The effect of speculative trades on basis risk: Evidence from crude oil futures

Abstract

We propose using a new speculative ratio, as defined by trading volume divided by open interest, to gauge speculative activities in the oil futures market. We demonstrate the application of the speculative ratio to examine the relation between basis and speculative activities in the oil futures market before and after Hurricane Katrina. The speculative ratio also works well in the post-2008 oil bubble period, as documented by a significant and negative impact of previous day's speculative activities on current basis in the post Katrina period. The conditional correlations between these two series change their values considerably, not only in the magnitude but also in sign, after Hurricane Karina. The correlation is negative in the pre-Katrina period, yet becomes positive in the post-Katrina period. In all, these results imply an oil futures market that is dominated by uninformed speculators in the post-Katrina period. Our findings carry some practical implications.

Key Words: Speculations, Oil Futures, Basis Risk

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1. Introduction

The crude oil futures contract is one of the most actively traded contracts and garners a significant interest among market participants and policy makers because of its potential impact on the global economy. Many agree that oil price shocks contributed to global recessions and many short-term negative shocks regionally and internationally over the last four decades. Studies have been conducted to determine the causes and the effects of oil price shocks. The sharp increase in oil price from 2003 to 2008 has had devastating effects on various sectors of the global economy. The potential causes of the drastic increases in oil price include increases in demand and stagnation in supply (Hamilton, 2009). The results of the oil price surge are similar to past oil price shocks, which include reduction in consumer spending, especially the purchase of automobiles that contributed to the start of the global recession in 2007. In addition, the oil price surge between 2003 and 2008 also has led to drastic increases in global food prices due to substitution effects and increasing uses of corn for bio-fuel (Headey and Fan, 2008).

Along with the oil price surge between 2003 and 2008, there is also a sharp increase in participation in the oil futures market, including speculative activities. Hedge funds, endowment funds, and even retail investors are all part of the increase in market activities in the oil futures market (Davis, 2007 and 2008; and Kruss, 2011). Whether speculative activities and oil price surges are connected is a debate that is largely unsettled. The oil price surge and subsequent sharp decline in late 2008 have provided sufficient anecdotal evidence to fuel the debate further. Sanders et al (2010) and Kilian (2009), find no strong evidence between speculative trades and oil price movement. The findings in Singleton (2011), Juvenal and Petrella (2012), and Du et al (2011), as well as anecdotal evidences in Master (2008), Sheppard (2011) and Lenzner (2012), however, suggest otherwise. Specifically, Sheppard (2011) and Lenzner (2012) both refer to the internal research notes by investment bank Goldman Sachs (the largest participant in the oil futures market) that reveal the speculative premium in the crude oil futures market to be as high as $21 to $26 a barrel.

The objective of this paper is to use a new proposed speculative ratio (trading volume divided by open interest, to be explained in Section 3) to examine the impact of speculative activities on the effective functioning of the oil futures market as a hedging tool. Specifically, we study the dynamic correlation between the new speculative ratio and oil futures basis in the pre- and post-Hurricane Katrina periods to illustrate the use of the new proposed ratio in capturing speculative activities. Hence, our findings provide an alternative perspective on the relation between speculative activities and oil futures price. Our study carries a practical implication because the United States government and various institutions use oil futures price as the benchmark price for some important charges, such as royalties in oil extraction. How speculative activities may have contributed to the oil futures market stability is an important consideration in the continuation of using oil futures prices as the benchmark. The challenge of the task is to measure the level of speculative activities in the oil futures market. The proposed speculative ratio fills this void.

While the connection between commodity futures price and speculative activities might be of more interest to policy makers, true hedgers who use commodity futures to hedge price risk are subject to basis risk. Thus, true hedgers will be more interested in the impact of speculations on basis volatility. Therefore, we examine the connection between speculative activities (using the speculative ratio as a proxy) and basis risk by utilizing a dynamic conditional correlation-general autoregressive conditional heteroskedasticity (DCC-GARCH) model that can capture the time-varying property of correlation between two variables to show the relation (correlation) between the speculative ratio and oil futures market basis.

As discussed in Section 3.1 later, the speculative ratio (trading volume divided by open interest) is able to capture the speculative elements reflected in trading volume and open interest. Using the daily NYMEX crude oil futures data from 1991 to 2011 and dividend the data from the pre- and post-periods of Hurricane Katrina in 2005, we document that the basis in previous trading day has significant positive effects on current day speculative activities before the Hurricane Katrina event in 2005. Such finding, however, disappears in the post-Katrina era. Instead, a significant negative impact of speculative activities appears in the previous day on the basis in current day. In addition, the correlation of basis volatility and speculative activity volatility is positive and significant in the post-Karina period. That is, the noise from speculative activity is spilling over to the basis. Both findings point to an implication that the oil futures market is increasingly dominated by uninformed speculators in the post-Karina period. We demonstrate that our proposed speculative ratio is able to capture the impact of an increase in speculative activities in the oil futures market. The findings cast doubt on the effectiveness of using oil futures price as a benchmark in setting important government-levied charges in the presence of high level speculative activities.

The remainder of the paper is organized as follow: Section 2 provides a literature review; The methodology is set out in section 3; Data description and analysis are presented in section 4; We conclude the study with a summary and discussion in section 5.

2. Literature Review

One of the key functions of the futures market is to provide price discovery for the spot market. If the market is efficient, the futures price should be an unbiased estimate for the spot price (Gülen, 1998). Any abnormality of this relation, if it exists, would provide arbitrage opportunities and attracts speculators to exploit the inefficiency. The theory of speculation and hedging in commodity futures markets has been studied systematically for many decades. Keynes (1930) argues that speculators are more informed than hedgers, and thus are able to make profits on their speculative trades. Suppose that the futures price is too high (low) in relative to the spot price, a speculator can buy (short) in the spot market and write (buy) equal amount of futures contracts and make a risk free profit. Such trades in both market will push up (down) the spot price and decrease (increase) the futures price, thus lowering (or even eliminating) the abnormality. For this to happen, several assumptions of the efficient market hypothesis must hold, namely no limit to arbitrage and a relatively small transaction cost. Speculators can also utilize unhedged arbitrage trades to eliminate the abnormality in the futures-spot price relationship.

Keynes' assertion that speculators are more informed than hedgers and thus can contribute to a more efficient market has been challenged theoretically and empirically. Grossman (1976), Black (1986), Hart and Kreps (1986), and Stein (1987) show that when traders have diverge information, their trades can destabilize the market. Figlewski

(1981), Lautier and Riva (2008), Reitz and Slopek (2008), and Tokic (2011), show that even hedging activities might increase volatility if there is too much noise introduced by uninformed traders into the market.

Many arguments against regulating speculative activities in the financial market rely on the assertion that speculators play an important role in assuring market efficiency in financial markets (Fama, 1970). This, however, require that most (if not all) speculators are informed traders. There is voluminous literature, both empirical and theoretical, on the roles played by speculators in the futures market. Working (1953a, 1953b) and Johnson (1960) argue against the simplistic assumption of a homogenous speculator, i.e., all speculators are informed traders. If all speculators are informed traders, their trades would lead to a more stable pricing relation between futures and spot prices. Empirical evidence on the effect of speculating activities on price volatility in the futures and spot markets has mixed results (see, for examples, Bessembinder and Seguin, 1992, 1993; Chang, Cheng and Pinegar, 1999; Foster, 1995; Fung and Patterson, 2003; Mazouz and Bowe, 2006).

One of the main challenges is to identify which trades were executed by speculators and which trades were executed by hedgers (Johnson, 1960). Bessembinder and Seguin (1993) suggest that open interest be used as a proxy for market depth, which are trades by hedgers. In contrast, they suggest using trading volume as a proxy for speculative activities. They suggest that by incorporating open interest alone with trading volume data may shed insight into the price effects of market activities generated by informed and uninformed traders. Empirical studies that followed show a significant, positive effect on volatility associated with trading volumes, particularly in the oil futures market (for example, Bessembinder and Seguin, 1993; Forster, 1995; Fung and Patterson, 2001; Grima and Mougoue, 2002; Lautier and Riva, 2008; Najand and Yung, 1991).

If the assumption is that hedgers are less sophisticated than speculators as Keynes (1930), Hawtrey (1940), and Delphine (1978) theorize and that hedgers mainly want to reduce their price risk, then the consequent assumption is that hedgers are more willing to take a futures price that is lower than the prevailing spot price (normal backwardation). In finance literature, the difference between the spot and the futures price is the basis (B_t): $B_t = S_t - F_t$. A normal backwardation implies that the basis is positive. In this scenario, hedgers are either producers or holders of the underlying asset that must be sold in some future dates, thus they are always in a short position. The speculators, on the other hand, are assumed to be armed with more information about price movements in the future and are willing to take on the price risk for a given premium, and they will always be in a long position.

Working (1953a, 1953b), however, suggests that the line between a hedger and speculator might not be clear cut. A speculator who sees opportunities for arbitrage between the spot market and the futures market might hold inventories of the underlying asset and go short on the futures position. Johnson (1960) suggests that expectation of relative and absolute price change in the future can affect the positions of the speculators. In other words, a speculator might be more interested in the variability of the basis (basis risk) than just the futures price variability alone. That is, using open interest and trading volume as proxies for hedging and speculative activities has weaknesses.

There are equally voluminous studies confined to the oil futures market. To test the hypothesis of an asymmetric relationship between trading volume and oil futures price change, Karkof (1987), Forster (1995) use GARCH and general methods of moments (GMM) models and find that both current and lag trading volumes can explain the price variability in crude oil futures. The results of these studies suggest that oil futures price and volatility may be driven by the same factors, presumably information. Though the results also provide empirical support for the Mixture of Distribution Hypothesis (MDH), suggested by Clark (1973) and Harris (1987), the contribution of lag trading volume to oil futures price volatility suggests a certain degree of market inefficiency in the oil futures market. However, Mossa and Silvapulle (2000) present empirical evidence that counters the finding by Forster (1995). Mougoue and Aggarwal (2011) find that the lead-lag relationship between trading volume and volatility in the exchange rate market does not support the MDH.

Testing the hypothesis that the futures price is an unbiased predictor of the spot price and the efficiency of the oil futures market, Mossa and Al-Loughani (1994) find that the West Texas Intermediate (WTI) posted price is neither an unbiased nor efficient predictor of spot price. Gülen (1998) uses monthly data from 1982:1 to 1995:10 and finds that the oil futures price is a more efficient predictor of spot price than the WTI posted price that was commonly used prior to development of the crude oil futures market. These two studies, while providing support for the oil futures price as a more efficient predictor of oil spot price, did not investigate the effects of trading activities on such property. Since oil futures price replaced WTI posted price as the benchmark price, how the speculative activities in the oil futures market affect the role of oil futures price as an efficient predictor of spot oil price is unknown.

The sharp increases in the oil price from 2004 to 2008, and subsequent sharp decline in the oil price in late 2008, sparked a renewed interest in research in the oil futures market. Kilian (2009) and Kilian and Murphy (2011) find little evidence to support a correlation between speculative activities and price increases in the oil futures market. Their findings suggest that speculative activities might actually be price-stabilizing. However, their results might be a product of utilizing less efficient econometric models. Larsson and Nossman (2011) and Arouri et al (2012) find that non-stochastic volatility models might not be able to capture the pricing dynamics in oil markets. Using more efficient models, Singleton (2011), Du et al (2011), Juvenal and Petrella (2012) find that speculative activities do play a role in driving up oil price. Hence, it remains a research question whether speculative activities in the oil futures markets are price-stabilizing.

The debate of the role of speculators in influencing the oil price will likely not be settled soon. This paper complements the current literature by providing evidence with a new speculative activities measure and applies it to study the basis risk in the oil futures market. Next discussed are the advantages of using the speculative ratio to gauge the intensity of speculative activities in the market and the research methods of the paper.

3. Speculative Ratio and Methods

3.1 Speculative Ratio

The existing literature primarily examines the separate impacts of speculation (using trading volume) and hedging (using open interest) activities, and the results generally conclude that speculative activities, at times, contribute to higher futures price volatility. However, recent studies, such as Lautier and Riva (2008), Reitz and Slopek

(2008) and Tokic (2011), show hedging activities can also contribute to higher futures market volatility. It is because if a hedger sees a potential positive price movement in the cash market, he is very likely to obtain more long positions in the futures market to better cover his underlying position (an increase the percentage of position covered). This is very common; especially because many hedgers do not perfectly hedge their initial long positions. By following the literature that uses open interest as a proxy for hedging and trading volume as a proxy for speculative activities, it is not possible to isolate the speculative elements from normal trading activities. Therefore, this paper utilizes a new measure that incorporates both trading volume and open interest and relates them to basis variability.

We define a speculative ratio of a trading day as the trading volume divided by the open interest on that day. Intuitively, a lower ratio between trading volume and open interest implies lower speculative activities relative to hedging activities or vice versa. That is, the proposed speculative ratio is a relative measure of the extent of speculative activities relative to hedging activities. The following example illustrates how the speculative ratio can capture speculative activities relative to hedging activities.

Consider a typical trading day in which there are 10,000 contracts in the open interest and a trading volume of 7,000 contracts on the same day. Of the 7,000 contracts in trading volume, hedgers execute 5,000 contracts while speculators account for 2,000 contracts on the day. The speculative ratio, according to the definition of trading volume divided by open interest, is 0.7. In this example, the hedging portion of the speculative ratio is 0.5 while the speculative portion is 0.2. Let's assume that the 0.5 and 0.2 portions of hedging and speculative activities in the speculative ratio remain the same in a normal trading day. Since there is no signature associated with any particular trade, observers do not know the correct percentage of the actual hedging and speculative activities in the futures market during any given trading day.

In the second day, the open interest continues to be 10,000 contracts, the trading volume rises to 12,000 contracts. The speculative ratio becomes 1.2. Without knowing which trades were executed by hedgers and which trades were executed by speculators, this example only estimates the trades by hedgers to be the typical ratio of 0.5, or 5,000 contracts (the same as the first day). This is a reasonable assumption of using the 0.5 ratio because hedgers usually have a price they want to execute the trades in mind and are willing to wait for the right price. Thus, the speculative portion of the speculative ratio is now 0.7, i.e., 1.2 minus 0.5, which presents a substantial increase from 0.2 in the previous day in speculative activities. For speculators, their trades are based on perceived price movements, and it is not in their best interest to hold inventory overnight unless the futures price is not good. If they do have some inventory, say 2,000 contracts of the 7,000 contracts traded today, these 2,000 contracts will likely be liquidated on the second trading day.

Since open interest represents the total contracts outstanding, let us assume that part of the 12,000 contracts traded (trading volume) in second day were newly established positions by speculators. Therefore, the open interest for the second trading day will consist of both true hedgers' and speculators' open positions. By the nature of speculators, they want to trade away the contracts carried over from the first trading day because they do not want to hold the inventory for another day and exposure themselves to price risk in the following day[1]. Let us further assume that speculators were successful in executing those contracts. Then, the trading volume of the second day would increase by 2,000 contracts regardless of what the normal activity would be. Therefore, using open interest and trading volume to represent hedging and speculative activities separately (as suggested is the literature) may not be helpful.

We can see the logic behind this by assuming that the trading activities on the third trading day are normal. On the third trading day, the open interest is 12,000 contracts and let us assumes that 2,000 contracts were newly established position from the second day. With a normal speculative ratio of 0.7, 6,000 contracts would be traded by the true hedgers and 2,400 contracts would be traded by speculators. With the addition of the 2,000 contracts carried over by the speculators in the second trading day, it would increase trading volume to 104,000 contracts during the third trading day. The speculative ratio under this scenario is 0.867(104,000/120,000). One can clearly see that the increase in trading volume as a result of speculators not being able to close out their positions from the second day is captured by the ratio in the third trading day. In fact, any speculative elements in open interest would increase the speculative ratio. The higher the carried over trades, the higher the impact it would have on the speculative ratio.

[1] Informed and uninformed speculators' current day activities could have different impact on the next trading day speculative activities. If informed speculators believe that the current price is "irrational", rather than closing out at a lower price to take an immediate loss, they can take delivery of the underlying asset and sit on the long position. During the sharp declines of the oil futures price in late 2008, combined with low tanker costs due to global recession, some well funded hedge funds were buying oil futures and taking delivery of the crude oil. They then stored the crude oil in tankers and sold them (or write futures contracts) when the price went up later. Such actions are considered as possible market manipulations. Some of these cases are under investigation by the CFTC, and civil suits against hedge funds have been filed (Kruss, 2011; Davis, 2008). Whether these cases are against the law or not, the actions of hedge funds, as informed speculators, would reduce trading volume.

One can notice that the proposed speculative ratio is not an absolute measure of hedging and speculative activities in the futures market. Rather, it is a relative measure. A high speculative ratio means high speculative activities relative to hedging activities. To demonstrate the application of the speculative ratio, we use a volatility model to examine the dynamic correlation between the speculative ratio and oil futures price changes in the pre- and post-Hurricane Katrina periods in 2005. The choice of the Hurricane Katrina periods is motivated by the anecdotal evidence (as shown in Table 1 later) that the oil futures price volatility displayed a significant increase in the post-Katrina period and several recent studies showing an increase in speculative activities in the post-Katrina period (Sheppard, 2011 and Lenzner, 2012)

3.2 Volatility Modeling

Nonlinear dynamics in crude oil futures price volatility and unidirectional effect from volume to price movement/volatility are well documented (for examples, Forster, 1995; Moosa and Silvapulle, 2000; Aoruri et al, 2012; Larsson and Nossman, 2011; Juvenal and Petrella, 2012). As we are interested in determining if the speculative ratio of trading volume over open interest of oil futures contracts relates to the volatility of the basis, we investigate the conditional correlation of this ratio and the basis, as well as the nonlinearity in their conditional volatilities.

Let $Basis_t$ be the basis and $Ratio_t$ be the speculative ratio at time *t*. The dynamics of these two variables are modeled as following:

$$Ratio_t = \alpha_0 + \alpha_1 Ratio_{t-1} + \alpha_2 Basis_{t-1} + u_{1t}, \quad (1)$$

$$Basis_t = \beta_0 + \beta_1 Ratio_{t-1} + \beta_2 Basis_{t-1} + u_{2t}, \quad (2)$$

where (u_{1t}) and (u_{2t}) ~ DCC-GARCH(1,1) of Engle (2002). Particularly, we have

$$u_{1t} = \varepsilon_{1t}\sqrt{h_{1t}} \text{with} h_{1t} = \alpha_{oh} + \alpha_{1h}u_{1t-1}^2 + \alpha_{2h}h_{1t-1}, \quad (3)$$

$$u_{2t} = \varepsilon_{2t}\sqrt{h_{2t}} \text{with} h_{2t} = \beta_{oh} + \beta_{1h}u_{2t-1}^2 + \beta_{2h}h_{2t-1}. \quad (4)$$

Thus, the conditional correlation of the speculative ratio and the basis can be expressed as

$$\rho_{12t} = \rho_{21t} = \frac{E_{t-1}(u_{1t}u_{2t})}{\sqrt{E_{t-1}u_{1t}^2 E_{t-1}u_{2t}^2}}. \quad (5)$$

Note that the DCC model is chosen over the CCC model (Constant Conditional Correlation) of Bollerslev (1990) because the DCC model is a generalization of the second one. This means that if the estimated correlation is not statistically time varying, the result is $\rho_{12t} = \rho_{21t} = \rho_{12}$ for all t, hence obtaining the constant correlation. Hereinafter, we denote $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ as the vector of standardized innovations, and $Q_t = E_{t-1}(\varepsilon_t\varepsilon'_t)$ as the conditional covariance matrix of (ε_t) and $S = E(\varepsilon_t\varepsilon'_t)$ as the unconditional covariance matrix. The dynamic of Q_t can be expressed, according to the DCC model of Engle (2002), in the following specification

$$Q_t = S \circ (11' - A - B) + A \circ (\varepsilon_{t-1}\varepsilon'_{t-1}) + B \circ Q_{t-1} \quad (6)$$

where A = $\begin{pmatrix} a_{11} a_{12} \\ a_{21} a_{22} \end{pmatrix}$, B = $\begin{pmatrix} b_{11} b_{12} \\ b_{21} b_{22} \end{pmatrix}$ are symmetric 2x2 coefficient matrices, and *1* is a vector of ones, and $\circ$ is the Hadamard product of two compatible matrices, which is the element-by-element multiplication. To ensure the positive definiteness of the covariance matrix Q_t, Ding and Engle (2001) show that at least one of the three matrices A, B, $(11' - A - B)$ should be positive definite, and the rest should be positive semi-definite.

If we let $q_{11,t}$, $q_{12,t}$, $q_{22,t}$ be the elements of Q_t, i.e. $Q_t = \begin{pmatrix} q_{11,t} & q_{12,t} \\ q_{12,t} & q_{22,t} \end{pmatrix}$ then the conditional correlation of the volatility measure and the ratio will be

$$\rho_{12,t} = \frac{q_{12,t}}{\sqrt{q_{11,t} q_{22,t}}}. \qquad (7)$$

The conditional correlation set out in equation (7) is a measure of contemporary information flow between the speculative ratio and basis. If $\rho_{12,t}$ is larger (smaller) in absolute value, there is more (less) information flowing between the basis and speculative trades on the same trading day. This correlation can be either negative or positive. If the conditional correlation is negative, a shock in the basis will attenuate the speculative ratio and vice versa. In this case, traders can distill information from noises, thereby stabilizing prices and reducing basis risk. In other words, there are more informed traders in the market as speculative trades are lowering basis risk.

On the other hand, if the conditional correlation is positive, shocks in the basis and the speculative ratio will amplify each other's effect, which makes the distillation of useful information from noises much more difficult. In this case, a smaller value of the conditional correlation implies a lesser extent to which speculative activities and basis risks are connected, presumably due to relatively greater numbers of uninformed traders' participating in the market with the informed traders. Therefore, if the proposed speculative ratio is able to capture the contemporary interaction between speculative activities and the basis risk, one should be able to observe either a decrease in positive values or an increase from negative to positive values of the conditional correlation between the speculative ratio and the basis in a period of high oil futures price volatility, such as the post-Katrina period.

4. Data and Empirical Analysis

4.1 Data and descriptive statistics

We obtain the daily NYMEX crude oil futures price data that spans from September 1991 to September of 2011. It is the daily settlement price of the most actively traded contracts. Following common practice, we rollover to the next nearby contract prior to the delivery month. The trading volume and open interest data correspond to the one-month maturity. There are a total of 5,024 daily observations.

Based on the anecdotal evidence and the fact that Hurricane Katrina is the most memorable major potential supply shock event in recent history, we choose Hurricane Katrina in 2005 as the dividing point to split the sample into the pre and post Karina periods to demonstrate the application of the proposed speculative ratio. If informed speculators and hedgers channel their information through open interest, the speculative ratio should not display a spike after an external shock such as Hurricane Katrina and vice versa.

While the increases in speculative elements in the oil futures market have started since 2004, we contend that the major event is Hurricane Katrina. Figure 1 plots the speculative ratio and basis and their corresponding kernel densities. We observe that there were only two days in which the speculative ratio is higher than 1 during a span of more than 14 years of data prior to Hurricane Katrina in 2005. During the buildup of Hurricane Katrina, there were spikes in trading volumes. But there were also sharp increases in open interest during this period as well. As a result, almost all of the speculative ratios were below 1 before the time of Hurricane Katrina. In contrast, there were more than 50 days in which the speculative ratio is higher than 1 since Hurricane Katrina. In fact, the majority of the trading days in which the speculative ratio is higher than 1 were around the run up of the oil price above $146 dollar a barrel on July 14th, 2008, and the subsequent collapse of the oil price to $38 dollar on December 24th, 2008. Thus, using the pre- and post-Katrina periods is a good avenue to demonstrate the application of speculative ratio on gauging the speculative activities in oil futures market. The spike of the oil price in the post-Katrina period is in line with the increase in the speculative ratio.

Table 1 presents the descriptive statistics. Columns 1, 2, and 3 display the statistics for the full sample of the pre and post-Katrina periods respectively. When comparing the pre- and post-Katrina periods, we notice that there is a vast difference between the speculative ratio before and after Hurricane Katrina. The mean values of speculative ratio are 0.4433 and 0.6069 in the pre- and post-Katrina period. Hence, the mean speculative ratio is significantly higher in the post-Katrina period. In addition, the maximum and minimum values are both higher after Hurricane Katrina. Overall, there is a significant change in the profile of the speculative ratio after Hurricane Katrina. Thus, the proposed speculative ratio appears to capture some changes in the oil futures market activities.

In terms of the basis, the descriptive statistics for pre- (column 2) and post-Katrina (column 3) are vastly different. In the pre-Katrina period, the mean value of the basis is relatively small at 0.1719, which is a small positive value (normal backwardation). This suggests that the oil futures market in the pre-Katrina period is similar to the market Keynes has in mind: a market dominated by informed speculators. In the post-Katrina period, the mean basis is much larger at -0.9190 and shows a negative value (contango). In other words, the futures price in the post-Katrina period is consistently higher than the spot price. One possible explanation for such a change in the relationship between futures price and the spot price is that there are much higher demands for futures contracts. The increases in demand can come from two sources: true hedgers and speculators.

There are anecdotal evidences of increases in demand from the airline industry since the oil price started to rise in late 2004. The increases in demand from the airline industry alone cannot explain the sharp increases in trading volumes, however. That leaves increases in speculative trades as the main reason for increases in demand for oil futures. If informed traders dominate the market, one should see a normal backwardation. Otherwise, a contango would suggest that the market is dominated by uninformed speculators. The kernel density graphs presented in Figure 1 also show that the distributions of both series are significantly different in the two sub-periods. Therefore, our graphical evidence and descriptive statistics suggest that, after Katrina, the oil futures market has had a larger participation from uninformed speculators.

4.2 Conditional Correlation of Speculative Ratio and Basis

Before we fit the data into our model, we performed an autoregressive conditional heterskedasticity (ARCH) test. The result is reported in Panel A in Table 2. All data samples show the ARCH effect. We also conduct the ARCH test for Open Interest (OI) and Volume (Vol) separately, rather than as a ratio. The result (available by request) shows that OI and Vol do not fit in the GARCH model when used separately. In other words, it is not appropriate to estimate their conditional correlation in this framework. Moreover, current value of the basis is not significantly affected by the lag value of OI or Vol. Therefore, OI and Vol, when used separately, do not provide useful information to traders. When these two pieces of information are used together, as a ratio, both contemporary and lag values provide useful information to traders, according to our model.

The empirical result for Equation (1) is reported in Panel B of Table 2. During the period of pre-Katrina, the previous trading day's basis had a significantly positive impact, α_2, on the current day's speculative ratio. In other words, an increase in the previous trading day's basis causes an increase in the next day's speculative trades, and vice versa. This result is consistent with the informed speculative trader hypothesis. When a divergence between futures and spot price occurs, informed traders take advantage of this arbitrage opportunity and force the futures-spot price relationship to converge. When the futures price converges towards the spot price, the opportunity for arbitrage reduces, thus resulting in a reduction in speculative trades. In the post-Katrina period, α_2 is not statistically significant. This means that speculative traders no longer base their trades on the previous day's market condition as strongly as they did during the pre-Katrina period.

Equation (2) measures the relationship between the current basis and the previous day's basis and speculative activities. Since most speculators are not willing to hold inventories, the previous day's speculative activities, if excessive, should have some measurable impact on the current day's basis. The impacts should depend on whether the speculators are informed or uninformed. In the case of informed speculators as theorized by Keynes (1930), their presence should stabilize the futures price, and thus the basis should stabilize as well. In fact, under Keynes's assertion, the basis should increase if the speculators are informed. If the speculative trades are executed by uninformed traders, the impact should be negative because the inventories that are being carried over would be executed at less optimal prices. Tokic (2011) demonstrates that, in a speculative bubble, the uninformed trader's action can force informed traders into pushing the futures price to a level far beyond the true fundamental. This would cause the basis to decline and even persist at the negative level.

The results are presented in Panel C of Table 2. The value of β_1 in the pre-Katrina period is -0.0099, which is not significant. It indicates that there is no effect on the basis from previous day's speculative ratio in the pre-Katrina period. This result is consistent with our hypothesis that speculators in the pre-Katrina period are more informed. In the post-Katrina period (Table 2 Panel C column (3)), the value of β_1 is negative (-0.1684) and significant. This result points to more uninformed trades in the speculative activities in the post-Katrina period, as hypothesized in Tokic (2011). The speculative ratio, as expected, is able to explain the change in the basis in the oil futures market.

Table 3 shows the conditional correlation between the speculative ratio and the basis. This represents the current relation (or contemporary information flow) between the shocks in the speculative ratio and the shocks in the basis. Panel A of Table 3 reports the results based on the DDC-GARCH (1,1) models with the summary statistics of the estimated time-varying conditional correlation ρ_{12t}. Note that on Panel A column (1), the standard errors of the estimates of coefficient matrices A and B are large. It is not surprising since we use a miss-specified model by fitting the entire data sample into the DCC-GARCH. In fact, it is very likely that there are structural breaks (regime shifts) in the oil futures prices dynamics with Hurricane Katrina as a hypothetical break-point. Thus, we divide the sample into two sub-periods, pre- and post-Katrina, and implement the analysis for each period. The results are reported in columns (2) and (3) of Table 3. As all elements of the coefficient matrices A and B of the correlation are not significantly different from zero. Hence, the conditional correlation of the speculative ratio and the basis in each period is not statistically time-varying. Therefore, we estimate the constant conditional correlation, i.e., $\rho_{12t} = \rho_{12}$ for all t and show the results in Panel B. During the pre-Katrina period, these shocks have a negative correlation (-0.0226), thereby dampening each other's effect. In contrast, during the post-Katrina period, they have a positive correlation (0.0421) that magnifies each other's fluctuations in the market. In other words, after taking into account the level effects of these variables on each other's current value, an increase in the volatility of basis causes a reduction in volatility of the speculative ratio in the pre-Katrina period. This result is consistent with the informed speculative trader hypothesis since speculators will increase their trade if basis volatility increases. On the other hand, in the post-Katrina period, the value is significantly positive and greater in absolute value. This means that volatilities in these two series are feeding each other. It is a sign that the speculative trades are noisier in the post-Katrina period.

For robustness, we provide additional empirical results of the relationship between the speculative ratio and the basis with a second break point began on July 1, 2008, which is the early start of the financial crisis and the oil price bubble (peak of oil price). The findings are in the Appendices 1 and 2. The presentation formats in Panels A and B in both appendices are the same as in Tables 2 and 3. The patterns of the coefficients in the post-2008 bubble period (in Appendix 2 Panel B column (2)) are similar to those of the post-Katrina period in Table 2. In addition, the constant conditional correlation (ρ_{12}) in

Appendix 2 Panel B is 0.0502, which is similar to the 0.0421 in Table 3 Panel B. Again, the proposed speculative ratio is able to capture the change in the basis after the oil bubble.

4.3 Discussion

The results in Table 1 show that oil futures basis volatility increases significantly after Hurricane Katrina. The graphical evidence cannot tell if speculative activities in the futures market play a role in the surge of basis volatility. We use the new speculative ratio to calculate a dynamic correlation between the new speculative ratio and oil futures basis in the pre- and post-Katrina periods to illustrate the use of the new proposed ratio in capturing the speculative activities.

Our findings imply that when there is a shock (e.g., a physical shock such as Hurricane Katrina), the oil futures basis volatility increases. Given that we are able to tell if the basis volatility is due to increases in speculative activities (using the proposed speculative ratio to gauge the level of speculative activities), we cast doubt on the usefulness of using the oil futures price as a benchmark price for some important charges, such as royalties in oil extraction. In this case, an alternative oil price benchmark receiving less impact from speculative activities needs to be developed.

As for hedgers, the results show that they can gauge the level of speculative activities in the oil futures market by simply using the speculative ratio. The relative level of speculative activities can help them to infer the effect of excessive speculations would have on their risk exposure. For instance, if hedgers find a high level of speculative activities by observing a high speculative ratio, they may want to increase the percentage of their positions covered, or consider cover their basis risk exposure.

5. Conclusion

In this study, we propose using a new speculative ratio, as defined by trading volume divided by open interest, to gauge speculative activities in the oil futures market. We demonstrate the application of the speculative ratio to examine the relation between the basis and speculative activities in the oil futures market before and after Hurricane Katrina. The speculative ratio also works well in the post-2008 oil bubble period.

The anecdotal evidence and descriptive statistics show an obvious increase in oil futures price volatility, basis (normal backwardation during pre-Katrina period and contango in post-Katrina period), and speculative activities during the post-Katrina period in 2005. The important finding is that previous trading day's basis has significant positive effects on the current day speculative activities before Hurricane Katrina. The effect of the previous trading day's basis on current day's speculative activities in the post Katrina period is reversed, though statistically insignificant. We also find a significant, negative impact of the previous day's speculative activities on the current basis in the post-Katrina period. The conditional correlations between these two series change their values considerably, not only in magnitude but also in sign, after Hurricane Katrina. The correlation is negative in the pre-Katrina period, yet it becomes positive in the post-Katrina period. In all, these results imply an oil futures market that is dominated by uninformed speculators in the post-Katrina period.

Our paper contributes to existing literature in two ways. First, we demonstrate the use of a new proposed speculative ratio to gauge speculative activities in the futures market. Second, we investigate the effect of speculative activities on the basis, which contains both futures and spot price information. Since the risk that hedgers face is the basis risk, the results of this paper are useful for hedgers in that they can infer what the effect of excessive speculations could have on their risk exposures.

There has been a growing list of evidences of manipulations in the oil futures market. Since the CFTC's civil suit against manipulators in West Texas Intermediate market (the WTI, which is the designed contract market for NYMEX futures), as reported by Kruss (2011), President Obama issued a statement and ordered the Justice Department to increase surveillance and enforcement effort against possible manipulations in oil markets, and charge the CFTC to make trading data on oil futures more easily accessible to analysts so that we can have a better understanding of the trading trends in oil futures market (The White House, 2012). More recently, a group of NYMEX traders filed a lawsuit against BP, Statoil, Royal Dutch Shell, Morgan Stanley and Vitol Group (the same hedge fund that Masters (2008) suggests to have manipulated the spot and futures markets) for manipulating the Brent Crude market (Van Voris et al, 2013). The suit alleged that Date Brent spot price was artificially driven up or down by the defendants in order to make profit from either spot, swap or futures market. Spoof orders (orders that were made in order to move the market and then canceled later) were placed with the price that benefited the defendants. Since Brent and Light Sweet Crude are highly correlated, the manipulation in the Brent market will spill significant noise (in this case, false price information) to the WTI markets, thus making speculative trades less informative. Our results might have captured the effects of these possible manipulations.

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Table 1: Descriptive Statistics

Table 1 presents the descriptive statistics of the speculative ratio and basis.

	Whole sample (1)		Pre-Katrina (2)		Post-Katrina (3)	
	Ratio	Basis	Ratio	Basis	Ratio	Basis
Min	0.0168	-12.0700	0.0168	-4.5600	0.0621	-12.0700
Max	2.3380	11.5500	1.2861	4.9400	2.3380	11.5500
1st quartile	0.3574	-0.5100	0.3259	-0.1800	0.4513	-1.3800
Median	0.4706	-0.0900	0.4333	0.0500	0.5664	-0.7200
3rd quartile	0.5998	0.3200	0.5492	0.4400	0.7230	-0.3800
Mean	0.4931	-0.1598	0.4433	0.1719	0.6069	-0.9189
Std	0.1984	1.0643	0.1620	0.6887	0.2254	1.3460
Skewness	1.1156	-1.4228	0.4787	0.7922	1.2598	-1.1625
Kurtosis	6.4734	17.9400	3.3409	9.5129	6.6152	16.4820
Jarque-Bera	3563.2	48375.0	150.2	6534.0	1231.5	11878.0
ADF t-test	-37.3	-20.5	-35.7	-19.4	-17.1	-10.4

Figure 1. The Speculative Ratio and the Basis with their Estimated Kernel Densities (whole sample and subsamples)

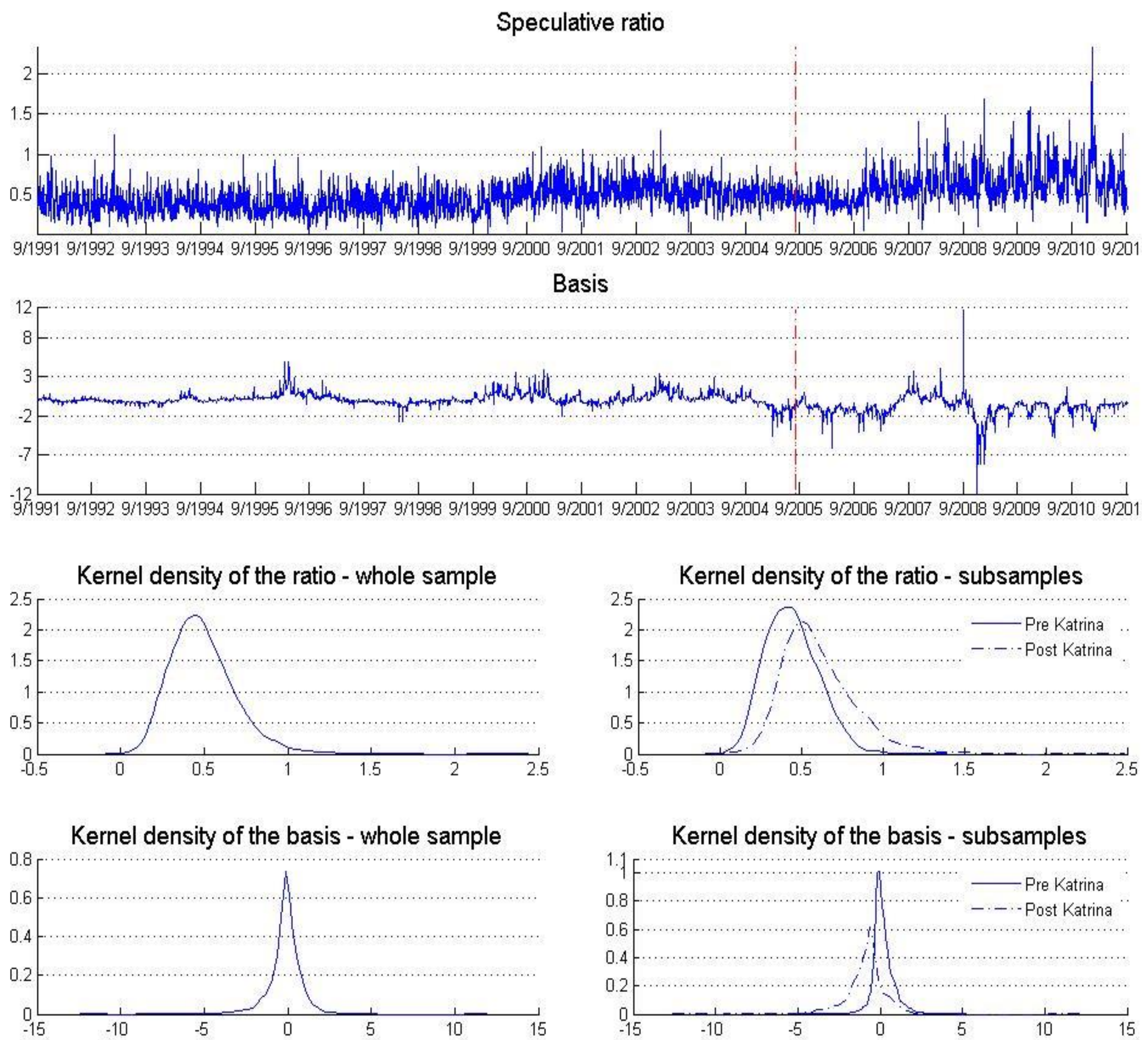

Table 2: Estimated Coefficients of the Conditional Means and Conditional Variances of the Speculative Ratio and the Basis

Table 2 reports the results of an ARCH test and the estimated coefficients on the ratio and basis series in Equations (1) to (4). Standard errors are in the parentheses. "*" indicates not significant at 5% level.

	Whole sample (1)		Pre-Katrina (2)		Post-Katrina (3)	
Panel A: GARCH(1,1) test						
Ratio	276.69		158.36		92.78	
Basis	888.78		243.66		256.06	
Panel B: Ratio						
Conditional mean						
α_0	0.1753	(0.0062)	0.1972	(0.0075)	0.1874	(0.0145)
α_1	0.6280	(0.0116)	0.5502	(0.0155)	0.6690	(0.0212)
α_2	-0.0068	(0.0020)	0.0082	(0.0034)	-0.0052*	(0.0030)
Conditional variance						
α_{0h}	0.0018	(0.0002)	0.0034	(0.0010)	0.0119	(0.0023)
α_{1h}	0.0779	(0.0071)	0.0612	(0.0126)	0.1772	(0.0256)
α_{2h}	0.8391	(0.0141)	0.7539	(0.0603)	0.3928	(0.1000)
Panel C: Basis						
Conditional mean						
β_0	0.0317	(0.0056)	0.0037*	(0.0053)	0.0459	(0.0180)
β_1	-0.1000	(0.0096)	-0.0099*	(0.0103)	-0.1684	(0.0267)
β_2	0.9308	(0.0018)	0.8889	(0.0029)	0.9338	(0.0050)
Conditional variance						
β_{0h}	0.0154	(0.0002)	0.0074	(0.0002)	0.0413	(0.0013)
β_{1h}	0.6692	(0.0117)	0.5821	(0.0150)	0.7916	(0.0265)
β_{2h}	0.3308	(0.0054)	0.4179	(0.0065)	0.2085	(0.0138)

Table 3: Estimated Conditional Correlation of the Speculative Ratio and the Basis

Table 3 reports in Equations (6) and (7) regarding the conditional correlation between the speculative ratio and the basis. The value in parentheses in the first panel is the standard error."*" indicates not significant at 5% level.

	Whole sample (1)		Pre-Katrina (2)		Post-Katrina (3)	
Panel A: DCC-GARCH(1,1)						
Estimated elements of the coefficient matrices A and B						
a_{11}	0.0026*	(1.26E+02)	0.0000*	(1.5490)	0.0120*	(2.2369)
b_{11}	0.9972*	(2.18E+02)	0.0000*	(0.0004)	0.1671*	(1.4601)
a_{22}	0.3159*	(1.27E+03)	0.0000*	(13.5470)	0.2848*	(3.8566)
b_{22}	0.2092*	(2.46E+03)	0.0000*	(10.2310)	0.5928*	(3.9057)
a_{12}	0.0287*	(3.48E+02)	0.0000*	(28.0230)	0.0360*	(0.0491)
b_{12}	-0.0010*	(3.04E+02)	-0.0008*	(9.5510)	-0.0010*	(7.0026)
Descriptive statistics of the estimated time varying conditional correlations $\rho_{12,t}$						
Min	-0.2660		-0.0252		-0.2416	
Max	0.2105		-0.0252		0.2092	
Median	-0.0142		-0.0252		0.0592	
Mean	-0.0133		-0.0252		0.0556	
Std	0.0234		1.25E-15		0.0361	
Panel B: CCC-GARCH(1,1)						
Estimated constant conditional correlations ρ_{12}						
	-0.0106	(1.85E-07)	-0.0226	(1.56E-08)	0.0421	(9.06E-08)

Appendix 1. Estimated Coefficients of the Conditional Mean and Conditional Covariance of the Speculative Ratio and the Basis in Post-2008 Bubble Period

This appendix provides empirical results of the relationship between the speculative ratio and the basis in the 2008 oil bubble. The break point is on July 1, 2008 which is the early start of the oil bubble. Standard errors are in the parentheses. "*" indicates not significant at 5% level.

	Pre-Katrina (1)		Post 2008-bubble period (2)	
Panel A: Ratio				
Conditional mean				
α_0	0.1972	(0.0075)	0.2370	(0.0208)
α_1	0.5502	(0.0155)	0.6149	(0.0308)
α_2	0.0082	(0.0034)	-0.0132	(0.0053)
Conditional variance				
α_{0h}	0.0034	(0.0010)	0.0203	(0.0043)
α_{1h}	0.0612	(0.0126)	0.2219*	(0.1350)
α_{2h}	0.7539	(0.0603)	0.1888	(0.0488)
Panel B: Basis				
Conditional mean				
β_0	0.0037*	(0.0053)	0.0749	(0.0300)
β_1	-0.0099*	(0.0103)	-0.2860	(0.0496)
β_2	0.8889	(0.0029)	0.8872	(0.0136)
Conditional variance				
β_{0h}	0.0074	(0.0002)	0.0591	(0.0065)
β_{1h}	0.5821	(0.0150)	0.1246	(0.0387)
β_{2h}	0.4179	(0.0065)	0.8754	(0.0651)

Appendix 2. Estimated Conditional Correlation of the Speculative Ratio and the Basis

	Pre-Katrina (1)		Post 2008-bubble (2)	
Panel A: DCC-GARCH(1,1)				
Estimated elements of the coefficient matrices				
a_{11}	0.0000*	(1.5490)	0.0958*	(1.1987)
b_{11}	0.0000*	(0.0004)	0.8961*	(1.2042)
a_{22}	0.0000*	(13.547)	0.1232*	(4.9537)
b_{22}	0.0000*	(10.231)	0.4216*	(6.3749)
a_{12}	0.0000*	(28.023)	0.0339*	(1.0131)
b_{12}	-0.0008*	(9.5510)	0.0000*	(12.211)
Descriptive statistics of the estimated time-varying conditional correlations $\rho_{12,t}$				
Min	-0.0252		-0.2001	
Max	-0.0252		0.2018	
Median	-0.0252		0.0610	
Mean	-0.0252		0.0593	
Std	1.3E-15		0.0330	
Panel B: CCC-GARCH(1,1)				
Estimated constant conditional correlations ρ_{12}				
	-0.0226	(1.56E-8)	0.0502	(4.96E-6)