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Abstract

In a period of great oil price volatility, the paper assesses the role of expected net demand compared to liquidity and leverage driven expansion in net long positions. We apply time series tests for mutual and across exchange causality, and lead-lag relationships, between crude oil spot and futures prices on two international and one Indian commodity exchange. We also search for short duration bubbles, and how they differ across exchanges. The results show expectations mediated through financial markets did not lead to persistent deviations from fundamentals. There is mutual Granger causality between spot and futures, and in the error correction model for mature exchanges, spot leads futures. Mature market exchanges lead in price discovery. Futures in these markets lead Indian (daily) futures-markets are integrated. But there is stronger evidence of short-term or collapsing bubbles in mature market futures compared to Indian, although mature markets have a higher share of hedging. Indian regulations such as position limits may have mitigated short duration bubbles. It follows leverage due to lax regulation may be responsible for excess volatility. Well-designed regulations can improve market functioning.

Keywords: crude oil spot, futures; commodity exchanges; short duration bubbles; position limits.

JEL Code: G13, G15, G18, E44, C32

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Regulations and price discovery: oil spot and futures markets

I. Introduction

Large recent oil price volatility motivates a reexamination of the interaction between oil spot and futures markets. We exploit the integration of a new commodity exchange, with a different regulatory regime, to isolate the contribution of regulations. Comparison is possible since the Indian Commodity exchange selected has sufficient liquidity and depth—in 2012 it became the third largest commodity exchange in the world.

As a physical commodity, the price of oil depends on the supply-demand balance, inventories, oil production capacity and costs. But as administrative price mechanisms were given up in the physical market, price discovery also began to take place in deep and liquid futures markets, which aggregated diverse views. As a financial asset, the price of oil depends on the structure of markets, expectations of oil fundamentals and of news impacting them. Prior to 2000, the expected long-run price of oil was stable. An oil shock was expected to reduce demand and to raise supply from Organization of the Petroleum Exporting Countries (OPEC) and non-OPEC sources. But these feedback mechanisms did not work in the sharp commodity booms of the 2000s (Fattouh 2010). Normal commodity cycles show a supply response after periods of sustained high prices. There are signs of this as shale oil and oil substitutes are developed.

Two classes of explanation are given for the unprecedented hardening of commodity prices in the new century. The first is driven by a changing structure of fundamentals—namely the rise in consumption given rapid growth in Asia especially China and India, countries with two-fifth of the world's population. That advanced economies with higher total consumption faced a slowdown, however, meant net demand fell. A price spike above equilibrium levels in a storable commodity should raise its stocks reflecting hoarding, but stocks were declining in most commodities in the period. If expectations that excess demand will persist become established and if inventories of a storable commodity are low, however, a demand or supply shock can result in a sharp rise in price since it takes time for supply to increase.

The second explanation is leverage from financial derivatives supported by quantitative easing in crisis-hit countries driving prices up across asset categories. Price discovery through futures markets does help producers to plan output and to hedge risks. As long as informed traders dominate they should not let values deviate far from fundamentals. Buying futures does not have the same effect as hoarding a commodity. Opposite paper positions can be generated in deep and liquid markets. But a fundamental change, starting in the 1990s, was the growth of investors who took positions in commodity futures as part of a diversified portfolio. Commodities became an asset class traded in modern financial markets. To facilitate such investment, intermediaries such as banks or 'swap dealers' provided products tracking commodity indexes. Examples of such products are exchange-traded funds (ETFs), or swaps, largely in over-the-counter (OTC) markets for large players such as hedge funds. In the US such swaps were granted exemptions from speculative position limits in the Bush years[1]. This coincided with large-scale index-based investment as pension funds etc. diversified their portfolios after the dot com crash. The commodity ETFs, traded in stock exchanges, are not for hedging purposes—they take positions based on expected price movements. There is no real exposure in commodities, no commodity delivery is involved, unlike in commodity exchanges. Investors are not commercial hedgers—their positions are continuously rolled over. Over 2004-08 open interest in oil derivatives more than tripled and the number of traders doubled, and positions were largely long. The sums involved are very large[2].

Position limits were the standard regulatory response to prevent large traders, alone or in concert, building up large positions in commodity markets to manipulate prices. In commodities limits tend to be tighter for near month contracts since concentration in maturing contracts causes' price volatility. Exemption from position limits was given on the grounds that transactions through OTC dealers are hedging activities, since the dealers buy futures to hedge their own short exposures, after netting across all their clients. But the positions swap dealers are hedging are financial not commercial positions, and investors themselves take a speculative view on future prices. Since the investments are very large, they can distort markets. Short positions can become risky if the large index funds are

[1] The Commodity Futures Modernization Act (CFMA) passed in 2000, weakened speculative position limits, among other deregulations.

[2] Commodities Futures Trading Commission (CFTC) data for West Texas Intermediate (WTI) crude, based on the average price of all contracts, shows the notional value of outstanding contracts grew from about $12 billion in 2000 to $75 billion in 2009, while the share of non-commercials grew from 15.5 to 41percent of the long open interest. When crude oil prices peaked in 2008 (average WTI price $101.5), the notional value of futures contracts was around $130 billion. In the US index funds held 24 percent of positions in all types of futures. (http://www.cftc.gov/ucm/groups/public/@newsroom/documents/file/cftcstaffreportonswapdealers09.pdf). IMF (2008), referred to such financialization by noting that the open interest in crude oil futures traded on the NYMEX had increased 155 percent during 2002-2008.

predominantly long. The consequent rise in margins may drive out commercial hedging by making it costlier. There are other concerns about delays in reporting[3], the quality of collateral used in such deals—potential exposure is large given explosive growth, and that ETFs sometimes deviate from the indexes they are supposed to track.

More research is required to distinguish between the alternative explanations for the rise in commodity prices. Arbitrage drives futures prices to equal expected future spot prices within the bounds set by risk aversion, transaction and carry costs. These no arbitrage bounds are smaller for commodities like oil with continuous production and high storability. Within these bounds, market expectations influence futures prices. If expectations dominate, nearby futures would cause spot prices. If fundamentals dominate, or futures markets had correctly assessed future spot prices, the causality is reversed so spot should cause nearby futures. Comparing EM with developed country exchanges gives an opportunity to test the alternative explanations. Leverage would only affect exchanges with weaker regulations, while global excess demand should affect all exchanges. Greater integration implies global liquidity can affect all prices. If outcomes still differ it would imply well designed regulatory regimes, can compensate for excess liquidity.

In order to assess the role of fundamentals compared to liquidity and innovation driven expansion in net long positions, and the effect of integration across exchanges, we first test for mutual Granger causality (GC), and lead-lags in vector error correction models (VECM), between crude oil spot and nearby futures prices on two international and one Indian commodity exchange. If futures are found to affect spot, but not vice versa, it could support the dominance of expectations mediated through financial markets on prices.

Second, we test if futures on one exchange affect spot markets in other regions. This contributes to understanding the nature of integration across different levels of market development.

Third, we examine if there are short duration bubbles in different oil futures series, and how they differ across exchanges. If integration is observed, yet the behavior of bubbles differs, it

[3] In the UBS scam of 2011, since several European banks do not issue confirmations until trades are settled after many days, the trader booked fake ETF trades to suggest his unauthorized positions were hedged.

could be due to different regulatory regimes, thus helping discriminate between expected fundamentals and leverage driven explanations of price volatility.

The results show fundamentals dominate in price discovery, in which developed market exchanges lead. There is mutual Granger causality between spot and futures, but in the error correction model for mature exchanges, spot leads futures. Developed market futures lead Indian (daily) futures—markets are integrated. But there is stronger evidence of short-term or collapsing bubbles in real developed market futures compared to Indian, although developed markets have a higher share of hedging. Indian regulations such as position limits and dynamic margins may have mitigated short-term deviations of prices from fundamentals. Therefore leverage due to lax regulation may be responsible for excess volatility. The results suggest well-designed regulations can improve market functioning.

The structure of the paper is as follows: Section II reviews selected research on oil futures; Section III tests the extent of global integration of Indian futures markets and its impact on interaction between spot and futures markets; Section IV tests for bubbles; Section V brings out implications for policy, before Section VI concludes.

II. Review of the Literature

The literature began with efficient market concepts and found support for them but as the literature matured, it also explored imperfections.

II.1 Price determination in the market for crude oil futures

A standard framework for thinking about the determination of futures prices in the market for crude oil is the theory of storage, generally applicable to markets for storable commodities. The spot price is the price at which the commodity is immediately available, and the futures price is the price at which the commodity will be available for delivery at a specified future date and place. Taking the supply of the commodity as given, the framework, in its simplest form, assumes that risk-neutral commodity processors operate in a competitive environment and will optimally choose the quantity of the commodity that they wish to consume today and the quantity that they wish to store. The assumption of risk neutrality ensures that the futures price equals the expected future spot price, adjusted for the costs and benefits associated with storing oil and having ready access to it. Expected new oil finds or inventions of crude oil substitutes also matter. Thus a close mathematical relation is expected between spot and futures prices if markets are efficient. This type of model has a long lineage, beginning with Kaldor (1939),Working (1949), Brennan (1958) and Gustafson (1958).More recent papers include Scheinkman et al (1983), Williams and Wright (1991), Deaton and Laroque(1992), and Ng and Ruge Murcia (2000).

II.2 Futures prices and market expectations

Futures prices can be used as a measure of the expected spot price and the term structure of futures prices as the expected time path of oil prices only if futures prices represent the rational expectation of the spot price of oil. The argument for using futures prices to represent market expectations thus relies on the premise that futures prices are unbiased predictors of the future spot price of oil. The available evidence is broadly consistent with that assumption. Although there is some evidence futures prices are biased predictors of the spot price, the bias is small, on average. Evidence that oil futures prices are a good first approximation to expected future spot prices, comes from Chernenko et.al. (2004), Arbatli (2008), Chinnet.al. (2005), and Alquist and Kilian (2010).

II.3 Using futures prices to forecast the spot price of crude oil

In efficient markets futures prices should forecast the spot price of oil out-of-sample. The main conclusion is that while futures prices tend to produce forecasts that are correct on average, such forecasts are also highly volatile relative to no-change forecasts. Therefore, futures-based forecasts may be very inaccurate at a given point in time. The variability of futures-based forecasts makes it advisable to use the information contained in oil-futures prices in conjunction with other types of information when arriving at a judgment about the future trajectory of oil prices.

Some early studies found evidence futures prices were accurate out-of-sample predictors of the future spot price of oil. Ma (1989) reports that futures price outperform the no-change, as well as other simple time-series model’s forecast, in out-of-sample forecasting exercises. Kumar (1992) reaches similar conclusions. He finds that futures prices provide more accurate forecasts than those obtained from alternative time-series models, including the random-walk model. In a study that uses data through the end of 2003, Chernenko et. al. (2004) provide evidence that futures-based forecasts have a marginally lower mean-squared prediction error than the no-change forecast. Three related papers are Chinn et. al. (2005), Wu and McCallum (2005), and Coibion and Chinn (2009). Chinn et al. conclude that futures-based forecasts are unbiased predictors of the spot price of oil and that they perform better than the random-walk forecast according to the mean-squared prediction error. However, when Coibion and Chinn (2009) updated the results from their earlier paper, they found that futures prices do not systematically outperform the random-walk forecast although they are superior to forecasts generated by other types of time-series models. Wu and McCallum (2005) report futures prices tend to be less accurate than the no-change forecast.

II.4. The futures-spot spread and precautionary demand

Alquist and Kilian (2010) propose a model in which the futures-spot spread may be viewed as an indicator of shifts in expectations about future oil-supply shortfalls. In their model, an oil-producing country exports oil to an oil-consuming country that uses the oil to produce a final good to be traded for oil or consumed domestically. Oil importers may insure against uncertainty about oil-supply shocks by holding above-ground oil inventories or by buying oil futures. Oil producers may sell oil futures to protect against endowment uncertainty.

One implication of the model is that increased uncertainty about future oil-supply shortfalls causes the oil-futures spread to fall and raises the current real spot price of oil, as precautionary demand for oil inventories increases. Such uncertainty thus causes the real price of oil to overshoot and then to decline gradually to a new steady-state value that is higher than the original one.

II.5 Oil volatility and speculation

Limited research on oil volatility tended to show that since the 1973 oil crisis, oil and energy prices in general, have been more volatile than other commodity prices (Fleming and Ostdiek 1999). Plourde and Watkins (1998) found that crude oil price volatility during the 1985-1994 period was in the upper end of the range of all measures of price volatility studied, but was not "clearly beyond the bounds set by other commodities".

Bessembinder and Seguin (1993) found that that open interest has significant negative effect on volatility, while trading volume has a significant positive effect. Fleming et. al. (1999) conducted a study based on daily spot prices and total open interest across all New York Mercantile Exchange (NYMEX) crude oil contracts lengths from 1982 to 1997 using public CFTC data. As in the Bessembinder et. al. (1993) study, they found a negative relation between open interest and volatility, and suggested that futures trading stabilizes the market as trading improves depth and liquidity. Dufour (2000) suggested a large volume of purchases might well cause price to increase, at least temporarily, until the investors have the chance to verify the true fundamentals. If there is a considerable difference in volume on either buy or sell side, potential investors may take this as a possible signal that there is something they don´t know, and hence buy or sell contracts not based on fundamental information. This may result in time periods with additional volatility, and as more speculators are entering the market it is reasonable to believe that the frequency of such time periods increases. Irwin and Holt (2004) show a small but positive relationship between trading volume and volatility.

A number of studies of the 2008 commodity spike, surveyed in Irwin and Sanders (2010), have on balance not found evidence that futures markets affect spot prices unrelated to fundamentals. Trader positions in the market follow prices rather than the other way around, and offsetting positions are taken. Haigh and Hranaiova (2007) conclude that hedge fund activity does not affect price levels in energy futures markets, and that speculators are providing liquidity to hedgers and not the other way around. Verleger (2009) found in his studies no correlation between WTI crude oil price and flows of money into the WTI futures contracts offered by the Intercontinental Exchange (ICE) and NYMEX. Nor did he find any correlation between crude oil prices and flows of money in or out of commodity index funds, which constitute the larger part of the speculative investments.

But large frequent global price spikes and lack of convergence between spot and futures prices in certain markets imply some malfunctioning of markets. Chowdhury (2011) demonstrates the clear correlation between large-scale growth of commodity index funds and price volatility, but causality is more difficult to establish. Gilbert (2010) finds some evidence of bubbles in energy and metals due to trend following commodity trade advisors. He also found index fund positions magnified the fundamental driven rise in energy and metal futures.

III. Integration across Exchanges

NYMEX is the world's largest physical commodity futures exchange and the most important trading forum for energy and precious metals[4]. Trading is largely conducted through futures contracts, which the Exchange introduced in 1981.

Established in May 2000, ICE expanded its business into futures trading in June 2001,by acquiring the International Petroleum Exchange (IPE), now ICE Futures. In most analysis, light sweet crude oil futures, traded in the NYMEX, and the Brent crude futures contract, traded in the ICE are considered. Because of their excellent liquidity and price transparency, the contracts serve as international pricing benchmarks. The Brent Crude Futures Contract, together with West Texas Intermediate Crude futures, accounts for nearly half of the world's global crude futures by volume of commodity traded.

Modern electronic commodity exchanges began operation in India after 2000 as part of liberalizing reform. Today there are five national commodity exchanges and sixteen regional exchanges. Multi Commodity Exchange (MCX), established in 2003, is the dominant exchange for metals and oil. It introduced trading in crude oil futures in 2005. In 2012 it became the 3rd largest exchange in the world based on number of futures contracts traded.

In the absence of full capital account convertibility there are restrictions on external investors taking positions on Indian commodity exchanges. Therefore price discovery cannot be expected to take place in those exchanges, although they offer a useful opportunity to Indian business to hedge (since domestic prices move closely with foreign) and to take positions independent of currency risk, at lower transaction costs compared to those abroad. Contract size is also lower. The open interest, which can be taken as an indicator of the share of hedging positions, is much lower in MCX compared to NYMEX and ICE, but regulations such as on position limits are tighter, and option contracts and other structured products are not yet permitted. Only 2-4 month contracts are liquid, so rollovers become necessary and increase transaction costs.

[4]It originated from the merger between New York's two largest exchanges, the New York Mercantile Exchange and the Commodity Exchange, in 1994. It operates through two divisions: the NYMEX division, where energy, platinum and palladium are traded, and the COMEX division, which is entitled for all other metals.

III.1 Linkages between the prices of oil futures traded on the NYMEX and the ICE

Spargoli and Zagaglia (2007) studied the linkages between the prices of oil futures traded on the NYMEX and ICE, by estimating a structural BEKK-GARCH model. They found that the oil futures traded on the NYMEX and ICE can be used for mutual hedging purposes only when the structural conditional variances of both innovations are modest and, as such, no turbulent events have taken place. They also found that during times of market turmoil, the structural variance of the returns on NYMEX futures becomes larger than that of ICE futures. This means that, when there are common shocks to both markets, the NYMEX reacts more strongly than the ICE. Of late prices in the two have diverged.

III.2 Data and methodology

We consider both monthly and daily time series, since transient trading features in daily data can obscure meaningful relationships, while there is loss of information in monthly aggregates. Data is taken over February 2005-June 2010, since this was a period of high volatility in oil prices and MCX commenced trading in crude oil futures on February 9, 2005. The dataset includes US WTI crude oil spot prices, UK Brent spot, MCX WTI spot, monthly or daily close nearby futures prices on the three commodity exchanges. The contracts selected are among the most liquid in the world. Volume and open interest are in lots; aggregate volume in all contracts during the period, cumulative OI in all contracts at the end of the period. The UK and US prices are in USD/bbl while those on MCX are in Rs/bbl term. All prices are converted into INR/bbl by using the average INR/USD exchange rate. Volume and open interest are in absolute numbers. While spot prices were monthly average, futures prices were month closing values.

Figure 1 and 2 show rough congruence, across the three exchanges, of monthly crude oil futures (Figure 1) and crude oil spot (Figure 2) prices in rupees per bbl[5]. The structure of volatility is similar, with a peak in mid-2008. Figure 3 shows the close correspondence between MCX spot and futures crude oil prices.

[5]Price is quoted in the standard oil barrel of 42 US gallons, abbreviated as bbl, which stands for British Barrel.

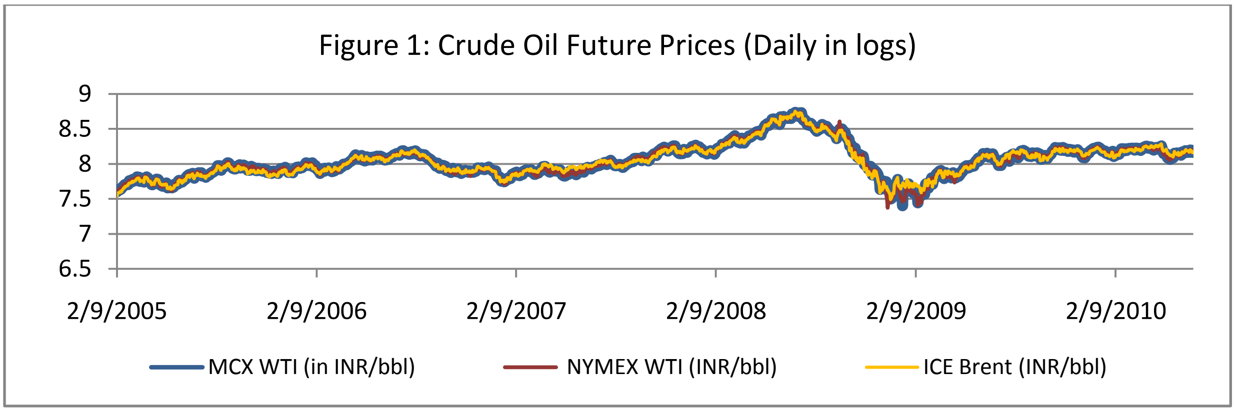


Figure 1: Crude Oil Future Prices (Daily in logs)
9
8.5
8
7.5
7
6.5
2/9/2005
2/9/2006
2/9/2007
2/9/2008
2/9/2009
2/9/2010
MCX WTI (in INR/bbl)
NYMEX WTI (INR/bbl)
ICE Brent (INR/bbl)

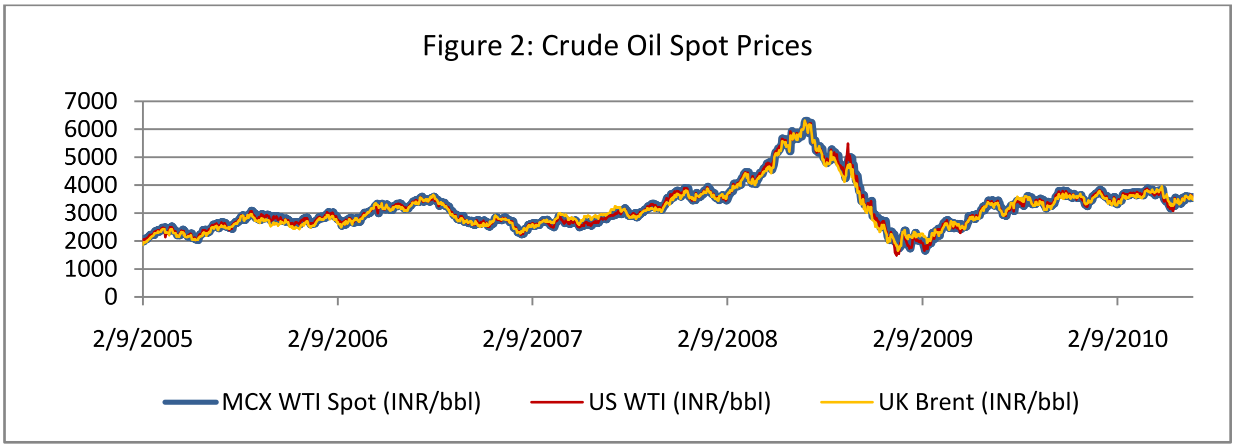


Figure 2: Crude Oil Spot Prices
7000
6000
5000
4000
3000
2000
1000
0
2/9/2005
2/9/2006
2/9/2007
2/9/2008
2/9/2009
2/9/2010
MCX WTI Spot (INR/bbl)
US WTI (INR/bbl)
UK Brent (INR/bbl)

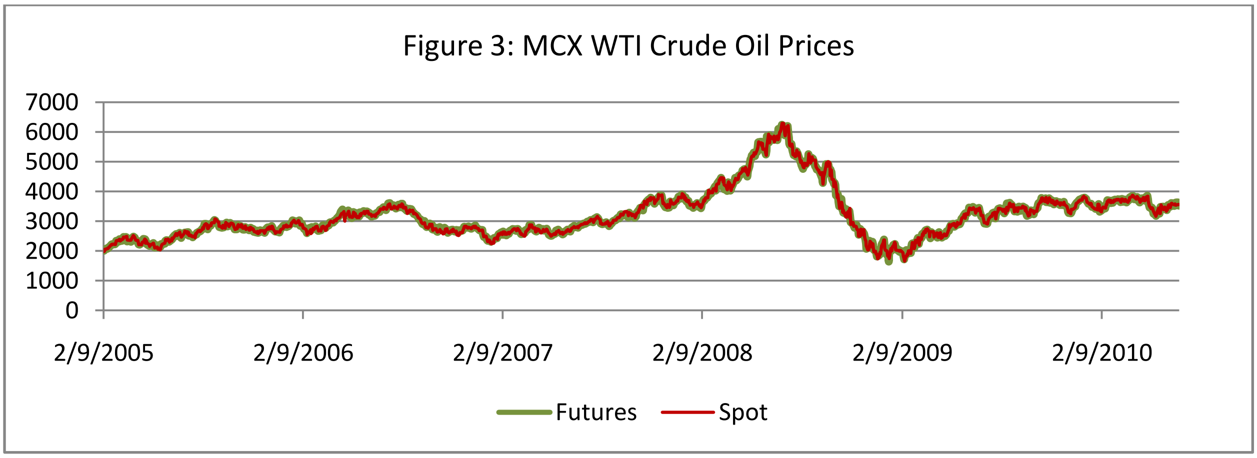


Figure 3: MCX WTI Crude Oil Prices
7000
6000
5000
4000
3000
2000
1000
0
2/9/2005
2/9/2006
2/9/2007
2/9/2008
2/9/2009
2/9/2010
Futures
Spot

Figure 4: Monthly Open Interest as a Percentage of Volume

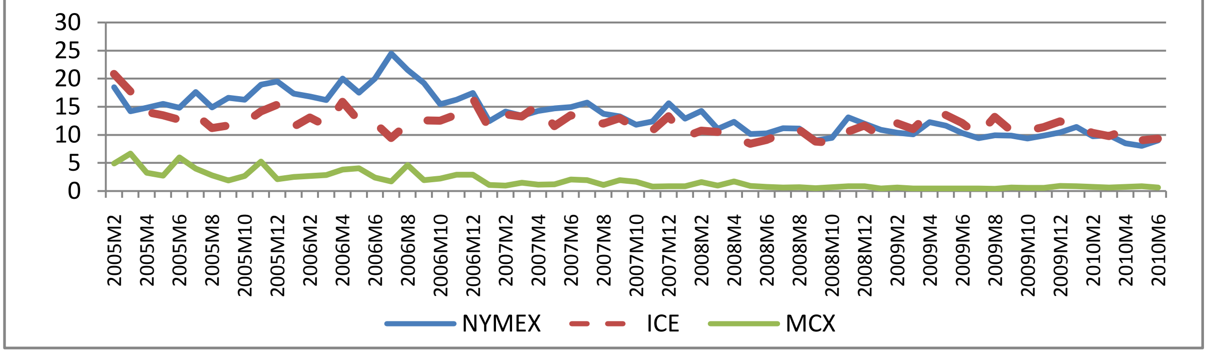
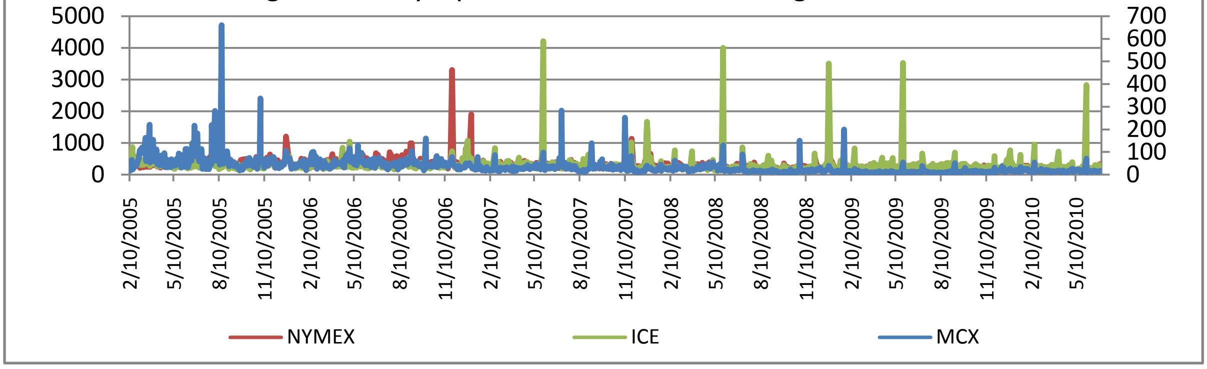


Figure 5: Daily Open Interest as a Percentage of Volume



Open interest (OI) represents the total number of contracts either long or short that have been entered into and not yet offset by delivery. Each open transaction has a buyer and seller, but for calculating open interest, only one side is considered. Since the transaction is not offset it is taken as an indicator of hedging. Volume represents the number of contracts traded on the selected date for all venues[6].Figure 4 shows monthly MCX open interest, as a percentage of volume, to be much lower than the other exchanges. The normalization by volume corrects for lower MCX volumes. For June 2010 the respective values were 19.7 for MCX, 263.6 for NYMEX and 243.5 for ICE. For June 2010 MCX volume was 25 percent of NYMEX volume and 45 percent of ICE volume. Figure 5, for daily open interest, with NYMEX and ICE on the primary axis and MCX on the secondary, shows a similar picture.

The log values of all the variables were tested for stationarity and were found to be non-stationary except MCX open interest (monthly and daily data), so we first differenced the data, all series except MOI, before testing for Granger causality (GC). The Zivot Andrews

[6]Normalization by volume is less distorted by the lower average size of contracts on MCX. Turnover ratio is volume divided by size. This tends to be higher in EMs.

(1992) endogenous test for a structural break, failed to find a break in any of the series. So the unit root in the series is not due to a structural break that would make the series diverge.

One time series is said to Granger cause another if the past values of the first improve the forecasts of the other. This is a statistical measure of causality, but is a stronger test than just a contemporaneous correlation between variables. In addition to standard bivariate GC tests we also, we also ran multivariate GC tests controlling for OI, since a low share of hedging may be expected to affect the relationship between spot and futures prices. Procedures suggested in Lütkepohl (2004) ensure the Wald statistic for zero restrictions has its usual limiting Chi-squared distribution even when testing for Granger causality in a multivariate system such as our test of X DGC Y (X does not Granger cause Y) conditional on Z. Overfitting the VAR order and ignoring the extra parameters can overcome singularity in the asymptotic distribution[7].Lags for the VAR models used in the GC tests were selected on the basis of Akaike Information criteria.

High frequency financial data are sometimes not covariance stationary. The latter is a prerequisite for GC tests (Pagan and Schwert, 1990). So we also estimated the Autocorrelation function (ACF) or correlogram for ICE, NYMEX and MCX spot as well as futures. Correlations are low and often not significant for first difference variables. So GC tests are valid. The VAR systems approach to test lead-lag dynamics improves the power of the tests since it includes contemporaneous correlation of model residuals across variables, correcting for covariance structures that may be expected in time series of volatile financial variables.

Since the spot-futures pairs were cointegrated, that is long-run relationships existed between them, we also estimated vector error correction models (VECM) that estimate the short run

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[7]The standard GC analysis is concerned with the linear regression of one random vector X, the predictee, on another random vector Y, the predictor. If, however, we have three jointly distributed stationary multivariate stochastic processes X_t, Y_t, Z_t, then to measure the GC from Y to X given Z, one wants to compare two multivariate autoregressive models. So the predictee variable $\boldsymbol{X}$ is regressed first on the previous p lags of itself plus r lags of the conditioning variable $\boldsymbol{Z}$ and second, in addition, on q lags of the predictor variable $\boldsymbol{Y}$. The test is given by the logarithmic of the ratio of the residual variances. The residual variance of the first regression will always be larger than or equal to that of the second, so that $F_{Y\rightarrow X|Z} \geq 0$ always. From statistical inference, it is known the corresponding maximum likelihood estimator $\bar{F}_{\bar{Y}\rightarrow \bar{X}|Z}$ will have (asymptotically for large samples) a χ^2 distribution under the null hypothesis $F_{Y\rightarrow X|Z}$ =0 and a non-central χ^2 distribution under the alternative hypothesis $F_{Y\rightarrow X|Z} > 0$.

adjustment to the long run equilibrium. An assessment of lead-lag relationships can be made based on the coefficients of the error correction terms.

Granger causality and VECM do not capture contemporaneous causation. Therefore we supplemented these tests with a test for short-term collapsing bubbles (due to Philips, Wu and Yu 2003)in futures prices. Such bubbles cannot be picked up by unit root and cointegration tests. The monthly futures series were converted into real values by deflating them by the respective consumer price index (USA and Indian consumer price index) and then taking log of the real values, to distinguish real from nominal bubbles. The test for S-T bubbles was also run with the Indian monthly wholesale price index for fuel. Data sources were Multi Commodity Exchange of India Ltd (MCX) and Reserve Bank of India (RBI).

III.3 Granger causality analysis

Table 1 defines the variables and reports the augmented Dickey-Fuller (ADF) test statistic for stationarity with monthly data.

Table 1: ADF test for stationarity with monthly data

Variables	ADF Test Statistic
Log(NYMEX open interest) (NOI)	0.0329
Log(ICE open interest) (IOI)	0.0572
Log(MCX open interest) (MOI)	-19.088
Log(NYMEX futures)(NFU)	0.0625
Log(ICE futures)(IFU)	0.0666
Log(MCX futures)(MFU)	0.0627
Log(NYMEX spot)(NSP)	0.0621
Log(ICE spot)(ISP)	0.0659
Log(MCX spot) (MSP)	0.0647
Critical value: -13.8(1%), -8.1(5%), -5.7(10%)	

First differenced variables are prefixed with D. A total of 14 VAR models were estimated for daily and monthly data. Bivariate VAR systems linked the spot price in each exchange to its own futures price and to the futures price in each other exchange. Trivariate VARs repeated this exercise conditional on open interest in each exchange. The 7 bivariate VAR systems estimated were:

Table 2: Estimated VARs

VAR Systems	Lags
DNSP, DNFU	4
DNSP, DIFU	4
DISP, DNFU	4
DISP, DIFU	4
DMSP, DNFU	4
DMSP, DIFU	3
DMSP, DMFU	3

The same 7, each now including open interest were:

Table 3: VARs including open interest

VAR Systems	Lags
DNOI, DNSP, DNFU	4
DNOI, DNSP, DIFU	2
DIOI, DISP, DNFU	4
DIOI, DISP, DIFU	4
MOI, DMSP, DNFU	4
MOI, DMSP, DIFU	4
MOI, DMSP, DMFU	3

Since do not Granger cause (DGC) is rejected for all except the bold lines in Table A1 (appendix), the results suggest mutual causality exists between spot and futures prices on each exchange (1A, 1B for NYMEX, 4A, 4B for ICE, and 7A and 7B for MCX). Spot and futures prices in NYMEX affect those in ICE and vice versa (2A, 2B and 3A, 3B). But while NYMEX and ICE futures affect spot prices in MCX, MCX spot does not Granger cause NYMEX and ICE futures (5A, 5B and 6A, 6B).

The results support efficient working of futures markets, and as expected, the lack of full integration of the Indian exchange. Causality runs from the large Western markets to Indian and not vice versa. DGC tests with daily data have a similar interpretation[8].

The causality analysis is also done including open interest as a control variable, since low open interest indicates a larger share of speculative positions that may affect the causality between spot and futures prices, giving expectations and therefore futures prices a greater impact on spot prices. The results do not change materially, implying that despite MCX's

[8] Tests with daily data, available on request, showed mutual causality for spot and futures across the exchanges, except that MSP DGC IFU conditional on OI cannot be rejected. Thus evidence for MCX affecting exchanges in advanced countries is weaker.

relatively lower volume of open interest, mutual causality continues to exist between spot and futures prices in MCX, so fundamentals influence futures prices. Foreign spot prices Granger-cause Indian spot prices, and although MCX spot prices now still do not GC ICE futures they do affect NYMEX futures. This could be picking up the response of international markets to emerging market demand.

The Johansen test gave pairwise cointegrating ranks to be one. Therefore VECM models were also estimated. The VECM shows mutuality in the cointegrating vector, consistent with the GC results. But the lead lag relationships from the error correction terms, some of which are reported in tables A4-A6,show short-term effects of futures on spot and not vice versa. These results are derived from the significance of the coefficients of the lagged error correction terms. For example, column 3 of Table A4 shows the lag MCX futures return is significant in the spot equation, but lag MCX spot return turns out to be insignificant in the futures equation.

Spot affects futures in the mature exchanges; futures affect spot in MCX, but advanced exchanges futures affect MCX futures (in daily data, there is no clear result for monthly data). It follows ICE and NYMEX futures affect MCX spot. But since advanced futures are affected by their own spot, overall prices are still fundamental driven.

The results suggest oil prices were not driven by expectations feeding on themselves. Granger causality, however, would not be able to pick up short-duration deviation from fundamentals, so we turn to another technique that allows tests for collapsing bubbles.

IV. Analysis of collapsing bubbles

Trend following behavior generates one-way movements in prices. The belief that prices will rise leads to behavior that raises prices further. Standard unit root tests are biased against finding collapsing bubbles in weakly explosive processes. Philips, Wu and Yu (2003) developed a methodology for the detection of collapsing or short-term bubbles in a financial time series, using the price data alone[9], which we apply to our data set.

[9] Gilbert (2010) applied it to test for bubbles in a number of commodity price series.

The test is based on the Augmented Dickey Fuller (ADF) autoregressive estimation, where the asset price, x_t, is regressed on its own lags with the lag length j chosen to make the residuals uncorrelated:

$$x_t = a_x + \delta x_{t-1} + \sum_{j-1}^{J} \beta_j \Delta x_{t-j} + \varepsilon_{xt}$$

For each series x_t, the ADF test for a unit root is applied against the alternative of an explosive root (which requires a right-tailed test). That is, the non-stationary unit root null hypothesis is H_0: δ= 0 and the right-tailed alternative hypothesis is H_1: δ > 1. An explosive series can reach infeasible values so δ is assumed to approach zero as the sample size increases. Philips, Wu and Yu (2003) work out the distribution theory for such weakly explosive processes.

Two methods are applied. First, forward recursive regressions—the above model is estimated repeatedly, using subsets of the sample data incremented by one observation at each pass. Second, rolling regression, in which each regression is based on a subsample of size (n) of smaller order than N and with the initialization rolling forward with adding one point at the end and at the same time leaving out one point from the start.

The corresponding t-statistics are matched with the right tailed critical values of the asymptotic distribution of the standard Dickey Fuller t-statistics. If the ADF test statistic exceeds its critical value on date d_1 then it is likely a bubble existed on that date. ADF test statistic falling below its critical value implies a collapse of the bubble. The critical value is defined as right side critical value of ADF corresponding to particular significance level (1%, 5%). However, for robustness authors directly estimated the critical value as:

CV = (log (log (sample size))/100

The tests were conducted on monthly real time series of MCX futures, ICE Brent futures, NYMEX WTI futures, and Indian WPI (fuel).Our first sample size is 40 in the recursive regression and it is increased by one data point thereafter. In rolling window, the window size is 40 for all regression. The results (Tables A3 and Figures 5 and 6) show bubbles in ICE and NYMEX futures, in the Indian WPI (fuel), but not in MCX futures in the first few periods which include the first three fourths of the year 2008.

Log daily nominal data for MCX, NYMEX and ICE futures was also used to test for collapsing bubbles with both the recursive and rolling regression method. Daily price indices were not available. Since nominal data was used, daily results can differ from the monthly results. These results would give evidence of short-term bubbles in nominal not real futures.

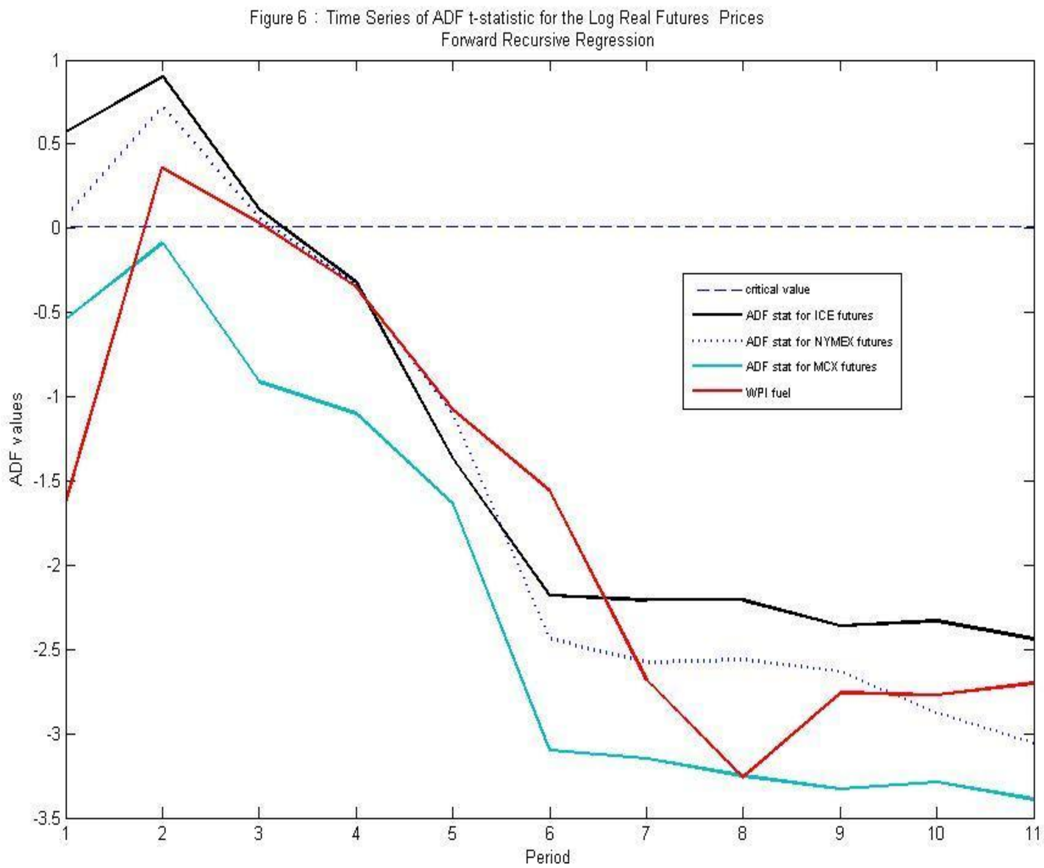


Figure 7: Time Series of ADF t-statistic for the Log Real Futures Prices Forward Rolling Regression

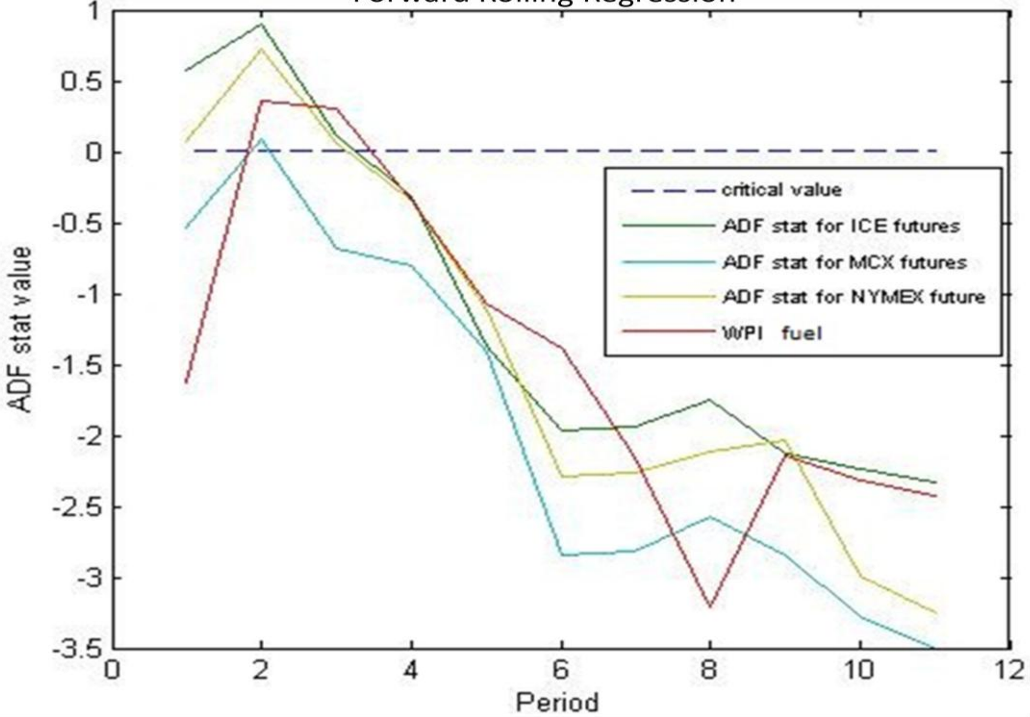
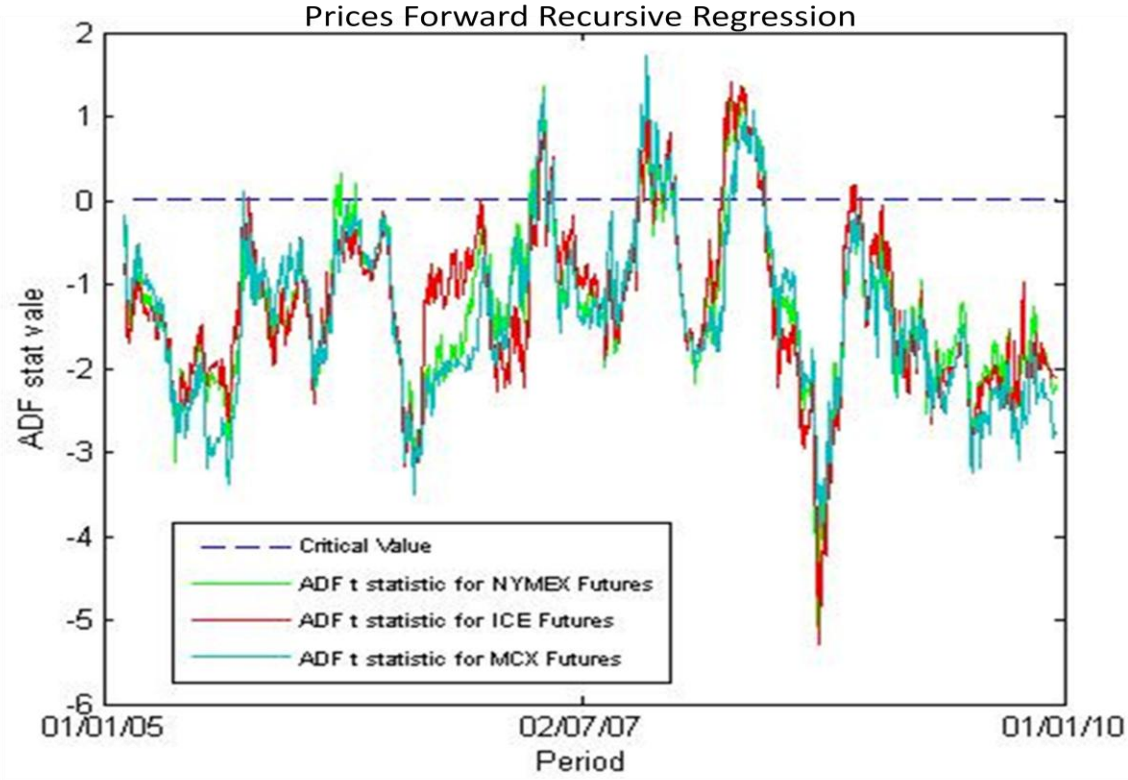


Figure 8: Time Series of ADF t-statistic for the Daily Futures Prices Forward Recursive Regression

Figure 9: Time Series of ADF t-statistic for the Daily Futures Prices Forward Recursive Regression



With daily data, the recursive method shows bubbles over 22/11/07 and 22/2/2008. According to rolling regression the bouts of price increases occurred over[10]:

1. 25/10/07 to 8/11/07
2. 15/11/07 to 12/12/07
3. 2/4/08 to 19/6/08

These bubbles occurred for all three futures series. The finer break up the daily data gives is subsumed in the broader range obtained in the monthly series. Collapsing bubbles existed over stretches of 2007-08 in NYMEX and ICE daily and deflated monthly futures.

That a collapsing bubble was present in the monthly Indian WPI, and in nominal daily MCX futures but not in deflated monthly MCX futures, suggest international price volatility affected the Indian WPI fuel index[11] may have affected the daily nominal MCX futures through that or through daily ICE and NYMEX futures. The VECM results show that daily

[10]As Gilbert (2010) argues, the method is not able to precisely date bubbles because the critical value indicates a bubble exists on that date, not necessarily that it began on that date.
[11]The Indian WPI (fuel) includes some administered prices which are sticky, but their share has steadily fallen.

(not monthly) ICE and NYMEX futures affect MCX futures. Thus the daily S-T nominal bubbles could be transmitted from the international exchanges.

But domestic rupee transactions in Indian commodity exchanges did not add volatility above international. The latter affected Indian prices more through the WPI rather than through domestic commodity futures. Despite lower OI, there are no collapsing bubbles in deflated monthly MCX futures. An interesting question therefore arises. Could the differences in bubble behavior across international and domestic exchanges be due to different regulations? The latter are examined in the next section.

V. Different Regulatory Regimes

Position limits reduce the impact of large trading positions. Since they reduce concentration in markets they help maintain competitive markets where no one party can affect prices. During the period of the analysis, US had position limits in a few commodity market contracts but had exemptions for swap dealers, where the major expansion in trading volume occurred. The UK has no position limits. The Indian Forward Markets Commission (FMC) imposes position limits. For members, limits on aggregate (all contract months) open positions and near month futures contract is either as mentioned in the contract or at 15 percent of the market wide open position whichever is higher. For clients it is around 20-30 percent of total members open positions. Indian exchanges also impose ex-ante retail margins that are value based and not volume/contract based as in NYMEX[12]. There are also price limits. These differential regulations may be part of the explanation for the absence of collapsing bubbles in monthly real MCX futures, despite its lower open or hedging interest.

Our result is important in view of the CFTC's (2011) move to tighten position limits and reduce exemptions for swap dealers. As its Chairman Gary Gensler describes the reforms: "The final rule fulfills the Congressional mandate that we set aggregate position limits that, for the first time, apply to both futures and economically equivalent swaps, as well as linked contracts on foreign boards of trade. The final rule establishes federal position limits in 28referenced commodities in agricultural, energy and metals markets (CFTC, 2011, Appendix 2, 71699)."

[12] For example although in 2011 Global Mutual Fund went bankrupt in the US due to misplaced bets on the Euro, its local arm survived in India. Global Mutual was unable to repay amounts it held in customer accounts, and as CME had not collected retail margins it also did not cover the loss. So, for the first time, exchange trading was exposed to counterparty risk.

Industry associations (ISDA) took the CFTC to court alleging an estimated $100b loss to the industry. They argued therefore CFTC must first establish overall gains before applying the regulations; cost of hedging could be expected to rise as liquidity fell and paperwork to establish valid hedging rose; the Government should not be telling the industry how to trade. The CFTC's reply was that it is not obliged to show gains, the overall mandate from Congress and the Dodd-Frank Act was sufficient, and it would go ahead with its schedule of implementation. The stiff reaction from the industry demonstrates how much the large swap dealers were gaining from exemptions. Criticism from outside the industry was that the proposed changes were too weak[13]. This is going to be an intensely watched and contested area over the next few years as the court cases progress and the CFTC reviews the impact of changes.

The lack of international coordination had hampered CFTC's earlier attempts to tighten regulation. In 2006 it extended its weekly collection of data on trader positions (COT) to provide details on positions of index providers for 12 agricultural futures markets, in order to distinguish the share of non-commercial positions in these. But it did not extend the detail to energy and metal futures since offsetting could be taking place in foreign exchanges (Gilbert, 2010)[14]. The UK, which is its major competitor, imposes no position limits, although major emerging markets like India and China do so (Shunmugam, 2011). The CFTC considered self-certification on position limits from swap dealers. International arbitrage is an issue raised by those who oppose the regulatory tightening even today (CFTC, 2011).

Since spot and futures markets around the world are tightly integrated, convergence to common regulatory standards is necessary. One region with lax standards would attract volumes, and be sufficient to destabilize others, especially during irrational periods of fear or hype. Arbitrage across regulatory regimes has to be reduced. The fear of loss of business makes any country unwilling to tighten regulation alone, and any institution unwilling to forsake risky strategies by itself. One reason CFTC has been able to progress even as much as it has is IOSCO (2011) has, after the crisis and on prodding by G-20, provided general

[13]Ranallo (2011) argues the new position limits are set too high to be effective, do not allow for emergency review in case of sharp price movements, and do not aggregate positions held by one entity across several trading venues. Since position limits are introduced for cash-settled only contracts, such contracts would be created for agricultural commodities where they do not at present exist.

[14]For energy markets in particular there are many ways to offset risk. Therefore open, cleared futures/options positions associated directly with index trading would not capture the impact of such trades on futures markets.

regulatory guidelines[15]. It is necessary G-20 continues to apply pressure for more countries to come on board.

Since expectations of future excess demand play a major role in futures markets, even as the effect of large one-way positions on expectations is moderated, another essential reform is to restrain conflicts of interest in advice. Goldman Sachs is a major swap dealer. Their analysis of an 'ignored energy crisis' and inadequate supply response even when oil prices crashed after the Lehman fall may have been instrumental in creating a psychology of scarcity[16]. Without such interventions and orchestrations oil prices would stay in a healthy 60-80$ range, which is bearable for consumers yet remunerative enough to finance adequate capacity expansion. Oil producers consider oil futures to be too volatile in the recent period to be useful and prefer to work with an expected price band of $60-80.Fattouh (2010) suggests policy makers should make the physical supply response more visible. Policy created foci for expectations work well during periods of high uncertainty when private information is discounted.

Other reforms are possible. Exchange imposed margins have two functions: they protect against default risk and second they control the leverage available to participants. The first makes them procyclical since margin calls rise as price fall increases losses. Withdrawing to meet margin calls reduces prices further. If initial margins or deposits are adequate to cover expected losses variation in margins can be countercyclical. Margins that increase with price would reduce momentum trading. Speculation has a function in providing liquidity. So if position limits prevent speculative positions from affecting prices, it would not be necessary to ban taking positions on expected prices. Differential margins and discounts in fees or taxes for hedgers and speculators can be tried to further encourage hedging.

VI. Conclusion

The results show mutual Granger causality between spot and futures markets, even controlling for the degree of hedging, implying fundamentals dominate price discovery in futures markets. Price discovery largely takes place in mature exchanges, where spot lead

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[15]General guiding principles include position management powers, including the power to set position limits, and call for all relevant data. Position Management can imply less restrictive responses to specific large concentrations, instead of general limits. But these would then be discretionary and therefore more difficult to implement.

[16] See Financial Times, 9 August 2009.

futures in short term error correction models—again fundamentals dominate. Reverse causality from emerging to mature exchanges is weak. But since prices on emerging exchanges are well correlated with those on mature exchanges they provide a valuable function in allowing firms to take a position or hedge price risk without incurring currency risk at the same time.

But there is evidence of collapsing or short-term bubbles in both real monthly and nominal daily international futures, but only in nominal daily Indian futures and monthly wholesale fuel indices. Since daily foreign futures lead Indian, the bubbles may be transmitted from abroad, partly through futures and partly through wholesale prices. Herd behavior and over-reaction can imply one-way movement in prices, over short periods, if everyone expects prices to rise, or if large one-way positions are built-up. That there are no collapsing bubbles in monthly real Indian futures despite a lower share of hedging and a short-term lead from futures to spot, suggests that
it was different regulations that mitigated collapsing bubbles, even in a period of great price volatility. The results also support the liquidity and leverage driven explanation over the excess demand explanation for oil price volatility. If the latter was the cause, collapsing bubbles would have occurred in real futures traded in the Indian exchange also.

Global coordination through the G-20 is required to ensure that US efforts to impose position limits in implementing Dodd-Frank fructify, and are adopted more universally. This should be an acceptable counter to possible effects of liquidity expansion on commodity prices. It could make markets more stable, while preserving valuable contributions to price discovery. To the extent commodity price inflation is mitigated, it would reconcile emerging markets to the expansion in liquidity aimed at encouraging activity in the West, even while directing the liquidity in more productive directions.

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Appendix

Table A1: Granger Causality Tests (monthly data)

		CHI SQUARE	P-VALUE
1A	DNSP DGC DNFU	22.59	0.000
1B	DNFU DGC DNSP	37.21	0.000
2A	DNSP DGC DIFU	21.36	0.000
2B	DIFU DGC DNSP	15.24	0.004
3A	DISP DGC DNFU	17.67	0.001
3B	DNFU DGC DISP	37.95	0.000
4A	DISP DGC DIFU	39.01	0.000
4B	DIFU DGC DISP	11.86	0.018
5A	**DMSP DGC DNFU**	**8.41**	**0.071**
5B	DNFU DGC DMSP	38.53	0.000
6A	**DMSP DGC DIFU**	**6.11**	**0.191**
6B	DIFU DGC DMSP	30.55	0.000
7A	DMSP DGC DMFU	12.63	0.013
7B	DMFU DGC DMSP	25.06	0.000

Table A2: Granger Causality test conditional on open interest (monthly data)

		CHI SQUARE	P-VALUE
1A	DNSP DGC DNFU	23.54	0.000
1B	DNFU DGC DNSP	35.77	0.000
2A	DNSP DGC DIFU	22.16	0.000
2B	DIFU DGC DNSP	15.12	0.004
3A	DISP DGC DNFU	17.24	0.002
3B	DNFU DGC DISP	38.06	0.000
4A	DISP DGC DIFU	36.13	0.000
4B	DIFU DGC DISP	11.55	0.021
5A	DMSP DGC DNFU	14.94	0.041
5B	DNFU DGC DMSP	38.47	0.000
6A	**DMSP DGC DIFU**	**5.88**	**0.208**
6B	DIFU DGC DMSP	30.16	0.000
7A	DMSP DGC DMFU	12.11	0.016
7B	DMFU DGC DMSP	24.57	0.000

Table A3: ADF Statistic Value

Recursive Regression					
2005M2 to	MCX	ICE	NYMEX	WPI	CV
2008M5	-0.54	0.57	0.07	-1.63	0.013
2008M6	-0.09	0.90	0.72	0.36	0.013
2008M7	-0.91	0.11	0.06	0.03	0.013
2008M8	-1.10	-0.32	-0.34	-0.35	0.013
2008M9	-1.64	-1.37	-1.11	-1.08	0.013
2008M10	-3.10	-2.18	-2.44	-1.56	0.013
2008M11	-3.15	-2.21	-2.58	-2.68	0.013
2008M12	-3.25	-2.21	-2.56	-3.26	0.013
2009M1	-3.33	-2.36	-2.63	-2.76	0.014
2009M2	-3.29	-2.33	-2.88	-2.77	0.014
2009M3	-3.39	-2.44	-3.06	-2.70	0.014

Rolling Regression					
	MCX	ICE	NYMEX	WPI	CV
2005M2-2008M5	-0.54	0.57	0.073	-1.625	0.013
2005M3-2008M6	0.09	0.90	0.722	0.354	0.013
2005M4-2008M7	-0.68	0.11	0.058	0.3	0.013
2005M 5-2008M8	-0.81	-0.32	-0.343	-0.351	0.013
2005M 6-2008M9	-1.41	-1.37	-1.114	-1.078	0.013
2005M7 -2008M10	-2.85	-1.96	-2.289	-1.387	0.013
2005M 8-2008M11	-2.82	-1.944	-2.261	-2.158	0.013
2005M 9-2008M12	-2.58	-1.751	-2.112	-3.21	0.013
2005M 10-2009M1	-2.85	-2.13	2.0401	-2.136	0.013
2005M 11-2009M2	-3.28	-2.24	2.997	-2.314	0.013
2005M 12-2009M3	-3.50	-2.33	-3.25	-2.429	0.013

Table A4: VECM model across spot and futures markets (daily)

		MCX spot and futures: futures lead spot			ICE spot and futures: spot leads future			MCX spot and ICE futures: futures lead spot		
Cointegration relation		m1 – 1.008m2			m1 – 1.016m2			m1 – 1.031m2		
		Coeff.	z-value	p-value	Coeff.	z-value	p-value	Coeff.	z-value	p-value
		3	4	5	6	7	8	9	10	11
Δm1										
	alpha1	-0.52746	-18.72	0	-0.091	-1.84	0.066	-0.095	-8.28	0.000
	Δm1(t-1)	-0.04788	-2.78	0.006	-0.032	-0.47	0.635	-0.009	-0.63	0.528
	Δm2(t-1)	**0.431022**	**14.74**	**0**	**-0.022**	**-0.33**	**0.740**	**0.815**	**41.25**	**0.000**
	const	0.000103	0.26	0.796	0.0004	0.69	0.490	0.0001	0.27	0.790
Δm2										
	alpha2	0.132761	3.07	0.002	.086	1.81	0.070	-0.021	1.14	0.253
	Δm1(t-1)	**-0.0398**	**-1.5**	**0.133**	**.313**	**4.75**	**0.00**	**-0.012**	**-0.52**	**0.605**
	Δm2(t-1)	0.09827	2.19	0.029	-.372	-5.57	0.00	-0.067	-2.07	0.039
	const	0.000411	0.67	0.504	0.0004	0.74	0.45	0.0004	0.72	0.473

Note:m1: Log MCX spot (cols 3-5); Log ICE spot (cols 6-8); Log MCX spot (cols 9-11)
m2: Log MCX futures (cols 3-5); Log ICE futures (cols 6-8); Log ICE futures (cols 9-11)

Table A5: VECM model across spot and futures markets (monthly)

		MCX spot and futures: No clear relationship			NYMEX spot and futures: spot leads future			MCX spot and NYMEX futures: futures lead spot		
Cointegration relation		m1 – 1.002m2			m1 – 0.983m2			m1 – 0.993m2		
		Coeff.	z-value	p-value	Coeff	z-value	p-value	Coeff	z-value	p-value
		3	4	5	6	7	8	9	10	11
Δm1										
	alpha1	0.951	1.50	0.133	-2.02	-2.90	0.004	-0.07	-1.08	0.28
	Δm1(t-1)	-0.47	-2.37	0.018	.831	1.31	0.190	-0.54	-2.10	0.04
	Δm2(t-1)	**0.74**	**2.79**	**0.005**	**-.690**	**-1.05**	**0.296**	**0.81**	**4.38**	**0.00**
	const	-.0002	-0.02	0.982	-.001	-0.10	0.919	0.01	0.31	0.75
Δm2										
	alpha2	2.04	2.34	0.019	-1.96	-2.24	0.02	-0.22	-2.59	0.01
	Δm1(t-1)	**-0.20**	**-1.41**	**0.159**	**0.83**	**2.30**	**0.02**	**0.14**	**0.41**	**0.68**
	Δm2(t-1)	0.68	1.96	0.050	-0.67	-2.01	0.04	0.11	0.47	0.64
	const	0.00	0.01	0.994	.001	0.08	0.93	-0.00	-0.07	0.94

Note:m1: Log MCX spot (cols 3-5); Log NYMEX spot prices (cols 6-8); Log MCX spot (cols 9-11)
m2: Log MCX futures (cols 3-5); Log NYMEX futures prices (cols 6-8); Log NYMEX futures (cols 9-11)

Table A6: VECM model across futures market (daily)

		MCX futures and NYMEX futures: NYMEX futures lead MCX futures			MCX futures and ICE futures: ICE futures lead MCX futures		
Cointegration relation		m1 – 1.190m2			m1 – 0.942m2		
		Coeff.	z-value	p-value	Coeff.	z-value	p-value
		3	4	5	6	7	8
Δm1							
	alpha1	0.03	3.49	0.00	-0.03	-3.60	0.00
	Δm1(t-1)	0.31	8.75	0.00	-0.24	-6.12	0.00
	Δm2(t-1)	**-0.31**	**-7.25**	**0.00**	**0.28**	**7.40**	**0.00**
	const	-0.00	-0.07	0.94	-0.00	-0.11	0.91
Δm2							
	alpha2	0.02	1.94	0.05	-0.02	-2.39	0.02
	Δm1(t-1)	**-0.02**	**-0.34**	**0.74**	**-0.01**	**-0.11**	**0.91**
	Δm2(t-1)	-0.05	-0.90	0.36	-0.08	-1.79	0.07
	const	0.00	0.09	0.93	0.00	0.14	0.88

Note: m1:Log MCX futures ; m2: Log NYMEX futures (cols 3-5) and Log ICE futures (cols 6-8)