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Trading Activity, Volatility and Market Conditions: An Investigation of Emerging Crude Futures Market

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Introduction

In recent years advances have been made in the theoretical and empirical understanding of relationship between trading activity and volatility of futures. In particular, the asymmetric relationship in contango and backwardation has generated a lot of interest (Wang, 2002; Alizadeh & Tamvakis, 2016; Wellenreuther & Voelzke, 2019). A market is said to be in contango when futures price is greater than the expected spot price and to be in backwardation when the future price is less than the expected spot price.

The theories on market-microstructure state that the trading activity in a market reflects information about the aggregate change in the expectation of market participants and this change affects the price volatility (Bessembinder & Seguin, 1993). In futures markets, it is assumed that the trading volume reflects speculators' opinion whereas open interest brings hedgers' opinion. Open interest, which is a proxy of market depth or hedging activity, is expected to mitigate volatility whereas trading volume, usually associated with speculation or informed trading, is expected to be positively correlated with volatility (Kamara, 1993; Bessembinder & Seguin, 1993; Bessembinder et al. , 1996; Chen et al. , 1995; Ederington & Lee, 2002). The relationship between trading activity and volatility could vary in different market conditions attributing different trading strategies followed by investors in backwardation and contango (Alizadeh & Tamvakis, 2016). For example, when the market is in strong backwardation (contango), the proportion of long hedgers (short hedgers) in the futures market would decrease as compared to short hedgers (long hedgers). In an economy which is a net consumer (producer) of the underlying commodity, long hedgers (short hedgers) would be more than short hedgers (long hedgers) in the futures markets. Combining these statements we can argue that in an economy which is anetconsumeroftheunderlyingcommodity(producer),dominanceofhedgingbehavior will reduce (increase) volatility in the futures markets during the backwardation. Therefore, the types of economy, the compositions of hedgers and speculators in the futures markets, and the changes in the dominance of speculative and hedging behaviors in dif-ferent market conditions affect the relationship between trading activity and volatility of the futures (Alizadeh et al. ,2004;Alagidede&Panagiotidis,2009;Wellenreuther& Voelzke, 2019; Todorova & Clements, 2018; Liang et al. ,2020).

The investigation of relationship between trading activity and volatility becomes more important in fastest growing emerging markets such as India which exihibit several distinct characteristics. First of all, in emerging commodity futures markets, the price discovery (information dissemination) and risk management roles of futures markets have been a subject of intense debate. It is argued that unregulated and poorly managed exchanges attract excessive speculative activities and in turn could destabilize the markets and other macro-economic variables (Algieri, 2016; Gilbert, 2018; Thiem, 2018).

The significant and positive (negative) contemporaneous volatility-volume (open interest) relationship should signify better functioning and support the superior information dissemination role of the futures market in emerging economies (Ripple & Moosa, 2009). Secondly, emerging markets are characterized by low liquidity, thin trading and high volatility (Antoniou et al. ,1997;Bekaert&Harvey,1997;Alagidede&Panagiotidis, 2009). These unique characteristics impose an important challenge in selecting an appropriate econometric model to explain the relationship. Thirdly, most of the emerging futures markets are linked to the developed markets and information spillover takes place from developed markets to emerging markets (Beirne et al. ,2013;Zhang&Wang,2014; Yarovaya et al. ,2016). However,thereisalwaysadebateaboutdisseminationoflocal information through trading activity vis-a-vis global information through strong linkages via return and volatility spillovers from the developed futures markets (Zhang & Wang, 2014; Batten et al. , 2015). Most of the empirical studies to explain the relationship between trading activity and volatility in emerging market context ignore such spillovers from the developed market and hence may be biased in their results. Fourthly, the futures markets in the emerging economies follow very conservative approach and are subject to stringent regulations. Derivatives markets in these economies have limited products and restricted participation. Better understanding of trading activity-volatility relationship will certainly help futures exchanges and regulators in strengthening the markets with

appropriate policy measures such as monitoring speculative positions, limits on openinterest, margin requirements, and other risk management tools. Understanding this relationship is equally helpful for traders including speculators and hedgers in forecasting return and volatility which will help in developing efficient portfolio, trading and hedging strategies and estimation of margin requirements to participate in the futures markets.

Within this context, understanding the behavior of crude futures prices and its relationship with trading activity, especially in emerging markets and particularly in India where majority of crude demand is met by imports, is of a great importance. As a significant portion of crude demand in India is met by imports, volatility and instability of the markets is still a major concern for the policy makers and traders. The Indian

derivatives market is one of the fastest growing markets in the world yet with few products and limited participation (Bhagwati, 2018). Until recently, only commodity futures contracts with short maturities and European type options on limited commodities are traded in national exchanges including Multi Commodity Exchange Limited (MCX) and National Commodity and Derivatives Exchange Limited (NCDEX). Also, participation in the derivatives markets is very limited. Big investors like hedge funds, mutual funds, banks, and foreign institutional investors are either not allowed to participate in most of the futures contracts or their participation is limited. As the Indian crude market is predominately a consumer market, backwardation in the market may reduce hedgers' participation as compared to speculators in contrast to contango. This shift in the market participation may affect the futures volatility differently. Hence, Indian crude oil futures market provides a unique opportunity to investigate the price-trading activity relation under different market conditions.

The empirical literature has been devoted to examine the volatility-trading activity relation in different markets (Gallo & Pacini, 2000; Mougoué & Aggarwal, 2011; Alizadeh &Tamvakis,2016;Bekiros&Uddin,2017;Haugom&Ray,2017;Koubaa&Slim,2019; Shen et al. ,2018;Go&Lau,2020). However,thereisalimitedresearchinthecontext of emerging markets. There is only one study by Alizadeh & Tamvakis (2016) who investigate the relationship between trading volume and volatility of New York Mercantile

Exchange (NYMEX) energy futures in different market conditions. This study does not included open interest in their analysis although open interest plays an important role in the futures price dynamics of both developed and emerging futures markets (Bessembinder & Seguin, 1993). Our work extends the relationship for emerging markets by including both open interest and volume in understanding the relationship with futures volatility. We model and investigate the asymmetric relationship between futures trading activity and volatility in Indian crude oil futures in different market conditions: contango and backwardation. Our model takes into consideration of return and volatility spillovers from the developed market (NYMEX) to Indian market and provides robust empirical evidences of futures trading activity and volatility relationship.

Our modeling approach and results discover very interesting characteristics of the emerging futures markets. First of all, we find evidence of the change in the dominance of speculative and hedging behaviors of futures market participants in contango and backwardation. This feature in the futures markets is linked to the net position in the underlying commodity whether the market is net consumer or producer. For instance, the Indian crude market is a net consumer market and the futures market should dominated by net long hedgers than short hedgers. Therefore, open interest decreases in the backwardation period and futures market becomes more dominated by speculative behavior than hedging. Secondly, the increase in dominance of speculative behavior in backwardation affect the volatility positively and more strongly than in contango. In emerging markets context, this is the first evidence of the asymmetric behavior of trading volume on volatility in different market conditions. Thirdly, we also provide evidence of the importance of open interest in reducing the market volatility. Although, the effect of open interest is not asymmetric in different market conditions, it provides market depth and helps in reducing volatility of the market. Finally, our empirical results strongly support information spillover from NYMEX market to Indian crude futures and advocate that the information spillover from developed market should be included while modeling price dynamics in emerging markets. Our results on the relationships between trading activity and volatility is robust as we control for the international information spillover effects

and use different model specifications.

This study complements the existing literature on the relationship between futures trading activity and volatility in several ways. One of the key contributions lies in its specification of the EGARCH model where return and volatility of the developed crude futures markets (NYMEX) are included in the mean and volatility equations of Indian crude futures respectively. We also model and investigate the asymmetric behavior of the NYMEX futures on the Indian futures in different market conditions. We reinforce strong evidence for the need to investigate the international linkages of emerging futures markets and to include spillover effects in empiricial studies of price dynamics in emerging futures markets. Secondly, we provide evidence of change in dominance of speculative and hedging behavior in different market conditions and link this to net position (consumer/producer) in the underlying commodity market. Thirdly, our results produce robust evidence of the asymmetric relationship between volatility and trading activity as we control for spillover effects. Finally, this is the first study in the Indian context where we support the asymmetric effect of expected and unexpected components of trading activity on crude futures volatility under different market conditions.

The rest of the paper proceeds as follows. In Section 2, some of the important theoretical and empirical papers explaining price-trading activity relationship under different market conditions are reviewed. Section 3 represents the data and its basic characteristics. Section 4 explains the process of developing a robust econometric framework to analyze price-trading activity relationship in emerging market context. The results are presented and discussed in Section 5, and Section 6 concludes the paper.

2LiteratureReview

2.1 Relationship between trading activity and volume

The relationship between trading activity and volatility has been extensively examined in different asset markets such as equity, commodity, currency and fixed income securities. It includes both theoretical and empirical studies investigating the relationship. Theo-

retically, there are two complementory arguments that explain the relationship between trading volume and price: 1) The mixture of distribution hypothesis (MDH) (Clark, 1973; Epps & Epps, 1976; Tauchen & Pitts, 1983; Harris, 1986; Lamoureux & Lastrapes, 1990) and 2) sequential arrival of information hypothesis (SAIH) (Morse, 1980; Jennings & Barry, 1983; Copeland, 1976). The MDH hypothesis explains that the change in price, measured through return and variance, and trading activity can both be proxied for information arrival in the market. In other words, both price and trading volume should change contemporaneously with the arrival of new information in the market. On the other hand, SAIH explains both contemporaneous and lagged relationship between volatility and trading activity. The SAIH assumes that the information is not readily

available to all the participants in the markets simultaneously. It is assumed that information is firstly known to the informed traders and sequentially passed to uninformed or noise traders. This is the reason why both contemporaneous and lagged volume are correlated with price volatility in some markets. In futures markets, besides trading volume, open interest is also considered as an important proxy of information. Open interest has been used as a proxy for informed trading and market depth (Bessembinder & Seguin, 1993; Kamara, 1993; Chen et al. ,1995)andisexpectedtomitigatereturn volatility. Bessembinder & Seguin (1993) suggest that inclusion of open interest along with volume in analyzing futures price volatility provides better understanding of the relationship between trading activity and volatility.

Empirically, a number of studies examine the relationship between trading activity and volatility in the US equity market (Lamoureux & Lastrapes, 1990, 1994; Andersen, 1996; Gallo & Pacini, 2000; Fleming et al. , 2006; Fleming & Kirby, 2011), other developed and emerging equity markets (Chan et al. ,2004;Slim&Dahmene,2016;Koubaa& Slim, 2019), and developed commodity, currency and bond futures markets (Majand &Yung,1991;Bessembinder&Seguin,1993;Bessembinderet al. ,1996;Foster,1995; Fung & Patterson, 1999; Mougoué & Aggarwal, 2011; Todorova & Clements, 2018). In emerging markets, extensive research has also been done to test MDH or SAIH in both equity and commodity futures markets (Brailsford, 1996; Lange, 1999; Pyun et al. ,2000;

Kalev et al. ,2004;Periet al. ,2014;Shenet al. , 2018). Most of these studies model futures price volatility as a generalized conditional heteroscedasticity (GARCH family) process and show that the inclusion of trading activity in the volatility model results in either decrease in the volatility persistence parameter of GARCH model or even causes it to vanish. This modeling approach seems justified while analyzing developed market, however, it is surprising to note that these papers have not included volatility spillovers from developed markets while modeling volatility of the emerging futures markets. It has been observed in previous studies that the informational role of developing markets has been increasing over time, hence it is important to include them in analyzing information transmission mechanism of emerging markets (Cho et al. ,2015;Diebold&Yilmaz,

2012; Singh et al. ,2010;Syriopouloset al. ,2015). Inthispaper,wehaveincluded the spillover effects from the US market to the Indian market while investigating the relationship between futures trading activity and volatility.

2.2 Asymmetric Relationship between Trading Activity and Volatility

under different market conditions

There are two popular theories of backwardation: the theory of risk premium (Keynes, 1930) and the theory of storage (Working, 1948). The theory of risk premium asserts that when prices are expected to go down, short hedgers would be more than the long hedgers, or risk aversion of the short hedgers would be more than the long hedger in the futures markets. In this situation long speculators may enter the futures markets and may ask for risk premium for bearing the risk of short hedgers. This will decrease the futures price relative to the expected spot price at maturity which is referred to as normal backwardation. If price is expected to go up, the long hedgers would be more than short hedgers, hence the futures price will exceed the expected spot price. The increase in futures price relative to the expected spot price is called contango. Imbalances between long and short hedging positions and degree of risk averseness lead to backwardation and contango. However, the theory of risk premium assumes that the market has equal number of long and short hedgers and market conditions affect the net hedging position

in the market. The assumption of equal number of hedgers may not be valid for a market which is a net consumer or a net producer of the underlying commodity. For instance, Indian crude oil market is a net consumer market and it is the third largest importer of crude oil in the world. Hence, the futures market would be dominated by more long hedgers as compared to short hedgers. Therefore strong backwardation in the crude market will reduce hedging activity in the Indian futures markets rather than increasing the short hedgers as suggested by the theory of risk premium. On the other hand, the theory of storage (Working, 1948) explains the difference between spot and futures prices in terms of interest forgone in storing a commodity, warehouse costs and convenience yield on inventory. The backwardation and contango in the market is explained by

convenience yield and convenience yield is inversely proportional to inventory conditions. When inventory is high, convenience yield will be zero and futures price would be more than the spot price (contango) whereas less inventory will give rise to positive convenience yield and futures price will become less than the spot price (backwardation). Either there is difference in the net positions of speculator and hedgers as advocated by the risk premium theory of normal backwardation, or there is a change in the inventory levels as indicated by the theory of storage, the relationship between trading activity and volume

seems to be different under different market conditions It would be interesting to see how speculative and hedgeing behavior changes in contango and backwardation and whether this change significantly impacts the futures volatility in Indian crude futures market.
Recent studies in the commodity futures markets also try to explain asymmetric nature of volume-volatility relationship. The asymmetric behavior of volatility has been mainly investigated either with positive or negative change in volume or change in the net positions of traders (speculators/hedgers). Most of the studies follow the methods used by Bessembinder & Seguin (1993) and divide the volume and open interest into expected and unexpected component (trading activity shocks) and the asymmetric relationship is examined by differentiating the effect of positive and negative unexpected components of trading activity on volatility. Todorova & Clements (2018) examine the volume-volatility relationship for five industrial metals futures and find that expected

and unexpected components of volume affect the volatility. Chevallier & Sévi (2012) find an asymmetric volatility-volume relationship in energy future markets. Alizadeh & Tamvakis (2016) further show that such asymmetry varies in different market conditions. The volume-volatility relationship is stronger during the backwardation. They also provide evidences of difference in the net positions of hedgers and speculators under backwardation and contango - hedgers and speculators tend to maintain their net long positions in backwardation and net short positions in contango.
While the existing literature supports the positive and asymmetric relationship between futures trading activity and volatility for different markets and commodities, emerging markets have been received very little attention. There is paucity of studies where

the asymmetric relationship has been investigated under different market conditions.
Also, while modeling the relationship between trading activity and volatility in emerging markets, the spillover effects of developed market has been ignored. To the authors knowledge, this is the first study in emerging market context where we investigate the asymmetric relationship between futures trading activity and volatility of Indian crude oil futures under different market conditions.

3Sample&Data

The data are collected from Bloomberg and covers the period from January 2009 to December 2017. The data has been adjusted for holidays, missing values and trading day difference between India and the USA. The final sample contains 2176 daily observations. Return series (MCX and NYMEX near-month futures) are calculated by using log difference of the daily futures prices. In order to eliminate any secular trend and to make volume and open interest series stationary, following exisiting literature (Fung & Patterson, 1999; Kim et al. , 2004; Kim, 2005), we transform the series by using 50-day moving average.

To measure the rel ati ve domi nance of specul ati ve behavi or as compared to hedgi ng behavior in the market, Garcia et al. (1986) introduce speculation ratio which is estimated

Figure 1: NYMEX and Indian crude near-month futures prices

as daily trading volume divided by the open interest. It is based on the assumption that speculators close their position daily and don't expose themselves to overnight volatility. In turn, hedgers keep their position open depending upon their exposure in the underlying markets (Bessembinder & Seguin, 1993; Ederington & Lee, 2002). Therefore, increase in the speculation ratio may reflect the increased participation of speculators in the futures market and it may affect the volatility differently. Therefore, we also calculate and compare speculation ratio in different market conditions to observe whether dominance of speculative and hedging behavior changes in contango vis-a-vis backwardation.

Our next step is to identify backwardation and contango periods in the crude market. First, we estimate the slope of the Indian crude futures price which is the difference between spot and near-month futures prices. The positive slope indicates backwardation whereas negative slope indicates contango in the market. We observe that the slope calculated by the difference of spot and near month Indian futures prices is very noisy. It may be because of the maturity effect in the futures markets where futures and spot price should converge at the time of maturity to minimize any chance of arbitrage in the market. As suggested by (Alizadeh & Tamvakis, 2016), we calculate the slope of the forward curve which is measured as a difference between the NYMEX 6-month and the

Figure 2: Slope of the forward curve

near-month futures prices to identify backwardation and contango.

Apositiveslopeof
the forward curve indicates contango whereas negative slope indicates backwardation in the market. The NYMEX and Indian crude near-month futures prices and the slope of the forward curve are depicted in Figure 1 and Figure 2 respectively. Figure 1 shows that the near-month futures prices of India and NYMEX are closely aligned. We find that the crude oil prices have decreased in year 2014-16 which represents the recent oil price crisis period.

4EmpericalFramework

We develop our empirical models within the Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) framework of Nelson (1991) to investigate the relationship between Indian crude futures trading activity and price volatility in different

2

Alternatively, we tried to use Indian six-month futures price to calculate the slop of the forward curve
but found that the Indian six month futures contracts are not liquid at all, therefore are less informative.

Also, crude is a global commodity, hence, market conditions (backwardation or contango) in one market
like NYMEX should reflect market conditions of other markets such as Indian futures market.

market conditions. The step-wise approach to develop the augmented EGARCH-X (1,1) model in an emerging market context is explained below. It has been observed that the return series of most of the financial assets and commodities including crude futures show volatility clustering and asymmetric effect for positive and negative shocks. The persistence and asymmetric characteristics of volatility can be captured though EGARCH model. A GARCH (1,1) process is chosen, corresponding to the existing evidence that this is usually sufficient to capture the volatility clustering properties of financial data series (Engle, 2004; Hansen & Lunde, 2005). The effect of futures trading activity on price volatility is modeled using augmented EGARCH-X (1,1) model where contemporaneous standardized volume and open interest are used as explanatory variables in the variance

equation as shown below:

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time . The effect of volume and open interest on futures volatility is captured through parameters γ and λ respectively. Following Alizadeh & Tamvakis (2016), we estimate the slope of forward curve as the difference between 6-month and near month NYMEX futures to identify contango and backwardation in the crude market. To differentiate the role of volume and open interest in different market conditions, we introduce an indicator variable, bdum, which takes value of 0 during the contango and value of 1 during the backwardation. We include interaction of indicator terms with trading volume and open interest as additional explanatory variables in the variance equation of the augmented EGARCH-X (1,1) model as follows:
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The above model captures the asymmetric behavior of volume and open interest on futures volatility in the different market conditions. For instance, when market is in contango, the relationship between volume (open interest) is captured by γ

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when the market is in backwardation the relationship is captured by γ

).

Therefore, in the backwardation period, the sign and significance of the parameters γ

and λ

indicate asymmetric relationship between volatility and volume and volatility and open interest respectively.

2

The literature suggests that information spillover through return and volatility takes place from developed markets to emerging markets (Zhang & Wang, 2014; Batten et al. ,2015;Dungey&Gajurel,2015;Battenet al. , 2019). Therefore, we argue that the

NYMEX, which is a developed commodity futures market, information flows from NYMEX to the Indian futures markets. Furthermore, the literature suggests that international spillovers could be different in different market conditions (Silvennoinen & Thorp, 2013). Hence, it is important to include the effect of NYMEX market while modeling the relationship between trading activity and volatility in Indian futures market. To capture the effect of NYMEX on the Indian market, first we estimate the conditional volatility of the NYMEX crude near-month futures using EGARCH (1,1) and then the conditional volatility of NYMEX is used as an explanatory variable in the variance equation of the Indian crude futures. To capture the potential asymmetric effect of NYMEX in different market conditions, we introduce an interactive term of indicator variable and NYMEX in both mean and variance equations as shown below:

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captures the effect of lagged NYMEX returns
captures any potential change
in this relationship in the backwardation period. Similarly, in the variance equation the

coefficient ß

on the Indian crude futures returns whereas coefficient b

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captures the volatility spillover from NYMEX to Indian market whereas

14

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(4)

coefficient ß

captures any potential change in the strength of this relationship in the backwardation period.

2

In line with the existing literature, we divide the total trading volume (open interest) into expected and unexpected components using an ARMA model (Fung & Patterson, 1999; Kim et al. , 2004; Kim, 2005). The predicted value and residuals from the ARMA model are treated as expected and unexpected components respectively. Next, the expected and unexpected components of the volume and open interest are incorporated in the variance equation of EGARCH (1,1) model as follows:

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is the unexpected open interest at time t. Once again, the interaction terms with indicative variable and expected and unexpected components of trading activity are used to test their asymmetric relationship with volatility. Therefore, coefficients γ_{11} (λ_{11}) measures the effect of expected volume (open interest) on volatility in contango whereas coefficients $\gamma_{11}+\gamma_{21}$ ($\lambda_{11}+\lambda_{21}$) measuresthesamerelationshipinthe backwardation. The effect of unexpected volume (open interest) on volatility in contango is captured by coefficients γ_{12} (λ_{12}), whereas the effect of unexpected volume (open interest) on volatility is measures by $\gamma_{12} + \gamma_{22}$ ($\lambda_{12}+\lambda_{22}$) inbackwardation. Hence,the sign and significance of the coefficients γ_{21} (λ_{21} + λ

22
) indicate asymmetric relationship between
volatility and expected volume (open interest) whereas the asymmetric relation between
volatility and unexpected volume (open interest) is indicated by coefficients γ
) in
the backwardation in contrast to contango period.
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5 Results and Discussions

5.1 Descriptive statistics

Summary statistics of near-month futures returns, volume, open interest and speculation ratio of Indian crude futures markets along with near-month futures returns of NYMEX in the overall sample period and two market conditions- contango and backwardation are given in Table 1. We find that the return series are stationary and Ljung-Box test shows strong presence of ARCH effect in the return series. The results of unit root tests on standardized volume and open interest indicate that volume and open interest series are stationary
3

and hence they can be used in the variance equation of the Indian crude futures returns.

We observe that the open i nterest of Indi an near- month f utures i s hi gher than the trading volume in the overall sample period as well as in both contango and backwardation periods. The average speculation ratio is 0.14, which indicates that the average open interest in the Indian crude futures is approximately seven times more than the average volume. This supports our argument to include open interest in analyzing the relationship between trading activity and volatility in a futures market. The slope of the NYMEX 6-month forward curve better explains the backwardation and contango periods in the crude market and therefore the mean returns of both NYMEX and Indian near-month crude futures are positive in contango and negative in backwardation. The NYMEX nearmonth futures is more volatile than Indian near month futures - in the overall periods as well as in different market conditions . The high volatility signifies more trading activity and better information dissemination as compared to emerging markets like India. In both contango and backwardation periods, we observe the difference in the speculative and hedging behavior of market participants by examining changes in the trading volume and open interest respectively. It is interesting to find that during the backwardation, volume increases, open interest decreases and therefore, the speculation ratio increases. This supports our argument that for a market which is a net consumer is less likely to

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The autocorrelation functions and results of unit root and ARCH test on India return, NYMEX return, standardized volume and standardized open interest can be obtained from authors upon request.

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Tabl e 1: Descri pti ve Stati sti cs

INDIA

	R	Std Vol.	Std Open Int.	Spec. Ratio	R
Panel A: Overall Sample Period					
Mean	0.0003	1.0333	1.1415	0.1402	0.0218
Median	0.0004	0.9944	1.1174	0.1244	0.0401
Maximum	0.2390	2.3969	2.5963	2.2880	13.1363
Minimum	-0.0852	0.0000	0.0618	0.0000	-11.1188
Std. Dev.	0.0183	0.3756	0.3275	0.0898	2.2815
Skewness	1.2350	0.4373	0.3893	8.0028	0.2174
Kurtosis	18.4697	3.4147	4.0614	159.9457	6.5688
Observations	2175	2175	2175	2175	2175
Panel B: Contango					
Mean	0.0005	1.0280	1.1587	0.1286	0.0191
Median	0.0006	0.9822	1.1357	0.1145	0.0493
Maximum	0.2390	2.3969	2.5963	2.2880	13.1363

Minimum	-0.0852	0.0000	0.0618	0.0000	-11.1188
Std. Dev.	0.0194	0.3710	0.3317	0.0837	2.4490
Skewness	1.2485	0.4871	0.3642	11.2526	0.2156
Kurtosis	17.6613	3.4826	4.0494	259.6716	5.9723
Observations	1784	1784	1784	1784	1784
Panel C: Backwardation					
Mean	-0.0001	1.0577	1.0627	0.1932	0.0341
Median	-0.0005	1.0466	1.0436	0.1687	0.0201
Maximum	0.0685	2.2465	2.4128	0.6389	4.3651
Minimum	-0.0519	0.0584	0.1071	0.0186	-4.6553
Std. Dev.	0.0122	0.3956	0.2951	0.0974	1.2627
Skewness	0.1683	0.2283	0.4062	1.7368	0.0373
Kurtosis	6.1824	3.1792	4.1079	6.5189	3.9809
Observations	391	391	391	391	391

Notes: This table reports the summary statistics of the near-month crude futures traded on Multi Commodity Exchange (MCX), India and New York Mercantile Exchange (NYMEX), USA. The sample period is from January 02, 2009 to December 31, 2017.
R
is the log difference of Indian near-month WTI crude futures prices traded in MCX. Std. Vol. is the standard volume measured by 50-day moving average of the daily volume, and Std. Open Int. is the standard open interest measured by 50-day moving average of daily the open interest. Spec. Ratio denotes speculation ratio- the ratio of daily trading volume and open interest. R
INDIA
is the log difference of near-month
WTI crude futures prices traded on NYMEX. Panel A provides summary statistics of the overall sample period whearas summary stattistics of the contago and backwardation periods is presented in Panel B and Panel C respectivey.
NYMEX

NYMEX

engage in hedging activities in the backwardation period and hence open interest should decrease in the this period. Also, in the backwardation period, speculators may likely to take more short positions and hedgers who are still participating in the market are more likely to close their positions, lead to increase in the volume. As shown in Figure 3, the increased speculation ratio confirms that Indian crude futures market becomes dominated by speculative behavior in the backwardation as compared to the contango period and this change in the behavior of market participants may affect the Indian futures volatility differently.

5.2 Relationship between Futures Volatility and Trading Activity

The empirical results examining the relationship between Indian futures volatility and trading activity are presented in Table 2. We start with the Model I which incorporates the standard volume and open interest in the variance equation of the Indian futures returns. The GARCH parameters, ↵

0

,↵

1

,↵

2

, and ↵

are statistically significant which

supports our choice of EGARCH framework. We find that the asymmetric GARCH parameter estimate, ↵

2

3

is statistically significant and negative indicating that the Indian

crude futures returns becomes more volatile when returns are negative. This result is contrary to the expected belief in the commodity markets where positive shocks have more impact on the volatility than negative shocks but consistent with the findings of Alizadeh & Tamvakis (2016) and Mohammadi & Su (2010) who argue that crude behave more like a financial asset than a commodity. The estimated coefficient of standard volume, γ, is positive and significant whereas coefficient of standard open interest, λ, is negative. The results indicate that the increase in contemporaneous trading volume increases futures volatility whereas increase in the open interest reduces it. Our results are in line with the finding of existing literature (Bessembinder & Seguin, 1993; Foster, 1995; Wang, 2002;

Alizadeh & Tamvakis, 2016). Although volume and open interest coefficients are significant but the coefficient of lagged variance term (↲

3

) has not reduced by incorporating

volume and open interest in the EGARCH equation. It indicates that although Indian crude futures volatility is sensitive to the new information coming through trading ac-

Figure 3: Open interest, volume and speculation ratios of Indian crude futures over the sample period

tivity but its volatility depends on its lagged volatility. Hence, there is less evidence to support the MDH hypothesis in the Indian crude futures markets. This result is expected for an emerging market like India where futures markets are less developed and probably the market is more sensitive to information coming from the developed market through return and volatility spillovers than domestic futures trading activity (Zhang & Wang, 2014; Batten et al. ,2015).

In Model II, we extend Model I by introducing different market conditions where asymmetric effect of volume and open interest on futures volatility is investigated by using dummy interaction terms as explained earlier in the Section 3. The results of the Model II indicates that the GARCH parameters are statistically significant and volatility

increases in response to negative shocks in the returns series. Similar to the findings of Model I, the results of Model II reveal that the volume and open interest parameters

(γ

1

and λ

) are statistically significant and affect the volatility positively and negatively respectively. The parameter estimates for dummy interactive terms for both standardized volume and open interest (γ

1

2

and λ

) are not statistically significant.

The Model III is a well specified model where international spillover effect from

2

NYMEX to Indian crude futures market is incorporated in both mean and variance equations. The asymmetric effect of NYMEX market in backwardation is also captured through dummy interaction terms. The coefficient of NYMEX return in the Indian mean equation (b

) is statistically significant and positive which indicates that the return

spillover takes place from the NYMEX market to the Indian market. The parameter

(b

2

1

) in the mean equation is statistically insignificant, implies that the effect of NYMEX return on Indian return is not significantly different in both market conditions. Turning to the variance equation, the coefficient of NYMEX volatility parameter (ß

) is statistically

significant and positive. The parameter (ß

) which captures the additional effect

of NYMEX volatility in backwardation is not significant. It implies that the volatility spillover also takes place from the NYMEX market to the Indian crude market and this

2

effect is almost similar is both contango and backwardation. It is important to note that after including the NYMEX conditional volatility in the Indian variance equation, the

20

1

Adjusted R-squared -0.0007 -0.0006 0.0044

Log likelihood 5918.19 5919.75 5934.71

) 0.0125 0.0089 0.1597

R-squared -0.0007 -0.0006 0.0053

) 0.0051 0.0015 0.0005

GARCH

) 0.0017 0.0280 0.9526 -0.0132 0.0431 0.7601 bdum (✓) -0.0016 0.0217 0.9410 0.0299 0.0315 0.3427

) -0.0206 0.0077 0.0071 -0.0276 0.0091 0.0025 -0.0441 0.0140 0.0016

Standard Open Interest ⇥ bdum (λ

) -0.0083 0.0224 0.7103 -0.0483 0.0273 0.0769

Standard Open Interest (λ

) 0.0413 0.0077 0.0000 0.0466 0.0089 0.0000 0.0554 0.0122 0.0000

Standard Volume ⇥ bdum(γ

0.9908 0.0017 0.0000 0.9883 0.0020 0.0000 0.9548 0.0100 0.0000

Standard Volume (γ

-0.0451 0.0069 0.0000 -0.0441 0.0078 0.0000 -0.0617 0.0117 0.0000

↲

0.0894 0.0117 0.0000 0.0951 0.0130 0.0000 0.1065 0.0174 0.0000

↲

-0.1624 0.0206 0.0000 -0.1828 0.0240 0.0000 -0.4850 0.0944 0.0000

↲

) 0.0000 0.0005 0.9579

Variance Equation

) 0.0007 0.0002 0.0000

R

Mean Equation

Intercept (↲) -0.0001 0.0003 0.6573 -0.0001 0.0003 0.7948 -0.0002 0.0003 0.5678

Coeff. Std. Error Prob. Coeff. Std. Error Prob. Coeff. Std. Error Prob.

Table 2: Results of EGARCH-X (1,1) model with standard volume and open interest

Model I Model II Model III

1

(b

NYMEX

R

2

t-1,NY MEX

s

2

+ß

refer to log difference of near-month WTI crude futures prices traded on Multi Commodity Exchange (MCX)

and New York Mercantile Exchange respectively, bdum is an indicator variable which takes value of 1 when market is in backwardation

⇥bdum)

where R

2

t-1,NY MEX

s

1

⇥bdum+✓bdum+ß

t

OI

2

+λ

t

OI

1

⇥bdum+λ

t

t

V

2

+γ

t

⇥ bdum + "

V

1

+γ

t-1

2

t-1

s

3

NYMEX

equations. The unrestricted model (Model III) is specified as:

R

Model II models the trading activity and volatility relationship in different market condiditon - contango and backwardation by using

interactive dummies. Model III also controls for the possible spillover effects from the US crude futures in both mean and variance

Notes: The table provides the parameter estimates of the EGARCH models of Indian crude future returns with various exogenous

variables. Model I is the basic EGARCH model with standard volume and open interest as exogeneous variable in the volatility equation.

2

+↲

R

2

t-1

+ b

z

2

2

2

1

NYMEX

| +↲

t-1

NYMEX,t-1

⇥ bdum (ß

1

2

1

and R

| z
R
(ß
1
1
and 0 otherwise.
INDIA
+↲
0
= a + b
NYMEX
NYMEX
⇥ bdum (b
=exp(↲
INDIA,t
GARCH
3
2
1
0
NYMEX
2
t
↲
s
21
coefficient of lagged variance term (↲
) has reduced from 0.9908 to 0.9548 . Therefore,

the results show the importance of incorporating spillover effects from NYMEX to Indian markets while modeling price dynamics in Indian futures markets. It supports our argument to check and include spillover effects from developed markets while analyzing the price dynamics in emerging markets. Now coming back to relationship between trading activity and volatility after controlling for NYMEX spillover effects, we find that the volume and open interest parameter estimates (γ

3

1

and λ

) are statistically significant.

Similar to the findings in Model I and II, standard volume affects the volatility positively whereas standard open interest affects it negatively. While open interest doesn't show any asymmetric behavior, coefficient for standard volume during the backwardation (γ

1

)

is negative and significant at 10% level of significance. It indicates that the volume reduces the volatility in the backwardation. The results are contrary to our belief that Indian futures trading volume which increases in the backwardation should affect the volatility positively. To analyze the effect of trading activity on volatility further and as suggested in the existing literature (Bessembinder & Seguin, 1993; Alizadeh & Tamvakis, 2016; Todorova & Clements, 2018), we divide the volume and open interest into expected and unexpected component and re-estimated the Model I, II and III using expected and unexpected components of the trading activity. The results are presented in Table 3.

The results of the models with expected and unexpected components are consistent with the findings of models with standard trading activity. We find that the expected volume coefficient (γ

) is positive and significant in all three models which indicates that the expected volume affects the volatility positively. The expected open interest parameter (λ

11

11

) is significant and negative in Model V and Model VI. The results are consistent with the finding of Bessembinder & Seguin (1993), Foster (1995), and Wang (2002), amongst others. We find very interesting results of effect of market condition on trading volume and volatility relationship. The expected volume coefficient in backwardation

(γ

12

) is significant and positive across both Model V and Model VI which
suggests that the effect of expected volume on volatility is stronger when market is in
the backwardation. Alizadeh & Tamvakis (2016) also find similar results while analyzing

) 0.0046 0.0072 0.5205
R-squared -0.0007 -0.0007 0.0055
) 0.0034 0.0011 0.0015
GARCH
) -0.1623 0.1194 0.1741 -0.1563 0.1476 0.2897
bdum (✓) -0.2496 0.0679 0.0002 -0.2246 0.0895 0.0121
) -0.0272 0.0372 0.4652 0.0018 0.0393 0.9641 0.0354 0.0500 0.4796
Unexpected Open Interest ⇥ bdum (λ
) 0.0794 0.0506 0.1168 0.0583 0.0680 0.3913
Unexpected Open Interest (λ
) -0.0179 0.0127 0.1596 -0.0277 0.0133 0.0367 -0.0520 0.0186 0.0052
Expected Open Interest ⇥ bdum (λ
) -0.5482 0.1753 0.0018 -0.6137 0.2227 0.0059
Expected Open Interest (λ
) -0.0107 0.0511 0.8343 0.0190 0.0536 0.7234 -0.0315 0.0616 0.6091
Unexpected Volume ⇥ bdum (γ
) 0.1495 0.0545 0.0061 0.1407 0.0718 0.0500
Unexpected Volume (γ
) 0.0549 0.0146 0.0002 0.0393 0.0154 0.0106 0.0587 0.0192 0.0023
Expected Volume ⇥ bdum (γ
0.9911 0.0017 0.0000 0.9905 0.0016 0.0000 0.9697 0.0069 0.0000
Expected Volume (γ
-0.0447 0.0069 0.0000 -0.0457 0.0083 0.0000 -0.0569 0.0110 0.0000
↵
0.0869 0.0120 0.0000 0.0674 0.0106 0.0000 0.0694 0.0147 0.0000
↵

-0.1747 0.0272 0.0000 -0.1377 0.0252 0.0000 -0.3206 0.0681 0.0000

↲

) 0.0000 0.0005 0.9774

Variance Equation

2

⇥ bdum (b

) 0.0008 0.0002 0.0000

R

Intercept (↲) -0.0002 0.0003 0.6332 -0.0001 0.0003 0.6953 -0.0001 0.0004 0.8369

Coeff. Std. Error Prob. Coeff. Std. Error Prob. Coeff. Std. Error Prob.

Mean Equation

Table 3: Results of EGARCH-X (1,1) model with expected and unexpected components of trading activity

Model IV Model V Model VI

1

(b

NYMEX

NYMEX

R

t

–

OI

21

+ λ

refer to log difference of near-month WTI crude futures prices in Multi Commodity Exchange (MCX) and

OI,t

OI,t

μ

12

is the unexpected open

interest at time t.

New York Mercantile Exchange respectively,bdum is an indicator variable which takes value 1 when market is in backwardation and 0

otherwise.

⇥ bdum +

λ

+ λ

t

is the expected open interest and μ

–

OI

11

⇥ bdum + λ

v,t

μ

22

t

⇥ bdum + γ

t

–

V

is the unexpected volume,

–

OI

21

+ γ

v,t

t

μ

12

+ γ

t

–

V

⇥ bdum)

where R

2

t-1,NY MEX

11

+ γ

⇥ bdum + "

v,t

2

t-1

s

s

2

3

NYMEX,t-1

model which incorporates different market conditions and possible spillovers from NYMEX to Indian futures market is:

R

Notes: The table provides the parameter estimates of the EGARCH models where the starbard trading volume and open interests are

decomposed into expected and unexpected components and included as explanatory variables in conditional variance equation. The final

Adjusted R-squared -0.0007 -0.0007 0.0041

Log likelihood 5918.53 5924.31 5938.92

22

+ ß

+ ↲

21

R

is the expected volume, µ

t-1

2

+ b

22
2
t-1,NY MEX
z
12
2
21
2
| +↵
11
NYMEX
NYMEX,t-1
⇥ bdum (ß
12
s
1
t-1
11
| z
1
and R
+ ✓bdum+ ß
R
(ß
1
1
+ ↵
t
–
V
INDIA
0
= a + b

NYMEX
NYMEX
OI,t
µ
=exp(↲
22
INDIA,t
GARCH
3
2
1
0
2
t
↲
s
23

the volume-volatility relationship for energy commodities traded on NYMEX. The unexpected volume and open interest coefficients are, in general, not statistically significant across all the model specifications.

The above findings suggest that the behavior of market participants changes during backwardation and therefore the relationship between trading volume and volatility also changes and becomes asymmetric. The volume increases whereas open interest decreases in the backwardation. Therefore, the speculation ratio increases during backwardation which indicates the dominance of speculative behavior over hedging behavior in the backwardation.

The increase in the dominance of speculative behavior in the backwardation period increases the strength of positive relationship between volume and volatility. To understand the effect of speculative and hedging behavior on the volatility of Indian crude futures market, we further modify the Model III by replacing the volume and open interest terms with the speculation ratio and label it Model VII. We also use the dummy interaction term with speculation ratio to see the asymmetric effect. The results are presented in Table 4.

It is very interesting to find that there is an asymmetric relationship between speculation ratio and volatility. The coefficient of speculation ratio is significant and negative in contango whereas the coefficient is significant and positive in the backwardation. We also test the combined effect (dampening effect) of speculation ratio on volatility in backwardation and find that speculation ratio increases volatility in the backwardation. As discussed earlier, the speculation ratio significantly increases in backwardation which indicates that the Indian crude futures market is dominated by speculative behavior in this period and the dominance of speculative behavior affects futures volatility positively and strongly. This result supports our findings for Model III and Model VI where increased volume in the backwardation positively affects volatility. The findings of the relationship between speculation ratio and futures volatility are similar to the findings of Wellenreuther & Voelzke (2019) who analyze the dynamic relationship between speculation ratio and volatility in Chinese futures markets and find that futures volatility and speculation ratio are linked with each other. Haugom & Ray (2017) also find that

Table 4: Parameter estimation results of EGARCH-X (1,1) model with speculation ratio

Model VII

	Coefficient	Std. Error	Prob.
Mean Equation			
Intercept (↲)	-0.0004	0.0003	0.1873
NYMEX (b)	0.0008	0.0002	0.0000
NYMEX ⇥ bdum (b ↲ 1)	-0.0002	0.0005	0.7307
Variance Equation			

0

2

-0.3993 0.0755 0.0000

↲

0.0307 0.0131 0.0191

↲

1

-0.0930 0.0101 0.0000

↲

2

0.9562 0.0086 0.0000

Speculation Ratio -0.0815 0.0491 0.0970

Speculation Ratio ⇥bdum 0.6257 0.1036 0.0000

GARCH

3

) 0.0050 0.0012 0.0000

GARCH

NYMEX

NYMEX

(ß

1

) 0.0143 0.0057 0.0125

bdum (✓) -0.1556 0.0266 0.0000

⇥ bdum (ß

2

R-squared 0.0045

Adjusted R-squared 0.0036

Log likelihood 5954.01

Notes: This table presents EGARCH results with speculation ratio- the ratio of trading volume and open interest as exogenoeus variable in the variance equation. The model is:

R

s

INDIA,t

2

t

= a + b
=exp(↲
+ß
where R
2
s
2
0
+ ↲
1
1
R
NYMEX,t-1
| z
t-1,NY MEX
INDIA
t-1
and R
| +↲
2
z
+ b
t-1
2
R
NYMEX,t-1
+ ↲
⇥ bdum + ✓bdum)
NYMEX
3
s
2
t-1

+ '

1

⇥ bdum + "

SR

t

+ '

2

t

SR

t

⇥ bdum + ß

refer to log difference of near-month WTI crude futures
prices traded on Multi Commodity Exchange (MCX) and NYMEX respectively, bdum is an indicator variable which takes value 1 when market is in backwardation and 0 otherwise, and SR is the speculation ratio.

25

1

s

2

t-1,NY MEX

speculative trading activity is associated with higher volatility and hedging activity on the other hand, has the opposite effect.

6ConcludingRemarks

Emerging commodity futures markets are generally characterized by speculative trading, limited volume of trade, and more influenced by information spillovers from developed markets. Understanding the relationship between futures trading activity and volatility in such emerging markets is very crucial as it helps in further development of the futures markets, attracting different types of market participants including hedgers and in envisaging optimal regulation to protect and facilitate trading activity in the market. We hypothesize that dynamics of emerging markets are different than the developed market hence should be modeled and investigated differently. We argue that that the speculative activities proxied by trading volume and hedging activities proxied by open interest in the emerging futures markets change under backwardation and contango and this change should cause asymmetric relationship between trading activity and volatility.

To test the asymmetri c rel ati onshi p between f utures tradi ng acti vi ty and vol ati l i ty in Indian crude futures markets under different market conditions backwardation and contango, we use EGARCH-X (1,1) model. We include open interest along with trading volume and also separate the negative and positive slope of forward spread regimes to investigate whether trading activity-volatility relationship changes when forward spread indicates backwardation in the market. In contrast to the previous research in the context of emerging markets, we control for the information spillover from developed markets to emerging markets and present robust results of the asymmetric relationship between trading activity and volatility.

When the relationship between trading activity and trading volatility is analyzed in different market conditions, we find that volume increases whereas open interest decreases in the backwardation. Our results confirm that the speculation ratio is significantly higher in the backwardation which indicates dominance of speculative behavior in contrast to

contango in Indian crude futures markets. India is a net consumer of crude oil, and consumers face risks when price goes up. Hence, strong backwardation in the crude market will reduce the number of long hedgers and therefore decrease the open interest in the futures markets. We find very important results of strong spillover effects from NYMEX to Indian crude futures markets. It is interesting to note that in Indian crude futures markets open interest is always higher than the trading volume and open interest helps in reducing volatility in the futures markets. The effect of trading volume is positive on the volatility and its effect become stronger in the backwardation. While speculation ratio is used to test the dominance of speculative behavior and its effect of volatility, we find that relationship between speculation ratio and volatility is asymmetric. The speculation ra-

tio reduces volatility in the contango but in backwardation the speculation ratio increase and positively affect the volatility. The understanding of this asymmetric relationship is equally important for policy makers in setting up appropriate risk management tools and for market participants in devising efficient trading and hedging strategies.

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