The Other Side of the Coin: Speculation in Bearish Natural Gas Markets

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Abstract

This paper analyses the possibility of speculative trader behavior in natural gas markets. We find that change in positions held by money managers (pure speculators) lead changes in spot prices and the incentive to hold inventories in bear markets and thus confirming the possibility of speculators influencing price dynamics of natural gas prices. Our results further suggest that the influence of speculators on futures price wear out with the time-to-maturity of the contract.

JEL classification: D84, Q40

Keywords: Speculation, Natural gas

1. Introduction

‘‘Financialization has led to excessive speculation" is a common statement among commentators and some researchers about commodities. A speculator is defined by Fattouh, Kilian, & Mahadeva (2013) as a market participant who does not trade commodities for consumption. Potentially this can be done in two different ways. Speculators may either purchase the commodity in the physical market to strengthen their inventory or they may take long futures positions in derivatives market. In both instances the expectation is a future

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increase in commodity prices. Further, Fattouh et al. (2013) argue that speculation is required to maintain the supply chain of products at stable prices. For instance, refiners keep inventories to maintain stable fuel prices during times of increased crude oil prices.

Though speculation is required for the smooth functioning of any market, there are claims that excessive speculation may cause commodity prices to increase, deviating from their fundamental values (Masters, 2008). Further according to Masters (2008), speculators who buy commodities as a financial assets are mainly responsible for the increase in prices. Speculators profit from expectations for higher prices by taking a long position on a far month contract, selling it at a higher price before the contract expires, and reinvesting the proceeds in a new far month contract. Index investors are also criticized by Masters (2008), where he claims that funds investing in commodity-based indices has nothing to do with physical demand and supply of individual commodities. Moreover, such investments create a flow of funds to all commodities according to weights assigned to each commodity.

Although there are number of claims against Masters (2008) based on the findings from crude oil market (Fattouh et al, 2013), Alquist & Gervais (2013) and Alquist & Kilian (2010) among others), the literature lacks evidence from other commodity markets. In this paper, we explore the validity of the above testimony with regard to natural gas market. Following Masters (2008), we argue that speculation may well be responsible for price decreases seen in natural gas market from 2014-2020. Speculators can profit from lower price expectations by taking a short position on a futures contract today and closing out at a lower price before the contract expiry. They can then reinvest their profits again in short positions, pushing prices down further.

According to literature on commodity futures markets non-commercial investors listed under Commodity and Futures Trading Commission (CFTC) are considered as speculators (Gorton, Hayashi, & Rouwenhorst, 2013)(Basu & Miffre, 2013). Non-commercial investors do not take positions in futures contracts with the intention of selling products or buying to consume on a future date in comparison to commercial investors (hedgers) who take positions with the intention of making or receiving the physical delivery. According to Keynes (1930), hedgers trader futures to transfer their future price risk to speculators and speculators earn a premium in return as the reward for the risk taken. Therefore, ideally speculators should take opposite positions to hedgers. Building on Keynes (1930), Working (1960) introduces an index (T-index) that measures the level of imbalance caused by speculators. We form this index for the natural gas futures market and compare its movements against the spot price of natural gas. We observe that prices increase and decrease with the T-index index, both in 2007-2008 and 2014-2017 periods. Moreover, the positions held by non-commercial investors after 2008 are mostly short and peaks of T-index coincides with peaks of net short positions held by non-commercial investors. This supports our earlier argument that speculation could have been a cause for the decrease in price after 2014.

We conduct Granger causality tests to determine the impact on spot and futures price of Natural gas that is caused by changes to disaggregated Commitment of Traders (COT) data on weekly trader positions across the full sample (2006/03-2020/05) and five sub-samples (2006/03-2008/06, 2008/07-2020/05, 2008/07-2013/12, 2013/12-2020/05), in order to verify the outcome of the above graphical analysis. We find that neither change in commercial nor the change in non-commercial positions do not predict natural gas price. However, we find some indications of speculation once those positions are further disaggregated based on the nature of trading. Change in positions held by money managers

are in fact found to be leading both spot and nearby futures price in the full sample, 2008/07-2020/05 and 2013/12-2020/05 subsamples. Moreover, the correlation between net long positions held by money managers and the price of natural gas is positive. This implies that money managers during this period have changes their positions according to their future expectations of prices. This is a significant piece of evidence in favor of price distortion caused by speculative trading. We find no evidence of positions held by money managers causing changes to 12-month futures contracts implying the reluctance of speculators to exploit these trading opportunities due to possible shortage and the subsequent cost of liquidity in distant futures contracts.

In order to overcome the dependence of subsamples above and to identify and quantify the magnitude of speculation under bullish and bearish market conditions, we further conduct a threshold vector autoregression (TVAR) analysis between change in spot/futures price of natural gas and the change in net long positions held by each trader group, after setting the past change in spot price as the threshold variable. One the one hand, we find evidence that changes to net long positions to money managers predict changes to spot price when markets are bearish on average. On the other hand, changes to spot prices drive net long positions taken by money managers under bullish market conditions.

The remainder of the paper is organized as follows; section 2 briefly reviews current literature, section 3 explains our sources of data and construction of variables, section 4 explains results and section 5 concludes.

2. Literature review

The link between financial speculation and formation of prices within commodity markets remain a topical issue. Many studies have opined that irrespective of the direction of

speculation, be it long or short, it remains a significant source of increasing price volatility; in addition to volatility and price spillovers from financial markets and into the commodity markets (often referred to as financialization). Within the oil market, Du, Yu & Hayes (2011) finds fluctuations in volatility resulting from speculation. This often has consequential adverse effects on the real economy, as stated in Haase, Zimmermann & Zimmermann (2016), and a decade earlier, Subrahmanyam (1996) highlights the destabilisation of prices as a result of misinformed speculation from index futures.

While this is the same position held by the 2008 report of the United States Commodity Futures Trading Commission (CFTC), other studies have produced contradictory results, like Paesani & Rosselli (2021) who highlight the role of speculation in levelling prices over time, ensuring that stakeholders can be protected against intertemporal price risks. In agricultural commodities, they find that speculation is quite effective at smoothing out seasonal variations in price. Stoll & Whaley (2010) insist that commodity price increases do not result from index speculation that is consistent with the findings of Sanders, Irwin, & Merrin (2010) and Irwin, Sanders, & Merrin (2009) .

Though speculation is required for the smooth functioning of any market, excessive speculation continues to contribute to fundamental value deviations, as noted by Masters, 2008. De Long et al (1990) agree in principle but point out that uninformed positive feedback trading can often result from rational speculation which magnifies price volatility, hence speculation can indeed lead to a trend in the price part and towards destabilisation as highlighted in Tse & Williams (2013). Cheng, Kirlenko & Xiong (2014) confirm that speculators who buy commodities as financial assets contribute significantly to increases in prices. Speculators profit from expectations of higher prices by taking a long position on a

far-month contract and selling it at a higher price before the contract matures. In investigating impact of market phases, Einloth (2009) find a varying impact of speculation on the price of crude oil across various sub-bull market phases and Kaufmann & Ullman (2009) presents the aggravating role of speculation in extending price rises during a bull period.

3. Data

We follow multiple methodologies to provide evidence for and against speculation in natural gas market. Therefore, we use multiple data sources fulfil our requirement. Our initial analysis covers the 1997/01-2020/05 period. This to establish some form of consistency with Alquist & Gervais (2013) and to highlight possible differences in the period that followed. We use data from aggregate COT reports published by Commodities and Futures Trading Commission (CFTC) for the period January 1997 to May 2020 to estimate the net long positions held by each category of traders, which in turn allows us to calculate Working's T index (Working, 1960) that captures excess speculation.

Although, aggregate COT data are available from 1997, the CFTC started publishing disaggregate[2] data from mid-2006. Therefore, our analysis of disaggregate COT data is limited to the 2006-2020 period. The daily spot price and the 1-month futures price of natural gas are downloaded from Bloomberg, while the1-month US treasury bill rate is obtained from the Federal Reserve of St. Louise (FRED) database.

[2] Disaggregate COT report further categorize commercial and non-commercial traders into producers/merchants/manufacturers, swap dealers and money managers. See CFTC (2009) for the definition of each trader category

Working's T index

Working's (1960) T index is designed to capture the excessive pressure caused by non-commercial traders. It is defined as;

$$T\ index = \begin{cases} 1 + \dfrac{SS}{LH + SH} & if\ \ SH \geq LH \\ 1 + \dfrac{LS}{LH + SH} & if\ \ SH < LH, \end{cases} \quad --------(1)$$

Where, SS is the short open interest of non-commercial traders (speculators), LS is the long open interest of non-commercial traders, SH is the short open interest of commercial traders (hedgers) and LH is the long open interest of commercial traders.

Spread

Given the price of the 1-month futures contract is f_1, the spot price is S_0 and the 1-month treasury bill rate (risk-free rate) is R_f, the spread is estimated as,

$$Spread = ln(f_1) - ln(S_0) - R_f \quad --------(2)$$

Assuming that the cost of storage remains constant over a period of time, higher the value of the spread, more incentive to hold inventories and vice versa.

4. Results

4.1 Working's T and the movement of spot price

Alquist & Gervais (2013) use the Working's T index (Working,1960) to examine whether there is any evidence to show that speculators have affected the spot price of crude oil. They

suggest that speculation has a minor role to play in driving crude oil prices. Figure 1 plots the T index that we constructed, along with the spot price of natural gas from 1997.

<Figure 1 about here>

We observe standout spot price peaks in 2000, 2003, 2005, 2008, 2014 and 2017. However, we only see large increases in the T index in 2008, 2014 and 2017. This suggests that speculation may have not been instrumental in driving the spot price of natural gas during, 2000-2005 period. However, we observe a steep increase in T index concurrent with the rapid increase in the natural gas spot price in 2008, followed by a significant drop almost at the same time as the price collapse towards the end of 2008. Moreover, the T index increased during the two major price increases in 2014 and 2017, and subsequently dropped alongside the price. The price of natural gas further decreased with the weakening speculative pressure towards the first quarter of 2020. These observations are substantially different to what Alquist & Gervais (2013) observe in relation to crude oil market, especially in the period that followed the Global Financial Crisis. In fact, our observations suggest that speculative pressure and the spot price of natural gas are related at least from 2008 onwards, and therefore indicating that speculation may have had a significant role to play in the movements in natural gas prices since 2008.

<Figure 2 about here>

Figure 2 exhibits the net long positions held by non-commercial investors scaled by total open interest alongside the Working's T index. We observe that non-commercial traders were in fact holding more short positions in comparison to long positions during the rapid price increase in 2008. This suggests that speculation may be ruled out as driver of natural

gas prices prior to Global Financial Crisis. According to this figure, a majority of non-commercial investors have been holding short positions on natural gas futures since the Global Financial Crisis for the most part. These positions are significantly large in comparison to positions held by them pre-global financial crisis. Peaks of speculative pressure indicated by T index is well supported by the short positions held by speculators. This is also consistent with our proposition that there is a possibility of speculators being instrumental in price decreases, although most claims on speculation discuss the upward movement of prices (Masters, 2008). The substantial involvement of speculators on the short side of natural gas futures market with the expectation of a price decreases could well distort the incentives for storage.

4.2 Correlation between prices and net positions

Working's T index is constructed based on commercial (hedgers) and non-commercial (speculators) trade positions. Commercial traders include producers, merchants and manufacturers (herein forth PRODs), while non-commercial traders accounts for swap dealers, defined as "an entity that deals primarily in swaps for a commodity and uses the futures markets to manage or hedge the risk associated with those swaps transactions" (CFTC, 2009) and money managers who are actively engaged in trading commodity futures contracts for their respective clients such as commodity investment advisors and pooled funds.

<Figure 3 about here>

Figure 3 exhibits the variation of 12-month moving average of total open interest of PRODs, swap dealers and money managers. The most significant observation of this graph is the dominance of money managers in relation to the total open interest. It increases rapidly

during the price collapse 2008 followed by a dramatic decrease. Subsequently, the open interest on natural gas has been on an increasing trend in general until 2016, after which the open interest of money managers depleted towards 2019. Interestingly, when the total open interest trended upwards, the spot price of natural gas was on a decreasing trend. Nevertheless, we do not know which category/categories of traders contributed to the price change if there is any at all. Therefore, it is essential that we examine the effects of these speculator forms as each category may have different effects on natural gas prices. We follow Büyükşahin & Harris (2011) as we first analyze the correlations between net long positions held by each trader group and the first futures price and then analyze the correlation between the change of net long positions and change in first futures price of natural gas.

<Table 1 about here>

Table 1 reports the correlation between the change in nearby futures price of natural gas and the level of net long positions of each trader category. Results suggest that the correlation between changes to futures price and, the net long positions of commercial and non-commercial trader groups are not statistically significant at 5% level. However, the net long positions estimated using disaggregated COT report data display significant correlations with futures price changes. Net positions held by money managers exhibit the only statistically significant correlation to futures price change in the full sample. Futures price change is also positively correlated to net long positions held by money managers in 2008/07-2020/05 and 2008/07-2013/12 subsamples. The traders that cannot be categorized under the three sub categories (CFTC, 2009) are negatively correlated to the

change in futures price and are statistically significant in all subsamples except 2013/12-2020/05 and 2013/12-2020/05.

<Table 2 about here>

We follow Alquist & Gervais (2013), Büyükşahin & Harris (2011) and Sanders, Boris, & Manfredo (2004) to examine the correlation between the changes to nearby futures price and changes to net long positions held by different categories of traders. These results are reported in table 2. All correlations except the one between change in futures price and net long positions held by swap dealers in 2006/03-2008/06 subsample, are statistically significant at 5% level. These results are consistent with the findings of Büyükşahin & Harris (2011) with regard to crude oil markets. Results suggest that commercial traders move against the prices while non-commercial traders move with the price changes. Therefore, net long positions held by non-commercial traders will increase with positive price changes and vice versa. Money managers exhibit characteristics of non-commercial traders. However, the correlation of net long positions held by money managers to changes in futures prices is much greater in comparison to that of non-commercial traders. Traders listed under the other category appear to exhibit qualities of commercial traders as the correlation with the change in futures price is relatively large and negative. We observe that these results are in line with the findings of Fishe & Smith (2019) in relation to natural gas markets.

Though correlation explains the nature of the relationship between price changes and change in net long positions held by traders, it does not necessarily mean that net long positions change due to changes in prices or vice versa. Therefore, we test for the existence of a causal relationship between price changes of natural gas and net long positions. Büyükşahin & Harris (2011) and Alquist & Gervais (2013) use a series of Granger causality

tests (Granger,1969) to determine such a relationship in the context of crude oil markets. We apply the same methodology into natural gas market.

4.3 Granger causality tests

In a study that evaluated the effect of speculation towards the price movements of crude oil, Büyükşahin & Harris (2011) conduct bi-variate Granger causality tests between changes to nearby futures price and changes to net positions of commercial and non-commercial traders in crude oil market. Alquist & Gervais (2013) test the above causality with change to spot price and, 12-month futures price instead of nearby futures price. They argue that aggregated data reported in COT may be sensitive to the prices of distant futures contracts as the spread between nearby and distant futures contracts of crude oil was significantly large especially during crisis times. We however examine the Granger causality between the change in net long positions and changes in spot price, changes in nearby futures price and changes in 12-month futures price.

<Table 3 about here>

Table 3 shows that the change in weekly spot prices on average are negative except in the 2006/03-2008/06 subsample. The results show that we cannot reject the null hypothesis that changes in commercial and non-commercial trader positions Granger cause price changes. However, once the trader position data are disaggregated, we find that changes in money managers (pure speculators according to Basu & Miffre(2013)) net positions and changes to the net positions of "Others", lead changes in spot prices in the full sample and, 2008/07-2020/05 and 2013/12-2020/05 subsamples. This finding contrasts the results of Brunetti, Büyükşahin, & Harris (2015) who examine data prior to 2009 and implies that

the positions taken by pure speculators such as money managers are incapable of Granger causing subsequent movements in price. Evidence regarding PRODs category is considered inconclusive as the causal relationship between price change and net position change is statistically significant in both directions.

<Table 4 about here>

Table 4 reports Granger causality results between the change in net long positions held by traders and changes to nearby futures price. Results with regard to commercial, non-commercial, producer/merchant/manufacturer and swap dealer positions suggest that only the changes to futures price Granger cause net positions in all subsamples except 2006/03-2008/06. This result and the correlation analysis in table 2 imply that speculators in general increase (decrease) net long positions when markets have risen (fallen) while hedgers, represented by commercial traders trade against the market sentiment. Wang (2003) reports similar findings on multiple futures markets. The null hypothesis that changes to net long positions held by money managers and the "other" category of traders Granger cause changes to futures prices is rejected at 5% level in 2008/07-2020/05 subsample. There is no further statistical evidence to claim that the change in net long positions could predict the change to nearby futures prices. Interestingly, we do not observe any evidence that net changes to long positions causing 12-months futures price to change (Table 5). Moreover, the evidence presented in table 5 implies that changes in 12-month futures prices post-global financial crisis Granger cause the positions held by commercial and non-commercial traders.

<Table 5 about here>

These results provide some interesting insights about speculation. First, neither change in commercial nor the change in non-commercial positions do not in any way predict changes to natural gas price. However, we find some indications of speculation once those positions are further disaggregated based on the nature of trading. This implies that although academic literature considers non-commercial traders to be "speculators", we may not be able detect speculation unless we decompose them further in to swap dealers, money managers, etc. Results show that the average weekly spot price change is negative in all subsamples where a change in positions held by money managers lead both spot and nearby futures price. This could be one of the reasons that we find contrasting results to Brunetti et al. (2015) who examine the speculation in natural gas markets prior to 2009 when the market was booming. Literature finds that positive feedback trading is a common strategy employed by speculators (noise traders) to deviate the asset price from its fundamentals (de Long et al., 1990). Further, Sentana & Wadhwani (1992) and Koutmos & Booth (1995) find that there is more positive feedback trading after market declines in comparison to market increases. Therefore, we find more reasons to believe that price speculation can be more pronounced in bearish markets in comparison to bullish markets.

According to our results above, the change in net long positions held by traders do not predict price changes of distant futures contracts including the net long positions held by money managers. Kang, Rouwenhorst, & Tang (2020) show that there are two independent premiums that explain commodity futures return. They are; 1) insurance premium which hedgers pay speculators in return for protection against future price risks and 2) liquidity premium that speculators pay hedgers in return for market liquidity. This implies that speculators incur a higher cost to compensate for the supply of liquidity. Moreover, Cho, Ganepola, & Garrett (2019) find natural gas to be a relatively illiquid commodity in

comparison to other energy commodities such as crude oil and heating oil. Further, the depletion of liquidity in commodity futures contracts with time to maturity (de Groot, Karstanje, & Zhou, 2014). Therefore, speculators may prefer nearby contracts of natural gas to minimize the liquidity risk and hence we may not observe changes to positions of distant contracts granger cause price changes.

Brunnemier and Pedersen (2009) show that losses to speculators may impose funding constraints to speculators and as a result, they will reduce their positions. As a result, speculators in particular could drive natural gas prices during bearish market conditions in comparison to bullish markets. Further, one might argue that our selection of bear market periods above is arbitrary. Therefore, our test results are further associated with the analysis of nonlinearity and threshold effect, which is an extension to the conventional linear regression allowing for coefficients to differ across regimes. The regimes are identified by a benchmark threshold variable, being above or below a threshold value. Specifically, our models are capable of capturing the abrupt breaks or asymmetries related to the changing market conditions. The general two-regime threshold regression model is specified considering a threshold level denoted by γ.

$$y_t = c + x_{t-1}\beta_{\overline{R_{t-1:t-4}}<\tau} + \epsilon_t \qquad if \qquad -\infty < w_t \leq \gamma$$

$$y_t = c + x_{t-1}\beta_{\overline{R_{t-1:t-4}}\geq\tau} + \epsilon_t \qquad if \qquad \gamma < w_t \leq \infty$$

where y_t is the dependent variable, x_t is a $1 \times k$ vector of covariates possibly containing lagged values, $\beta_1 \text{and } \beta_2$ are $k \times 1$ vectors of regime-dependent parameters, and w_t is a threshold variable. We assign the change in spot price and change in futures price to y_t, while the change to net positions of each trader category remains the threshold dependent

variable. Correspondingly, the subset of observations in which the value of threshold variable w_t is lesser than the threshold level γ is referred to as regime 1, while the regime 2 is defined as a subset of observations greater than γ. The estimation method is based on a conditional least-square regression used to determine the threshold value by minimizing the sum of squared residuals for all tentative thresholds. We use the average change to the lagged four-week spot-price as the threshold variable representing the price trend of natural gas as an indicator of market sentiments. Ones we have the threshold, we estimate granger causality between change in spot/futures price and change in net long positions above and below this threshold. Results pertaining to the threshold effect and regime-dependent Granger causality between changes to spot (futures) prices and changes to net positions are reported in table 6 (table 7).

We infer three themes from reviewing the results. Specifically, we uncover significant evidence of the threshold effect in the associations between change in spot price and lagged net position changes. Such threshold effects are predominantly discernible at levels within close proximity to zero. Moreover, our test results broadly reveal the evidence of significant positive/negative relationship below the threshold point. The impact of net positions held by money managers and non-commercial investors on the price changes is positive and statistically significant at levels below the threshold, while those of swap dealers and other traders are positive. Interestingly, the relationship between change in spot prices and, change to net positions of money managers and non-commercial traders are statistically not significant, suggesting the change in net long positions can only predict changes to spot prices when the average spot price change over the past four weeks is below the estimated threshold.

<Table 6 about here>

Considering the causality analysis, our results show prominent evidence of reverse causation moving from the change in net positions held by money managers to the change in spot price at levels below the threshold point, whereas change in spot prices lead change in net positions in the context of PRODs and swap dealers. Correspondingly, we find the evidence of causation from change in net long positions held by PRODs and swap dealers to changes in spot price above the threshold level. These findings broadly reveal that positions taken by speculators (money managers) positions drive spot prices below the estimated threshold which implies bear market conditions for the most part[3]. Further, the same trader group is price driven under bullish market conditions. Since the threshold is very close to zero, this could be that short positions taken by speculators in bearish and near bearish market conditions affecting spot prices while they continue to take long positions in following past price trends in expectation of future returns in bullish markets.

<Table 7 about here>

According to table 7, the influence of the change in net positions on change in nearby futures price is more pronounced when the average change in spot price over the previous 4 weeks is above the threshold estimated. Granger causality results reveal that change in futures price lead the change in net positions of, swap dealers when past 4-week average spot price change is below the threshold. We observe a similar result in relation to commercial traders,

[3] The threshold variable, average 4-week change in spot price varies between -25.1% to 15.45%. The threshold value estimate of 2.44% for money managers falls in the 68th percentile of this distribution while a change of 0% falls in the 52nd percentile. This implies bearish market conditions for the most part when the average 4-week change in spot price falls below the estimated threshold.

non-commercial traders and PRODs when the past 4-week average change in spot price is above the estimated threshold.

4.4 Future expectations and inventory levels

Futures price of commodities is decided upon the ability to maintain inventories. Alquist & Gervais (2013) and Alquist & Kilian (2010) suggest that the physical market for commodities reflect the acts of financial speculation. Therefore, on the one hand, an accumulation of inventories can be expected when a potential price increase of natural gas is foreseen by financial speculators. Such incentives may reduce the availability of natural gas in the physical market. On the other hand, a potential drop in future spot price may reduce the incentive to hold inventories. Therefore, financial speculative traders would reduce their inventory, thereby increasing the quantity of natural gas in the physical market (Irwin et al. ,2011). Subsequently, any change to positions held by non-commercial traders that affects the incentive to hold natural gas inventories implies financial speculation.

The incentive to hold commodities, also known as convenience yield, is widely proxied by the basis in excess of risk-free rate assuming that cost of storage remains a constant. Following Alquist & Gervais (2013), we examine the relationship between change in net long positions of each trader group, and the spread which is the difference between natural log of 1-month futures price and natural log of spot prices in excess of the 1-month treasury bill rate (risk-free rate). Findings are reported in table 8.

<Table 8 about here>

The futures-spot spread is negative, indicating a lower incentive to hold inventories on average except in the 2008/07-2013/12 subsample. However, the question is whether the

changes to futures positions taken by the traders had anything to do with the change made to the incentive to hold inventories. Granger causality results reported in table 6 confirm that positions taken by the PRODs group and the money managers influence the futures-spot spread in the full sample, 2008/07-2020/05 and 2013/12-2020/05 subsamples. Interestingly, we observe that both commercial and non-commercial traders too influence the incentive to hold inventories in natural gas in the 2013/12-2020/05 subsample.

<Figure 4 about here>

Alquist & Gervais (2013) argue that rational traders may accumulate inventories, if there is an incentive to store crude oil, i.e. positive futures-spot spread. They deny of any speculative activity in crude oil market in 2007-2008 by pointing out the decrease in oil inventories in the presence of a negative futures-spot spread. Therefore, it is worth examining the size of inventories against the spread in natural gas market especially over the period 2008/07-2013/12, where we find evidence against the change in net long positions of non-commercial traders leading the future-spot spread. Figure 4 shows the 12-month moving average of natural gas inventories together with the futures-spot spread in excess of the 1-month treasury bill rate. The spread remains positive for the most part of 2008/07-2013/12 period implying an upward sloping futures curve. We also observe a substantial increase in natural gas inventory from 2009-2012 alongside this appealing incentive to store oil. This further confirms our earlier evidence on financial speculation. Table 3 and table 4 provide evidence on money managers ability to predict spot and nearby futures price in 2008/07-2020/05 period. Now that we have already examined the 2008/07-2013/12 period, it is worth examining the variation of inventories from 2014-2020. We observe an upward-sloping futures curve during 2014-2017 that coincides with rapid accumulation of

inventories, which is similar to what we saw in 2008/07-2013/12 subsample. Further, we observe a negatively sloped futures curve for the most part of 2017/12-2019/02 alongside a sizable drop in natural gas inventory. This implies that with the reduction of incentive to hold inventories, the inventories decrease while increasing the natural gas quantity available in the physical market. Figure 4 shows that the positions held by money managers are substantially large in comparison to the other two categories of traders in 2014-2017 period. Therefore, there is a higher probability that money managers were in fact driving the price of natural gas.

5. Conclusion

We employ a range of methods used in literature to examine whether the price of natural gas has been affected by the positions taken by speculators. Following our examination of the index of excess speculation and spot prices provide evidence that speculators must have affected the spot prices as we observe price increase and decrease coinciding with increases and decrease of excess speculation. These results are significantly different from the results obtained in the context of crude oil markets and hence highlighted the lack of evidence in favor of speculation.

The correlation analysis between changes to nearby futures prices of natural gas and net long positions held by different trader groups demonstrates unique characteristics of each trader group and there trading patterns according to price changes. We find that commercial traders move against the prices while non-commercial traders move with the price changes. Therefore, the net long positions held by non-commercial traders increases with positive price changes and vice versa. money managers exhibit characteristics of non-commercial traders.

We conduct Granger causality tests to examine the lead-lag relationship between spot prices, nearby futures prices and distant futures prices and positions held by commercial traders and non-commercial traders. Results could only confirm that change in prices lead change in positions by each trader, where we cannot reject our hypothesis that non-commercial traders (speculators) cannot predict prices. However, these findings changed, once these positions are disaggregated further into PRODs, swap dealers and money managers. We find that change in positions held by money managers lead changes in spot and nearby futures prices, in 2008/07-2020/05 and 2013/12-2020/05 subsamples. Our findings therefore exhibit no evidence of speculation in rather bullish 2006/03-2008/06 subsample, which falls in line with their findings in crude oil markets. The threshold analysis keeping 4-week spot price changes as the threshold variable, shows that positions taken by money managers cause spot prices to change below a certain threshold while they exhibit a feedback trading behavior above the same threshold. Our findings confirm that natural gas markets are influenced by speculators during bearish market conditions.

Granger causality between changes to net long positions and excess spot-futures spread implies that financial speculators proxied by non-commercial traders have a significant effect on the incentive to hold natural gas inventories in 2008/07-2013/12 subsample. further, the traders under other category of disaggregated COT reports shows predictability in the direction from change in long positions towards spreads in the full sample and all subsamples except 2006/03-2008/06. Although we do not find any signs of financial speculation in natural gas markets prior to Global Financial Crisis, our results indicate that positions taken by money managers, a sub-category of non-commercial traders may have a significant impact on natural gas prices over the years that followed.

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Table 1: Correlation between the change in contract price and net long positions of Commercial, Non-Commercial, Producers/Merchants/Manufacturers (PRODs), Swap dealer, Money manager and other trader groups. Relevant P-values are reported in square brackets. Bold fonts indicate statistical significance at 5% level.

	Commercial	**Non-Commercial**	**PRODs**	**Swap dealers**	**Money managers**	**Others**
2006/03-2020/05	-0.0480	0.0536	-0.0604	-0.0243	**0.0778**	-0.0663
	[0.1958]	[0.1485]	[0.1033]	[0.5133]	[0.0358]	[0.0738]
2006/03-2008/06	0.0430	-0.0451	-0.1414	0.0650	0.0149	**-0.2609**
	[0.6587]	[0.6431]	[0.1443]	[0.5038]	[0.8782]	[0.0064]
2008/07-2020/05	-0.0168	0.0256	-0.0744	0.0229	**0.0954**	**-0.1343**
	[0.6764]	[0.5239]	[0.0642]	[0.5685]	[0.0174]	[0.0008]
2008/07-2013/12	-0.0003	0.0134	**-0.1286**	0.0903	**0.1708**	**-0.2412**
	[0.9959]	[0.8206]	[0.0292]	[0.1264]	[0.0036]	[0.0000]
2013/12-2020/05	-0.0171	0.0254	-0.0013	-0.0210	0.0507	-0.0630
	[0.7563]	[0.6444]	[0.9814]	[0.7031]	[0.3567]	[0.2518]

Table 2: Correlation between the change in nearby futures contract price and changes to net long positions of Commercial, Non-Commercial, Producers/Merchants/Manufacturers (PRODs), Swap dealer, Money manager and other trader groups. Relevant P-values are reported in square brackets. Bold fonts indicate statistical significance at 5% level

	Commercial	Non-Commercial	PRODs	Swap dealers	Money managers	Others
2006/03-2020/05	**-0.2074**	**0.1790**	**-0.2285**	**-0.1184**	**0.3379**	**-0.3347**
	[0.0000]	[0.0000]	[0.0000]	[0.0014]	[0.0000]	[0.0000]
2006/03-2008/06	**-0.3402**	**0.3247**	**-0.3792**	-0.1413	**0.4878**	**-0.3059**
	[0.0003]	[0.0006]	[0.0001]	[0.1446]	[0.0000]	[0.0013]
2008/07-2020/05	**-0.2187**	**0.1806**	**-0.2223**	**-0.1377**	**0.3804**	**-0.3975**
	[0.0000]	[0.0000]	[0.0000]	[0.0006]	[0.0000]	[0.0000]
2008/07-2013/12	**-0.2845**	**0.2175**	**-0.3354**	**-0.1653**	**0.4321**	**-0.4178**
	[0.0000]	[0.0002]	[0.0000]	[0.0049]	[0.0000]	[0.0000]
2013/12-2020/05	**-0.2061**	**0.1930**	**-0.1734**	**-0.1480**	**0.4096**	**-0.4360**
	[0.0002]	[0.0004]	[0.0015]	[0.0068]	[0.0000]	[0.0000]

Table 3: Reports Granger-causality test results between the change in spot prices and the change in net positions held by commercial traders, non-commercial traders, producers/merchants/manufacturers (PRODs), swap dealers, money managers and other traders. Bold figures indicate statistical significance at 5% level.

Period	Average Weekly spot price change (%)	Hypothesis (Direction)	Trader Group					
			COT(Aggregate)		COT(Disaggregate)			
			Commercial Positions	Non-Commercial positions	PRODs	Swap dealers	Money managers	Others
2006/03-2020/05	*-0.16*	$\Delta NetPositions \rightarrow \Delta Price$	0.335	0.428	**0.005**	0.124	**0.014**	**0.008**
		$\Delta Price \rightarrow \Delta NetPositions$	**0.000**	**0.000**	**0.001**	**0.000**	0.440	0.130
2006/03-2008/06	0.69	$\Delta NetPositions \rightarrow \Delta Price$	0.878	0.557	0.479	0.677	0.703	0.862
		$\Delta Price \rightarrow \Delta NetPositions$	0.713	0.728	0.862	0.804	0.954	0.761
2008/07-2020/05	-0.31	$\Delta NetPositions \rightarrow \Delta Price$	0.288	0.461	**0.005**	0.117	**0.005**	**0.000**
		$\Delta Price \rightarrow \Delta NetPositions$	**0.000**	**0.000**	**0.003**	**0.000**	0.376	0.207
2008/07-2013/12	-0.36	$\Delta NetPositions \rightarrow \Delta Price$	0.519	0.579	0.443	0.712	0.255	0.260
		$\Delta Price \rightarrow \Delta NetPositions$	**0.013**	**0.012**	**0.016**	0.058	0.203	0.496
2013/12-2020/05	-0.27	$\Delta NetPositions \rightarrow \Delta Price$	0.033	0.066	**0.006**	0.053	**0.004**	**0.006**
		$\Delta Price \rightarrow \Delta NetPositions$	**0.003**	**0.004**	**0.036**	**0.010**	0.554	0.305

Table 4: Reports Granger-causality test results between the change in nearby futures prices and the change in net positions held by commercial traders, non-commercial traders, producers/merchants/manufacturers (PRODs), swap dealers, money managers and other traders. Bold figures indicate statistical significance at 5% level.

Period	Hypothesis (Direction)	Trader Group					
		COT(Aggregate)		COT(Aggregate)			
		Commercial Positions	Non-Commercial positions	PRODs	Swap dealers	Money managers	Others
2006/03-2020/05	$\Delta NetPositions \rightarrow \Delta Price$	0.691	0.601	0.982	0.296	0.319	0.581
	$\Delta Price \rightarrow \Delta NetPositions$	**0.000**	**0.000**	**0.002**	**0.000**	0.954	0.219
2006/03-2008/06	$\Delta NetPositions \rightarrow \Delta Price$	0.393	0.153	0.672	0.788	0.793	0.193
	$\Delta Price \rightarrow \Delta NetPositions$	0.286	0.376	0.870	0.160	0.395	**0.027**
2008/07-2020/05	$\Delta NetPositions \rightarrow \Delta Price$	0.705	0.348	0.945	0.670	**0.036**	**0.099**
	$\Delta Price \rightarrow \Delta NetPositions$	**0.000**	**0.000**	**0.000**	**0.000**	0.663	0.551
2008/07-2013/12	$\Delta NetPositions \rightarrow \Delta Price$	0.507	0.232	0.500	0.652	0.758	0.607
	$\Delta Price \rightarrow \Delta NetPositions$	**0.007**	**0.002**	**0.014**	**0.029**	0.882	0.136
2013/12-2020/05	$\Delta NetPositions \rightarrow \Delta Price$	0.179	0.678	0.263	**0.028**	0.188	0.555
	$\Delta Price \rightarrow \Delta NetPositions$	**0.000**	**0.000**	**0.004**	**0.000**	0.085	0.162

Table 5: Reports Granger-causality test results between the change in 12-month futures prices and the change in net positions held by commercial traders, non-commercial traders, producers/merchants/manufacturers (PRODs), swap dealers, money managers and other traders. Bold figures indicate statistical significance at 5% level.

Period	Hypothesis (Direction)	Trader Group					
		COT(Aggregate)		COT(Aggregate)			
		Commercial Positions	Non-Commercial positions	PRODs	Swap dealers	Money managers	Others
2006/03-2020/05	$\Delta NetPositions \rightarrow \Delta Price$	0.790	0.495	0.381	0.753	0.236	0.628
	$\Delta Price \rightarrow \Delta NetPositions$	0.084	0.074	0.076	0.097	0.928	0.480
2006/03-2008/06	$\Delta NetPositions \rightarrow \Delta Price$	0.394	0.122	0.393	0.570	0.617	0.253
	$\Delta Price \rightarrow \Delta NetPositions$	0.744	0.961	0.841	0.710	0.409	0.291
2008/07-2020/05	$\Delta NetPositions \rightarrow \Delta Price$	0.737	0.365	0.724	0.837	0.167	0.392
	$\Delta Price \rightarrow \Delta NetPositions$	**0.000**	**0.000**	**0.010**	**0.001**	0.702	0.768
2008/07-2013/12	$\Delta NetPositions \rightarrow \Delta Price$	0.982	0.598	0.847	0.877	0.985	0.827
	$\Delta Price \rightarrow \Delta NetPositions$	**0.022**	**0.009**	**0.032**	0.073	0.791	0.841
2013/12-2020/05	$\Delta NetPositions \rightarrow \Delta Price$	0.693	0.480	0.542	0.374	0.205	0.432
	$\Delta Price \rightarrow \Delta NetPositions$	**0.001**	**0.003**	0.117	**0.000**	0.554	0.594

Table 6: The table reports results from estimating the threshold regression model (1) with the change in spot price as the dependent variable and the threshold variable defined as the average spot price change over the past 4 weeks ($\overline{R_{t-1:t-4}}$). Bold figures under Granger causality test results indicate statistical significance at 5% level. Newey-West standard errors (Newey & West, 1987) are given in parenthesis while, ***,**,* represent statistical significance at 1%, 5% and 10% levels, respectively.

		Trader Group					
		COT(Aggregate)		**COT(Disaggregate)**			
		Commercial Positions	**Non-Commercial positions**	**PRODs**	**Swap dealers**	**Money managers**	**Others**
Threshold model							
Threshold Value (τ)(%)		-1.97	3.12	2.44	2.44	3.12	3.12
Threshold Percentage		57.07%	69.63%	67.94%	67.94%	69.63%	69.63%
$\beta_{\overline{R_{t-1:t-4}}<\tau}$		0.051	0.141***	-0.201***	-0.137***	0.286***	-0.262***
Standard Error		(0.073)	(0.037)	(0.041)	(0.039)	(0.034)	(0.036)
$\beta_{\overline{R_{t-1:t-4}}\geq\tau}$		-0.187***	-0.106	-0.341***	-0.002	0.032	-0.067
Standard Error		(0.041)	(0.114)	(0.101)	(0.101)	(0.103)	(0.107)
Threshold	**Hypothesis (Direction)**						
$\overline{R_{t-1:t-4}} < \tau$	$\Delta NetPositions \rightarrow \Delta Price$	0.378	0.219	0.632	0.289	**0.006**	**0.041**
	$\Delta Price \rightarrow \Delta NetPositions$	0.356	0.077	**0.018**	**0.013**	0.993	**0.005**
$\overline{R_{t-1:t-4}} \geq \tau$	$\Delta NetPositions \rightarrow \Delta Price$	0.860	0.842	**0.044**	**0.044**	0.861	0.112
	$\Delta Price \rightarrow \Delta NetPositions$	**0.005**	0.211	0.754	0.599	**0.022**	0.206

Table 7: The table reports results from estimating the threshold regression model (1) with the change in nearby futures price as the dependent variable and threshold variable defined as the average spot price change over the past 4 weeks ($\overline{R_{t-1:t-4}}$). Bold figures under Granger causality test results indicate statistical significance at 5% level. Newey-West standard errors (Newey & West, 1987) are given in parenthesis while, ***,**,* represent statistical significance at 1%, 5% and 10% levels, respectively.

		Trader Group					
		COT(Aggregate)		**COT(Disaggregate)**			
		Commercial Positions	**Non-Commercial positions**	**PRODs**	**Swap dealers**	**Money managers**	**Others**
Threshold model							
Threshold Value (τ)(%)		-1.98	-1.99	-3.92	-1.98	0.03	0.10
Threshold Percentage		57.05%	57.01%	52.26%	57.05%	62.00%	62.19%
$\overline{R_{t-1:t-4}} < \tau$		0.017	0.012	-0.087	0.054	0.208***	-0.235***
Standard Error		(0.050)	(0.051)	(0.081)	(0.051)	(0.029)	(0.031)
$\overline{R_{t-1:t-4}} \geq \tau$		-0.166***	0.153***	-0.204***	-0.121***	0.321***	-0.335***
Standard Error		(0.027)	(0.027)	(0.026)	(0.028)	(0.030)	(0.032)
Threshold	**Hypothesis (Direction)**						
$\overline{R_{t-1:t-4}} < \tau$	$\Delta NetPositions \rightarrow \Delta Price$	0.523	0.612	0.453	0.582	0.980	0.572
	$\Delta Price \rightarrow \Delta NetPositions$	0.166	0.111	0.876	**0.015**	0.132	0.850
$\overline{R_{t-1:t-4}} \geq \tau$	$\Delta NetPositions \rightarrow \Delta Price$	0.588	0.186	0.544	**0.048**	0.595	0.903
	$\Delta Price \rightarrow \Delta NetPositions$	**0.000**	**0.001**	**0.005**	**0.000**	0.427	0.808

Table 8: Reports Granger-causality test results between spread (negative basis in excess of 1-month T-bill yield) and the change in net positions held by commercial traders, non-commercial traders, producers/merchants/manufacturers (PRODs), swap dealers, money managers and other traders. Bold figures indicate statistical significance at 5% level.

Period	Average spread	Hypothesis (Direction)	Trader Group					
			COT(Aggregate)		COT(Disaggregate)			
			Commercial Positions	Non-Commercial positions	PRODs	Swap dealers	Money managers	Others
2006/03-2020/05	*-0.0041*	$\Delta NetPositions \rightarrow Spread$	0.177	0.077	**0.016**	0.813	**0.030**	0.088
		$Spread \rightarrow \Delta NetPositions$	**0.032**	0.082	0.748	**0.007**	0.555	0.834
2006/03-2008/06	-0.0143	$\Delta NetPositions \rightarrow Spread$	0.512	0.679	0.217	0.919	0.413	**0.023**
		$Spread \rightarrow \Delta NetPositions$	0.131	0.158	0.079	0.287	0.237	0.403
2008/07-2020/05	-0.0024	$\Delta NetPositions \rightarrow Spread$	0.215	0.132	**0.026**	0.782	**0.042**	0.058
		$Spread \rightarrow \Delta NetPositions$	**0.047**	0.094	0.586	**0.012**	0.519	0.867
2008/07-2013/12	0.0128	$\Delta NetPositions \rightarrow Spread$	0.928	0.588	0.896	0.420	0.356	0.437
		$Spread \rightarrow \Delta NetPositions$	0.909	0.946	0.541	0.847	0.370	0.288
2013/12-2020/05	-0.0155	$\Delta NetPositions \rightarrow Spread$	**0.040**	**0.046**	**0.025**	0.243	**0.020**	0.141
		$Spread \rightarrow \Delta NetPositions$	0.075	0.235	0.833	**0.023**	0.519	0.917

Figure 1: This graph represents the movement of working's T index (Working,1960) vs, the spot price of natural gas.

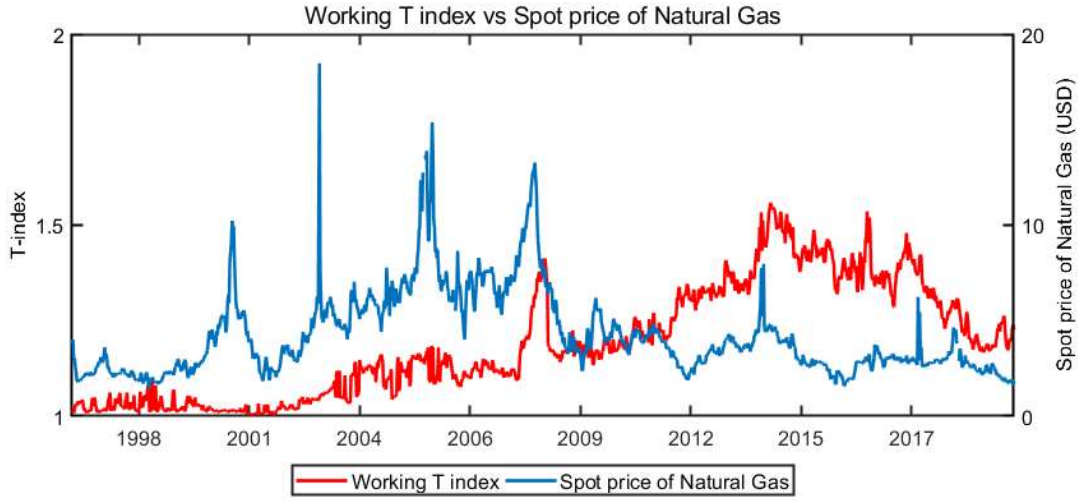

Figure 2: This graph represents the movement of working's T index (Working,1960) vs, the net long positions held by non-commercial investors.

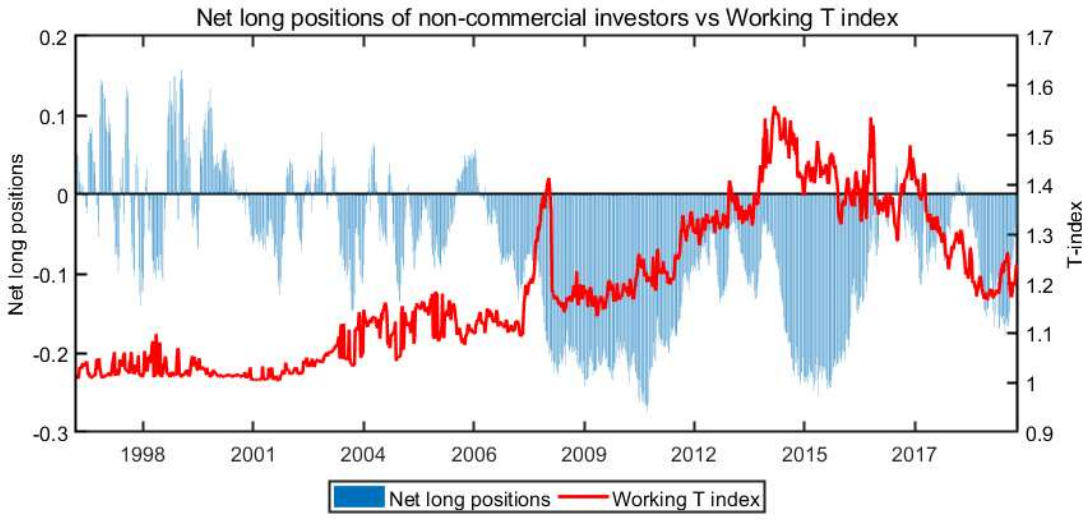

Figure 3: This graph represents the total positions held by natural gas producers/merchants/users (PROD), Swap dealers (SWAP) and Money managers (MM). The definition of each trader category is based on CFTC (2009)

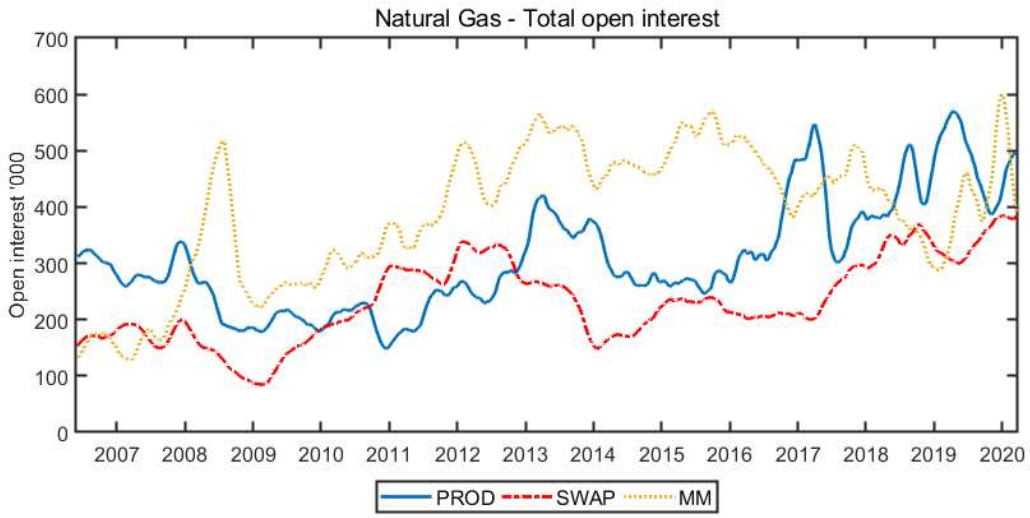

Figure 4: This graph represents the 12-month moving average of natural gas inventories together with the futures-spot spread in excess of the 1-month treasury bill rate.