged portfolio returns as:

   $$r_{\text{hedged},i,t} = r_{\text{spot},i,t} - \text{HR} \times r_{\text{futures},i,t}$$

   where $r_{\text{hedged},i,t}$ denotes the returns on the hedged portfolio for commodity 'i' at time 't', $r_{\text{spot},i,t}$ indicates the returns on the spot market, and $r_{\text{futures},i,t}$ indicates the returns on the futures market. Here, HR takes values of 1, 0.75, 0.50 and 0.25.

3. Compare the average daily volatility of the hedged and the unhedged portfolios.

The futures markets has a high hedging effectiveness if the hedged portfolio has lower volatility relative to the unhedged position.

Variance reduction in the unhedged portfolio

In this approach, instead of using an ad-hoc value of HR, we estimate the optimal value as described below:

1. Estimate the following regression for each commodity:

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

   The estimated value of β ($\hat{\beta}$) represents the optimal HR Myers and Thompson (1989).

   Here, returns are calculated as the first difference in log closing prices for both the spot and futures markets.

2. Use $\hat{\beta}$ from the above regression to calculate variance of the hedged portfolio, Var(Hedged), and of the unhedged portfolio, Var(Unhedged), for a given commodity 'i' as:

$$\begin{aligned} \text{Var(Hedged)}_i &= \text{Var}(r_{\text{spot},i,t} - \hat{\beta} \times r_{\text{futures},i,t}) \\ \text{Var(Unhedged)}_i &= \text{Var}(r_{\text{spot},i,t}) \end{aligned}$$

3. Compute the variance reduction (VarRedn) for commodity 'i' derived from hedging as (in %):

$$\text{VarRedn}_i = 100(1 - \text{Var(Hedged)}_i/\text{Var(Unhedged)}_i)$$

A significant decrease in the variance of the hedged portfolio compared to the unhedged commodity position implies that the futures is an effective instrument to hedge price exposure in the underlying commodity.

In both the measurement of price discovery and hedging effectiveness, we evaluate each method for the *full* period, as well as for the more recent period from 2010 onwards.

4 Data

The data used for the analysis is obtained from three commodity exchanges – MCX, NCDEX, and NMCE – for the period between 2003-2014. The first part of the analysis uses daily price data on both the spot and the futures prices, similar to that what is available in the bhav copy of the exchange. The analysis uses closing prices for each commodity on each of the exchanges.

In addition to the price data, we also use market microstructure data on market liquidity and trader participation. If there is variation in how price discovery and hedging effectiveness takes place on these derivatives contracts, these observations can be used to test for a link between market microstructure and these outcomes. These variables include: daily traded volumes (in

Table 2 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 missing data because the futures was banned from trading.

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
Rubber	NMCE	Feb '04 - Jan '14	May '08 - Nov '08
Non-agri commodities			
Crude oil	MCX	Feb '05 - Jan '14	-
Gold	MCX	Nov '03 - Jan '14	-

number of contracts), daily open interest (in number of contracts), participation of proprietary trading in daily volumes and in daily open interest (in fraction of number of contracts), margins charged (in percentage).

4.1 The commodities selected

We focus on six agricultural and two non agricultural commodities, which are described in Table 2. Our analysis excludes the period during which trading on the commodity was banned. The data consists of daily closing prices on the futures contract as well as the spot market.[4] 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.

[4]Daily open prices are also available for the futures contracts.

Table 3 IS of the futures market for the full period and for post 2010

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 and for a subset period (2010 onwards).

	Full period	From 2010 onwards
CastorSeed	0.66	0.68
Pepper	0.50	0.52
Rubber	0.66	0.80
Soya Oil	0.65	0.69
Sugar	0.56	0.10
Wheat	0.88	0.81
Crude	0.94	0.98
Gold	0.56	0.36

5 Results

5.1 Information share and price discovery

Table 3 presents the estimated values of the IS of the futures market for each commodity[5] for the *full* period, and for the more recent *subset* period from 2010 onwards.

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 results of the median values of the $IS_{futures}$ mirror the pattern.

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, the reason could be the recent import ban on the spot commodity, which could in turn influence the traders use of futures and how effective it is in price discovery. While these are likely reasons, we do not explicitly establish these as the cause of the fall in $IS_{futures}$.

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

Table 4 Average daily volatility of the hedged and unhedged portfolios

The table presents the average variance of the spot commodity and the hedged portfolios, where the spot is combined with the futures in some value of the hedge ratio. When the futures value is the same as the spot, the hedge ratio is 1. For each commodity, the variance of the hedged portfolio is calculated for four values of the hedge ratio: 1.00, 0.75, 0.50, 0.25. The hedged portfolio for any commodity where the variance is the least, has been highlighted in the values below.

in (%)

	σ_{spot}	σ of the hedged portfolio			
		HR =			
Commodity		1.00	0.75	0.50	0.25
Castorseed	1.36	1.32	1.16	**1.11**	1.18
Pepper	1.04	1.46	1.15	0.94	**0.90**
Rubber	2.02	1.46	**1.28**	1.34	1.62
Soya oil	0.88	0.76	0.63	**0.61**	0.70
Sugar	0.71	1.12	0.92	0.77	**0.69**
Wheat	0.87	1.22	1.02	0.88	**0.82**
Crude oil	2.12	2.59	2.36	2.19	**2.11**
Gold	1.00	1.11	0.99	**0.93**	0.93

5.2 Hedging effectiveness

Variance of the hedged vs. unhedged portfolio

Table 4 presents the results of hedging effectiveness by comparing the average daily standard deviation of a hedged portfolio with that of the spot commodity (the unhedged portfolio). We anticipate that the variance of the hedged portfolio would be significantly lower if the futures has a high degree of hedging effectiveness.

Table 4 shows that the hedging effectiveness of the futures vary across commodities. The drop in variance is highest for hedged portfolios in soya oil, rubber and castorseed. The value of the hedge ratio (HR) which minimizes the variance, however differs across commodities.

Variance reduction in a hedged portfolio

Table 5 presents the results of hedging effectiveness as measured by variance reduction of a hedged portfolio compared to an unhedged portfolio.

Table 5 Variance reduction in the unhedged portfolio obtained from the futures

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. The results are presented for the full as well as the more recent period post 2010.

	Annualised	Full period		Post 2010	
	σ_{spot} (%)	$\hat{\beta}$ (HR)	VarRedn (%)	$\hat{\beta}$ (HR)	VarRedn (%)
Castorseed	21.5	0.52	33.55	0.60	43.56
Pepper	16.4	0.32	27.01	0.30	25.31
Rubber	31.9	0.69	60.54	0.30	16.72
Soya oil	13.9	0.58	53.06	0.42	37.91
Sugar	11.2	0.18	7.70	0.17	8.52
Wheat	13.8	0.25	11.37	0.22	11.87
Crude Oil	33.5	0.15	1.67	0.15	1.63
Gold	15.8	0.39	15.88	0.37	15.68

Within agricultural commodities, the estimated variance reduction for the rubber futures contract is the highest (61%), while that from the sugar futures contract is the lowest (8%). This means that a rubber farmer can reduce the risk of the rubber price changing at the time that he sells his output of rubber sheets in the market by 61%. At Rs.14,400/ton of rubber, this translates into a saving of Rs.227/ton[6] for a rubber farmer who holds a hedged position and rubber 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 gives 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 rubber farmer stands to benefit more from using futures than the sugar farmer.

The amount of variance reduced from holding the futures contract is a function of the β, the level of association between the spot and futures returns. The higher the β, the higher the amount of variance reduction. Thus, among agricultural commodities, rubber has the highest β at 0.69, while sugar has the lowest at $\beta = 0.18$. The low levels of estimated β indicates that the futures contract is not a good substitute for the spot commodity.

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

The variance reduction for non agricultural commodities is even smaller. Crude oil futures has the lowest amount of variance reduction achieved as well as the lowest β of only 0.15. Taken together, these results indicate that the hedging effectiveness of commodities futures in India is not very high for all eight commodities analysed.

5.3 Interpretation and implications

The results show that while the commodity futures markets perform the role of price discovery reasonably well, their role in effectively reducing the risk in commodity exposure is not as strong. There is significant variation in price discovery as well as hedging effectiveness varies across commodities. However, other than for sugar and gold, the average information share (IS) of futures is consistent across the full period or the more recent period after 2010.

In contrast, the hedging effectiveness of commodities futures is not very high. The variance of the prices in commodities markets is quite high. As a comparison, the annualised volatility of crude oil prices over the period of the study is 33.5%. This is higher than the annualised volatility of the Indian equity markets, where the Nifty volatility was 26%.

But, the correlation between the Nifty and the near-month futures contract was 1.006, and the hedging effectiveness was 92% while the crude oil futures had a hedging effectiveness of 1.67% only.

One argument that might explain the difference between the hedging effectiveness of these two markets is that the Indian equity market is one of the most liquid markets in the world. However, while the liquidity of the commodity derivatives markets is far lower than the equity markets, there is significant volumes in some of these, especially crude oil. We examine a set of liquidity and market size measures to see if there is a correlation between hedging effectiveness and commodity market liquidity, as shown in Table 6. We find that there is no obvious evidence of any relationship between these.[7]

[7] A more detailed analysis has also been done using a time series of IS and hedging effectiveness calculated based on estimates for rolling windows of 500 days each. Details of these results are not presented in this paper, and is available upon request from the authors. The estimation methodology used is a fixed effects regression with contemporaneous microstructure variables as the independent variables. The equation used is as follows:

$$\text{IS}_{i,t} = \alpha_i + \beta_1 \times \text{TV}_{i,t} + \beta_2 \times \text{OI} + \beta_3 \times (\text{Prop. in TV})_{i,t} + \beta_4 \times (\text{Prop. in OI})_{i,t} + \epsilon_{i,t}$$

Where TV is the traded volume, OI is the open interest, (Prop. in TV) and (Prop.

Table 6 Price discovery and hedging effectiveness in comparison with market liquidity and participation, 2004–2014

The tables presents the $\hat{\beta}$, hedging effectiveness and price discovery (IS) for commodity futures, 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 what fraction of the traded volumes and the open interest can be attributed in a month to proprietary traders, as compared to their customers and clients.
The table shows that there is no visible link between high IS and high values of the market outcomes, or between high hedging effectiveness and the same. For example,

	β	VarRedn (in %)	IS	Market size Trd. Vol (Rs. lakhs)	Max OI (Contracts)	Prop. positions in Trd. Vol (in %)	in OI
Castorseed	0.52	33.55	0.66	218	4,6000	18.67	13.42
Pepper	0.32	27.01	0.50	2,816	4,408	29.44	13.13
Rubber	0.69	60.54	0.66	671	1910	2.00	1.00
Soya oil	0.58	53.06	0.65	8,864	33,690	43.81	26.20
Sugar	0.18	7.70	0.56	13	26,830	26.45	17.54
Wheat	0.25	11.37	0.88	385	17,440	29.13	22.90
Crude Oil	0.15	1.67	0.94	525,692	2,899,400	52.66	22.00
Gold	0.39	15.88	0.56	729,826	21,861	55.68	33.00

As discussed in Section 3, both price discovery and hedging effectiveness are measured from the relationship between the market prices for the spot and the futures contracts. Price discovery depends upon how information is transmitted in price across time, but hedging effectiveness is based on the contemporaneous relationship between the two prices at any given point in time. Given the results from the Indian markets, we attempt some factors that may cause the hedging effectiveness is relatively low.

Section 3.2 showed that hedging effectiveness depends upon the relationship between the spot and futures price when the hedger sells the commdity in the market at S_T and simultaneously unwinds the futures position at F_T. As long as the relationship ($S_T - F_T = C$) holds, the hedger will benefit from using the futures market. If there are exogenous factors that disrupt the market's expectation about any of these values, or their joint relationship, then the hedger will perceive few benefits from futures markets.

In the Indian context, there are several exogenous factors that can potentially disrupt the relation between the spot and futures prices. A few that we conjecture can be important are:

Factors affecting the futures prices

- The futures exchanges gather orders from across the nation onto a single platform, and the delivery takes place at certain designated centers. Futures traders located far away from these designated delivery centers incur the cost of transporting the commodity to and from the centers, and this must get reflected into the traded futures price. This causes ($S_T - F_T$) to be wider than expected.
- Delivery on the futures trades are made in warehouses, which issue a warehouse depository receipt (WDR) that the seller transfers to the buyer. There is no standardisation of warehouses.[8] This has meant a wide variation in the quality of delivery received at the exchange, and causes ($S_T - F_T$) to be wider than expected.

Factors affecting the spot commodity

in OI) is the fraction of proprietary trading in the traded volume and the open interest respectively.

None of the estimated coefficients are found to be significant. This indicates that there is no correlation across the contemporaneous values of the performance and the microstructure variables, which is consistent across the observations in Table 6.

[8]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.

- Indian commodities exchanges typically trade a single grade for any commodity. However, there is very little standardisation of the underlying commodity. For instance, there are more than 350 grades of wheat in India, and only one grade on which the futures trades. This implies that there can frequently be a significant gap in the quality of what is traded and what is delivered. This in turn, causes ($S_T - F_T$) to be wider than expected.
- Commodity derivatives are regulated under the Forwards Contract (Regulation) Act, 1952, which specifies forward contracts on *goods*. Thus, whether the futures trades on non-agricultural commodities where typically prices are influenced by international information, or in agricultural commodities where there are both domestic and international influences, they are all treated under the same framework. The lack of a distinction for how prices are influenced in turn, can cause ($S_T - F_T$) to be wider than expected for either set of commodities.
- There is a multiplicity of laws that govern spot commodities which can adversely impact ($S_T - F_T$) through S_T.

  For instance, different states can have different rules on permitted inventory of agricultural commodities. These rules can be changed at the discretion of the state government at any time. If there is a change in the permitted amount of inventory that can be held of (say) cotton, this can cause cotton prices to drop if the excess supply comes suddenly into the market. This can adversely impact ($S_T - F_T$) through S_T or C.

  The Essential Commodities Act (ECA), 1955, empowers the Central Government to set rules on the prices and permitted inventory of a certain set of commodities which are designated as essential. The Central Government can choose to set a Minimum Support Price (MSP) for the spot commodity, which can impact ($S_T - F_T$) through S_T. For example, the Government of India sets a Minimum Support Price (MSP) each year for sugar and wheat, both of which has a low hedging effectiveness (Table 7).

  Another example is the effect of the recently enacted Food Standards and Safety Act (FSSA), 2006. The FSSA 2006 defines standards on what is permitted for consumption. However, when the Forwards Markets Commission stipulated that futures contracts must have grades that are FSSA compliant, this can cause a gap between the available supply of the commodity and what can be delivered. This can have an adverse impact on ($S_T - F_T$). For example, the quality of pepper permitted under FSSA 2006 is very different from what is available for sale in the spot market. Since the futures contract can only deliver FSSA compliant pepper, there is a divergence in the price in the spot

Table 7 State controls on the agricultural spot commodity markets

The table presents which commodity prices are set under the Minimum Support Price (MSP) or fall into the categories of the Essential Commodities Act (ECA), 1955, or whether the futures have been banned in the period 2004-2014.

	Casterseed	Pepper	Rubber	Soya Oil	Sugar	Wheat
MSP	×	×	×	×	Yes	Yes
ECA	Yes	×	×	Yes	Yes	Yes
Ever Banned	×	×	×	Yes	Yes	Yes
Period of ban (years)	×	×	×	0.5	1.33	2.25
Hedging Effectiveness	33.55	27.01	60.54	53.06	7.70	11.37

market and the price of the grade traded in the futures.

In all the above instances, there is an adverse impact on ($S_T - F_T$) which, in turn, can cause the hedging effectiveness to be low. Thus, rubber has the highest hedging effectiveness, and is also the commodity which does not fall under the ECA, nor has a state set MSP, or had the futures contract been banned.

Policy interventions to improve the hedging effectiveness of commodity futures, particularly those on agricultural goods, may benefit from a focus on the above factors.

6 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 derivatives 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.

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

We find that these two outcomes are not related to other microstructure outcomes like market liquidity or market size. Rather, we conjecture that issues that prevent the following relationship from holding – ($S_T -$ $F_T = C$) – also prevent higher hedging effectiveness of the futures markets. Some of these issues include a low credibility of warehouse receipts, 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.

We conjecture that these factors cause disruptions in either the spot price or the futures price or both, in such a way that the hedging benefits to using the futures is significantly reduced. Thus, while the commodity futures markets were reformed so that futures markets could be a substitute for commodity price risk management through price controls by the government, 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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